

**Investigating health impacts and equity in communities
surrounding large natural resource extraction projects in
sub-Saharan Africa: a contribution to sustainable
development**

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List of abbreviations

ACHEIA:	Australasian Collaboration for Health Equity Impact Assessment
CSR:	Corporate social responsibility
DHS:	Demographic and Health Survey
EHIA:	Environmental health impact assessment
EHSIA:	Environmental health social impact assessment
EIA:	Environmental impact assessment
EPFI:	Equator Principle Financing Institutions
FGD:	Focus group discussion
GIA:	Gender impact assessment
GIS:	Geographic information system
HEIA:	Health equity impact assessment
HIA:	Health impact assessment
HIA4SD:	Health impact assessment for sustainable development
IFC:	International Finance Corporation
KII:	Key informant interview
LMIC:	Low- and middle-income country
MDG:	Millennium Development Goal
NEPA:	National Environmental Policy Act
NREP:	Natural resource extraction project
r4d programme:	Research for development programme
SDC:	Swiss Agency for Development and Cooperation
SDG:	Sustainable Development Goal
SIA:	Social impact assessment
SOPHIA:	Society of Practitioners of Health Impact Assessment
SNSF:	Swiss National Science Foundation
Swiss TPH:	Swiss Tropical and Public Health Institute
WHO:	World Health Organization

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Summaries

Summary

Background: Large natural resource extraction projects (NREPs) can have positive but also negative effects on the health of surrounding communities, governed by demographic, economic, environmental, physical and social changes. Health impact assessment (HIA) is a decision-support tool that aims at maximizing benefits and minimizing negative impacts on people's health. Yet, HIA is underutilized in sub-Saharan Africa, where about a third of the remaining world's mineral reserves are located. In the frame of a larger research project, this PhD project is a contribution to strengthen HIA in sub-Saharan Africa by generating scientific evidence about perceived health impacts of mining industries on local populations. Specifically, the work presented focuses on the social determinants of health and health equity in communities next to industrial mining sites.

Objectives: The following five specific objectives were pursued: (i) to assess whether and to what extent is HIA utilized to address health equity in the context of NREPs in sub-Saharan Africa; (ii) to explore community member's perception of the mechanisms through which their health has been affected by mining projects and to identify health implications of different extraction settings in Burkina Faso, Mozambique and Tanzania; (iii) to understand how NREPs influence the wider environmental, economic and social determinants of health and how the respective health outcomes are distributed in communities, with a focus on the differences between men and women; (iv) to deepen the understanding of health equity in communities next to industrial mining projects; and (v) to investigate how mining projects affect the health of local communities through impacts on water and water infrastructure by combining qualitative and quantitative data.

Methodology: The first objective was addressed with a literature review scrutinizing health and health equity of different population groups in impact assessment guidelines and peer-reviewed literature pertained to impact assessment in areas of natural resource extraction. All other objectives were based on a qualitative field study with affected communities in Burkina Faso, Ghana, Mozambique and Tanzania. More specifically, we conducted participatory focus group discussions (FGDs) in 12 study sites in the four countries. For the fifth objective, an additional set of geo-referenced qualitative data from two study sites in Tanzania were integrated and triangulated with geo-referenced quantitative data.

Principal findings: The literature review showed that health equity is addressed in impact assessment by looking into different population groups. However, specific guidance for community stratification and evidence pertained to differential health impacts remains weak. Drawing on the perception of affected communities from the different countries, the

implementation of the mine induces changes on various aspects of environmental, social and economic determinants of health, which consequently affected their perceived health and well-being. Negative changes for their health and well-being prevailed, while particularly women were affected disproportionately. Positive changes were primarily related to interventions such as new health centers or water access points, yet benefits were not distributed equally among impacted communities. Engaging with affected communities revealed concerns about water quality and availability, which were hidden in the positive trend of water infrastructure in mining regions.

Conclusion: HIA is a promising approach to systematically address health impacts and their distribution among affected population groups. However, the predominating negative perception of affected communities indicates a gap between theory and practice. Hence, there is pressing need to strategically manage health impacts of large NREPs with particular attention on most marginalized population groups. Especially in the light of the 2030 Agenda for Sustainable Development, HIA offers a unique opportunity. Adopted by the countries' legislation, commissioned by the extractive industries and driven by the citizens HIA hold promise to act on wider determinants of health, which is needed to reduce health inequities and ultimately contribute to good health and well-being for all. To foster the institutionalization of HIA, this PhD thesis lays a foundation for the forthcoming policy dialogue to promote the application and uptake of HIA in producer regions in sub-Saharan Africa.

Résumé

Contexte: Les projets d'extraction de ressources naturelles à grande échelle peuvent avoir des effets positifs comme négatifs sur la santé des communautés alentour, régis par des changements démographiques, économiques, environnementaux, physiques et sociaux. L'évaluation de l'impact sur la santé (EIS) est un outil d'aide à la décision qui vise à maximiser les avantages et à minimiser les effets négatifs sur la santé des personnes. Pourtant, l'EIS est sous-utilisée en Afrique subsaharienne, où se trouvent environ un tiers des réserves minérales mondiales restantes. Dans le cadre d'un large projet de recherche, ce doctorat contribue à renforcer l'usage de l'EIS en Afrique subsaharienne en apportant des preuves scientifiques sur les impacts sanitaires des industries minières perçus par les populations locales. Ce travail de recherche se concentre particulièrement sur les déterminants sociaux de la santé et l'égalité en matière de santé dans les communautés situées autour des sites miniers industriels.

Objectifs: Les cinq objectifs spécifiques suivants ont été poursuivis: (i) évaluer si et dans quelle mesure l'EIS est utilisée pour promouvoir l'égalité en matière de santé dans le contexte des grands projets d'extraction de ressources naturelles en Afrique subsaharienne; (ii) explorer comment les communautés perçoivent les mécanismes par lesquels les projets miniers affectent leur santé et identifier les implications sanitaires des différents projets d'extraction au Burkina Faso, Mozambique et en Tanzanie; (iii) comprendre comment les grands projets d'extraction de ressources naturelles influencent les déterminants environnementaux, économiques et sociaux de la santé et comment ces résultats sont distribués au sein des communautés locales, en particulier les différences entre les hommes et les femmes; (iv) approfondir la compréhension de l'égalité en matière de santé dans les communautés à proximité des projets miniers industriels; et (v) étudier comment les projets miniers affectent la santé des communautés locales par le biais de l'eau et des infrastructures hydrauliques en combinant des données qualitatives et quantitatives.

Méthodologie: Le premier objectif a été abordé par une revue de littérature examinant la santé et l'égalité en matière de santé pour différents groupes de population dans les guidelines sur l'évaluation de l'impact et la littérature scientifique concernant l'évaluation de l'impact dans les zones d'extraction de ressources naturelles. Tous les autres objectifs sont basés sur une étude qualitative de terrain auprès des communautés touchées au Burkina Faso, au Ghana, au Mozambique et en Tanzanie. Dans ce but, nous avons mené des discussions de groupe participatives dans 12 sites d'étude situés dans ces quatre pays. Pour le cinquième objectif, une autre base de données qualitatives géo-référencées provenant de deux sites d'étude en Tanzanie a été intégrée et triangulée avec des données quantitatives géo-référencées.

Résultats: La revue de littérature a montré que l'égalité en matière de santé est prise en compte dans l'évaluation de l'impact en examinant différents groupes de la population. Toutefois, les orientations spécifiques concernant la stratification des communautés et les preuves par rapport aux impacts différentiels sur la santé restent faibles. Sur la base de la perception des communautés touchées dans les différents pays à l'étude, l'implémentation de sites miniers cause des changements sur divers aspects des déterminants environnementaux, sociaux et économiques de la santé, qui affectent à leur tour la perception de leur santé et de leur bien-être par les communautés locales. Les changements négatifs en termes de santé et de bien-être étaient les plus notoires, en particulier auprès des femmes. Les changements positifs étaient quant à eux principalement liés à des interventions telles que la création de nouveaux centres de santé ou points d'accès à l'eau potable. Toutefois, les bénéfices n'étaient pas répartis de manière égale au sein des différentes communautés touchées. L'engagement auprès des communautés a révélé des préoccupations concernant la qualité et la disponibilité de l'eau, qui étaient masquées par la tendance positive de l'infrastructure de l'eau dans les régions minières.

Conclusion: L'EIS est une approche prometteuse pour aborder systématiquement les impacts sanitaires et leur distribution parmi les groupes de population touchées. La perception négative prédominante des communautés touchées indique une différence entre la théorie et la pratique. Il est donc urgent de gérer stratégiquement les impacts sanitaires des grands projets d'extraction de ressources naturelles, en commençant par cibler les groupes de population le plus marginalisés. Pour cela, l'EIS offre une opportunité unique, en particulier dans le contexte de l'Agenda 2030 pour le développement durable. Adoptée par la législation des pays, commandée par les industries extractives et dirigé par les citoyens, l'EIS promet d'agir sur des déterminants de la santé plus larges, ce qui est nécessaire à la réduction des inégalités en matière de santé, et finalement de contribuer à la santé et au bien-être de tous. Pour favoriser l'institutionnalisation de l'EIS, cette thèse pose les bases du dialogue politique à venir visant à promouvoir l'application et l'adoption de l'EIS dans les régions minières d'Afrique subsaharienne.

Resumo

Introdução: Grandes projetos de extração de recursos naturais tanto podem ter efeitos positivos como negativos na saúde das comunidades afetadas, regidos por mudanças demográficas, económicas, ambientais, físicas e sociais. A avaliação de impacto na saúde (AIS) é uma ferramenta de apoio à decisão que visa maximizar benefícios e minimizar os impactos negativos na saúde das pessoas. No entanto, a AIS é subutilizado em África subsariana, onde cerca de um terço das reservas minerais do mundo estão localizadas. No âmbito de um projeto de pesquisa mais amplo, este projeto de doutoramento é uma contribuição para fortalecer a AIS na África subsariana, gerando evidências científicas sobre a percepção das populações locais acerca dos impactos das indústrias mineiras na saúde. O trabalho apresentado foca-se nas determinantes sociais da saúde e da equidade na saúde em comunidades que vivem próximo de zonas de mineração industrial.

Objetivos: Assim, os seguintes cinco objetivos específicos foram trabalhados: (i) avaliar se e em que medida a AIS é utilizada para abordar a equidade na saúde no contexto dos projetos de extração de recursos naturais na África Subsariana; (ii) explorar a percepção dos membros da comunidade acerca dos mecanismos através dos quais a sua saúde foi afetada por projetos de mineração e identificar as implicações para a saúde de diferentes ambientes de extração no Burkina Faso, Moçambique e Tanzânia; (iii) compreender como os projetos de extração de recursos naturais influenciam os determinantes ambientais, económicos e sociais mais amplos da saúde e como os respectivos efeitos de saúde são distribuídos nas comunidades, com um foco nas diferenças entre homens e mulheres; (iv) aprofundar a compreensão da equidade na saúde em comunidades próximas de projetos de mineração industrial; e (v) investigar como os projetos de mineração afetam a saúde das comunidades locais por meio de impactos na água e na infraestrutura hídrica, combinando dados qualitativos e quantitativos.

Metodos: O primeiro objetivo foi abordado com uma revisão da literatura para examinar a saúde e a equidade na saúde de diferentes grupos populacionais nas diretrizes de avaliação de impacto e em literatura publicada referente à avaliação de impacto em áreas de extração de recursos naturais. Todos os outros objetivos foram baseados num estudo de campo qualitativo com comunidades afetadas no Burkina Faso, Gana, Moçambique e Tanzânia. Mais especificamente, conduzimos grupos focais em 12 centros de estudo nos quatro países. Para o quinto objetivo, um conjunto adicional de dados qualitativos georreferenciados de dois locais de estudo na Tanzânia foram integrados e triangulados com dados quantitativos georreferenciados.

Resultados: A revisão da literatura mostrou que a equidade em saúde é abordada na avaliação de impacto analisando diferentes grupos populacionais. No entanto, a orientação

específica para a estratificação da comunidade e as evidências relativas aos impactos diferenciais na saúde permanecem fracas. Com base na percepção das comunidades afetadas de diferentes países, a implementação da mina induziu mudanças em vários aspectos dos determinantes ambientais, sociais e económicos da saúde que, conseqüentemente, afetaram as percepções de saúde e bem-estar. Mudanças negativas para sua saúde e bem-estar prevaleceram, e as mulheres foram afetadas de forma desproporcional. As mudanças positivas foram principalmente relacionadas intervenções, como novos centros de saúde ou pontos de acesso à água, mas os benefícios não foram igualmente distribuídos entre as comunidades afetadas. A discussão com as comunidades afetadas revelou preocupações sobre a qualidade e disponibilidade da água, que estavam ocultas na tendência positiva da infraestrutura hídrica nas regiões de mineração.

Conclusão: A AIS é uma abordagem promissora para abordar de forma sistemática os impactos na saúde e sua distribuição entre os grupos populacionais afetados. No entanto, a percepção negativa predominante das comunidades afetadas aponta para uma lacuna entre a teoria e a prática. Assim, há uma necessidade urgente de ferir de forma estratégica os impactos de grandes projetos de extração de recursos naturais na saúde, dando particular atenção aos grupos populacionais mais marginalizados. Especialmente à luz da Agenda 2030 de Desenvolvimento Sustentável, a AIS oferece uma oportunidade única. Adotada pela legislação de países, solicitada pelas indústrias extrativas e impulsionada pelos cidadãos a AIS promete agir em áreas mais amplas da saúde, e tal é necessário para reduzir as iniquidades em saúde e, em última análise, contribuir para a boa saúde e bem-estar para todos. Para fomentar a institucionalização da AIS, esta tese estabelece uma base para o próximo diálogo político para promover a aplicação e aceitação da AIS em regiões produtoras na África Subsaariana.

Muhtasari

Utangulizi: Miradi mikubwa ya uchimbaji wa madini (NREPS) inaweza kuwa na athari za kiafya chanya au hasi katika jamii zinazoishi karibu na miradi hiyo. Tathmini ya athari za kiafya (Health Impact Assessment - HIA) ni zana ya kusaidia maamuzi ambayo yanakusudia kuongeza faida na kupunguza athari za afya kwa jamii husika. Hata hivyo, matumizi ya HIA katika nchi za Kusini mwa Jangwa la Sahara Afrika (Sub Saharan Africa - SSA) si yakuridhisha ukizingatia kwamba theluthi moja ya akiba ya madini yanyopatikana duniani kote yapo SSA. Kwa kutumia muktadha wa taarifa za miradi mikubwa, lengo la shahada hii ya uzamivu ni kuongezea na kuboresha mfumo wa tathmini za athari za kiafya kwa nchi za SSA na vilevile kupata taarifa zilizothibitika kisayansi kwa ajili ya mustakabali wa kusaidia miradi mikubwa kulinda mathara ya kiafya kwa jamii inayoishi kuzunguka machimbo ya madini. Hasa haswa, lengo la shahada hii ya uzamivu ni kuangalia athari zinazotokana na viwanda/machimbo vya madini kwenye afya na usawa wa kiafya.

Malengo: Malengo mahususi yafuatayo yalifuatwa (i) kutathimini kwa kiwango gani HIA imetumika kwenye kushughulikia usawa wa afya kwa muktadha wa NREPs kwenye nchi za ukanda wa jangwa la Sahara Afrika; (ii) kuchunguza na kupata maoni ya jamii husika ili kutambua namna gani afya zao zimethirika kutokana na kuwepo kwa miradi ya uchimbaji madini na matokoe yake kwenye nchi tofauti(iii) kuelewa namna gani miradi ya uchimbaji madini inachangia vigezo mbali mbali katika nyanja ya mazingira, uchumi, afya ya jamii na matokeo mtambuka yanayovyofikia jamii kwa kuzingatia jinsia ya kiume na kike (iv) kupata undani na kuimarisha uelewa usawa afya kwa jamii inayoishi karibu na viwanda vya madini; na (v) kuchunguza jinsi gani miradi ya madini inaathiri afya za jamii kupitia madhara katika maji au miundo mbinu ya maji kwa kutumia njia ya takwimu au udodosaji wa maungumzo.

Mbinu au njia zilizotumia: Lengo la kwanza limefanyika kwa kupitia fasihi za kisayansi mbalimbali yanayozungumzia usawa katika masuala ya afya pamoja na tathmini ya athari za kiafya katika maeneo ya uchimbaji. Malengo mengine yaliyobaki yamehusisha utafiti wa takwimu za afya kutoka sehemu ya mafunzo zilizoathirika huko Burkina Faso, Ghana, Msumbiji na Tanzania. Hasa haswa, tulifanya majadiliano ya vikundi (Focus Group Discussion - FGDs) katika sehemu 12 za utafiti uliofanyika katika nchi tajwa. Kwa lengo la tano, seti ya nyongeza ya data ya ubora inayorejelewa kwa jiografia kutoka kwa tovuti mbili za utafiti nchini Tanzania ziliunganishwa na kupunguzwa pembe tatu na data ya idadi ya marejeleo ya jiografia.

Matokeo: Mapitio ya fasihi yalionyesha kuwa usawa wa afya unashughulikiwa katika tathmini ya athari kwa kuangalia katika vikundi tofauti vya idadi ya watu. Walakini, mwongozo maalum wa utabakaji wa jamii na ushahidi unaohusu athari tofauti za kiafya unabaki dhaifu.. Kwa kuzingatia maoni ya jamii zilizoathiriwa kutoka nchi tofauti, utekelezaji wa mgodi

unasababisha mabadiliko katika mambo anuwai ya mazingira, kijamii na kiuchumi viashiria vya afya, ambavyo viliathiri afya na ustawi wao. Mabadiliko hasi kwa afya ya ustawi wa jamii yalidumu, wakatiulinganisho wa baadhi ya wanawake ulionyesha tofauti mbalimbali. Mabadiliko chanya yalihusishwa na uwepo wa vituo vipya vya afya au vituo vya upatikanaji wa maji, lakini faida hazikusambazwa sawa kati ya jamii zilizoathiriwa. Kuhusisha jamii zilizoathiriwa kulifunua wasiwasi juu ya ubora wa maji na upatikanaji, ambao ulifichwa katika mwenendo chanya wa miundombinu ya maji katika mikoa ambayo madini yanapatikana.

Hitimisho: Kwa kuhitimisha, HIA ni njia mojawapo inayoweza inayoweza kutoa taarifa zinazohusiana na athari za kiafya na kuonyesha makundi ya watu walioathirika. Walakini, maoni hasi ya jamii zilizoathiriwa yanaonyesha pengo kati ya nadharia na vitendo. Kwa hivyo, kuna haja kubwa ya kusimamia kimkakati athari za kiafya za NREPs kwa umakini zaidi kwa vikundi vya watu waliotengwa. Hasa ukilinganisha na Ajenda ya Maendeleo Endelevu ya 2030, HIA inatoa fursa ya kipekee. HIA ni nyenzo ambayo inaweza kuchangia kupunguza ukosefu wa usawa wa kiafya na mwishowe kuwezesha kunawili kwa afya njema na ustawi kwa wote. Kukuza taasisi kwa HIA, nadharia hii inaweka msingi wa mazungumzo ya sera zijazo ili kukuza matumizi na utumiaji wa HIA kati ya wazalishaji wa nchi za SSA.

Zusammenfassung

Hintergrund: Grosse Projekte zur Gewinnung natürlicher Ressourcen können positive, aber auch negative Auswirkungen auf die Gesundheit der betroffenen Bevölkerung haben, die von demografischen, wirtschaftlichen, ökologischen, physischen und sozialen Veränderungen betroffen sind. Die Gesundheitsfolgenabschätzung (Health Impact Assessment, HIA) ist ein Verfahren, einen Entscheidungsfindungsprozess zu unterstützen mit dem Ziel, den Nutzen zu maximieren und die negativen Auswirkungen auf die Gesundheit der Menschen zu minimieren. Dennoch wird HIA in Afrika südlich der Sahara, wo sich etwa ein Drittel der verbleibenden Mineralreserven der Welt befinden, nicht ausreichend genutzt. Im Rahmen eines grossen Forschungsprojekts trägt diese Dissertation zur Stärkung der HIA Afrika südlich der Sahara bei, indem es über wissenschaftliche Erkenntnisse der wahrgenommenen gesundheitlichen Auswirkungen der Bergbauindustrie auf die lokale Bevölkerung berichtet. Im Besonderen fokussiert diese Arbeit auf die sozialen Determinanten der Gesundheit und gesundheitliche Chancengleichheit in Bevölkerungsgruppen in der Nähe industrieller Abbaustätten.

Ziele: Die folgenden fünf spezifischen Ziele wurden verfolgt: (i) zu beurteilen, ob und in welchem Umfang HIA im Zusammenhang mit industriellen Rohstoffabbau Projekten in Afrika südlich der Sahara zur Förderung der gesundheitlichen Chancengleichheit eingesetzt wird; (ii) zu untersuchen, wie lokale Bevölkerungsgruppen die Gesundheitsauswirkungen der Bergbauprojekte und deren Mechanismen wahrnehmen, und die Unterschiede der gesundheitlichen Auswirkungen der verschiedenen Bergbauprojekte in Burkina Faso, Mosambik und Tansania aufzuzeigen; (iii) zu verstehen, wie die industrielle Rohstoffabbau Projekte die umfassenderen ökologischen, wirtschaftlichen und sozialen Determinanten der Gesundheit beeinflussen und wie die jeweiligen Gesundheitsergebnisse in den Bevölkerungsgruppen verteilt sind, insbesondere die Unterschiede zwischen Männern und Frauen; (iv) das Verständnis der gesundheitlichen Chancengleichheit in Bevölkerungsgruppen von industriellen Bergbauprojekten betroffenen zu vertiefen; und (v) basierend auf der Kombination von qualitativer und quantitativer Forschung zu untersuchen, wie Bergbauprojekten sich auf die Wasserinfrastruktur und das Wasser auswirken und wie sie dadurch die Gesundheit lokaler Bevölkerungsgruppen beeinflussen.

Methodologie: Das erste Ziel wurde mit einer Review der Literatur zur Untersuchung der Gesundheit und der gesundheitlichen Chancengleichheit verschiedener Bevölkerungsgruppen untersucht, für welche Leitfäden der Folgenabschätzung und wissenschaftliche Publikationen im Bereich der Gewinnung natürlicher Ressourcen analysiert wurden. Alle anderen Ziele basierten auf einer qualitativen Feldstudie mit betroffenen Bevölkerungsgruppen in Burkina Faso, Ghana, Mosambik und Tansania. Dazu wurden

partizipative Gruppendiskussionen an 12 Studienorten in den vier Ländern durchgeführt. Für das fünfte Ziel wurde ein zusätzlicher Satz georeferenzierter qualitativer Daten von zwei Studienorten in Tansania integriert und mit georeferenzierten quantitativen Daten trianguliert.

Resultate: Die Review zeigt, dass die gesundheitliche Chancengleichheit bei der Folgenabschätzung durch die Untersuchung verschiedener Bevölkerungsgruppen berücksichtigt wird. Spezifische Leitlinien für die Stratifizierung von Bevölkerungsgruppen und die Evidenz für unterschiedliche gesundheitliche Auswirkungen sind jedoch nach wie vor schwach ausgeprägt. Ausgehend von der Wahrnehmung der betroffenen Bevölkerungsgruppen aus den verschiedenen Ländern haben die Bergbauprojekte Veränderungen in verschiedenen Aspekten der ökologischen, sozialen und wirtschaftlichen Gesundheitsdeterminanten bewirkt, die sich folglich auf ihre wahrgenommene Gesundheit und Wohlbefinden auswirkten. Negative Veränderungen für ihre Gesundheit und ihr Wohlbefinden überwogen, von denen insbesondere Frauen unverhältnismässig stark betroffen waren. Positive Veränderungen wurden in erster Linie durch Interventionen wie neue Gesundheitszentren oder Wasserzugangspunkte ausgelöst, doch deren Vorteile wurden nicht gleichmässig auf betroffenen Bevölkerungsgruppen verteilt. Die Zusammenarbeit mit den betroffenen Bevölkerungsgruppen machte die Bedenken hinsichtlich der Wasserqualität und -verfügbarkeit deutlich, die im positiven Trend der Wasserinfrastruktur in Bergbauregionen verdeckt waren.

Schlussfolgerung: Fazit: HIA erweist sich als vielversprechender Ansatz, um die Auswirkungen auf die Gesundheit und deren Verteilung auf betroffene Bevölkerungsgruppen systematisch anzugehen. Die vorherrschende negative Wahrnehmung der betroffenen Bevölkerungen deutet jedoch auf eine beträchtliche Differenz zwischen Theorie und Praxis hin. Daher besteht die dringende Notwendigkeit, die gesundheitlichen Auswirkungen grosser NREPs strategisch zu regeln – mit besonderer Aufmerksamkeit auf vernachlässigte Bevölkerungsgruppen. Insbesondere im Hinblick auf die Agenda für nachhaltige Entwicklung bis 2030 bietet HIA eine einzigartige Chance. Institutionalisiert in der Gesetzgebung der Länder, umgesetzt von der Rohstoffindustrie und getrieben von der Bevölkerung verspricht HIA auf breitere Gesundheitsdeterminanten einzuwirken, was notwendig ist, um gesundheitliche Ungleichheiten zu verringern und letztlich zu guter Gesundheit und Wohlbefinden für alle beizutragen. Diese Arbeit bietet eine Grundlage für den bevorstehenden politischen Dialog zur Förderung der Anwendung und Übernahme von HIA in den Erzeugerregionen in Afrika südlich der Sahara.

1. Introduction

This PhD thesis pertains to health of communities affected by large natural resource extraction projects (NREPs), such as industrial gold mines. As part of a larger research project, the generated evidence will be used to strengthen health impact assessment (HIA) in sub-Saharan Africa. The main outcomes of this study are presented as papers (Chapters 2-6) or online accessible videos (Chapter 7), preceded by a general introduction. Therefore, the following chapter introduces the interlinkage of health and natural resource extraction. It starts with a brief overview of the social determinants of health and health equity and the understanding and importance of health considerations in global development (not only during pandemics). Finally, it touches upon the natural resource extraction sector, its likely positive and negative impacts on local populations and strategies to mitigate these impacts (i.e. HIA, health equity impact assessment (HEIA) and gender impact assessment (GIA)).

1.1 Social determinants of health and health equity

Despite major achievements in population health during the past several decades, there remain wide disparities in the health status of different social groups from different countries around the globe (Barreto, 2017). For example, life expectancy has increased about 20 years since the 1950, but there remains a gap of 38.5 years among different countries, as well as almost 20 years within a country (GBD 2017 Mortality Collaborators, 2018). However, this gap should not be inevitable. To further improve health of populations across the world, including those furthest behind, action on people's living and working conditions is needed (Irwin et al., 2006; Marmot, 2005). As defined by the World Health Organization (WHO), these conditions, in which people are born, grow, live and work are the social determinants of health (WHO, 2017a). In fact, there is ample evidence that health is determined by various factors, such as the level of education, the work we do, the place where we live as well personal traits including gender, age and ethnicity (Bambra et al., 2009; Marmot, 2007). Furthermore, these underlying conditions are influenced by the distribution of money, power and resources – all of which ultimately affect health and well-being (Marmot, 2005). The unequal distribution of these factors are causing inequities in health (Marmot, 2007). In turn, health equity refers to the equal opportunity for everyone to achieve their full health potential, while no one should be disadvantaged (Whitehead, 1991). The concept of health equity is therefore concerned about equal opportunities and reducing health disparities as far as possible (Braveman, 2014; Whitehead, 1991). Moreover, health inequities can be translated into health inequalities, which are group level differences and are widely used to assess health equity (Barreto, 2017; Braveman, 2014).

In the past 20 years, social determinants of health and health equity were increasingly discussed using different frameworks (Lucyk & McLaren, 2017). A compendium of existing frameworks of the determinants of health was developed by the Canadian Council on Social Determinants of Health, collating different conceptualizations of the complex relationship of health and health determinants (CCSDH, 2015). The most widely known and used models was developed by Dahlgren and Whitehead in 1991, suggesting to act on the wider determinants toward social equity in health (Dahlgren & Whitehead, 1991). Indeed, inequities are shaped by a complex interplay of multiple factors rather than single, distinct factors (CSDH & WHO, 2008; Irwin et al., 2006). Using the intersectionality perspective, inequities are the result of intersecting social locations of a person (such as gender, age, ethnicity, socio-economic status or employment) within given systems or power relations (e.g. laws or policies) (Hankivsky, 2014).

In Africa, the unequal distribution of health care, high burden of illness and premature deaths reflect the equity gap and thus, emphasize the clear need of action on the social determinants of health (Boidin, 2019; Eshetu & Woldesenbet, 2011). Particularly high level of inequities are demonstrated by low rates of accessing and utilizing health care of mothers living in rural areas and with low economic status and education background (Mutangadura et al., 2007). These examples indicate that social justice and good quality health care are closely intertwined with poverty (Donkin et al., 2018). Hence, tackling poverty in Africa should be an immediate concern to improve health for all (Worku & Woldesenbet, 2015).

The diversity and complexity of the determinants of health reflects the need of cross-sectoral approaches to improve health (CSDH & WHO, 2008; Marmot, 2007). Action on various sectors (i.e. academia, government and society), also referred to “Health in all policies” is needed for to reach “health for all [people]” (Dietler and Leuenberger et al., 2019; WHO, 2013, 2017b). Such a multidisciplinary approach and the use of synergies of different levels has already been proposed by Dahlgren and colleagues in 1991 (Dahlgren & Whitehead, 1991). Today, the three main focus areas to act on the social determinants of health and improve health equity are: (i) improving daily living conditions; (ii) tackling the inequitable distribution of power, money, and resources; and (iii) measuring and understand the problem and assessing the impact of action (CSDH & WHO, 2008).

Taken together, the complex nexus of social determinants of health and health equity has gained popularity (Lucyk, 2017). Yet, wide disparities in health remain between and within countries, which calls for action across sectors and disciplines aiming for further development toward a more equitable and healthy world (Dietler and Leuenberger et al., 2019; Irwin et al., 2006).

1.2 Development agendas and health

1.2.1 Millennium Development Goals

Health has played a critical role in the global development agendas. In 1993, the “World Development Report” published by the World Bank focused on health, “as an objective and not only a means to development” (Musgrove, 1993). Development and economic growth is especially important for poor countries, since it may result in opportunities to invest for population health (CSDH, 2008). Eradicating extreme poverty was the major objective of the Millennium Development Goals (MDGs), launched by the United Nations Assembly in the year 2000 (UN, 2000). Three out of eight MDGs addressed health issues explicitly. Within their due time until 2015, the MDGs catalyzed global health issues, including increase in global average of life expectancy by 20 years (GBD 2017 Mortality Collaborators, 2018). However, several challenges for global health have remained unsolved. Particularly addressing marginalized population groups and those who are hard to reach was identified as pressing need (GBD 2017 SDG Collaborators, 2018).

1.2.2 2030 Agenda for Sustainable Development

In 2015, a new agenda was launched aiming for social, economic and environmental sustainable development (UN, 2015). In pursuit of a more equitable world, the 17 Sustainable Development Goals (SDGs), 169 targets and 230 indicators offers a great opportunity to monitor and strive toward sustainable development (UN Statistical Commission, 2020). Health is integrated as a central issue and addressed explicitly in SDG 3, aiming for “good health and well-being for all at all ages” as well as connected to more than five other SDGs (Buse & Hawkes, 2015). To date, SDG 3 has been most widely researched around the globe (Meschede, 2020). Yet, health indicators vary across world regions, with Africa lagging behind (GBD 2016 SDG Collaborators, 2017). For instance, many African countries face a multiple burden of diseases, embracing high burden of infectious diseases, malnutrition and maternal mortality as well as emerging non-communicable diseases (Agyepong et al., 2017; Gouda et al., 2019). Additionally, low- and middle-income countries (LMICs) face other health challenges, related to their particular vulnerability to climate change (Walpole et al., 2009) or as important producers for global supply of natural resources (Schrecker et al., 2018). To improve health as a cross-cutting issue, there is a pressing need for novel partnerships and intersectoral collaboration, including the mining sector (Fraser, 2019; Hussain et al., 2020).

1.2.3 Agenda 2063: «The Africa we want»

In relation to natural resource extraction in Africa and its potential for economic development, the Agenda 2063 was adopted in 2013 by the African Union (AUDA-NEPAD, 2015). With its seven aspirations and 20 goals, the Agenda has the overarching objective to achieve “an

integrated, prosperous and peaceful Africa”. Within the first aspiration, health is explicitly addressed in two goals aiming for “high standard of living, quality of life and well-being for all” and “healthy and well-nourished citizens”. Throughout the framework document, health is together with education considered as social outcome. While promoting health, equity is reported to be addressed through universal health coverage. This includes sustainable funding strategies, such as health insurance schemes to guarantee basic health provision for all. Overall, the agenda emphasize the need of people driven and population centered development. Governing natural resources will contribute to develop human capital and together with public spending boosting Africa’s indigenous transformation toward their envisioned future Africa (AUDA-NEPAD, 2015).

1.3 Natural resource extraction projects and health

Endowing about a third global natural reserved, which are being extracted in more than 700 active mines, NREPs are important drivers of the African economy (Standard & Poor Global, 2020; UNECA, 2011; World Bank, 2017).¹ Thus, many African countries are dealing with international and national companies that extract resources such as metals, minerals, petroleum and gas. On the national level, multinationals can act as “growth poles” and contribute to the countries’ prosperity, by paying taxes or boosting the economy (Africa Pogress Panel, 2013; Hilson, 2019). On the local level, the implementation of NREPs change the physical, natural and social and environment of hosting districts, which ultimately may affect the health of local communities (Schrecker et al., 2018). Benefits on the local level are shown by community development and improved living standards (Mamo et al., 2019; Virah-Sawmy, 2015). Extractive industries may contribute (financially) to upgraded public infrastructure, such as road network (Mamo et al., 2019), access to water (Admiraal, 2017) or health care facilities (Knoblauch et al., 2017; Utzinger et al., 2004). Potential benefits are however opposed by potential negative impacts. Water, air and soil pollution can directly affect the health of surrounding communities (Aboka et al., 2018; Von der Goltz & Barnwal, 2019). By the creation of new job opportunities, NREPs can also affect migration patterns (Dietler et al., 2020a). Often the infrastructure and essential services (i.e. water, sanitation and health care) are stressed and likely to be overburdened by the increased demand (IFC, 2009b; Utzinger et al., 2005). Project-related in-migration is often associated with HIV/AIDS, an infectious disease whose transmission is driven mainly by social factors (Knoblauch et al., 2017; Oster, 2012). Additionally, projects raised issues related to equality and gender equity (Benshaul-Tolonena et al., 2019). As a consequence of insufficient stakeholder involvement,

¹ Note: Artisanal mining is an important economic activity particularly in rural areas of sub-Saharan Africa. As this is often in the informal sector, which is difficult to govern by national regulations, this thesis focuses on large extractive industries.

the potential positive impacts are often prevailed by adverse impacts, which have also led to local conflicts and injustice (Berman et al., 2017).

These examples show that impacts of large NREPs are closely linked to the social determinants of health as they have a direct effect on the underlying factors of the societal structure and correspondingly health (Carney & Gushulak, 2016; Von der Goltz & Barnwal, 2019). Evidently, good management is needed in order to mitigate potential negative impacts and maximize benefits for local communities and their health.

1.4 Impact assessment

Impact assessment is an overarching approach aiming to identify likely impacts on the environment, society and public health prior to a project, policies or programs. Nowadays, environmental impact assessment (EIA) has been recognized as “significant decision tool” around the globe, also in the context of natural resource extraction (Cashmore, 2004; Harris et al., 2015). The first impact assessment legislation was adopted in the National Environmental Policy Act (NEPA) in the United States more than 50 years ago. As emerging concept, EIA included a broad range of topics, including health. (Morgan, 2012). Later on, health aspects were considered as part of social impact assessment (SIA), which developed as separate stream in the 1970s (Esteves et al., 2012). Besides the separate types of impact assessments, health have also been considered in integrated approaches, such as environmental health social impact assessment (EHSIA) or environmental health impact assessment (EHIA).

1.4.1 Health impact assessment

To create a common understanding and to emphasize the importance of promoting and protecting human health HIA was officially adopted by the European Center for Health Policy in the Gothenburg consensus paper in 1999 (WHO European Centre for Health Policy, 1999). To date, HIA practice and legislation varies around the globe, but there is international consensus about best practice principles (Quigley et al., 2006; Winkler et al., 2020b). Importantly, HIA is underpinned by the wider determinants of health, emphasizing a comprehensive understanding of health. Further, four core values are at the heart of HIA. Namely these are (i) democracy, (ii) ethical use of evidence, (iii) equity and (iv) sustainability. Democracy intends to involve people in the formulation and health decisions that affect them. The potential of a participatory HIA to create responsive policies is however hampered by the lack of clear guidance (Den Broeder et al., 2017). Ethical use of evidence relates to develop recommendations impartially by using best available evidence in a transparent manner. Equity emphasizes the focus on social justice and the intention to consider the whole population, particularly paying attention to vulnerable groups (due to their physical status or social

position). Equity in HIA has been studied widely and is further discussed in the next chapter (Harris-Roxas et al., 2004; Heller et al., 2014; Simpson et al., 2005). Sustainability draws attention to short and long-term effect, while particularly meeting the needs for future generations. Indeed, HIA, “as a way of thinking and acting”, could serve as catalyst toward the achievement of the 2030 Agenda for Development (Gulis, 2019).

Since the beginning of HIA, its practice has rapidly evolved around the globe, while it is most developed in Europe, North America, Asia and Australia (Winkler et al., 2020b). However, lacking capacities and policies remain important barriers for further expansion of HIA (Winkler et al., 2020b). Hence, there is a call toward institutionalization of HIA to further promote sustainable development (Thondoo & Gupta, 2020). Particularly with regard on the African continent, where HIA is mostly driven by international practitioners and researchers, there remains a large gap between theory and practice (Dietler et al., 2020b; Leuenberger et al., 2019).

In many developed countries HIA is legally required but unfortunately, no single country in Africa actively promotes HIA (Winkler et al., 2013). This holds true for the four partner countries of the framing project of this PhD thesis (Health impact assessment for sustainable development project, short HIA4SD) namely Burkina Faso, Ghana, Mozambique and Tanzania (Farnham et al., 2020; Winkler et al., 2020a). The inclusion of health in impact assessment in the respective countries presents as follows:

In **Burkina Faso**, health is addressed by EIA, which is regulated by the “Code de l’Environnement” (2013). While focusing on environmental determinants of health i.e. hazardous waste and other emissions, social aspects of health such as health equity are neglected (L’Assemblée Nationale, 2013).

In **Ghana**, possible health effects should be covered by an environmental impact statement, following the “Environmental Assessment Regulation” (1999) (Ghana Environmental Protection Agency, 1999).

In **Mozambique**, EIA is legally required and regulated by the “Environmental Impact Assessment Regulations “ (2004), but mentions only health impacts related to waste or hazardous waste (República de Moçambique, 2004).

In **Tanzania**, the “Environmental Management Act” (2004) requires EIA, including environmental health aspects. Social and health impacts are mentioned briefly without further specification (United Republic of Tanzania, 2004).

Overall, EIA is required legally in all of the four partner countries, including, more or less, environmental health-related issues. Little specificity is provided on social aspects, such as

health equity and gender issues, in the regulations of the four partner countries. However, particularly in the context of national resource extraction, which pose a potential risk to public health in producer regions, the systematic and rigorous inclusion of health in impact assessment is critical (Harris et al., 2015; Winkler et al., 2013).

Given the fact that no single country in Africa is actively promoting HIA on national level, international financing organizations play an important role (Winkler et al., 2013). As a start of the engagement of the private sector with the International Finance Corporation (IFC), the Equator Principles were launched in 2003 aiming to assess, determine and manage environmental and social risks of projects. To date, the majority of international project finance debts of emerging markets are covered by Equator Principle Financing Institutions (EPFI) from 38 designated countries (The Equator Principles Association, 2020). The principles are based on the Performance Standards of the IFC and the environment, health and safety guidelines of the World Bank, which mainly guide and promote impact assessments of large development projects (IFC, 2012; IFC & The World Bank Group, 2007). In light of this, specific HIA guidelines have been published by IFC in 2009 (IFC, 2009a). Despite this promising thinking to promote health and well-being of affected populations, HIA remain underutilized in producer regions in sub-Saharan Africa (Leuenberger et al., 2019; O'Keefe & Scott-Samuel, 2010; Thondoo et al., 2019).

1.4.2 Health equity impact assessment

In regions, where HIA is well-established, the HIA methodology has been advanced toward HEIA. Researchers have been investigating, how HIA can contribute to equity (Sohn et al., 2018), while others have scrutinized equity in HIA (Povall et al., 2014; Snyder et al., 2012). Alongside the equity metrics for health impact assessment (Heller et al., 2014), there are two more guidelines available, namely the equity-focused health impact assessment (EFHIA) framework (Mahoney et al., 2004a) and the HEIA workbook (Ontario Ministry of Health and Long-Term Care, 2012). The equity metrics were put forth by the Society of Practitioners of Health Impact Assessment (SOPHIA) Equity Working group and comprise 23 measures of equity, aiming to systematically include equity into the HIA process (Heller et al., 2014). The EFHIA framework was developed by the Australasian Collaboration for Health Equity Impact Assessment (ACHEIA), emphasizing potential differential and distributional impacts among different population groups throughout the whole HIA process (Mahoney et al., 2004b). The HEIA workbook was developed by Ontario Public Health to specifically identify unintended potential health impacts of projects or policies, aiming to stimulate an intersectoral dialogue (Ontario Ministry of Health and Long-Term Care, 2012).

Recent literature from various countries, show how HEIA has been applied in different settings, such as tobacco control (Costa et al., 2018), air pollution (Kihal-Talantikite et al., 2018), e-health initiatives (Fang et al., 2018), transportation projects (Cole et al., 2019) as well as natural resource extraction (Snyder et al., 2012). Besides case studies of HEIA, several studies have also reflected and evaluated the HEIA methodology and its effectiveness (Povall et al., 2014; Sadare et al., 2020; Simpson et al., 2005; Tyler et al., 2019). Collectively, two major strategies to address equity can be revealed: (i) social stratification and (ii) empowering affected communities.

Social stratification entails the (systematic) consideration of the distribution of health impacts among different populations and sub-group to reduce health disparities. Several case studies show that special attention should be drawn to marginalized, disadvantaged and vulnerable population groups, be it in terms of biological, geographical, cultural, social or economic reasons (Aldrich et al., 2005; Costa et al., 2018; Gunning et al., 2011).

Empowering affected communities means to build capabilities and self-determination and also embraces different ways of participation of communities in the process. Of note, this approach was strongly recommended in the guidelines from the SOPHIA Equity Working group (SOPHIA Equity Working Group, 2016). It is suggested that empowerment is more likely to address the root causes of inequities (Buse et al., 2019). However, based on findings from the United States, empowering affected communities was used secondary as strategy compared to promoting health equity by considering differential health impacts (Cole et al., 2019).

1.4.3 Gender impact assessment

With regard to different population groups and sub-groups, gender is indeed a key determinant. Distinct from the biological differences between men and women, gender refers to the different socially constructed roles, behaviors and activities and the relationship between people (Krieger, 2003). Against this background, not everyone is equally affected by the implementation of extraction projects. Specific guidelines for GIA in the context of natural resource extraction have been developed by OXFAM (Hill et al., 2017). As pointed out in the guidelines, conducting GIA is important to empower women and overcome persistent and structural gender inequalities that exist and may be exacerbated in the given settings. Advancing gender equality and shifting gender norms is also essential toward health equity, especially in the light of the SDGs (Gupta et al., 2019; Manandhar et al., 2018).

1.5 Identified research needs

HIA in settings of large NREPs hold potential to improve health and well-being as well as reducing health inequities in affected communities, and ultimately contributing to sustainable

development (Winkler et al., 2020b). However, as highlighted in the previous sub-chapters, HIA is yet underutilized in sub-Saharan Africa and there is a paucity of research pertained to health in mining communities. Research investigating the social determinants of health and health equity is scarce, particularly the perception of affected communities is underrepresented. Studies that explore beyond separate case studies, are needed, allowing for pooled analysis across different countries and settings. Taken together, there is lack of sound evidence to inform a potential policy dialogue toward the institutionalization of HIA in sub-Saharan Africa. Understanding of the underlying factors and the root causes determining health is crucially important for effective promotion of health and reducing health inequities in these highly dynamic settings - especially in the strive of the SDGs, as well as the people-centered Agenda 2063, which are both aiming for good health and well-being for all.

1.6 Specific objectives and research questions of this PhD thesis

In line with the overarching goal of the HIA4SD project, to strengthen HIA in Africa, it is the aim of this PhD thesis to contribute to better understanding of health-related changes and implications for health equity in communities living around large NREPs. Specifically, this PhD thesis aims to represent the perception of affected communities. Therefore, the following five specific objectives and research questions were formulated:

Objective 1

To assess whether and to what extent HIA is utilized to address health equity in the context of NREP in sub-Saharan Africa.

- (i) How is the health of different population groups integrated in impact assessment guidelines and peer-reviewed literature related to NREPs in sub-Saharan Africa?

Objective 2

To explore community member's perception of the mechanisms through which their health has been affected by mining projects and to identify health implications of different extraction settings in Burkina Faso, Mozambique and Tanzania.

Base on the perception of affected communities,

- (i) how has their health been impacted by mining projects?
- (ii) which determinants of health have played a role for the above mentioned relationship?
- (iii) what are differences and similarities of perceived health impacts of mining projects in affected communities in Burkina Faso, Mozambique and Tanzania?
- (iv) what are site-specific health implications of different extraction projects?

Objective 3

To understand how NREPs influence the wider environmental, economic and social determinants of health and how the respective health outcomes are distributed in communities, with a focus on the differences between men and women.

- (i) How do affected communities perceive impacts of large NREPs on the wider determinants of health?
- (ii) How are these impacts distributed among key population subgroups?
- (iii) How are the differences between men and women explained?

Objective 4

To deepen the understanding of health equity in communities next to industrial mining projects.

- (i) What are perceived inequities induced by industrial mining projects?
- (ii) How do the perceived inequities relate to the different layers of the framework of the wider determinants of health?
- (iii) How do perceived inequities translate into health inequities?

Objective 5

To investigate how mining projects affect the health of local communities through impacts on water and water infrastructure by combining qualitative and quantitative data.

- (i) How do mining projects affect the health of local communities through impacts on water and water infrastructure on a regional level (based on quantitative findings)?
- (ii) How do mining projects affect the health of local communities through impacts on water and water infrastructure on a local level (based on qualitative findings)?
- (iii) What are differences between quantitative and qualitative findings?

1.7 Methodological overview

This PhD thesis is framed by the HIA4SD project, a multi-country, multi-phase and multi-focus project, aiming to promote HIA in sub-Saharan Africa (Farnham et al., 2020; Winkler et al., 2020a). For this purpose, the project is partnering with research institutes in four countries, namely Burkina Faso, Ghana, Mozambique and Tanzania. The project is organized in two phases (2017-2020 and 2020-2023) and divided in two work streams (research and governance stream). Firstly and under the guidance research stream, scientific evidence is generated about various aspects of health in mining settings. Secondly and under the guidance of the governance stream, the generated evidence will be used to inform and facilitate a policy dialogue toward the institutionalization of HIA in the project partner countries. This thesis took part in the first phase of the project. As one out of six thematically focused PhD theses, the current work addresses health of affected communities in mining settings

from an equity perspective (see **Figure 1**). An overview of the individual objectives and the related methodological approach is given in **Figure 2**.

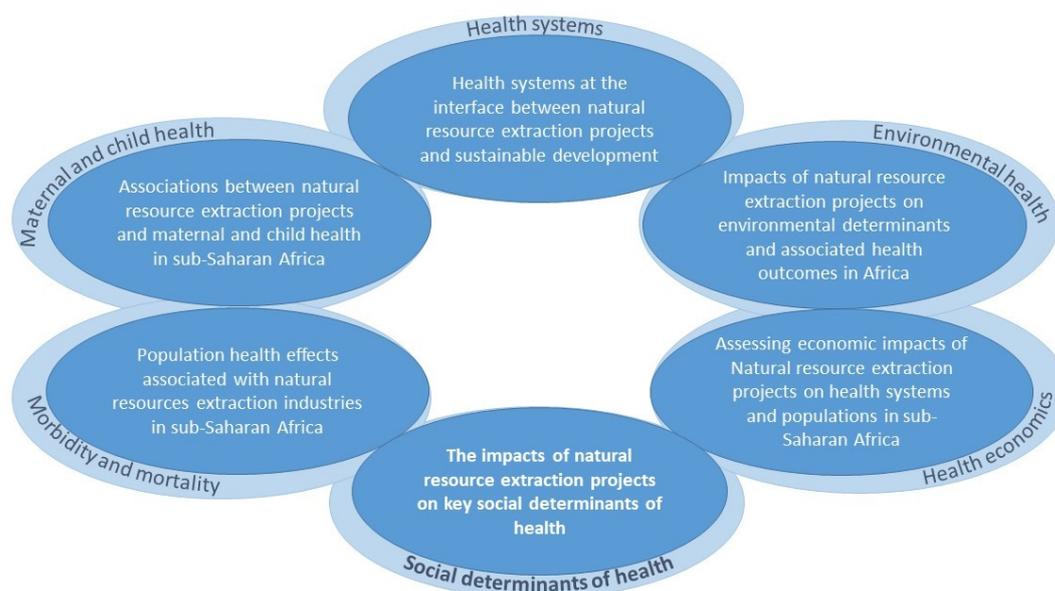


Figure 1: Topics and titles of the six PhD proposals embraced in the HIA4SD project (HIA4SD: Health impact assessment for sustainable development)

Objective	Methodology		Outcome
Understanding inclusion of health equity in HIA	Systematic search and analysis of environmental, social and health impact assessment guidelines and peer-reviewed literature		Peer-reviewed literature review (Chapter 2)
Comparing and contrasting perceived health and well-being of affected communities	Thematic analysis of participatory FGDs conducted with communities around industrial mining sites in Burkina Faso, Mozambique and Tanzania		Qualitative peer-reviewed paper (Chapter 3)
Exploring distribution of health impacts among subpopulation groups in affected communities	Thematic analysis of participatory FGDs conducted with communities around industrial gold mining sites in Tanzania		Qualitative peer-reviewed paper (Chapter 4)
Deepen the understanding of health equity in communities next to industrial mining projects	Drawing on the framework method to map inequities perceived by communities around industrial mining sites in Burkina Faso, Mozambique and Tanzania to the wider determinants of health		Qualitative peer-reviewed paper (Chapter 5)
Investigating impacts on water infrastructure and implications for health	Triangulation of quantitative findings (DHS data) from sub-Saharan Africa and Tanzania with qualitative findings, including geo-referenced points of interest in study villages in Tanzania		V-Health communication (Chapter 6)

Figure 2: Schematic overview of methodologies and outcomes of the individual objectives in this PhD thesis (green: literature based research, yellow: qualitative research, blue: mixed methods approach; DHS: Demographic and Health Survey, FGD: Focus group discussion)

To address the first objective, a literature review was conducted including impact assessment guidelines and peer-reviewed literature (see Chapter 4).

All other objectives were related to a qualitative study, implemented in all four project countries. Therefore, a core team of the HIA4SD project jointly developed a data collection manual comprising the different data collection tools pertained to the different research topics. The study was then implemented in study sites selected for the project at large, mostly under the lead of PhD students. At the beginning of each study site, a transect walk was conducted to obtain an overview of the impacts in the study sites and identify heavily impacted study villages. In total, seven different data collection tools were implemented in each study site for the data collection at large (including key informant interviews (KIIs) about health economics, health systems, partnership and maternal and child health, as well as focus group discussions (FGDs) about maternal and child health, adolescents' health and community health).

The qualitative work included in this PhD thesis is based on the FGDs about community health conducted with men and women who were knowledgeable about their villages and the dynamics induced by the mining projects. Using a participatory tool, we collected, classified and ranked perceived health impacts of community members living in proximity of the mining site (Chambers, 1994). The analysis for the papers were based on verbatim transcripts of the FGDs. A thematic analysis for the Tanzania data was conducted to investigate gendered health impacts (Chapter 4). To compare the data across the different countries and settings (Chapter 3) the coding scheme was re-developed. The initial analysis included data from all four countries. At the time point of writing up the paper, the data from Ghana was not yet completely available. Hence, the final analysis included data from Burkina Faso, Mozambique and Tanzania. Using the same set of data, perceived inequities (Chapter 5) were scrutinized by drawing on the framework method (Gale et al., 2013).

To achieve objective five, a more innovative approach was applied using an additional layer of data collection. First, we extracted statements about water sources and bodies from the FGDs from Tanzania. Rooted in qualitative GIS (GIS: geographic information system) (Lechner et al., 2019), we then re-visited two study sites to capture the geographic position of these water sources and bodies. We further triangulated these findings with quantitative data from Demographic and Health Surveys (DHS). The geo-referenced qualitative and quantitative data are being prepared for visualization and publication.

In addition to the individual objectives, the current work has been coined by the 2030 Agenda for Sustainable Development. To make the connection of each paper included in this PhD thesis and the relevant SDGs evident, the papers (Chapter 2-6) are tagged with SDGs.

This is done in accordance with the new SDG reporting scheme established and currently used by “*Tropical Medicine and International Health*” (Galli, Dietler and Leuenberger et al., 2020) (see Annex A1). Additionally, short video clips were produced as part of a digital storytelling project. This project was launched by the “Research for development programme” (r4d programme) of the Swiss National Science Foundation (SNSF) and Swiss Agency for Development and Cooperation (SDC), aiming to document the contributions of the r4d projects toward the achievement of the SDGs. The concepts for the clips (so-called “story grids”) were developed by the filmmakers, who also filmed all scenes. The material was edited by professional filmmakers. As a result, three short clips are showcasing insights from the field work and the HIA4SD project at large (see Chapter 7).

1.8 References

- Aboka, Y. E., Cobbina, S. J., & Doke, A. D. (2018). Review of environmental and health impacts of mining in Ghana. *Journal of Health and Pollution* 8(17), 43-52. doi:10.5696/2156-9614-8.17.43.
- Africa Progress Panel. (2013). *Equity in extractives: Stewarding Africa's natural resources for all*. Geneva, Switzerland: Africa Progress Panel.
- Agyepong, I. A., Sewankambo, N., Binagwaho, A., Coll-Seck, A. M., Corrah, T., Ezeh, A., Fekadu, A., Kilonzo, N., Lamptey, P., Masiye, F., et al. (2017). The path to longer and healthier lives for all Africans by 2030: the Lancet Commission on the future of health in sub-Saharan Africa. *Lancet*, 390(10114), 2803-2859. doi:10.1016/S0140-6736(17)31509-X.
- Aldrich, R., Mahoney, M., Harris, E., Simpson, S., & Stewart-Williams, J. (2005). Building an equity focus in health impact assessment. *New South Wales Public Health Bulletin*, 16(7-8), 118-119. doi:10.1071/nb05032.
- AUDA-NEPAD. (2015). *Agenda 2063 framework document*. African Union Development Agency (AUDA). Addis Ababa, Ethiopia.
- Bambra, C., Gibson, M., Amanda, S., Wright, K., Whitehead, M., & Petticrew, M. (2009). Tackling the wider social determinants of health and health inequalities: evidence from systematic reviews. *J Epidemiol Community Health*, 64, 284-291. doi:10.1136/jech.2008.082743.
- Barreto, M. L. (2017). Health inequalities: a global perspective. *Ciência e Saúde Coletiva*, 22(7), 2097-2108. doi:10.1590/1413-81232017227.02742017.
- Benshaul-Tolonena, A., Punam, C.-P., Dabalenb, A., Kotsadamc, A., & Sanohb, A. (2019). The local socio-economic effects of gold mining: evidence from Ghana. *Extractive Industries and Society*, 6(4), 1234-1255. doi:10.1016/j.exis.2019.07.00.
- Berman, N., Couttenier, M., Rohner, D., & Thoenig, M. (2017). This mine is mine! How minerals fuel conflicts in Africa. *American Economic Review*, 107(6), 1564-1610. doi:10.1257/aer.20150774.
- Boidin, B. (2019). Sustainable Development Goals: an opportunity for health in Africa? *Global Health Promotion*, 26(1), 91-94. doi:10.1177/1757975916677513.
- Braveman, P. (2014). What are health disparities and health equity? We need to be clear. *Public Health Rep.*, 129(1), 5-8. doi:10.1177/00333549141291S203.

- Buse, C. G., Lai, V., Cornish, K., & Parkes, M. W. (2019). Towards environmental health equity in health impact assessment: innovations and opportunities. *International Journal of Public Health*, 64(1), 15-26. doi:10.1007/s00038-018-1135-1.
- Buse, K., & Hawkes, S. (2015). Health in the Sustainable Development Goals: ready for a paradigm shift? *Globalization and Health*, 11(13). doi:10.1186/s12992-015-0098-8.
- Carney, J. G., & Gushulak, B. D. (2016). A review of research on health outcomes for workers, home and host communities of population mobility associated with extractive industries. *J Immigrant Minority Health*, 18(3), 673-686. doi:10.1007/s10903-015-0328-4.
- Cashmore, M. (2004). The role of science in environmental impact assessment: process and procedure versus purpose in the development of theory. *Environmental Impact Assessment Review*, 24(4), 403-426. doi:10.1016/j.eiar.2003.12.002.
- CCSDH. (2015). *A review of frameworks on the determinants of health*: Canadian Council on Social Determinants of Health (CCSDH).
- Chambers, R. (1994). The origins and practice of participatory rural appraisal. *World Development*, 22(7), 953-969. doi:10.1016/0305-750x(94)90141-4.
- Cole, B. L., MacLeod, K. E., & Spriggs, R. (2019). Health impact assessment of transportation projects and policies: living up to aims of advancing population health and health equity? *Annual Review of Public Health*, 40(1), 305-318. doi:10.1146/annurev-publhealth-040617-013836.
- Costa, A., Cortes, M., Sena, C., Nunes, E., Nogueira, P., & Shivaji, T. (2018). Equity-focused health impact assessment of Portuguese tobacco control legislation. *Health Promotion International*, 33(2), 279-287. doi:10.1093/heapro/daw076.
- CSDH, & WHO. (2008). *Closing the gap in a generation: health equity through action on the social determinants of health*. Geneva, Switzerland: Commission on Social Determinants of Health (CSDH), World Health Organization (WHO).
- Dahlgren, G., & Whitehead, M. (1991). *Policies and strategies to promote social equity in health*. Institute for Futures Studies. Stockholm, Sweden. Retrieved from: <https://core.ac.uk/download/pdf/6472456.pdf>
- Den Broeder, L., Uiters, E., ten Have, W., Wagemakers, A., & Schuit, A. J. (2017). Community participation in health impact assessment: a scoping review of the literature. *Environmental Impact Assessment Review*, 66, 33-42. doi:10.1016/j.eiar.2017.06.004.
- Dietler, D., Farnham, A., de Hoogh, K., & Winkler, M. S. (2020a). Quantification of annual settlement growth in rural mining areas using machine learning. *Remote Sensing*, 12(2), 235. doi:10.3390/rs12020235.
- Dietler, D., Leuenberger, A., Bempong, N. E., Campbell-Lendrum, D., Cramer, C., Eggen, R. I. L., Erismann, S., Ferazzi, S., Flahault, A., Fletcher, H. A., et al. (2019). Health in the 2030 Agenda for Sustainable Development: from framework to action, transforming challenges into opportunities. *J Glob Health*, 9(2), 020201. doi:10.7189/jogh.09.020201.
- Dietler, D., Lewinski, R., Azevedo, S., Engebretsen, R., Brugger, F., Utzinger, J., & Winkler, M. S. (2020b). Inclusion of health in impact assessment: a review of current practice in sub-Saharan Africa. *International Journal of Environmental Research and Public Health*, 17(11), 4155. doi:10.3390/ijerph17114155.
- Donkin, A., Goldblatt, P., Allen, J., Nathanson, V., & Marmot, M. (2018). Global action on the social determinants of health. *BMJ Global Health*, 3(Suppl 1), e000603. doi:10.1136/bmjgh-2017-000603.
- Eshetu, E. B., & Woldesenbet, S. A. (2011). Are there particular social determinants of health for the world's poorest countries? *African Health Sciences*, 11(1), 108-115. Retrieved from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3092326/>.

- Esteves, A. M., Franks, D., & Vanclay, F. (2012). Social impact assessment: the state of the art. *Impact Assessment and Project Appraisal*, 30(1), 34-42. doi:10.1080/14615517.2012.660356.
- Fang, M. L., Siden, E., Korol, A., Demestihias, M.-A., Sixsmith, J., & Sixsmith, A. (2018). A scoping review exploration of the intended and unintended consequences of eHealth on older people: a health equity impact assessment. *Human Technology*, 14(3), 297-323. doi:10.17011/ht/urn.201811224835.
- Farnham, A., Cossa, H., Dietler, D., Engebretsen, R., Leuenberger, A., Lyatuu, I., Nimako, B., Zabre, H. R., Brugger, F., & Winkler, M. S. (2020). Investigating health impacts of natural resource extraction projects in Burkina Faso, Ghana, Mozambique, and Tanzania: protocol for a mixed methods study. *JMIR Research Protocols*, 9(4), e17138. doi:10.2196/17138.
- Fraser, J. (2019). Creating shared value as a business strategy for mining to advance the United Nations Sustainable Development Goals. *Extractive Industries and Society*, 6(3), 788-791. doi:10.1016/j.exis.2019.05.011.
- Gale, N. K., Heath, G., Cameron, E., Rashid, S., & Redwood, S. (2013). Using the framework method for the analysis of qualitative data in multi-disciplinary health research. *BMC Medical Research Methodology*, 13, 117. doi:10.1186/1471-2288-13-117.
- Galli, A., Leuenberger, A., Dietler, D., Fletcher, H. A., Junghanss, T., & Utzinger, J. (2020). Tropical Medicine and International Health and the 2030 Agenda for Sustainable Development. *Trop Med Int Health*, 25(1), e1-e13. doi:10.1111/tmi.13368.
- GBD 2016 SDG Collaborators. (2017). Measuring progress and projecting attainment on the basis of past trends of the health-related Sustainable Development Goals in 188 countries: an analysis from the Global Burden of Disease Study 2016. *Lancet*, 390(10100), 1423-1459. doi:10.1016/S0140-6736(17)32336-X.
- GBD 2017 Mortality Collaborators. (2018). Global, regional, and national age-sex-specific mortality and life expectancy, 1950–2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet*, 392(10159), 1684-1735. doi:10.1016/s0140-6736(18)31891-9.
- GBD 2017 SDG Collaborators. (2018). Measuring progress from 1990 to 2017 and projecting attainment to 2030 of the health-related Sustainable Development Goals for 195 countries and territories: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet*, 392(10159), 2091-2138. doi:10.1016/S0140-6736(18)32281-5.
- Environmental Impact Assessment Regulations, (1999).
- Gouda, H. N., Charlson, F., Sorsdahl, K., Ahmadzada, S., Ferrari, A. J., Erskine, H., Leung, J., Santamauro, D., Lund, C., Aminde, L. N., et al. (2019). Burden of non-communicable diseases in sub-Saharan Africa, 1990–2017: results from the Global Burden of Disease Study 2017. *Lancet Global Health*, 7(10), e1375-e1387. doi:10.1016/s2214-109x(19)30374-2.
- Gulis, G. (2019). Health impact assessment and the Sustainable Development Goals. *Health Promotion International*, 34(3), 373-375. doi:10.1093/heapro/daz052.
- Gunning, C., Harris, P., & Mallett, J. (2011). Assessing the health equity impacts of regional land-use plan making: an equity focussed health impact assessment of alternative patterns of development of the Whitsunday Hinterland and Mackay Regional Plan, Australia (Short report). *Environmental Impact Assessment Review*, 31(4), 415-419. doi:10.1016/j.eiar.2010.03.005.
- Gupta, G. R., Oommen, N., Grown, C., Conn, K., Hawkes, S., Shawar, Y. R., Shiffman, J., Buse, K., Mehra, R., Bah, C. A., et al. (2019). Gender equality and gender norms: framing

- the opportunities for health. *Lancet*, 393(10190), 2550-2562. doi:10.1016/s0140-6736(19)30651-8.
- Hankivsky, O. (2014). *Intersectionality 101*. Vancouver, Canada: The Institute for Intersectionality Research & Policy.
- Harris-Roxas, B., Simpson, S., & Harris, L. (2004). *Equity-focused health impact assessment: a literature review*. Sydney, Australia: Australasian Collaboration for Health Equity Impact Assessment (ACHEIA).
- Harris, P., Viliani, F., & Spickett, J. (2015). Assessing health impacts within environmental impact assessments: an opportunity for public health globally which must not remain missed. *International Journal of Environmental Research and Public Health*, 12(1), 1044-1049. doi:10.3390/ijerph120101044.
- Heller, J., Givens, M. L., Yuen, T. K., Gould, S., Jandu, M. B., Bourcier, E., & Choi, T. (2014). Advancing efforts to achieve health equity: equity metrics for health impact assessment practice. *International Journal of Environmental Research and Public Health*, 11(11), 11054-11064. doi:10.3390/ijerph111111054.
- Hill, C., Madden, C., & Collins, N. (2017). *A guide to gender impact assessment for the extractive industries*. Oxfam. Melbourne, Australia. Retrieved from: https://www.oxfam.org.au/wp-content/uploads/2017/04/2017-PA-001-Gender-impact-assessments-in-mining-report_FA_WEB.pdf
- Hilson, G. (2019). Why is there a large-scale mining 'bias' in sub-Saharan Africa? *Land Use Policy*, 81, 852-861. doi:10.1016/j.landusepol.2017.02.013.
- Hussain, S., Javadi, D., Andrey, J., Ghaffar, A., & Labonte, R. (2020). Health intersectoralism in the Sustainable Development Goal era: from theory to practice. *Globalization and Health*, 16(1), 15. doi:10.1186/s12992-020-0543-1.
- IFC. (2009a). *Introduction to health impact assessment*. International Finance Corporation (IFC). Washington DC, USA. Retrieved from: <https://www.ifc.org/wps/wcm/connect/e7f68206-7227-4882-81ad-904cd6387bb7/HealthImpact.pdf?MOD=AJPERES&CACHEID=ROOTWORKSPACE-e7f68206-7227-4882-81ad-904cd6387bb7-jqeABQN>
- IFC. (2009b). *Projects and people: A handbook for addressing project-induced in-migration*. International Finance Corporation (IFC). Washington DC, USA. Retrieved from: http://www.ifc.org/wps/wcm/connect/Topics_Ext_Content/IFC_External_Corporate_Site/Sustainability-At-IFC/Publications/Publications_Handbook_Inmigration_WCI_1319576839994
- IFC. (2012). *Performance standards on environmental and social sustainability*. International Finance Corporation (IFC). Washington DC, USA. Retrieved from: http://www.ifc.org/wps/wcm/connect/115482804a0255db96bffd1a5d13d27/PS_English_2012_Full-Document.pdf?MOD=AJPERES
- IFC, & The World Bank Group. (2007). *Environmental, health and safety guidelines*. International Finance Corporation (IFC). Washington DC, USA. Retrieved from: <https://www.ifc.org/wps/wcm/connect/29f5137d-6e17-4660-b1f9-02bf561935e5/Final%2B-%2BGeneral%2BEHS%2BGuidelines.pdf?MOD=AJPERES&CVID=jOWim3p>
- Irwin, A., Valentine, N., Brown, C., Loewenson, R., Solar, O., Brown, H., Koller, T., & Vega, J. (2006). The Commission on Social Determinants of Health: tackling the social roots of health inequities. *PLoS Med*, 3(6), e106. doi:10.1371/journal.pmed.0030106.
- Kihal-Talantikite, W., Legendre, P., Le Nouveau, P., & Deguen, S. (2018). Premature adult death and equity impact of a reduction of NO₂, PM₁₀, and PM_{2.5} levels in Paris: a

- health impact assessment study conducted at the census block level. *International Journal of Environmental Research and Public Health*, 16(1), 38. doi:10.3390/ijerph16010038.
- Knoblauch, A. M., Divall, M. J., Owuor, M., Nduna, K., Ng'uni, H., Musunka, G., Pascall, A., Utzinger, J., & Winkler, M. S. (2017). Experience and lessons from health impact assessment guiding prevention and control of HIV/AIDS in a copper mine project, northwestern Zambia. *Infectious Diseases of Poverty*, 6(1), 11. doi:10.1186/s40249-017-0320-4.
- Krieger, N. (2003). Genders, sexes, and health: What are the connections - and why does it matter? *International Journal of Epidemiology*, 32(4), 652-657. doi:10.1093/ije/dyg156.
- Code de l'environnement de Burkina Faso, (2013).
- Lechner, A. M., Owen, J., Ang, M., & Kemp, D. (2019). Spatially integrated social sciences with qualitative GIS to support impact assessment in mining communities. *Resources*, 8(1), 47. doi:10.3390/resources8010047.
- Leuenberger, A., Farnham, A., Azevedo, S., Cossa, H., Dietler, D., Nimako, B., Adongo, P. B., Merten, S., Utzinger, J., & Winkler, M. S. (2019). Health impact assessment and health equity in sub-Saharan Africa: a scoping review. *Environmental Impact Assessment Review*, 79, 106288. doi:10.1016/j.eiar.2019.106288.
- Lucyk, K., & McLaren, L. (2017). Taking stock of the social determinants of health: a scoping review. *PLoS ONE*, 12(5), e0177306. doi:10.1371/journal.pone.0177306.
- Mahoney, M., Simpson, S., Harris, E., Aldrich, R., & Stewart Williams, J. (2004a). *Equity-focused health impact assessment framework*. Newcastle, Australia: Australasian Collaboration for Health Equity Impact Assessment (ACHEIA).
- Mahoney, M., Simpson, S., Harris, E., Aldrich, R., & Stewart Williams, J. (2004b). *Equity-focused health impact assessment framework*. Newcastle, Australia: Australasian Collaboration for Health Equity Impact Assessment (ACHEIA).
- Mamo, N., Bhattacharyya, S., & Moradi, A. (2019). Intensive and extensive margins of mining and development: evidence from sub-Saharan Africa. *J. Dev. Econ.*, 139, 28-49. doi:10.1016/j.jdeveco.2019.02.001.
- Manandhar, M., Hawkes, S., Buse, K., Nosrati, E., & Magar, V. (2018). Gender, health and the 2030 Agenda for Sustainable Development. *Bulletin of the World Health Organization*, 96(9), 644-653. doi:10.2471/BLT.18.211607.
- Marmot, M. (2005). Social determinants of health inequalities. *Lancet*, 365(9464), 1099-1104. doi:10.1016/S0140-6736(05)71146-6.
- Marmot, M. (2007). Achieving health equity: from root causes to fair outcomes. *Lancet*, 370(9593), 1153-1163. doi:10.1016/S0140-6736(07)61385-3.
- Meschede, C. (2020). The Sustainable Development Goals in scientific literature: a bibliometric overview at the meta-Level. *Sustainability*, 12(11). doi:10.3390/su12114461.
- Morgan, R. K. (2012). Environmental impact assessment: the state of the art. *Impact Assessment and Project Appraisal*, 30(1), 5-14. doi:10.1080/14615517.2012.661557.
- Musgrove, P. (1993). Investing in health: the 1993 World Development Report of the World Bank. *Bull. Pan Am. Health Organ.*, 27(3), 284-286. Retrieved from <https://www.ncbi.nlm.nih.gov/pubmed/8220523>.
- Mutangadura, G., Gauci, A., Amah, B., Woldemariam, E., Ayalew, D., & Egu, B. (2007). *Health inequities in selected African countries: review of evidence and policy implications*. Paper presented at the African Economic Conference, Addis Ababa, Ethiopia.

- 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: Planning, Administration, Evaluation*, 40(2), 339-345. doi:10.2190/HS.40.2.o, .
- Ontario Ministry of Health and Long-Term Care. (2012). *Health Equity Impact Assessment (HEIA) Workbook*. Ontario Ministry of Health and Long-Term Care. Toronto, ON, Canada.
- Oster, E. (2012). Routes of infection: exports and HIV incidence in sub-Saharan Africa. *Journal of the European Economic Association*, 10(5), 1025-1058. doi:10.1111/j.1542-4774.2012.01075.x.
- Povall, S. L., Haigh, F. A., Abrahams, D., & Scott-Samuel, A. (2014). Health equity impact assessment. *Health Promotion International*, 29(4), 621-633. doi:10.1093/heapro/dat012, .
- Quigley, R., den Broeder, L., Furu, P., Bond, A., Cave, B., & Bos, R. (2006). Health impact assessment international best practice principles. *International Association for Impact Assessment*. Retrieved from http://www.iaia.org/uploads/pdf/SP5_3.pdf.
- Decreto n.45/2004: Regulamento sobre o processo de avaliação do impacto ambiental, (2004).
- Sadare, O., Williams, M., & Simon, L. (2020). Implementation of the health equity impact assessment (HEIA) tool in a local public health setting: challenges, facilitators, and impacts. *Canadian Journal of Public Health*, 111(2), 212-219. doi:10.17269/s41997-019-00269-2.
- Schrecker, T., Birn, A.-E., & Aguilera, M. (2018). How extractive industries affect health: political economy underpinnings and pathways. *Health and Place*, 52, 135-147. doi:10.1016/j.healthplace.2018.05.005.
- Simpson, S., Mahoney, M., Harris, E., Aldrich, R., & Stewart-Williams, J. (2005). Equity-focused health impact assessment: a tool to assist policy makers in addressing health inequalities. *Environmental Impact Assessment Review*, 25(7-8), 772-782. doi:10.1016/j.eiar.2005.07.010.
- Snyder, J., Wagler, M., Lkhagvasuren, O., Laing, L., Davison, C., & Janes, C. (2012). An equity tool for health impact assessments: reflections from Mongolia. *Environmental Impact Assessment Review*, 34, 83-91. doi:10.1016/j.eiar.2011.08.006.
- Sohn, E. K., Stein, L. J., Wolpoff, A., Lindberg, R., Baum, A., McInnis-Simoncelli, A., & Pollack, K. M. (2018). Avenues of influence: the relationship between health impact assessment and determinants of health and health equity. *J. Urban Health*, 95(5), 754-764. doi:10.1007/s11524-018-0263-5.
- SOPHIA Equity Working Group. (2016). *How to advance equity through health impact assessments*. Society of Practitioners of Health Impact Assessment (SOPHIA). Toronto, ON, Canada.
- Standard & Poor Global. (2020). Market Intelligence Platform. Retrieved from <https://www.spglobal.com/marketintelligence/en/solutions/market-intelligence-platform>
- The Equator Principles Association. (2020, 2011). Equator Principles. *The Equator Principles: Official website*. Retrieved from <http://www.equator-principles.com/>
- Thondoo, M., & Gupta, J. (2020). Health impact assessment legislation in developing countries: a path to sustainable development? *Review of European, Comparative and International Environmental Law*, 00, 1-11. doi:10.1111/reel.12347.
- Thondoo, M., Rojas-Rueda, D., Gupta, J., de Vries, D. H., & Nieuwenhuijsen, M. J. (2019). Systematic literature review of health impact assessments in low and middle-income countries. *International Journal of Environmental Research and Public Health*, 16(11), 2018. doi:10.3390/ijerph16112018.

- Tyler, I., Pauly, B., Wang, J., Patterson, T., Bourgeault, I., & Manson, H. (2019). Evidence use in equity focused health impact assessment: a realist evaluation. *BMC Public Health*, 19(1), 230. doi:10.1186/s12889-019-6534-6.
- UN. (2000). *A/RES/55/2: United Nations Millennium Declaration: resolution adopted by the General Assembly*. United Nations (UN). New York, USA.
- UN. (2015). *Transforming our world: the 2030 Agenda for Sustainable Development*. United Nations (UN). Geneva, Switzerland. Retrieved from: <https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf>
- UN Statistical Commission. (2020). *Report of the inter-agency and expert group on Sustainable Development Goal indicators (E/CN.3/2020/2)*. United Nations. New York, USA. Retrieved from: <https://unstats.un.org/sdgs/indicators/indicators-list/>
- UNECA. (2011). *Minerals and Africa's development*. United Nations Economic Commission for Africa. Addis Ababa, Ethiopia.
- United Republic of Tanzania. (2004). Environmental Management Act.
- Utzinger, J., Wyss, K., Moto, D., Tanner, M., & Singer, B. (2004). Community health outreach program of the Chad-Cameroon petroleum development and pipeline project. *Clinics in Occupational and Environmental Medicine*, 4(1), 9-26. doi:10.1016/j.coem.2003.09.004.
- Utzinger, J., Wyss, K., Moto, D. D., Yémadji, N. D., Tanner, M., & Singer, B. H. (2005). Assessing health impacts of the Chad–Cameroon petroleum development and pipeline project: challenges and a way forward. *Environmental Impact Assessment Review*, 25(1), 63-93. doi:10.1016/j.eiar.2004.04.002.
- Virah-Sawmy, M. (2015). Growing inclusive business models in the extractive industries: Demonstrating a smart concept to scale up positive social impacts. *Extractive Industries and Society*, 2(4), 676-679. doi:10.1016/j.exis.2015.07.003.
- Von der Goltz, J., & Barnwal, P. (2019). Mines: The local wealth and health effects of mineral mining in developing countries. *J. Dev. Econ.*, 139, 1-16. doi:10.1016/j.jdeveco.2018.05.005.
- Walpole, S. C., Rasanathan, K., & Campbell-Lendrum, D. (2009). Natural and unnatural synergies: Climate change policy and health equity. *Bulletin of the World Health Organization*, 87(10), 799-801. doi:10.2471/blt.09.067116.
- Whitehead, M. (1991). The concepts and principles of equity and health. *Health Promotion International*, 6(3), 217-228. doi:10.1093/heapro/6.3.217.
- WHO. (2013). *Health in all policies: report on perspectives and intersectoral actions in the African Region*. Geneva, Switzerland: World Health Organization (WHO).
- WHO. (2017a). About social determinants of health. *Social Determinants of Health*. Retrieved from http://www.who.int/social_determinants/sdh_definition/en/
- WHO. (2017b). *Progressing the Sustainable Development Goals through Health in All Policies*. Geneva, Switzerland: World Health Organization (WHO).
- WHO European Centre for Health Policy. (1999). *Gothenburg Consensus Paper*. World Health Organization Regional Office for Europe. Brussels, Belgium.
- Winkler, M. S., Adongo, P. B., Binka, F., Brugger, F., Diagbouga, S., Macete, E., Munguambe, K., & Okumu, F. (2020a). Health impact assessment for promoting sustainable development: the HIA4SD project. *Impact Assessment and Project Appraisal*, 3(8), 225-232. doi:10.1080/14615517.2019.1694783.
- Winkler, M. S., Furu, P., Viliani, F., Cave, B., Divall, M., Ramesh, G., Harris-Roxas, B., & Knoblauch, A. M. (2020b). Current global health impact assessment practice.

International Journal of Environmental Research and Public Health, 17(9), 2988. doi:10.3390/ijerph17092988.

Winkler, M. S., Krieger, G. R., Divall, M. J., Cissé, G., Wielga, M., Singer, B. H., Tanner, M., & Utzinger, J. (2013). Untapped potential of health impact assessment. *Bulletin of the World Health Organization*, 91(4), 298-305. doi:10.2471/BLT.12.112318.

Worku, E. B., & Woldesenbet, S. A. (2015). Poverty and inequality – but of what - as social determinants of health in Africa? *African Health Sciences*, 15(4), 1330-1338. Retrieved from <https://www.ajol.info/index.php/ahs/article/view/128506>.

World Bank. (2017). *The growing role of minerals and metals for a low carbon future*. World Bank. Washington, D.C., USA.

2. Health impact assessment and health equity in sub-Saharan Africa: a scoping review

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2.1 Abstract

Background: Natural resource extraction projects can have positive but also negative effects on the health of affected communities, governed by demographic, economic, environmental, physical and social changes. Negative effects often prevail and these might widen existing health inequities. Health impact assessment (HIA) is a decision-support tool that aims at maximizing benefits and minimizing negative impacts on people's health. A core value of HIA is equity; yet, little is known about health equity in the frame of HIA, particularly in sub-Saharan Africa.

Methodology: We conducted a scoping review to determine whether and to what extent HIA in sub-Saharan Africa addresses health equity. We included peer-reviewed publications and guidelines pertaining to HIA, environmental impact assessment (EIA) and social impact assessment (SIA). Health equity was investigated by identifying (i) how health considerations were addressed and (ii) whether health was stratified by subgroups of the community.

Results: Out of 1'640 raw hits, we identified 62 articles (16 HIA, 36 EIA, one SIA and nine integrated assessments), 32 of which specifically addressed health. While 20 articles focused on a specific health topic, 12 articles used a more comprehensive approach to address health. In 15 articles there were specific subgroup analyses (e.g. mothers, children or marginalized groups) as a measure of health equity. Another 12 papers referred to the community in a more general way (e.g. affected). Without exception, health was an integral part of the nine included guidelines. HIA guidelines addressed health systematically through environmental health areas, risk assessment matrix or key performance indicators.

Conclusions: We found evidence that previously conducted HIA in sub-Saharan Africa and current guidelines address health equity. However, there is a need to stratify community subgroups more systematically in order to determine health differentials better. Future HIA should consider community heterogeneity in an effort to reduce health inequities by "leaving no one behind", as suggested by the Sustainable Development Goals.

2.2 Introduction

Natural resource extraction projects (NREPs) in sub-Saharan Africa have the potential to foster economic and social development, and hence, play a role in the current era of the Sustainable Development Goals (SDGs) (UNDP, 2016). Health is explicitly addressed in SDG 3 that is “ensure healthy lives and promote well-being for all at all ages” and closely interlinked with many of the remaining 16 SDGs (Buse and Hawkes, 2015; United Nations, 2015).

NREPs can influence health-related SDGs through proximal and distal causes and pathways. For example, NREPs can directly strengthen health systems and improve people's health through specific disease prevention and health promotion measures (Knoblauch et al., 2014, 2017). Indirectly, NREPs can improve health through changes in people's socio-economic status or by upgrading infrastructure and public services, such as education and access to clean water, sanitation and hygiene (WASH) (Knoblauch et al., 2018; Utzinger, Wyss, Moto, Tanner, and Singer, 2004; Winkler et al., 2012). These examples highlight that NREPs act on the wider determinants of health (Carney and Gushulak, 2016; Dahlgren and Whitehead, 1991).

Potential positive effects of NREPs are opposed by potential adverse impacts (Coelho et al., 2011). For instance, project-induced in-migration, environmental degradation and changing life styles often lead to adverse health outcomes in impacted communities, particularly affecting the most vulnerable groups such as children, women or the elderly (Carney and Gushulak, 2016; Winkler, Krieger, Divall, Singer, and Utzinger, 2012). Taken together, NREPs hold promise, yet might pose challenges for health as a cross-cutting issue in the 2030 Agenda for Sustainable Development.

2.2.1 Impact assessment

The impact assessment process serves as a decision-support tool for projects, programmes and policies. In the context of NREPs, it aims to minimize negative consequences on the environment, society and public health, while promoting sustainable development (Quigley et al., 2006). Countries worldwide have established the legal requirement that an environmental impact assessment (EIA) must be conducted prior to implementation of a project, programme or policy (Morgan, 2012). In contrast to EIA, only a few countries have established a legal requirement for other forms of impact assessment, such as social impact assessment (SIA), health impact assessment (HIA) and human rights impact assessment (HRIA), which have – at least partially – arisen through discontent with EIA practice (Harris-Roxas et al., 2012; Krieger et al., 2012; Salcito et al., 2015). This holds particularly true for Africa, where not a single country specifically promotes HIA through a policy or regulation, despite health in the context of NREPs being a seminal issue (Erlanger, Krieger, Singer, and Utzinger, 2008;

Winkler et al., 2013). HIA is guided by individual, social, environmental and institutional determinants of health with the following five core values: (i) democracy; (ii) equity; (iii) ethical use of evidence; (iv) sustainable development; and (v) comprehensive approach to health (Quigley et al., 2006). These core values emphasize the importance of disclosure and involvement of different stakeholders, including participation of affected communities and reducing inequities (Kemmer, Parry, and Palmer, 2004; Krieger et al., 2012). Yet, a considerable gap exists between theory and current best practice (Glucker, Driessen, Kolhoff, and Runhaar, 2013; Harris-Roxas et al., 2012; Morgan, 2012).

2.2.2 Rationale

Health impacts of NREPs are, beyond physical and environmental changes, closely linked to factors related to the societal structure and public health (Carney and Gushulak, 2016). These factors are known as social determinants of health (SDH), and consist of the conditions in which people are born, grow, live, work and age (Marmot, 2005; WHO, 2017). The uneven – and indeed unfair and unjust – distribution of the SDH leads to differences in health outcomes and, consequently to inequities in health (Marmot, 2005). Hence, the SDH are a root cause of the gap in health equity linked to differential education, socio-economic status and gender among different population subgroups (Marmot, 2005). Focussing on specific population groups, such as the vulnerable, disadvantaged or more specifically the poor, unemployed or illiterate, reflects that a community is not a homogenous structure but rather consists of different subgroups, which are governed by SDH (O'Neill et al., 2014).

Driven by the imperative “to leave no one behind” as of the 2030 Agenda for Sustainable Development, there is a pressing need to improve health and its determinants to achieve the SDGs (Hosseinpoor, Bergen, Schlottheuber, and Boerma, 2018; Watkins, 2014). For this objective, HIA in the context of NREPs should play a central role by mitigating negative impacts and maximizing benefits in order to primarily contribute to SDG3 and thus, to improve health for all at all ages (United Nations, 2015). Moreover, HIA holds promise to promote action for better access to education (SDG4), improving access to clean water and sanitation (SDG6), reducing poverty (SDG1), reducing malnutrition rates (SDG2), improving housing conditions (SDG11), reducing inequality (SDG10) and promoting gender equity (SDG5). Additionally, HIA might aid establishing strong institutions (SDG16) and partnerships (SDG17) by further promoting HIA (Buse and Hawkes, 2015; Quigley et al., 2006; Singer and de Castro, 2007; United Nations, 2015).

While the actions of NREPs on the SDGs were recently mapped by the International Council on Mining and Minerals (ICMM) and the United Nations Development Programme (UNDP) (ICMM, 2018; UNDP, 2016), research about social disparities in health in low- and

middle-income countries (LMICs) lags behind (Fullman et al., 2017). Furthermore, tackling the gap in health equity across populations, regions and countries has been a particular challenge for Africa. Indeed, many African countries still face a high burden due to infectious diseases, child and maternal mortality, and malnutrition, while non-communicable diseases and climate change-related health issues are rapidly gaining importance (Agyepong et al., 2017). This gap in health equity, in combination with a “growing appetite” for natural resources in Africa (IEA, 2014), means that promoting HIA is an immediate priority (Winkler et al., 2013).

Despite numerous literature reviews pertaining to specific aspects of HIA, there is a paucity of whether and how HIA has been utilized to address health equity in sub-Saharan Africa (den Broeder et al., 2017; Erlanger, Krieger, Singer, and Utzinger, 2008; Harris-Roxas, Simpson, and Harris, 2004; Hebert, Wendel, Kennedy, and Dannenberg, 2012; Povall, Haigh, Abrahams, and Scott-Samuel, 2014). For instance, three recent reviews pertaining to health and well-being in mining regions were carried out independently of HIA (Brisbois et al., 2018; Loewenson, Hinricher, and Papamichail, 2016; Mactaggart, McDermott, Tynan, and Whittaker, 2018).

The work presented here is guided by the overarching question: “Whether and to what extent is HIA utilized to address health equity in the context of NREP in sub-Saharan Africa?” More specifically, by means of a scoping review, we aimed to evaluate how the health of different population groups is integrated in impact assessment for NREPs in sub-Saharan Africa.

2.3 Methodology

2.3.1 Scoping review

A scoping review was conducted targeting both, peer-reviewed literature about and guidelines for impact assessment. The methodology was inspired by two recent literature reviews (den Broeder et al., 2017; Pereira et al., 2017).

The term “natural resource extraction project” is hereafter used to refer to different kinds of development projects, including project from the mining, minerals, oil and gas, timber, and biofuel sectors, as well as other infrastructure projects such as hydro dams and other power plants. Of note, artisanal and small-scale mining (ASM) was not considered in the current scoping review.

While the focus of our research was on HIA, other forms of impact assessment, specifically EIA and SIA, were also considered in order to get the full spectrum of health in impact assessment. Henceforth, the broad term “impact assessment” was employed to refer to the three main types of impact assessment (EIA, HIA and SIA) as well as integrated

approaches, such as environmental, social and health impact assessment (ESHIA), environmental health impact assessment (EHIA), environmental social impact assessment (ESIA) and social environmental impact assessment (SEIA).

2.3.2 Peer-reviewed literature

We conducted a systematic search guided by the “Preferred Reporting Items for Systematic Reviews and Meta-Analyses” (PRISMA) statement (Moher et al., 2009). The search terminology was developed as an iterative process and consisted of three search term blocks: (i) sub-Saharan African countries; (ii) NREPs; and (iii) impact assessments. The search strategy was applied in PubMed, Scopus and the African Journal Online (AJOL) with search terms amended to the specific features of the databases. There was no language restriction, while temporally, the search was restricted from January 1, 1998 to December 31, 2018. Details of the search strategy are available in a supplementary file (Appendix A1).

All records were independently screened by two of the authors using EndNote version X7.9 for data management (Thomson Reuters Corp.; New York City, NY, USA). Discrepancies were discussed among the two authors and, if needed with a third author until consensus was reached. Research articles (of note, conference proceedings and books were excluded) were considered as eligible if they were: (i) accessible with the rights of the University of Basel; (ii) pertained to a country, project or region in sub-Saharan Africa; (iii) focussed on NREP; and (iv) related to an official EIA, HIA, SIA or integrated impact assessment. For instance, studies about life cycle assessment were excluded for the current scoping review. Additionally, citations from all relevant publications were screened for additional studies.

The included studies were analysed based on a qualitative thematic analysis, as described by Levac, Colquhoun, and O'Brien (2010). In short, background data (i.e. author, year of publication, affiliation, type of impact assessment, project country and natural resource extracted/type of infrastructure project) were extracted based on full-text analysis and entered into an Excel spread sheet (Microsoft Excel 2010, Microsoft Corp.; Redmond, WA, USA). Additionally, data about the study purpose were extracted.

A two-step procedure was applied for the analysis from a health equity perspective. First, data about how health was addressed in all identified studies were extracted. Second, the “health-integrating studies” were analysed about how the community and its subgroups were considered (O'Neill et al., 2014). Extracted text segments were coded for relevant themes (i.e. study purpose, health, population groups addressed and level of engagement) and deriving codes were assigned to all studies where applicable.

2.3.3 Guidelines

Complementary to the peer-reviewed literature, international guidelines for EIA, HIA and SIA and national guidelines for HIA from sub-Saharan African countries were systematically searched. As detailed in the supplementary file (Appendix A2), HIA guidelines were searched in Google (in English, French and Portuguese), the “Grey Literature Report” database, the Guidelines International Network and the World Health Organization Library Database (WHOLIS) by combining search terms for HIA and guidelines (e.g. “assessing impact*” or “guide”) and – if applicable – the countries of sub-Saharan Africa. This initial search for HIA guidelines was complemented by a hand search for EIA and SIA guidelines. Publications provided by the International Association for Impact Assessment (IAIA) were used as starting point (i.e. fast tips, international best practice principles and key citations). Additionally, all impact assessment guidelines referenced in the retrieved studies were extracted and systematically searched. The guidelines were reviewed by a single assessor and consolidated by an experienced HIA researcher and practitioner, who is broadly networked with HIA experts in different parts of the world.

Based on full-text screening, guidelines from the past 20 years were considered as eligible if they were: (i) available online; (ii) containing an introduction about the concept of EIA, HIA or SIA; and (iii) providing methodological guidance to conduct EIA, HIA or SIA. As the current research is focused on HIA for NREPs in sub-Saharan Africa, national impact assessment guidelines for specific programmes or policies in high-income countries were excluded.

The following data were extracted and entered into an Excel spread sheet based on full-text analysis: institution/publisher, year, title, consortium, steps/process, health definition, health determinants addressed, suggested tools, indicators for measurement, population groups addressed and the intended level of stakeholder engagement or community participation.

2.4 Results

2.4.1 Peer-reviewed literature

As shown in **Figure 3**, 62 articles out of 1'640 raw hits met our inclusion criteria, of which 36 were related to EIA, 16 to HIA, one to SIA and the remaining nine to integrated approaches (four ESHIA, three ESIA, one SEIA and one SIA in EIA). The retrieved articles pertained to studies carried out in 16 countries of sub-Saharan Africa (**Figure 4**). Nigeria and South Africa were the two countries with the largest number of studies; nine in each of them. Of note, 10 studies included more than one country in sub-Saharan Africa. The studies included a host of extractive industries or infrastructure projects, including mining (n = 20), oil and gas (n = 11), hydro dams (n = 9), biofuel projects (n = 3) and timber (n = 1). Moreover, 18 studies pertained more generally to development projects. Of note, when impact assessments were conducted

for a specific sector or project, often more than one paper was published, such as for the oil and gas sector in Nigeria ($n = 4$) and the Chad-Cameroon petroleum development and pipeline project ($n = 3$). A summary of the 62 studies retrieved is given as supplementary file (Appendix A3).

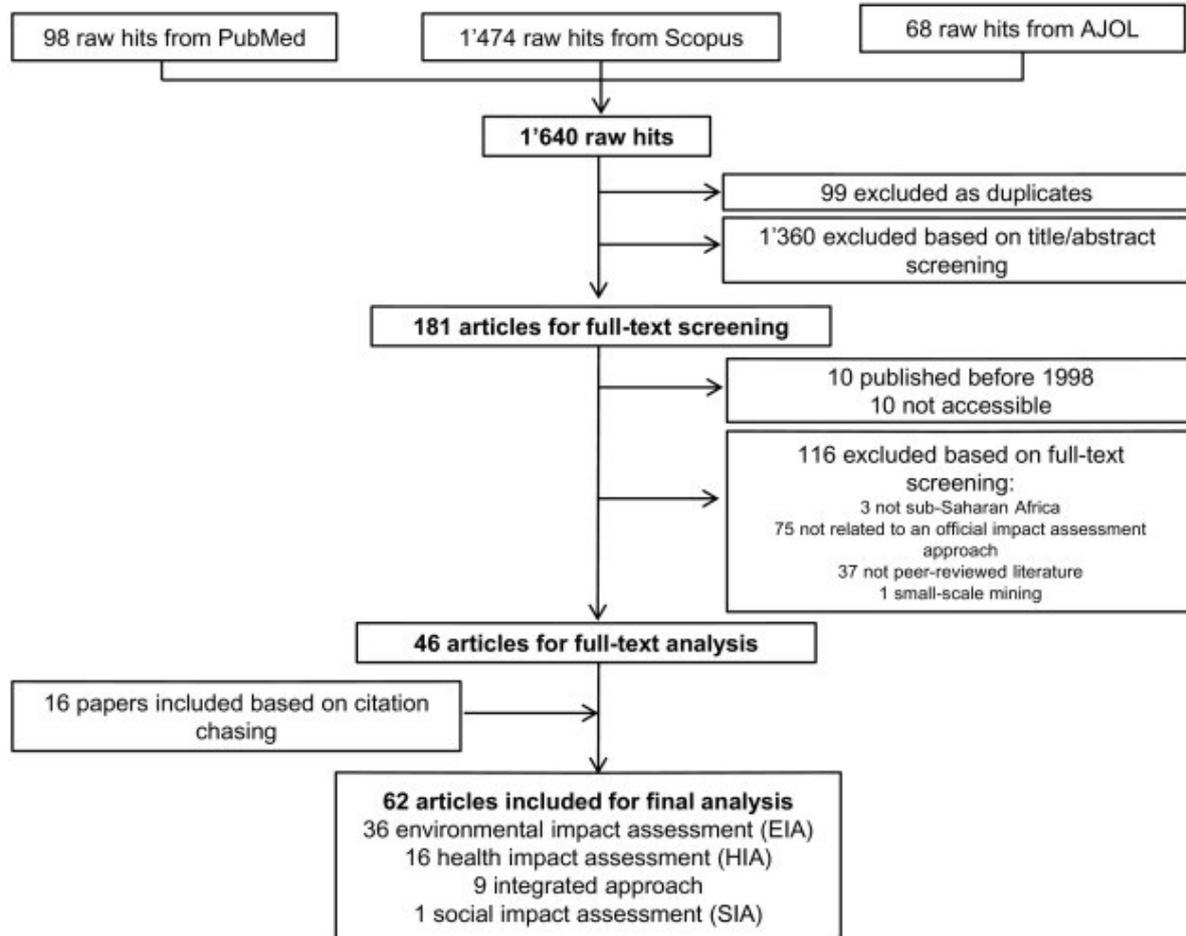


Figure 3: PRISMA flowchart showing the selection process of the peer-reviewed literature (AJOL: African Journal Online).

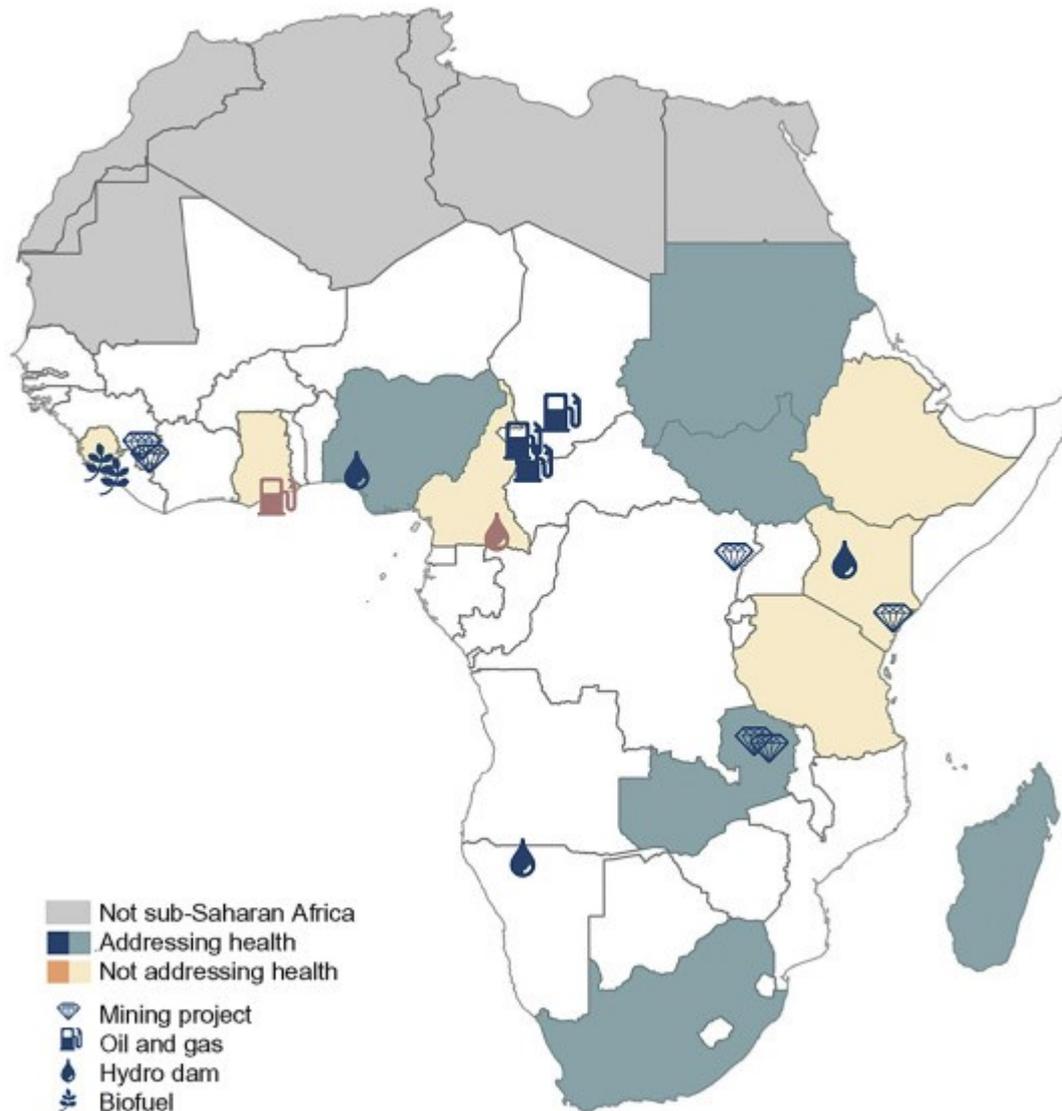


Figure 4: Geographic distribution of included studies addressing health (blue) and issues other than health (orange); icons indicating type and location of case studies; countries are coloured if there was at least one published study about the evaluation of impact assessment in the given country. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Based on the extracted data, the studies were classified into two main groups and three subgroups, as summarized in **Figure 5**. Sixteen studies belonged to the first main group, characterized by impact assessment applied either simultaneously or prospectively of a project development, and hence, we considered them as case studies. These case studies can be further subdivided into (i) full impact assessment studies ($n = 4$); (ii) focused impact assessment studies ($n = 7$); and (iii) methodological impact assessment studies ($n = 5$).

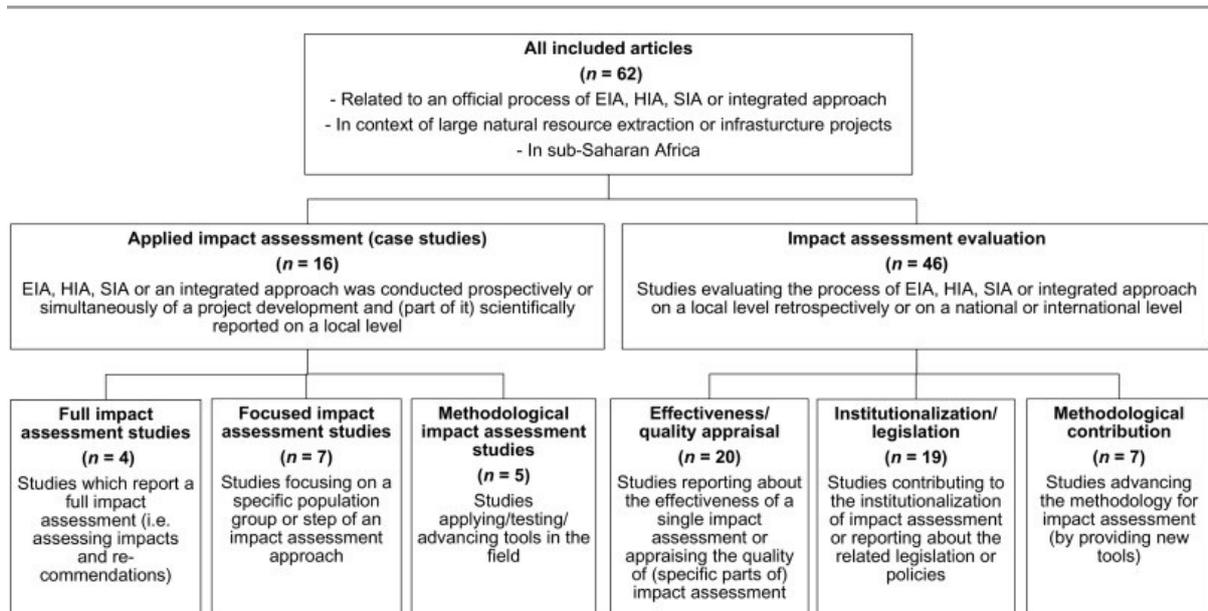


Figure 5: Overview of main- and subgroups of the study purposes of all included studies revealed by the qualitative thematic analysis.

The remaining 46 studies were tagged as impact assessment evaluation studies, as they were carried out mainly retrospectively, either at the local, national or international level. These evaluation studies can be further differentiated into (i) evaluation of effectiveness or quality appraisal of impact assessment ($n = 20$); (ii) evaluation of the institutionalization or national legislation of impact assessment ($n = 19$); and (iii) methodological contributions ($n = 7$). Further specificity for the different groups and subgroups are provided in **Figure 5**.

Regarding study purposes, stratified by the different types of impact assessment, more than half of the case studies were related to HIA (9 of 16; 56%). As regards the second main group of the evaluation studies, most of them pertained to effectiveness and institutionalization/legislation subgroup, and hence, were related to EIA (12 of 19; 63%). However, in the third subgroup of methodological contributions, HIA played an important role (3 of 7; 43%).

As shown in **Figure 6**, health was addressed in 32 of the 62 studies identified through our scoping review (52%), revealing two different approaches. Among all health-integrating studies, 20 had an overarching thematic orientation of health, such as health monitoring ($n = 5$), environmental health ($n = 4$), public health ($n = 4$), health impacts ($n = 3$), health promotion ($n = 3$) and health care services ($n = 1$). The remaining 12 health-integrating studies covered multiple of these categories and employed an even more comprehensive definition of health. With regard to case studies ($n = 16$), all, except two of five EIA related case studies, addressed health.

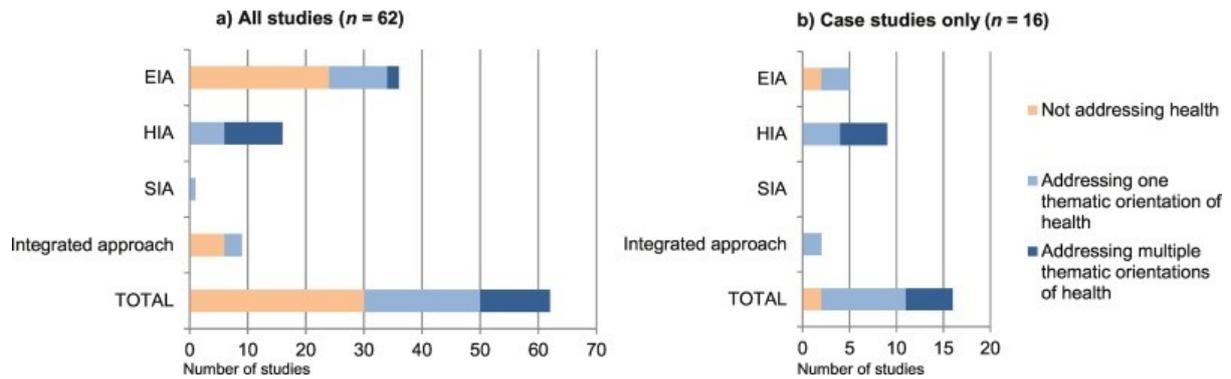


Figure 6: Number of studies not addressing health (orange), addressing one thematic orientation of health (light blue) or multiple thematic orientations (blue), stratified by type of impact assessment (EIA, environmental impact assessment; HIA, health impact assessment; SIA, social impact assessment; integrated approach, combination of specific impact assessments) and in total. The results are presented for a) all included studies ($n = 62$) and b) the case studies only (i.e. impact assessments conducted prospectively or simultaneously to the project development, $n = 16$). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Within all health-integrating studies, reporting about communities was categorized in four subtypes, as shown in **Figure 7**. Almost half of the studies ($n = 15$) stratified the communities into subgroups, mentioning them explicitly (e.g. mothers, children and workers). Twelve studies reported about communities in a more general fashion and thus, did not refer to specific subgroups of the populations, with the exception of terms such as vulnerable or affected. A few studies focused on specific subgroups (women, mothers and children) throughout the entire study ($n = 3$) or did not mention the community specifically ($n = 2$).

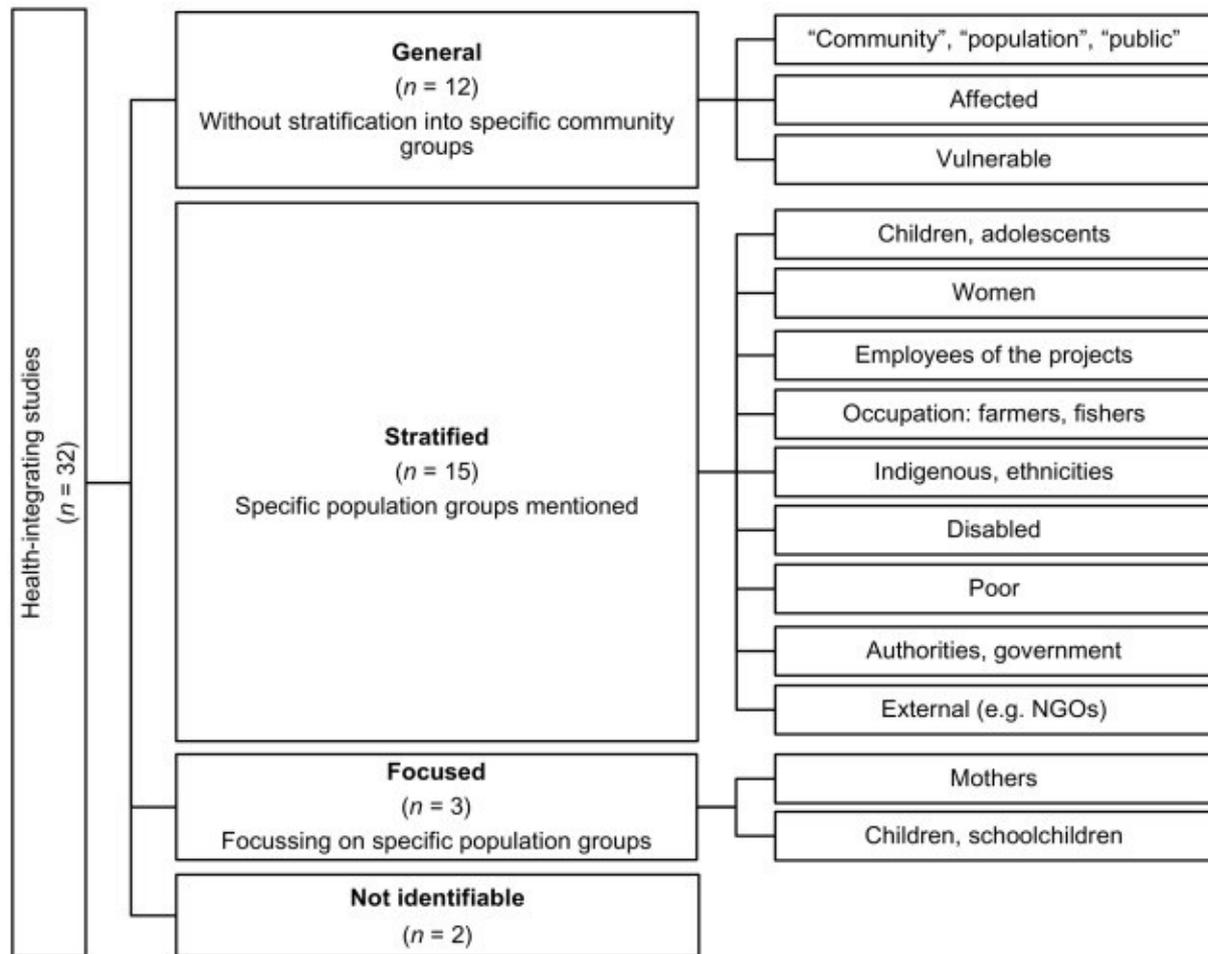


Figure 7: Categories (and their definitions) used by health-integrating studies to stratify communities into subgroups derived by qualitative thematic analysis (NGO: non-governmental organization).

2.4.2 Guidelines

Overall, 17 impact assessment guidelines met our inclusion criteria, and hence, were subjected to full-text screening (eight HIA, five SIA, two EIA, one EHIA and one strategic environmental and social assessment (SESA)). However, eight of these guidelines were excluded after full-text analysis, because they provided insufficient methodological guidance on impact assessment ($n = 5$) (Loayza and Albarracin-Jordan, 2010; Mahoney, Simpson, Harris, Aldrich, and Stewart Williams, 2004; Quigley et al., 2006; Senécal, Goldsmith, Conover, Sadler, and Brown, 1999; Vanclay, 2003), were not specifically about impact assessment ($n = 1$) (Macdonald and Schloeffel, 2014) or focussed on the Australian continent ($n = 2$) (enHealth, 2017; Franks, 2012). Hence, nine guidelines (five HIA, two SIA, one EHIA and one EIA) were included in the final analysis (see Appendix A4). In cases where more than one version was available from the same publisher, the latest version was considered.

The nine guidelines were published by international health, environmental, financial or industrial institutions or national health departments. All of them were written or reviewed by an international committee with considerable impact assessment expertise. While seven

guidelines were written for development projects in general or various kinds of NREPs, the HIA guidelines published by ICMM and the International Petroleum Industry Environmental Conservation Association (IPIECA) were sector-specific for mining or the oil and gas sectors, respectively (ICMM, 2010; IPIECA, 2016). In addition to the international guidelines, only one national guideline for EHIA was included, published by the South African Department of Health (2010). Of note, the HIA and EIA guidelines were all based on common processes (consisting of screening, scoping, assessment, recommendation, reporting, monitoring and evaluation phase), while the processes for SIA were based on different phases or elements.

Health was – beyond the HIA and EHIA guidelines – also addressed in the included EIA and SIA guidelines. The environmental determinants of health (e.g. air, soil and water pollution) were used in the EIA and EHIA guidelines (Abaza, Bisset, and Sadler, 2004; South Africa, 2010). The EHIA guidelines from South Africa aim to integrate health systematically into the national EIA process. The SIA guidelines addressed health comprehensively as a cross-cutting issue between social and environmental impacts (Kvam, 2018) or even as social impact per se (Vanclay, Esteves, Aucamp, and Franks, 2015). In all HIA guidelines, health was addressed comprehensively by drawing on different wider determinants of health, including environmental, social, institutional, modifiable or contextual determinants (ADB, 2018; Bhatia et al., 2014; ICMM, 2010; IFC, 2009a; IPIECA, 2016). By the introduction of environmental health areas, risk assessment matrix and key performance indicators, the International Finance Corporation (IFC), IPIECA and to some extent the ICMM guidelines for HIA, offered a particularly systematic methodology to address health, assess health impacts and monitor the health of communities over time.

All guidelines emphasized the need to include particularly vulnerable population groups, but at different levels. Specific social groups (e.g. women, elderly and the poor) were named in the EIA guidelines. The social gradient among communities was emphasized by the Asian Development Bank (ADB). Considering different “potentially affected communities”, based on the geographic distance between the communities and the affected project area, was suggested by the IFC and IPIECA guidelines for HIA. A separate profiling step to disentangle the community into different population groups was introduced in the ICMM and ADB guidelines for HIA. Attention was drawn to the heterogeneity of the population throughout the entire process in the SIA guidelines. However, no concrete tool for profiling the community based on socio-economic background was given in any of the guidelines scrutinized in the current scoping review. Besides addressing the community, the level of public participation ranged from involvement and consultation in EIA guidelines, democracy as a core value in HIA guidelines up to empowerment of the community in the SIA guidelines. Taken together,

equity in health in NREPs in sub-Saharan-Africa is addressed in existing HIA and SIA guidelines examined here.

2.4.3 Guidelines referred to in the peer-reviewed literature

The identified articles in the peer-reviewed literature referred to five different types of guidance documents for impact assessment. First, environmental national regulations and associated guidance documents such as 'Environmental Management and Coordination Act' (Kenya), 'Environmental Impact Assessment Procedural Guidelines' (Nigeria), 'Environmental Protection Agency Act' (Sierra Leone) and 'Environmental Conservation Act' (South Africa) were referenced. Second, international guidance documents about specific topics such as immigration were referenced (IFC, 2009b). Third, international conventions such as the Aarhus convention (UNECE for Europe, 1998), the Gothenburg consensus paper (WHO, 1999) and the Equator Principles (The Equator Principles Association, 2011) were also referenced, including performance standards on environmental and social sustainability by IFC (in particular performance standard #4 about community health, safety and security and performance standard #5 about land acquisition and involuntary resettlement) (IFC, 2012). Fourth, several text books about HIA and EIA were referenced (e.g. Birley, 1995; British Medical Association, 1999). Fifth, guidance documents referenced for HIA specifically included the ICMM, IFC, IPIECA and the Society of Practitioners of Health Impact Assessment (SOPHIA) guidelines, as well as the IAIA best practice principles (Quigley et al., 2006). Overall, the IFC guideline was a major resource for different researchers not only with the various types of publications they provide (HIA guidelines and topical best practice handbooks) but also as an international regulating body of the projects with its performance standards and the associated guidance notes.

2.5 Discussion

The potential impacts that NREPs have on people's health and well-being, which should be predicted and managed by prospective HIA, are linked not only to physical and environmental changes but also to societal factors (Carney and Gushulak, 2016). Indeed, unequal distributions of SDH can lead to health disparities between countries and within communities in a given setting. The current scoping review provides evidence that HIA in sub-Saharan Africa, which is mainly researched and regulated on an international level, holds promise for monitoring and potentially reducing health disparities.

2.5.1 HIA and health in impact assessment in sub-Saharan Africa

Our scoping review identified 62 studies. Interestingly, only one study related to SIA, which might be explained by various trends within SIA (e.g. human rights or social performance) as well as a more practical rather than publishing oriented community (Esteves, Franks, and

Vanclay, 2012). Most studies included in the current review criticized the effectiveness or the legislation of the EIA process, whereas HIA studies were mostly case studies about prospective impact assessments and methodological contributions. Our findings are consistent with previous papers emphasizing that HIA is, compared to EIA, a relatively recent approach and remains to be institutionalized in sub-Saharan African countries (Erlanger, Krieger, Singer, and Utzinger, 2008; Winkler et al., 2013). Nevertheless, compared to several retrospective EIA studies, many HIA studies included in the current review were conducted prospectively or simultaneously to the project development, and henceforth more likely to inform decisions to safeguard health of the affected populations.

In addition to the peer-reviewed literature, nine guidelines on impact assessment met our inclusion criteria, of which five were HIA guidelines. For EIA, only one international guideline was identified (Abaza, Bisset, and Sadler, 2004), while the peer-reviewed literature mostly referred to national documents related to EIA. Hence, our findings demonstrate that EIA in sub-Saharan Africa is mostly regulated and legally required at the national level (Morgan, 2012). With regard to HIA, South Africa is the only country in sub-Saharan Africa with publically available guidelines, aiming to include health systematically into the national EIA process (South Africa, 2010). Taken together, HIA in sub-Saharan Africa is – compared to EIA – mostly researched, promoted and regulated by an international community consisting of researchers, practitioners, financial and private organizations aiming to improve health and well-being of people affected by the extraction of natural resources.

2.5.2 HIA to address health equity in sub-Saharan Africa

In the current scoping review, we found evidence that health was addressed in about half of the studies identified and about one third of all studies considered different population subgroups, which we considered as a proxy for measuring equity. Beyond health and addressing different subgroups of the community, another crucial factor for equity in impact assessment is public participation, which is considered as key feature of HIA (Kemmer, Parry, and Palmer, 2004; Quigley et al., 2006; Utzinger, Wyss, Moto, Tanner, and Singer, 2004). However, several studies included in our review reported about the ineffectiveness of EIA in sub-Saharan Africa due to the lack of public participation (Bawole, 2013; Okello, Beevers, Douven, and Leentvaar, 2009; Ridl and Couzens, 2010). Moreover, some authors referred to EIA as compliance-oriented approach or check-box exercise (Morgan, 2012). The challenge of public participation in HIA and the lack of a coherent methodology for participation in HIA has been stressed by different researchers in regions where HIA is more advanced as compared to Africa (den Broeder et al., 2017; Heller et al., 2014; McCallum, Ollson, and Stefanovic, 2015). Of note, the heterogeneity of a community as well as the empowerment of the impacted community was highlighted in SIA guidelines included in our piece (Kvam, 2018;

Vanclay, Esteves, Aucamp, and Franks, 2015). Hence, for the further promotion of HIA towards institutionalization in sub-Saharan Africa, and to ensure a participatory and community-based process, lessons learned from EIA and experiences from world regions other than Africa will be important. In this regard, the SIA guidelines could be used as source for inspiration.

While previous HIA studies conducted in Australia and Canada (Harris-Roxas, Simpson, and Harris, 2004; Povall, Haigh, Abrahams, and Scott-Samuel, 2014), along with a specific equity-focused framework for HIA published by the Australasian Collaboration for Health Equity Impact Assessment (ACHEIA) (Mahoney, Simpson, Harris, Aldrich, and Stewart Williams, 2004), demonstrate the potential of HIA to address health inequalities, this has not yet been reported for sub-Saharan Africa. By triangulating the analysis of the HIA peer-reviewed literature and guidelines included in our review, we found evidence that HIA for NREPs in sub-Saharan Africa is underpinned by a consistent and field approved methodology across different guidelines, including equity as a core value. The environmental health areas approach embraces health topics systematically and identified health impacts are weighted by means of a risk assessment matrix. This finally allows for monitoring key performance indicators (ICMM, 2010; IPIECA, 2016; Winkler et al., 2010, Winkler et al., 2012). Furthermore, it is suggested to identify “potentially affected communities” within the larger project area (IFC, 2009a; IPIECA, 2016; Winkler et al., 2011). Yet, although a specific profiling step is introduced in the ICMM guidelines (ICMM, 2010), an advanced methodology to stratify the community into subgroups – moving beyond geographical classification to take into account the wider determinants of health – is still missing. This is reflected by the strong variation in the approach to identify health impacts among sub-categories of the community in the identified studies of this review. As suggested by Povall, Haigh, Abrahams, and Scott-Samuel (2014), a qualitative participatory data collection tool to assess health impacts differentially and to generate evidence for differential recommendations with the overarching objective to improve HIA for health equity.

Nevertheless, some positive effects of interventions sponsored by extractive industries on the health of particularly vulnerable groups are reported in relation to HIA (Knoblauch et al., 2014, Knoblauch et al., 2017). Consequently, we consider HIA as a promising approach to contribute to narrowing the health equity gap in settings where NREPs are being implemented in sub-Saharan Africa and elsewhere. This requires new research about community stratification and participation in HIA, while placing particular emphasis on prospectively conducting HIA for communities, extractive industries and local health systems, beyond single case studies. In addition, HIA practitioners should work with policy experts to ensure that

research findings are translated into specific policy recommendations to improve population health.

2.5.3 Limitations

Our scoping review has several limitations that are offered for discussion. First, we focused on large NREPs, while the economically important informal sector of natural resource extraction (i.e. ASM), which might have negative impacts on the health of miners and surrounding populations, were not considered (Gibb and O'Leary, 2014). This is explained by the fact that ASM is, in most cases, an informal economic activity and, thus, the application of impact assessments prior to the establishment of ASM is not a standardized practice. Second, we only included studies published in the peer-reviewed literature, while studies reported in the grey literature were not reviewed. Additionally, databases with an emphasis on social sciences could have complemented our electronic searches for the peer-reviewed literature. Third, our search strategy was not specified for the nationalities of the sub-Saharan African countries (e.g. Angola*/Angolan, Benin*/Beninese, Botswana*/Botswanan, etc.). Fourth, in addition to international guidelines, national regulations or legislation particularly for EIA might have served as complementary data sources. Despite these limitations, it should be noted that previous reviews pertaining to HIA employed similar methodologies (Erlanger, Krieger, Singer, and Utzinger, 2008; Hebert, Wendel, Kennedy, and Dannenberg, 2012; Pereira et al., 2017).

2.6 Conclusion

The potential impacts of NREPs on people's health and well-being are largely determined by social factors beyond physical and environmental changes. These social factors, and how they are shaped by NREPs, should be measured and managed by prospective HIA, which ideally also includes differential recommendations to address the needs of different population groups adequately. Although HIA has yet to be institutionalized in most parts of sub-Saharan Africa, we found evidence that HIA is underpinned by a systematic and field-approved methodology. Moreover, there are first reports about positive effects on the health of vulnerable population groups in context where rigorous HIA was commissioned by extractive industries. In view of the strengths of rigorously conducted HIA, which might improve health equity, we recommend inclusion of a qualitative data collection step during profiling, in order to stratify the community into subgroups, address health differentials adequately and most importantly "to leave no one behind", as suggested by the 2030 Agenda for Sustainable Development. HIA and the accompanying methods for research pertaining to HIA should be further promoted in different sectors engaged in natural resource extraction in sub-Saharan Africa to improve the health of differently affected population groups and to act towards health equity.

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2.8 References

- Abaza H, Bisset R, Sadler B. Environmental impact assessment and strategic environmental assessment: towards an integrated approach. 1st ed. Geneva, Switzerland: Economics and Trade Branch, Division of Technology, Industry, and Economics, United Nations Environment Programme; 2004.
- ADB. Health impact assessment: a good practice sourcebook. Manila, Philippines: Asian Development Bank; 2018. doi:10.22617/TIM189515-2.
- Agyepong IA, Sewankambo N, Binagwaho A, Coll-Seck AM, Corrah T, Ezeh A, et al. The path to longer and healthier lives for all Africans by 2030: the Lancet Commission on the future of health in sub-Saharan Africa. *Lancet* 2017;390:2803–59. doi:10.1016/S0140-6736(17)31509-X.
- Bawole JN. Public Hearing or ‘Hearing Public’? An Evaluation of the Participation of Local Stakeholders in Environmental Impact Assessment of Ghana’s Jubilee Oil Fields. *Environ Manage* 2013;52:385–97. doi:10.1007/s00267-013-0086-9.
- Bhatia R, Frahang L, Lee M, Orenstein M, Richardson M, Wernham A. Minimum elements and practice standards for health impact assessment. Society for Health Impact Assessment Practitioners; 2014.
- Birley MH. The health impact assessment of development projects. London: His Majesty’s Stationary Office (HMSO); 1995.
- Brisbois BW, Reschny J, Fyfe TM, Harder HG, Parkes MW, Allison S, et al. Mapping research on resource extraction and health: a scoping review. *Extr Ind Soc* 2018. doi:10.1016/j.exis.2018.10.017.
- British Medical Association, editor. Health and environmental impact assessment: an integrated approach. Reprinted. London: Earthscan; 1999.
- den Broeder L, Uiters E, ten Have W, Wagemakers A, Schuit AJ. Community participation in health impact assessment: a scoping review of the literature. *Environ Impact Assess Rev* 2017;66:33–42. doi:10.1016/j.eiar.2017.06.004.
- Buse K, Hawkes S. Health in the Sustainable Development Goals: ready for a paradigm shift? *Glob Health* 2015;11:13. doi:10.1186/s12992-015-0098-8.
- Carney JG, Gushulak BD. A review of research on health outcomes for workers, home and host communities of population mobility associated with extractive industries. *J Immigr Minor Health* 2016;18:673–86. doi:10.1007/s10903-015-0328-4.
- Dahlgren G, Whitehead M. Policies and strategies to promote social equity in health. Stockholm, Sweden: Institute for Futures Studies; 1991.
- enHealth. Health impact assessment guidelines. Australia: Environmental Health Standing Committee (enHealth); 2017.
- Erlanger TE, Krieger GR, Singer BH, Utzinger J. The 6/94 gap in health impact assessment. *Environ Impact Assess Rev* 2008;28:349–58. doi:10.1016/j.eiar.2007.07.003.

- Esteves AM, Franks D, Vanclay F. Social impact assessment: the state of the art. *Impact Assess Proj Apprais* 2012;30:34–42. doi:10.1080/14615517.2012.660356.
- Franks D. Social impact assessment of resource projects. Queensland, Australia: Social impact assessment of resource projects Daniel Franks International Mining for Development Centre (IM4DC); 2012.
- Fullman N, Barber RM, Abajobir AA, Abate KH, Abbafati C, Abbas KM, et al. Measuring progress and projecting attainment on the basis of past trends of the health-related Sustainable Development Goals in 188 countries: an analysis from the Global Burden of Disease Study 2016. *Lancet* 2017;390:1423–59. doi:10.1016/S0140-6736(17)32336-X.
- Gibb Herman, O’Leary Keri Grace. Mercury exposure and health impacts among individuals in the artisanal and small-scale gold mining community: a comprehensive review. *Environ Health Perspect* 2014;122:667–72. doi:10.1289/ehp.1307864.
- Glucker AN, Driessen PPJ, Kolhoff A, Runhaar HAC. Public participation in environmental impact assessment: why, who and how? *Environ Impact Assess Rev* 2013;43:104–11. doi:10.1016/j.eiar.2013.06.003.
- Harris-Roxas B, Simpson S, Harris L. Equity-focused health impact assessment: a literature review. Sydney, Australia: Australasian Collaboration for Health Equity Impact Assessment (ACHEIA); 2004.
- Harris-Roxas B, Viliani F, Bond A, Cave B, Divall M, Furu P, et al. Health impact assessment: the state of the art. *Impact Assess Proj Apprais* 2012;30:43–52. doi:10.1080/14615517.2012.666035.
- Hebert KA, Wendel AM, Kennedy SK, Dannenberg AL. Health impact assessment: a comparison of 45 local, national, and international guidelines. *Environ Impact Assess Rev* 2012;34:74–82. doi:10.1016/j.eiar.2012.01.003.
- Heller J, Givens ML, Yuen TK, Gould S, Jandu MB, Bourcier E, et al. Advancing efforts to achieve health equity: equity metrics for health impact assessment practice. *Int J Environ Res Public Health* 2014;11:11054–64. doi:10.3390/ijerph111111054.
- Hosseinpour AR, Bergen N, Schlottheuber A, Boerma T. National health inequality monitoring: current challenges and opportunities. *Glob Health Action* 2018;11. doi:10.1080/16549716.2017.1392216.
- ICMM. Making a positive contribution to the SDGs. *Int Counc Min Met* 2018. <https://www.icmm.com/sdgs> (accessed November 2, 2018).
- ICMM. Good practice guidance on health impact assessment. London, UK: International Council on Mining and Metals; 2010.
- IEA. WEO-2014 special report: Africa energy outlook. International Energy Agency; 2014.
- IFC. Performance standards on environmental and social sustainability. Washington DC: International Finance Corporation; 2012.
- IFC. Introduction to health impact assessment. Washington DC: International Finance Corporation; 2009a.
- IFC. Projects and people: a handbook for addressing project-induced in-migration. Washington DC: International Finance Corporation; 2009b.
- IPIECA. Health impact assessment - a guide for the oil and gas industry. London, UK: International Petroleum Industry Environmental Conservation Association; 2016.
- Kemm J, Parry J, Palmer S. What is HIA? Introduction and overview. In: Kemm J, Parry J, Palmer S, editors. *Health Impact Assessment*, Oxford University Press; 2004, p. 1–14. doi:10.1093/acprof:oso/9780198526292.003.0001.

- Knoblauch A, Hodges M, Bah M, Kamara H, Kargbo A, Paye J, et al. Changing patterns of health in communities impacted by a bioenergy project in northern Sierra Leone. *Int J Environ Res Public Health* 2014;11:12997–3016. doi:10.3390/ijerph111212997.
- Knoblauch AM, Divall MJ, Owuor M, Musunka G, Pascall A, Nduna K, et al. Selected indicators and determinants of women's health in the vicinity of a copper mine development in northwestern Zambia. *BMC Womens Health* 2018;18. doi:10.1186/s12905-018-0547-7.
- Knoblauch AM, Divall MJ, Owuor M, Nduna K, Ng'uni H, Musunka G, et al. Experience and lessons from health impact assessment guiding prevention and control of HIV/AIDS in a copper mine project, northwestern Zambia. *Infect Dis Poverty* 2017;6:11. doi:10.1186/s40249-017-0320-4.
- Krieger G, Singer B, Winkler M, Divall M, Tanner M, Utzinger J. Health impact assessment in developing countries. In: Kemm J, editor. *Health Impact Assessment*, Oxford University Press; 2012, p. 265–76. doi:10.1093/acprof:oso/9780199656011.003.0029.
- Kvam R. *Social impact assessment: integrating social issues in development projects*. Inter-American Development Bank (IDB); 2018.
- Levac D, Colquhoun H, O'Brien KK. Scoping studies: advancing the methodology. *Implement Sci* 2010;5:69. doi:10.1186/1748-5908-5-69.
- Loayza F, Albarracin-Jordan J. *Mining sector strategic environmental and social assessment (SESA) 2010*.
- Loewenson R, Hinricher J, Papamichail A. *Corporate responsibility for health in the extractive sector in East and Southern Africa*. Harare, Zimbabwe: EQUITYNET Training and Research Centre; 2016.
- Macdonald C, Schloeffel A. *Social responsibility in the mining and metals sector in developing countries*. Australian Government; 2014.
- Mactaggart F, McDermott L, Tynan A, Whittaker M. Exploring the broader health and well-being outcomes of mining communities in low- and middle-income countries: a systematic review. *Glob Public Health* 2018;13:899–913. doi:10.1080/17441692.2016.1240821.
- Mahoney M, Simpson S, Harris E, Aldrich R, Stewart Williams J. *Equity-focused health impact assessment framework*. Newcastle, Australia: Australasian Collaboration for Health Equity Impact Assessment (ACHEIA); 2004.
- Marmot M. Social determinants of health inequalities. *Lancet* 2005;365:1099–104. doi:10.1016/S0140-6736(05)71146-6.
- McCallum LC, Ollson CA, Stefanovic IL. Advancing the practice of health impact assessment in Canada: obstacles and opportunities. *Environ Impact Assess Rev* 2015;55:98–109. doi:10.1016/j.eiar.2015.07.007.
- Moher D, Liberati A, Tetzlaff J, Altman DG, Group TP. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLOS Med* 2009;6:e1000097. doi:10.1371/journal.pmed.1000097.
- Morgan RK. Environmental impact assessment: the state of the art. *Impact Assess Proj Apprais* 2012;30:5–14. doi:10.1080/14615517.2012.661557.
- Okello N, Beevers L, Douven W, Leentvaar J. The doing and un-doing of public participation during environmental impact assessments in Kenya. *Impact Assess Proj Apprais* 2009;27:217–26. doi:10.3152/146155109X465940.
- O'Neill J, Tabish H, Welch V, Petticrew M, Pottie K, Clarke M, et al. Applying an equity lens to interventions: using PROGRESS ensures consideration of socially stratifying factors to illuminate inequities in health. *J Clin Epidemiol* 2014;67:56–64. doi:10.1016/j.jclinepi.2013.08.005.

- Pereira CAR, Périssé ARS, Knoblauch AM, Utzinger J, Hacon S de S, Winkler MS. Health impact assessment in Latin American countries: current practice and prospects. *Environ Impact Assess Rev* 2017;65:175–85. doi:10.1016/j.eiar.2016.09.005.
- Povall SL, Haigh FA, Abrahams D, Scott-Samuel A. Health equity impact assessment. *Health Promot Int* 2014;29:621–33. doi:10.1093/heapro/dat012.
- Quigley R, den Broeder, L, Furu P, Bond A, Cave B, Bos R. Health impact assessment international best practice principles. *Int Assoc Impact Assess* 2006:4.
- Ridl J, Couzens E. Misplacing NEMA? A consideration of some problematic aspects of South Africa's new EIA Regulations. *Potchefstroomse Elektron Regsblad* 2010;13:80–121.
- Salcito K, Utzinger J, Krieger GR, Wielga M, Singer BH, Winkler MS, et al. Experience and lessons from health impact assessment for human rights impact assessment. *BMC Int Health Hum Rights* 2015;15:24. doi:10.1186/s12914-015-0062-y.
- Senécal P, Goldsmith B, Conover S, Sadler B, Brown K. Principles of environmental impact assessment best practice. *Int Assoc Impact Assess* 1999.
- Singer BH, de Castro MC. Bridges to sustainable tropical health. *Proc Natl Acad Sci U S A* 2007;104:16038–43. doi:10.1073/pnas.0700900104.
- South Africa. Environmental health impact assessment in South Africa - Guidelines. South Africa: Department of Health; 2010.
- The Equator Principles Association. Equator Principles. Equat Princ Off Website 2011. <http://www.equator-principles.com/> (accessed January 5, 2018).
- UNDP. Mapping mining to the Sustainable Development Goals: an atlas. United Nations Development Programme; 2016.
- UNEC for Europe. Convention on access to information, public participation in decision-making and access to justice in environmental matters. United Nations Economic Commission for Europe; 1998.
- United Nations. Transforming our world: the 2030 Agenda for Sustainable Development. Geneva, Switzerland: 2015.
- Utzinger J, Wyss K, Moto D, Tanner M, Singer B. Community health outreach program of the Chad-Cameroon petroleum development and pipeline project. *Clin Occup Environ Med* 2004;4:9–26. doi:10.1016/j.coem.2003.09.004.
- Vanclay F. International principles for social impact assessment. *Impact Assess Proj Apprais* 2003;21:5–12. doi:10.3152/147154603781766491.
- Vanclay F, Esteves AM, Aucamp I, Franks D. Social impact assessment: guidance for assessing and managing the social impacts of projects. International Association for Impact Assessment (IAIA); 2015.
- Watkins K. Leaving no one behind: an agenda for equity. *Lancet* 2014;384:2248–55. doi:10.1016/S0140-6736(13)62421-6.
- WHO. About social determinants of health. *Soc Determinants Health* 2017. http://www.who.int/social_determinants/sdh_definition/en/ (accessed October 26, 2017).
- WHO, European Centre for Health Policy. Gothenburg Consensus Paper. Brussels, Belgium: World Health Organization Regional Office for Europe; 1999.
- Winkler MS, Divall MJ, Krieger GR, Balge MZ, Singer BH, Utzinger J. Assessing health impacts in complex eco-epidemiological settings in the humid tropics: the centrality of scoping. *Environ Impact Assess Rev* 2011;31:310–9. doi:10.1016/j.eiar.2011.01.003.

-
- Winkler MS, Divall MJ, Krieger GR, Balge MZ, Singer BH, Utzinger J. Assessing health impacts in complex eco-epidemiological settings in the humid tropics: advancing tools and methods. *Environ Impact Assess Rev* 2010;30:52–61. doi:10.1016/j.eiar.2009.05.005.
- Winkler MS, Divall MJ, Krieger GR, Schmidlin S, Magassouba ML, Knoblauch AM, et al. Assessing health impacts in complex eco-epidemiological settings in the humid tropics: modular baseline health surveys. *Environ Impact Assess Rev* 2012a;33:15–22. doi:10.1016/j.eiar.2011.10.003.
- Winkler MS, Krieger GR, Divall MJ, Cissé G, Wielga M, Singer BH, et al. Untapped potential of health impact assessment. *Bull World Health Organ* 2013;91:298–305. doi:10.2471/BLT.12.112318.
- Winkler MS, Krieger GR, Divall MJ, Singer BH, Utzinger J. Health impact assessment of industrial development projects: a spatio-temporal visualization. *Geospatial Health* 2012b;6:299. doi:10.4081/gh.2012.148.

2.9 Supplementary files

Appendix A1: Search strategy for the different data-bases for peer-reviewed literature

Data base	Search terminology
Scopus	<p>TITLE-ABS-KEY (((africa OR african OR angola OR benin OR botswana OR "burkina faso" OR burundi OR "côte d'ivoire" OR "cote d'ivoire" OR "ivory coast" OR cameroon OR camerun OR kamerun OR "central african republic" OR chad OR congo OR djibouti OR "equatorial guinea" OR eritrea OR ethiopia OR gabon OR gambia OR ghana OR guinea OR "guinea bissau" OR "guinea-bissau" OR kenya OR lesotho OR liberia OR madagascar OR malawi OR mali OR mauritania OR mozambique OR namibia OR niger OR nigeria OR rhodesia OR rwanada OR senegal OR "sierra leone" OR somalia OR "south africa" OR "south sudan" OR sudan OR swaziland OR tanzania OR togo OR uganda OR "upper volta" OR zaire OR zambia OR zimbabwe)</p> <p>AND</p> <p>(exploration OR exploitation OR extractive OR extraction OR mine OR mines OR mining OR industry OR industries OR factory OR factories OR plantation OR production OR dam OR drilling) AND (asbestos OR carbon OR coal OR diamond OR diamonds OR fluorite OR gas OR "natural gas" OR metal OR metals OR salt OR aluminum OR alumina OR bauxite OR cobalt OR copper OR chrome OR chromium OR gold OR iron OR "iron ore" OR lead OR manganese OR nickel OR phosphate OR phosphor OR palladium OR platinum OR potassium OR silver OR steel OR sulphate OR sulphur OR tin OR titanium OR tungsten OR uranium OR vermiculite OR zinc OR zirconium OR hydrocarbon OR oil OR petrol OR gas OR hydroelectric OR hydropower OR biofuel OR biofuels OR timber OR electricity OR electricities OR cement) OR ("extractive industry" OR "extractive industries" OR "mining development" OR "mining industry" OR "mining industries" OR "resource curse" OR "resource extraction" OR "power plant" OR "power plants"))</p> <p>AND</p> <p>(eia OR "environmental impact" OR "environmental impacts" OR "environmental impact assessment" OR hia OR "health impact" OR "health impacts" OR "health impact assessment" OR sia OR "social impact" OR "social impacts" OR "social impact assessment" OR esia OR eshia OR "integrated impact" OR "integrated impacts" OR "integrated impact assessment"))</p>
PubMed*	<p>((africa[tiab] OR african[tiab] OR angola[tiab] OR benin[tiab] OR botswana[tiab] OR "burkina faso"[tiab] OR burundi[tiab] OR "côte d'ivoire"[tiab] OR "cote d'ivoire"[tiab] OR "ivory coast"[tiab] OR cameroon[tiab] OR camerun[tiab] OR kamerun[tiab] OR "central african republic"[tiab] OR chad[tiab] OR congo[tiab] OR djibouti[tiab] OR "equatorial guinea"[tiab] OR eritrea[tiab] OR ethiopia[tiab] OR gabon[tiab] OR gambia[tiab] OR ghana[tiab] OR guinea[tiab] OR "guinea bissau"[tiab] OR "guinea-bissau"[tiab] OR kenya[tiab] OR lesotho[tiab] OR liberia[tiab] OR madagascar[tiab] OR malawi[tiab] OR mali[tiab] OR mauritania[tiab] OR mozambique[tiab] OR namibia[tiab] OR niger[tiab] OR nigeria[tiab] OR rhodesia[tiab] OR rwanada[tiab] OR senegal[tiab] OR "sierra leone"[tiab] OR somalia[tiab] OR "south africa"[tiab] OR "south sudan"[tiab] OR sudan[tiab] OR swaziland[tiab] OR tanzania[tiab] OR togo[tiab] OR uganda[tiab] OR</p>

"upper volta"[tiab] OR zaire[tiab] OR zambia[tiab] OR zimbabwe[tiab] OR "Africa South of the Sahara"[MeSH])

AND

((eia[tiab] OR "environmental impact"[tiab] OR "environmental impacts"[tiab] OR hia[tiab] OR "health impact"[tiab] OR "health impacts"[tiab] OR "health impact assessment"[MeSH] OR sia[tiab] OR "social impact"[tiab] OR "social impacts"[tiab] OR esia[tiab] OR eshia[tiab] OR "integrated impact"[tiab] OR "integrated impacts"[tiab])

AND

((exploration[tiab] OR exploitation[tiab] OR extractive[tiab] OR extraction[tiab] OR mine[tiab] OR mines[tiab] OR mining[tiab] OR industry[tiab] OR industries[tiab] OR factory[tiab] OR factories[tiab] OR plantation[tiab] OR production[tiab] OR dam[tiab] OR drilling[tiab]) AND (asbestos[tiab] OR carbon[tiab] OR coal[tiab] OR diamond[tiab] OR diamonds[tiab] OR fluorite[tiab] OR gas[tiab] OR "natural gas"[tiab] OR metal[tiab] OR metals[tiab] OR salt[tiab] OR aluminum[tiab] OR alumina[tiab] OR bauxite[tiab] OR cobalt[tiab] OR copper[tiab] OR chrome[tiab] OR chromium[tiab] OR gold[tiab] OR iron[tiab] OR "iron ore"[tiab] OR lead[tiab] OR manganese[tiab] OR nickel[tiab] OR phosphate[tiab] OR phosphor[tiab] OR palladium[tiab] OR platinum[tiab] OR potassium[tiab] OR silver[tiab] OR steel[tiab] OR sulphate[tiab] OR sulphur[tiab] OR tin[tiab] OR titanium[tiab] OR tungsten[tiab] OR uranium[tiab] OR vermiculite[tiab] OR zinc[tiab] OR zirconium[tiab] OR hydrocarbon[tiab] OR oil[tiab] OR petrol[tiab] OR gas [tiab] OR hydroelectric[tiab] OR hydropower[tiab] OR biofuel[tiab] OR biofuels[tiab] OR timber[tiab] OR electricity[tiab] OR electricities[tiab] OR cement[tiab] OR "natural resources"[MeSH]) OR ("extractive industry"[tiab] OR "extractive industries"[tiab] OR "mining development"[tiab] OR "mining industry"[tiab] OR "mining industries"[tiab] OR "resource curse"[tiab] OR "resource extraction"[tiab] OR "Extraction and Processing Industry"[MeSH]))

AND

((eia[tiab] OR "environmental impact"[tiab] OR "environmental impacts"[tiab] OR hia[tiab] OR "health impact"[tiab] OR "health impacts"[tiab] OR "health impact assessment"[MeSH] OR sia[tiab] OR "social impact"[tiab] OR "social impacts"[tiab] OR esia[tiab] OR eshia[tiab] OR "integrated impact"[tiab] OR "integrated impacts"[tiab])

AJOL[†]

(extract* OR min* OR industry* OR "natural resource*" OR metal OR mineral OR coal OR gold OR silver OR copper OR oil OR gas OR dam)

AND

("environmental impact*" OR "health impact*" OR "social impact*" OR "integrated impact*" OR "impact* assessment*")

*[tiab] specify the search for titles and abstracts

[†]African Journal Online, search field restricted to 255 characters

Appendix A2: Search strategy for international and national HIA guidelines of sub-Saharan African countries (EIS: Évaluation d'impact sanitaire, HIA: Health impact assessment, WHOLIS: World Health Organization Library Information System)

Search engine	Search terms
Google* (English) Part 1	("Health Impact Assessment" OR HIA) AND (guide OR guideline OR guidelines) AND (international OR global OR Africa OR African OR Angola OR Benin OR Botswana OR "Burkina Faso" OR "Upper Volta" OR Burundi OR "Côte d'Ivoire" OR "Cote d'Ivoire" OR "Ivory Coast" OR Cameroon OR Camerun OR Kamerun)
Google* (English) Part 2	("Health Impact Assessment" OR HIA) AND (guide OR guideline OR guidelines) AND ("Central African Republic" OR Chad OR Congo OR Djibouti OR "Equatorial Guinea" OR Eritrea OR Ethiopia OR Gabon OR Gambia OR Ghana OR Guinea OR "Guinea Bissau" OR "Guinea-Bissau" OR Kenya OR Lesotho OR Liberia OR Madagascar OR Malawi OR Mali OR Mauritania)
Google* (English) Part 3	("Health Impact Assessment" OR HIA) AND (guide OR guideline OR guidelines) AND (Mozambique OR Namibia OR Niger OR Nigeria OR Rhodesia OR Rwanda OR Senegal OR "Sierra Leone" OR Somalia OR "South Africa" OR "South Sudan" OR Sudan OR Swaziland OR Tanzania OR Togo OR Uganda OR Zaire OR Zambia OR Zimbabwe)
Google* (French) Part 1	("Évaluation d'impact sur la santé" OR "Évaluation d'impact sanitaire" OR EIS) AND (guide OR "code de pratiques" OR "code de bonnes pratiques") AND (international OR international OR global OR globale OR Afrique OR africain OR africaine)
Google* (French) Part 2	("Évaluation d'impact sur la santé" OR "Évaluation d'impact sanitaire" OR EIS) AND (guide OR "code de pratiques" OR "code de bonnes pratiques") AND (Bénin OR "Burkina Faso" OR Burundi OR Cameroun OR "République Centrafricaine" OR Congo OR "Côte d'Ivoire" OR Djibouti OR Gabon OR Guinée OR "Guinée Équatoriale" OR Madagascar OR Mali OR "République Démocratique du Congo" OR RDC OR Rwanda OR Sénégal OR Tschad OR Togo)
Google* (Portuguese)	("Avaliação de Impacto na Saúde" OR "Impacto na Saúde") AND Guia AND (África OR Angola OR Guiné-Bissau OR Guiné Equatorial OR Moçambique)

Grey Literature Report[†]	"Health impact assessment"
Guidelines International Network	(Health AND Impact AND Assessment)
WHOLIS	Health Impact Assessment AND Guide

*search restricted to 32 terms

†no Boolean operators allowed, automatic truncation

Appendix A3: Overview of studies included in the review stratified by type of study (case studies or impact assessment evaluation) and impact assessment approach (EIA: environmental impact assessment, HIA: health impact assessment, SIA: social impact assessment, DB: Data base, Cit: Citation chasing)

First author (year)	Study purpose	Country	Project sector	Geographical level	Source
Case studies (n=16)					
EIA (n=5)					
Abuodha, J.O.Z. (2002)	Full IA study	Kenya	Mining	local	DB
Bawole, J.N. (2013)	Focused IA study	Ghana	Oil	local	DB
Jobin, W. (2003)	Focused IA study	Cameroon	Oil	local	DB
Tarr, P. (2007)	Focused IA study	Angola & Namibia	Hydro dam	local	DB
Tedjio, R.C (2016)	Methodological IA study	Cameroon	Hydro dam	local	DB
HIA (n=9)					
Bilewu, S.O. (2017)	Full IA study	Nigeria	Hydro dam	local	DB
Knoblauch, A. (2017)	Focused IA study	Zambia	Mining	local	DB
Knoblauch, A. (2018)	Focused IA study	Zambia	Mining	local	DB
Leonard, L. (2003)	Methodological IA study	Chad	Oil	local	DB
Renshaw, M. (1998)	Full IA study	Kenya	Hydro dam	local	DB
Utzinger, J. (2005)	Full IA study	Cameroon & Chad	Oil	local	DB
Winkler, M.S. (2011)	Methodological IA study	Republic of Guinea	Mining	local	Cit
Winkler, M.S. (2010)	Methodological IA study	Democratic Republic of Congo	Mining	local	DB
Winkler, M.S. (2011)	Methodological IA study	Republic of Guinea	Mining	local	DB
Integrated approach (n=2)					
Knoblauch, A. (2014)	Focused IA study	Sierra Leone	Biofuel	local	Cit
Winkler, M.S. (2014)	Focused IA study	Sierra Leone	Biofuel	local	Cit

Impact assessment evaluation (n=46)**EIA (n=31)**

Acquah, P.C. (2000)	Effectiveness	Ghana	Mining	local, national	DB
Adgolign, T.B. (2016)	Institutionalization/Legislation	Ethiopia	Hydro dam	local, national	DB
Ahmed, M.I. (2011)	Institutionalization/Legislation	Sudan	general	national	DB
Alemagi, D.(2013)	Effectiveness	Cameroon	Forestry	local, national	Cit
Ali, O.M.M. (2007)	Effectiveness	Sudan	general	national	Cit
Anifowose, B. (2016)	Effectiveness	Nigeria	Oil (& Gas)	national	DB
Anifowose, B. (2014)	Methodological contribution	Nigeria	Oil	national	DB
Anyadiegwu, C.I. (2012)	Institutionalization/Legislation	Nigeria	Oil (& Gas)	national	DB
Appiah, D.O. (2014)	Effectiveness	Ghana	Mining	local	Cit
Couzens, E. (2006)	Effectiveness	South Africa	Hydro dam	local	DB
Davies, T.C. (2005)	Institutionalization/Legislation	Kenya	Mining	local	DB
Eneh, O.C. (2011)	Effectiveness	Nigeria	general	national	DB
Esterhuyse, S. (2017)	Methodological contribution	South Africa	Oil (& Gas)	national	DB
Guilanpour, K. (2012)	Effectiveness	Tanzania	general	local	Cit
Gwimbi, P. (2016)	Effectiveness	Zambia	Mining	national	DB
Gwimbi, P. (2016)	Effectiveness	Zambia	Mining	local	DB
Gwimbi, P. (2017)	Effectiveness	Zambia	Mining	local	DB
Gwimbi, P. (2016)	Effectiveness	Zambia	Mining	local	DB
Kornelius, N. (2003)	Institutionalization/Legislation	South Africa	Mining, Oil	national	DB
Kuma, J.S. (2002)	Methodological contribution	Ghana	Mining	national	DB
Leonard, L. (2017)	Effectiveness	South Africa	Mining	local	DB
Mason, N.H. (2014)	Institutionalization/Legislation	Sierra Leone	Mining	national	DB
Nwapi, C. (2015)	Institutionalization/Legislation	Madagascar	Oil	national	DB
Nwoko, C.O. (2013)	Effectiveness	Nigeria	general	national	Cit
Ogunba, O.A. (2004)	Institutionalization/Legislation	Nigeria	general	national	Cit
Okello, N. (2012)	Institutionalization/Legislation	Kenya	general	national	Cit
Olokesusi, F. (1998)	Institutionalization/Legislation	Nigeria	general	national	DB
Ridl, J. (2010)	Institutionalization/Legislation	South Africa	general	national	Cit
Sandham, L.A. (2013)	Effectiveness	South Africa	general	national	Cit
Sandham, L.A. (2008)	Effectiveness	South Africa	Hydro dam	local	Cit
Sandham, L.A. (2008)	Effectiveness	South Africa	Mining	national	DB

HIA (n=7)					
Calaian, P. (2008)	Effectiveness	international	Oil	international	DB
Erlanger, T.E. (2008)	Institutionalization/Legislation	international	general	international	DB
Knoblauch, A. (2017)	Methodological contribution	Zambia	Mining	local	DB
Lerer, L.B. (1999)	Methodological contribution	international	general	na	Cit
Mercier, J.R. (2003)	Institutionalization/Legislation	international	general	local, international	Cit
Winkler, M.S. (2013)	Institutionalization/Legislation	international	general	international	Cit
Winkler, M.S. (2012)	Methodological contribution	international	general	international	DB
SIA (n=1)					
Nwapi, C. (2015)	Institutionalization/Legislation	international	Mining	international	DB
Integrated approach (n=7)					
Anyogu, F. (2012)	Institutionalization/Legislation	Nigeria	Oil	national	DB
Castro, M.C. (2016)	Effectiveness	international	general	local, international	DB
Duvail, S. (2012)	Effectiveness	Kenya	Biofuel	local	DB
Hensengerth, O. (2013)	Institutionalization/Legislation	Ghana	Hydro dam	local	DB
Pisani, J.A. (2006)	Institutionalization/Legislation	South Africa	general	national	Cit
Rosa, J. (2015)	Methodological contribution	international	general	international	DB
Siciliano, G. (2018)	Methodological contribution	international	Hydro dam	international	DB

Appendix A4: Overview of impact assessment guidelines stratified by type of impact assessment

Publisher	Title	Year	Pages
EIA (n=1)			
United Nations Environment Programme (UNEP)	Environmental impact assessment and strategic environmental assessment: toward an integrated approach	2004	163
HIA (n=5)			
Asian Development Bank (ADB)	Health impact assessment: a good practice sourcebook	2018	189
International Council on Mining and Metals (ICMM)	Good practice guidance for health impact assessment	2010	96
International Finance Corporation (IFC)	Introduction to health impact assessment	2009	68
International Petroleum Industry Environmental Conservation Association (IPIECA)	Health impact assessment - A guide for the oil and gas industry	2016	100
Society of Practitioners of HIA (SOPHIA)	Minimum elements and practice standards for health impact assessment	2014	13
SIA (n=2)			
International Association for Impact Assessment (IAIA)	Social impact assessment - Guidance for assessing and managing the social impacts of projects	2015	107
Inter-American Development Bank (IDB)	Social impact assessment - Integrating social issues in development projects	2018	54
Integrated approach (n=1)			
Department of Health, South Africa	Environmental health impact assessment in South Africa	2010	56

3. Health impacts of industrial mining on surrounding communities: local perspectives from three sub-Saharan African countries

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3.1 Abstract

Industrial mining projects can play an important role in global sustainable development if associated health risks are minimised and opportunities maximised. While a broad body of evidence from quantitative studies exists that establishes the interlinkages between mining operations and effects on public health, little research has been conducted investigating health impacts from the perspective of affected communities. This is particularly true in sub-Saharan Africa, where about a third of the remaining global mineral resources are endowed and health-related indicators for sustainable development are lagging behind. In this multi-country qualitative study, we explore community perceptions regarding impacts of industrial mining on their health and well-being. In nine study sites in Burkina Faso, Mozambique and Tanzania, we conducted 83 participatory focus group discussions with a total of 791 participants (385 men, 406 women). Our findings reveal a broad range of perceived impacts on environmental, economic and social determinants of health, with secondary health implications related to morbidity, mortality and well-being. Overall, perceived negative impacts prevailed, mainly related to environmental pollution, change in livelihoods or social disruption. Perceived positive impacts on health and well-being were related to interventions implemented by the mines such as new or improved water sources, health care facilities, roads and schools. The consistency of these findings across countries and study sites suggests a structural problem and indicates a pressing need to address health by acting on the wider determinants of health in mining regions. Participatory health impact assessment should be strengthened in host countries to foster strategic interventions, include marginalised population groups, and protect and promote the health of local communities. By including community perspectives on health before and during project implementation, policymakers can take advantage of economic opportunities while avoiding the pitfalls, bringing their communities closer to achieving good health and well-being goals by 2030 and beyond.

3.2 Introduction

Africa endows about a third of global reserves of natural resource of metals and minerals (World Bank, 2017). The continent is currently hosting about 700 active industrial mines and many more are planned, partly in response to the global transition toward a low-carbon future (Standard & Poor Global, 2020; World Bank, 2017). Large-scale extraction projects are important drivers for the economic development of low- and middle-income countries and thus, can play a critical role in the frame of the 2030 Agenda for Sustainable Development (USGS, 2019; Yakovleva et al., 2017). This also encompasses implications for health, which is a central aspect of sustainable development (Buse & Hawkes, 2015; Fraser, 2019). For example, if mining projects work in partnership with local health systems, it is expected that better health and well-being of local communities can be achieved in communities living in mining regions (Knoblauch et al., 2020; Knoblauch et al., 2014). It has been shown that upgraded infrastructure and increased socio-economic conditions can result in a diverse set of health opportunities such as reduced childhood mortality, improved public infrastructure and increased wealth index (Benshaul-Tolonena et al., 2019; Mamo et al., 2019; Utzinger et al., 2004).

On the other hand, potential health benefits of mining industries are opposed by potential negative effects on the environment, society and health, which need to be adequately managed to strive toward sustainable development (Carvalho, 2017). Indeed, a large body of research investigates environmental pollution in mining areas, including related consequences for the health of affected populations (Aboka et al., 2018; Antabe et al., 2017; Porgo & Gokyay, 2017). Project-induced in-migration has also been identified as a major concern in mining regions that is associated with an array of health risks, including overburdened public infrastructure and social services or increased burden of sexually transmitted diseases (Cronjé et al., 2013; Dietler et al., 2020a; IFC, 2009).

Overall, existing literature focusing on health and well-being of communities affected by large natural resource extraction projects is predominately quantitative in nature and mostly focused on specific diseases or specific causes for health impacts (Brisbois et al., 2018). Only few studies have focused on the wider determinants of health in the context of resource extraction (Mactaggart et al., 2018). In addition, there is a paucity of qualitative studies investigating health as multi-factorial issue (Karakaya & Nuur, 2018). Consequently, voices from affected communities tend to be heavily underrepresented in the scientific literature at hand. Hence, the missed opportunity to capture perceptions and attitudes in a comprehensive manner is problematic and limits full engagement with communities.

Focus group discussions (FGDs), based on fruitful discussions about views and experiences shared with others, can be particularly insightful to gain understanding of

community perspectives on health and well-being (Wong, 2008). A community-based approach might generate new findings and potentially reveal the “underlying truth”, compared to quantitative studies, which are often hypothesis-driven (Mays & Pope, 1995). Additionally, well-designed qualitative studies in multiple countries have been shown to preserve the richness of data and simultaneously reveal country specific aspects (Moretti et al., 2011; Tong et al., 2007). The inductive nature of qualitative research allows the investigation of complex issues, such as health, and particularly offers insights into “how” health and well-being is impacted by virtue of social processes (Britten, 1995; Pope & Mays, 1995). Despite the potential of qualitative community-based research from different countries, comparative research investigating the perceived health and well-being of local communities affected by natural resource extraction projects is currently missing.

To address this gap, we aimed to explore (i) community member’s perception of the mechanisms through which their health has been affected by mining projects and (ii) to identify the implications of different extraction projects for health and well-being in Burkina Faso, Mozambique and Tanzania. To focus on the perception of affected communities, the following four research questions guided the current research: (i) how has health and well-being been impacted by mining projects? (ii) which determinants of health have played a role for the above mentioned relationship? (iii) what are the differences and similarities of perceived health impacts of mining projects in affected communities in Burkina Faso, Mozambique and Tanzania? (iv) what are site-specific implications for health and well-being in the communities surrounding different extraction projects?

3.3 Methods

This study was conducted as part of a mixed-methods and multi-country research project, aiming to promote Health Impact Assessment (HIA) practice in sub-Saharan Africa (Farnham et al., 2020; Winkler et al., 2020a). Quantitative data from existing routine health data (e.g. Demographic and Health Survey, DHS) are being used to better understand impacts of natural resource extraction projects on population health by comparing impacted and comparison sites. Qualitative data were collected in the four project partner countries (Burkina Faso, Ghana, Mozambique and Tanzania) to explore the perspectives of different stakeholders, including the voices of affected communities. The generated evidence will be used to inform a policy dialogue toward the institutionalisation of HIA.

3.3.1 Study sites

The work presented included qualitative data from nine study sites in three sub-Saharan African countries, namely Burkina Faso, Mozambique and Tanzania (**Figure 8**). Although the study was also conducted in the fourth partner country of the framing project (Ghana), data

was incomplete at the time point of the analysis and thus, not included in the current work. Characteristics of the study sites investigated are compiled in **Table 1**. Key aspects of the different countries and sites are described in the following paragraphs. In all study countries, environmental impact assessments (EIA) are required by law to obtain a mining license. Yet, specific national regulations for health impact assessment and the rigorous inclusion of health in other forms of impact assessment remain an unmet need (Dietler et al., 2020b; Winkler et al., 2013).



Figure 8: Overview of countries and study sites. Map indicating project partner countries, study sites and number of focus group discussions (FGDs) conducted.

Table 1: Characteristics of study sites. Overview of characteristics of study sites, including information about the mining projects and data collection (ICVL: International Coal Venture Private Limited).

Mining project	Operator (location of corporate office)	Resource extracted	Year opened	Type of mine	Language	Time point of data collection	Number of FGDs	Additional information
Burkina Faso								
Bissa Gold Mine	Nord Gold SE (United Kingdom)	Gold	2013	Open-pit	Mooré	May 2019	8	- Repeated terrorist attacks in the region (but not primarily related to the mine) <i>n/a</i>
Yaramoko Gold Mine	Roxgold Inc (Canada)	Gold	2016	Underground	Bwamou, Dioula, Mooré	April 2019	8	<i>n/a</i>
Houndé Gold Mine	Endeavour Mining (United Kingdom)	Gold	2017	Open-pit	Bwamou, Dioula, Mooré	March 2019	8	<i>n/a</i>
Mozambique								
Montepuez Ruby Mining	Gemfields (Mozambique)	Ruby	2011	Open-pit	Emakuwa	May 2019	9	- Province marked by insurgencies
Kenamre Titanium Mine	Kenmare Resources Plc (Ireland)	Titanium	2007 and expected start of extraction in 2020	Open-pit	Emakuwa, Ekoti	July 2019	16	- Study site comprised two mining sites (8 FGDs conducted around mining site, 16 in total) - One mining site was under construction during data collection - Mining sites located next to the coast
Moatize Coal Mine	ICVL (India) and Vale (Brazil)	Coal	2005 (ICVL) 2013 (Vale)	Open-pit	Nyungwe	September 2019, January 2020	10	- Several mines located in the same study area - Villages investigated were primarily impacted by the ICVL and Vale mine - Mine and communities located next to the Zambezi and Rovuboe rivers
Tanzania								
Bulyanhulu Gold Mine	Acacia Mining Plc (United Kingdom)	Gold	2001	Underground	Swahili	April, May 2019	8	- Reduced production (no extraction of raw material)
Buzwagi Gold Mine	Acacia Mining Plc (United Kingdom)	Gold	2009	Open-pit	Swahili	April 2019	8	- Reduced production (no extraction of raw material)
Geita Gold Mine	Anglo Gold Ashanti (South Africa)	Gold	2000	Open-pit	Swahili	March, April 2019	8	<i>n/a</i>

In Burkina Faso the study was carried out in communities around three gold mines, namely the Bissa Gold Mine, the Yaramoko Gold Mine and the Houndé Gold Mine. The Bissa Gold Mine is located in the north of the country, next to a small city and surrounded by three villages, where data was collected. The mine opened in 2013 and is an open-pit mine. Repeated terrorist attacks happened in the region, but they were not related to the mining activities. The Yaramoko Gold Mine is located in the western part of the country, between Ougadougou (capital) and Bobo-Dioulasso (second largest city). Data was collected in two neighbourhoods of the closest town that were near the mine. The mine is operational since 2016 and extracts the ore from underground. Less than 100 km away from the Yaramoko Gold Mine, one can find the Houndé Gold Mine. The open-pit mine opened in 2017. Three villages located next to the mine were selected for data collection.

In Mozambique, the following three study sites were selected for our study: the Montepuez Ruby Mining, the Kenmare Moma Mining with its two mining sites and two mining sites of the Moatize Coal Mines. All are open-pit mines, located in the northern part of the country. The Montepuez Ruby Mining is located in a region currently affected by armed insurgency. The mine opened in 2011 and is placed between four communities where data was collected. The Kenmare Moma Mining has two Titanium minerals mining sites located along the coast. The first mining site was opened in 2004 and data has been collected in the four villages closest to the mine. The second mining site has been established a few kilometres south and was under construction during the data collection. Another four villages, which were heavily impacted by the implementation of the mine, were selected for data collection. In both mines, a magnetic plant is used for processing the raw material. The complex of the Moatize Coal Mines is next to Tete, the closest city and in proximity to the Zambezi and Rovuboe rivers. In the study area, several mining pits of different commodities (e.g. gold, graphite) are operated by different companies. The 14 communities included in the study were primarily affected by coal mines operated by Vale Mozambique and International Coal Venture Private Limited (ICVL). The mining site of Vale Mozambique opened in 2005 and ICVL in 2013.

In Tanzania data was collected around three gold mines, namely, Bulyanhulu Gold Mine, Buzwagi Gold Mine and Geita Gold Mine. All three gold mines are located in the north-west of the country and not more than 100 km away from Lake Victoria. The Bulyanhulu mine opened in 2001 and was in a reduced production state at the time point of data collection, meaning that raw material was processed but not extracted. Data were collected in three communities in proximity to the Bulyanhulu mine. Near the Buzwagi mine, which is 6 km away from Kahama town, three communities were selected for our study. The mine has been operating since 2009 but was in a reduced production state at the time point of the field research. Around the Geita Gold Mine, which is next to Geita, the main city of the district, another three villages were

selected for data collection. This open-pit mine opened in the year 2000 and was fully operational at the time point of visit.

3.3.2 Terminology

Hereafter, we use the general term “community” to refer to different country-specific terminologies for the unit investigated in the field, such as villages, settlements, neighbourhoods or localities. Similarly, we use the term “health facility” in its broadest sense to refer to any locations where health care is provided and therefore embodies the different levels of health care (i.e. primary, secondary and tertiary) and country-specific terminologies (e.g. centres for health and social promotion, dispensaries, health centres, clinics or hospitals). “Perceived health impacts” refer to the changes induced by the industrial mining project on the wider determinants of health as reported by the study participants. The health determinants include a broad range of factors, including water, income generating activities and health care among others (CSDH & WHO, 2008; Marmot, 2005). “Perceived health outcomes” are reported secondary consequences for the health and well-being of affected communities caused by the changes in health determinants.

3.3.2 Ethical approval

Ethical approval for the study was received in all three countries prior to beginning the fieldwork. Hence, the study was approved by national and institutional review boards in the three countries as well as Switzerland. Namely, the study protocol was approved by the Ethics committee for health sciences (Comité d’Ethique pour la Recherche en Santé) in Burkina Faso (No. 2019-013), and Institutional Committee on Bioethics in Health at the Manhica Health Research Centre (Comité Institucional de Bioética para Saúde do Centro de Investigação em Saúde de Manhica) in Mozambique (No. CIBS-CISM/048/2018), Ifakara Health Institute Review Board (No. 32-2018) and National Institute for Medical Research (NIMR) in Tanzania (No. 2969), and the Institutional Review Board of the Swiss Tropical and Public Health Institute (Swiss TPH), the Ethics committee of Northwestern and Central Switzerland (Ethikkommission Nordwest- und Zentralschweiz, EKNZ) in Switzerland (No. 2018-00386). All study participants provided written informed consent to participate in the study and to be recorded during the FGDs. Participants were reimbursed for travel expenses or provided with snacks and refreshments in accordance to local research standards.

3.3.3 Sampling and recruitment

In each study site, the field teams from the partnering health research institute collaborated closely with local gatekeepers, including healthcare professionals and local government officers. To obtain an overview of the study site, a transect walk was conducted under the guidance of the gatekeepers. This approach allowed the research teams to identify eligible

communities in a systematic manner. Once in the selected communities and with the assistance of the respective community leaders or community health workers, FGDs were held with purposively sampled community members. In order to generate comparative data from the different settings and countries, two to four sessions were planned with 6 -10 participants per session. People above 18 years and knowledgeable about the community and its dynamic were invited to take part in gender-separated sessions.

3.3.4 Data collection

Data were collected from March 2019 (first FGD in Burkina Faso) until January 2020 (last FGD in Mozambique). With the help of a project specific data collection manual, the same participatory data collection tool was administered in all study sites. The tool guide was translated from English to official languages (i.e. French in Burkina Faso, Swahili in Tanzania and Portuguese in Mozambique) by the local researchers involved in the same project, who were, thus, knowledgeable about the purpose of the research and the site's context. The core of the discussion was the participatory listing of perceived impacts on the wider determinants of health, followed by a categorization and ranking to further stimulate discussion. An example of the outcome is given as supplementary file (see S1 Fig). All FGDs were conducted in local languages (Bwamou, Dioula and Mooré in Burkina Faso; Emakuwa and Nyungwe in Mozambique; Swahili in Tanzania), moderated by trained research assistants, and held in central places of the community (e.g. community offices, schools, guesthouses). An additional observer from the field team assisted the moderator during the sessions. The sessions were audio-recorded and lasted on average 81 minutes (Burkina Faso: 90 minutes; Mozambique: 68 minutes; Tanzania: 91 minutes). Demographic background information of all participants were registered in standardised forms prior to each discussion. All fieldwork activities were coordinated and supervised by PhD candidates involved in the research project. Occasionally, these activities were overseen by their local supervisors. Regular exchange among PhD students in the field ensured consistency across the countries.

3.3.5 Data management and analysis

All FGDs were transcribed by research assistants into official languages (i.e. French, English, and Portuguese) of the three countries. All of them were reviewed for quality control by local researchers involved in the project (Poland, 2016).

To explore the community members' perception of the mechanisms through which their health is affected by mining projects and identify unique aspects of study countries and settings, a thematic analysis was conducted. Multiple authors were involved in the analytical process. The coding was mainly done by HC, OC and AL, using Nvivo (Nvivo 12 Pro, QSR International), and closely supervised by a senior social behavioural scientist (KM). The

analysis began with repeated review of a few transcripts to develop a code system. After coding together a first transcript, coding for another transcript was done individually, followed by a discussion. The coding system was based on predefined categories informed by the data collection tool as well as themes emerging from the data. Rooted in the concept of the wider determinants of health, perceived impacts were categorised into (i) environmental aspects, (ii) economic aspects and (iii) aspects of the social services and organisation. Emerging sub-codes were added during the analysis (see S2 Table). While analysing transcripts from the different countries in parallel, the coding system became static when about one third of all the data was coded. During the entire coding process, the researchers collaborated closely and discussed unclassified segments, most interesting findings and tentative interpretation on a regular basis. The interpretative examination during the regular discussion meetings enabled the international research team to reveal similarities but also differences across the countries and settings, as well as scrutinise the pathway of perceived impacts on health and the interconnection between different impacts. A separate code for cases that were unclear was used in case of doubt and to ensure interrater-reliability. Additionally, illustrative quotations were captured in a separate code. The findings were visualized based on the coding queries administered in the qualitative data analysis software (NVivo).

3.4 Results

3.4.1 Study population

An overview of the socio-demographic background of study participants per country is given in **Table 2**. In total, 791 community members (406 women, 385 men) participated in our study, with an average of 9 community members per FGD. In Burkina Faso and Tanzania, 8 FGDs were conducted in each of the three study sites (24 FGDs per country in total), while in Mozambique 8-16 were conducted in each of its three sites (35 FGDs in total; see **Figure 8**). Participants were aged between 18 and 89 years, and on average 42 years old, while they had lived on average for 20 years in their community. Participants attended on average less than four years of formal education and were mainly active in the agricultural sector. Only few participants reported to be employed by the mining companies ($n = 13$). In all mining sites, artisanal mining or the search for abandoned coal mining pits was reported during the FGDs as common income generating activity for local communities.

Table 2: Study participants. Number of focus group discussion (FGD) study participants and their socio-demographic characteristics by country and in total).

	Burkina Faso (24 FGDs)	Mozambique (35 FGDs)	Tanzania (24 FGDs)	Total (83 FGDs)
Number of participants				
Men	115 (49.8%)	181 (48.0%)	89 (48.6%)	385 (48.7%)
Women	116 (50.2%)	196 (52.0%)	94 (51.4%)	406 (51.3%)
Total	231	377	183	791
Average number (and range) of participants per FGD				
Men	9.6 (6-10)	10.6 (6-12)	7.6 (6-8)	9 (6-12)
Women	9.6 (7-10)	10.8 (8-13)	7.8 (6-10)	9.2 (6-13)
Total	9.6 (6-10)	10.7 (6-13)	7.6 (6-10)	9.1 (6-13)
Average age (and age range) in years				
Men	42.0 (23-71)	44.9 (19-89)	47.6 (19-77)	44.7 (19-89)
Women	30.8 (18-49)	43.8 (29-83)	41.5 (20-77)	39.4 (18-83)
Total	36.7 (18-71)	44.4 (19-89)	44.5 (19-77)	42.0 (18-89)
Average years (and range) living in the community				
Men	26.2 (3-67)	36.9 (3-89)	22.1 (2-66)	30.3 (2-89)
Women	13.2 (1-44)	36.4 (1-83)	18.9 (1-77)	25.4 (1-83)
Total	19.7 (1-67)	36.7 (1-89)	20.5 (1-77)	27.8 (1-89)
Average number (and range) of years of school attended				
Men	2.7 ^a (0-10)	3.8 (0-12)	7.4 (0-14)	4.4 (0-14)
Women	1.2 ^a (0-10)	1.4 (0-12)	7.3 (0-14)	2.9 (0-14)
Total	1.9^a (0-10)	2.6 (0-12)	7.4 (0-14)	3.6 (0-14)

^a Data from 2 FGDs with men and 2 FGDs with women missing (totally from 4 FGDs missing)

3.4.2 Perceived health impacts and related health outcomes

In all three countries, a wide diversity of perceived impacts of the industrial mines on wider determinants of health were revealed during the FGDs. Codes about the various impacts and a description of the themes that emerged, complemented with indicative quotations, are compiled and added as supplementary material (see S2 Table). Perceived changes in health status, resulting from changes in health determinants, emerged as secondary effects that can be clustered in three overarching themes, namely: (i) morbidity (including diseases, disabilities and injuries), (ii) mortality and (iii) well-being. Exemplary quotations for these different themes are compiled in

Table 3: Exemplary quotations of coded health outcomes. Overview of selected quotations of positive and negative health outcomes, categorized by morbidity, mortality, well-being as of the coding system (quotations in the original languages can be found in the supplementary file S3 Table).

	Positive	Negative
Morbidity		
Diseases	<ul style="list-style-type: none"> - We put the soap next to the toilet so that one can wash the hand after defecation in order to avoid the diseases (BF2_L2) - We appreciate the bed net they gave us because it reduces the mosquito bites a little (MZ2.2_L1) - We acknowledge because we can go to the hospital [...] to receive medicines from [the company], they give it and we take it (MZ2.2_L7) - Now due to the presence of a dispensary children are taken there for testing and if they diagnosed with malaria they are given medicines (TZ3_L2) - There is testing of HIV frequently in our community (TZ2_L3) 	<ul style="list-style-type: none"> - Since the implementation of the mine we are falling sick (BF2_L7) - The company causes many diseases (MZ2.2_L1) - We were using unprotected wells, they had no much effect but after the mining [...], now there are many diseases and we think it is caused by water (TZ2_L7) - Dust is produced when they are grinding stones and this dust is spreading to the community where people are living. As a result people are getting cough (TZ2_L3) - Also there is an increase of HIV transmission because many people from different regions came to work in the mining (TZ2_L1)
Accidents and injuries	n/a	<ul style="list-style-type: none"> - The traffic accidents, which we encounter as part of vehicles and their trucks (BF1_L4) - [A car] from the Kenmare company almost hit me (MZ2.1_1) - If adult caught for stealing Magwangala [ore in the mine] are beaten so badly because you are matured enough to know what you are doing is wrong (TZ3_L7)
Disabilities	<ul style="list-style-type: none"> - We have good cooperation with the NREP [natural resource extraction project] we are allowed to employ this woman who is a cripple (TZ1_L6) - The mining sponsors for medical treatment for children who have midomo ya sungura [open-cleft] (TZ3_L3) 	<ul style="list-style-type: none"> - (the came to search everything with their machines causing quiet geniuses starting to mix with humans this caused that certain women gave birth to weird children (BF1_L3) - These diseases now are full and it is different from the past, the topic of «rheumatism» is created because of the dust (MZ2.1_L2) - I was working in the mining but later they discovered that I have sight problem (TZ1_L3)

Mortality

- We appreciate the mosquito nets that they gave us [...], without these **nets**, nobody would survive here in the community (MZ2.2_L11)
 - We were travelling long distance to **get health services** so it was costful also we losted our beloved ones a mother or child because of delivering on the way to the health facility and some women decided to deliver at home because they couldn't afford the cost to go to the health center all these led to maternal deaths in our community but now situation has been improved (TZ1_L2)
 - Those who are suffering from the risk to die in their houses because they don't have anything to eat anymore (BF1_L2)
 - Since the mine has come, honestly there is no health anymore and the people **are not living long** anymore) (BF3_L1)
 - There are many diseases that **kill us** (MZ2.2_L2)
 - Those who have the courage to go in the bush [for artisanal mining], even if **they can be killed** because they try to dig (MZ3_L7)
 - When the houses have cracks the vibrations may cause the house to fall down and **you will all die** in there (TZ3_L3)
 - Going to steal remaining of the processed stones called "magwangala", so **the security guard kills them** for self-defence (TZ3_L1)
 - The use of unsafe water is what causes **miscarriage** (TZ2_L2)
 - If you consider all these factors the answer is people from [our village] are **the living dead** (they are expecting to die) because they are using things which are not safe (TZ3_L7)
-

Well-being

- The people can look after their children compared to before, because some parents who are working in the mine (BF3_L5)
- Drilled well has improved **healthy** because water is safe (TZ1_L6)
- The ENREP [natural resource extraction project] has constructed school, classrooms and toilets which has improved our **well-being** (TZ2_L5)
- So when mining built this health center here we **feel good**, we get treatment near our homes and we don't waste transport fee as we used to do before (TZ2_L7)
- We **don't have a good quality of life** anymore, it is not easy to live permanently «under the dust» (BF2_L8)
- There is no water, no jobs, it is the **misery** (BF1_L2)
- When they are blasting, we are **frightened** any moment (BF1_L4)
- We eat badly, **we don't sleep comfortably**, our farms have reduced to 50 meters and the rest are for these white people (MZ2.2_L3)
- People are currently living with **fear** because boundaries between the community and mining are not clear (TZ1_L5)
- We **do not trust** the water that we use (TZ1_L5)
- We are in a very **difficult situation** because the poisons they using are dangerous (TZ3_L4)
- We have been **weak** due to lack of money from mining jobs (TZ2_L2)

(quotations in the original languages are given in supplementary file S3 Table). An overview of the distribution of perceived positive and negative impacts and related health outcomes are shown in **Figure 9**. **Figure 10** indicates the proportion of FGDs having discussed the different topics of impacts, stratified by countries and type of resource extracted. In the following sections, we describe participants' perceptions of different impacts on the wider determinants of health and related implications for their health and well-being, including country-specific examples.

Table 3: Exemplary quotations of coded health outcomes. Overview of selected quotations of positive and negative health outcomes, categorized by morbidity, mortality, well-being as of the coding system (quotations in the original languages can be found in the supplementary file S3 Table).

	Positive	Negative
Morbidity		
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Accidents and injuries	n/a	<ul style="list-style-type: none"> - The traffic accidents, which we encounter as part of vehicles and their trucks (BF1_L4) - [A car] from the Kenmare company almost hit me (MZ2.1_1) - If adult caught for stealing Magwangala [ore in the mine] are beaten so badly because you are matured enough to know what you are doing is wrong (TZ3_L7)
Disabilities	<ul style="list-style-type: none"> - We have good cooperation with the NREP [natural resource extraction project] we are allowed to employ this woman who is a cripple (TZ1_L6) - The mining sponsors for medical treatment for children who have midomo ya sungura [open-cleft] (TZ3_L3) 	<ul style="list-style-type: none"> - (the came to search everything with their machines causing quiet geniuses starting to mix with humans this caused that certain women gave birth to weird children (BF1_L3) - These diseases now are full and it is different from the past, the topic of «rheumatism» is created because of the dust (MZ2.1_L2) - I was working in the mining but later they discovered that I have sight problem (TZ1_L3)

Mortality

- We appreciate the mosquito nets that they gave us [...], without these **nets**, nobody would survive here in the community (MZ2.2_L11)
 - We were travelling long distance to **get health services** so it was costful also we losted our beloved ones a mother or child because of delivering on the way to the health facility and some women decided to deliver at home because they couldn't afford the cost to go to the health center all these led to maternal deaths in our community but now situation has been improved (TZ1_L2)
 - Those who are suffering from the risk to die in their houses because they don't have anything to eat anymore (BF1_L2)
 - Since the mine has come, honestly there is no health anymore and the people **are not living long** anymore) (BF3_L1)
 - There are many diseases that **kill us** (MZ2.2_L2)
 - Those who have the courage to go in the bush [for artisanal mining], even if **they can be killed** because they try to dig (MZ3_L7)
 - When the houses have cracks the vibrations may cause the house to fall down and **you will all die** in there (TZ3_L3)
 - Going to steal remaining of the processed stones called "magwangala", so **the security guard kills them** for self-defence (TZ3_L1)
 - The use of unsafe water is what causes **miscarriage** (TZ2_L2)
 - If you consider all these factors the answer is people from [our village] are **the living dead** (they are expecting to die) because they are using things which are not safe (TZ3_L7)
-

Well-being

- The people can look after their children compared to before, because some parents who are working in the mine (BF3_L5)
- Drilled well has improved **healthy** because water is safe (TZ1_L6)
- The ENREP [natural resource extraction project] has constructed school, classrooms and toilets which has improved our **well-being** (TZ2_L5)
- So when mining built this health center here we **feel good**, we get treatment near our homes and we don't waste transport fee as we used to do before (TZ2_L7)
- We **don't have a good quality of life** anymore, it is not easy to live permanently «under the dust» (BF2_L8)
- There is no water, no jobs, it is the **misery** (BF1_L2)
- When they are blasting, we are **frightened** any moment (BF1_L4)
- We eat badly, **we don't sleep comfortably**, our farms have reduced to 50 meters and the rest are for these white people (MZ2.2_L3)
- People are currently living with **fear** because boundaries between the community and mining are not clear (TZ1_L5)
- We **do not trust** the water that we use (TZ1_L5)
- We are in a very **difficult situation** because the poisons they using are dangerous (TZ3_L4)
- We have been **weak** due to lack of money from mining jobs (TZ2_L2)

	Positive health outcomes			Negative health outcomes		
	Morbidity	Mortality	Well-being	Morbidity	Mortality	Well-being
Environmental						
Water (quality and availability)	1	0	1	120	17	71
Air quality	1	0	0	114	16	61
Housing and living environment	3	0	1	39	11	80
Soil and land	1	0	0	27	6	49
Sanitation	3	0	0	33	5	24
Economic						
Income generating activities	1	0	3	33	11	54
Working conditions and job opportunities	2	0	12	20	1	32
Unemployment	1	0	0	10	4	37
Living costs	0	0	0	34	6	42
Poverty	0	0	0	16	6	21
Compensation	0	0	0	16	3	14
Economic benefits	0	0	4	4	1	12
Social services and organization						
Health care	10	2	8	129	38	66
Culture and community dynamics	1	0	2	97	31	81
Schooling	2	0	3	14	3	29

Figure 9: Qualitative matrix of perceived impacts and health outcomes. Distribution of perceived positive (green) and negative (red) impacts on the wider determinants of health and related health outcomes; colour gradient indicates coding frequency, numbers indicate coded references.

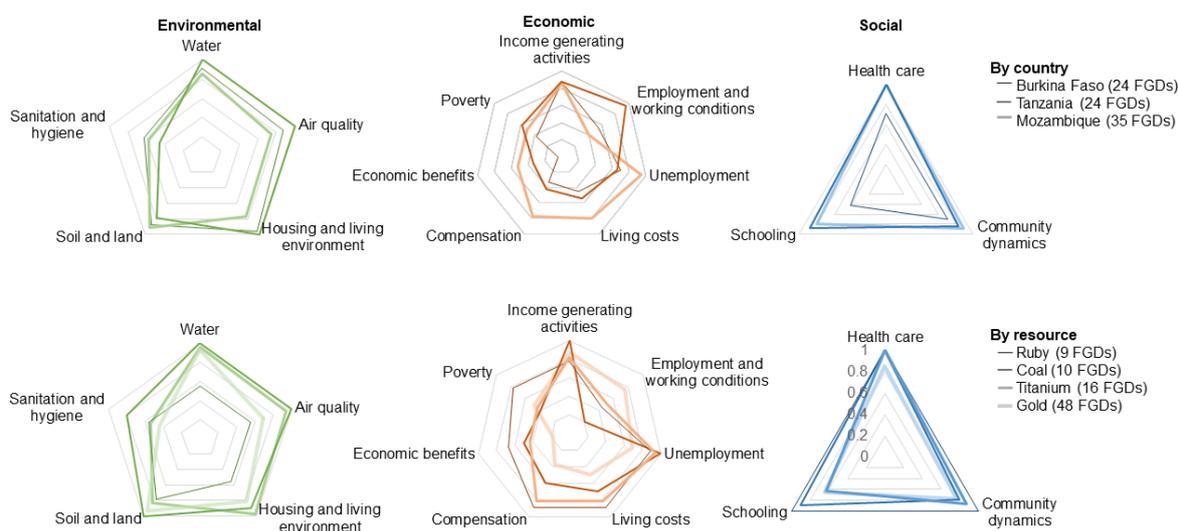


Figure 10: Consistency of findings across countries and settings. Radar graphs indicating proportion of focus group discussions (FGDs) where the different topics of environmental, economic and social aspects were discussed (0 not mentioned in any FGD, 1 mentioned in all FGDs).

3.4.3 Perceived health impacts related to health determinants

Environmental determinants

With regards to environmental determinants of health, participants reported impacts related to water, air, housing and living environment, soil and land (incl. agriculture) and sanitation and hygiene.

Most prominently, participants reported water quality and availability of reliable water sources. Community members complained about pollution of different water bodies by the chemicals used in the mine as well as completely dried up wells due to the increased water demand related to the mining activities. Around gold and coal mines, they also perceived that the rain water is polluted with particles or chemicals coming from the mine, which were washed

from the roof in their water collection system. Several communities around gold mines in Tanzania reported water flowing from the mine to water sources, be it during normal circumstances or in the case of a tailing dam bursting:

Here is a dam for keeping dirty water containing chemicals. Something happened and water flowed to outside the mining and contaminated water in a pond near the mining then flowed to the rice farms. People who were planting rice got skin infection and animals died because of drinking the contaminated water TZ1_L2

Linked with the contamination and scarcity of water, participants from all countries reported different water-borne diseases as well as skin rashes after being exposed. They revealed an increase in malformations in newborns or miscarriages, which they linked to chemicals in the water. On the other hand, in almost all study sites participants felt relieved by interventions upgrading the water infrastructure. Many new water pumps or taps were installed by the mining companies. According to the participants, the availability of water contributed to their health and well-being.

Secondly, different types of air pollution were described during the FGDs. Most importantly, respondents referred to dust coming from the mine and polluting the environment. Of note, heavy dust emissions were particularly reported around gold and coal mines where mining-related blasting (explosions) were common. Around gold mines dust was described to contain chemicals or “particles”, which potentially cause toxic effects, such as changing the colour of the water. According to participants, dust from coal mines was black and thick layers stacked on surfaces inside and outside the houses. Another source of dust was along the roads where heavy mining trucks pass, which was particularly perceived in sites with unpaved main access roads. In one study site in Tanzania, participants recognised that mining companies treated the main access roads occasionally to reduce the dust load, by watering the road for instance. According to participants from all countries, dust was a major issue deterring the maintenance of hygienic conditions, causing respiratory diseases and to a lesser extent also eye infections. While some of the diseases mentioned were recognised as not being new per se, respondents asserted increasing numbers of disease cases. Furthermore, a shift to increased chronic disease since the implementation of the mine was reported.

The whole population is suffering from cold and chronic cough. Before the [opening of the] mine toward the end of February, there was no cough and no cold. But since the mine has come these respiratory affection continue until winter. We can see the layer of dust after the

blasting rising and falling on the houses, in this regard we can confirm that we are all potentially sick. BF2_L8

Bad smell was reported mostly from communities next to gold mines and was further associated with cases of fainting of students. In settings of coal, titanium and ruby extraction, dust from the mine and bad smell were mentioned considerably less often. Participants from one study site in Tanzania reported the existence of educational programs about the hazards of the bad smell and toxins around the mine, but actual health impacts were often poorly understood. Taken together, although when there were few mitigation measures in place, perceived negative health impacts associated with air pollution clearly prevailed, especially around industrial gold mines.

Themes related to people's housing and living environment were the third most important as measured by coding frequency. Participants around gold and coal mines were especially concerned about the effects related to the blasting in the mine, which caused cracks in their houses, frightening vibrations and loud noise, illustrated as follows:

They hear the boom duuumh, tikitikitiki (the tremor due to the explosions of the mines) ... And it explodes a lot, then people are scared and this causes heart problems, it provokes [affects] the heart [even] more, so we say that our health is not good. MZ1_L7

They further expressed fear of death when cracked houses collapse while families are sleeping inside. Participants in Tanzania noticed less noise when the mine was operating underground, while they were still afraid of the vibrations and cracks in the houses. Respondents from all countries perceived the increase in traffic to and away from the mine as cause of higher risk for accidents, particularly for children who are playing in the streets. However, new or improved roads were helpful for their mobility and particularly needed to access health care, as they reported.

In all countries, resettlement was a recurrent and closely interrelated theme. Some communities were hoping for resettlement to be further away from the mine and to receive compensation payment. In contrast, others felt deceived after being resettled, as the compensation was inadequate (e.g. not enough money, barren land). In Mozambique, several houses of a community were located within the mining concession and reported to be burned before the resettlement took place. Overall, these different threats, fears or insecurity affected participants' well-being, which was sometimes associated with the risk of death.

The topic of soil and land was diverse in itself and three distinct aspects were revealed. The main concerns of participants were related to decreased conditions for agriculture. They

described several reasons, including the land taken or their resettlement, reduced accessibility or availability of their land, as well as soil pollution and less rainfall, which they all linked to the mining project and their activities respectively. Related to agriculture, reduced availability and poor quality of food was also mentioned. According to reports from participants, this caused hunger along with perceived stresses to provide food for their families. On the other hand, in Burkina Faso and in one study site in Tanzania, participants reported alternative farming methods (“*zaï*” in Burkina), which were introduced by mining-related companies in the case of Tanzania.

Besides agriculture, pastoralism and fishing were also impacted in similar ways. Grassland for herding became scarce with the implementation of the mine and in one study site in Mozambique access to water for fishing was restricted by the mines, as participants asserted. In one study site in Tanzania, where the “*mining dam*” (as participants referred to the tailing dam) broke, participants were upset because of the deaths of animals. According to them, the dam with the drinking water for cows was heavily polluted after the burst of the “*mining dam*”, causing them to die. Thirdly, deforestation (“*cutting of forests*” in the words of the participants) was a recurrent theme among all countries and sites. Consequently, communities also lost their source of firewood for cooking as well as traditional medicinal plants, as they reported. In Burkina Faso, women struggled to collect and produce shea butter (“*beurre de karité*”), which was perceived as a particular loss, as it is not only an important ingredient of local dishes but also used for personal hygiene and businesses.

The last themes that emerged in the category of environmental impacts were related to sanitation and hygiene. Communities reported open-defecation along the mining fence, because there were no toilets installed for security guards. Inappropriate waste management was another concern. Particularly in Burkina Faso, maintaining hygienic conditions was perceived as a major challenge and often reported in relation to people’s and children’s health and well-being:

It is true, we were not in perfect health before, but the problems brought by the mines made it worse. We could make efforts for the hygiene, the drinking water, our food, but with our new neighbour this is no longer possible, we cannot maintain good health. Otherwise among us, we could work together to maintain our hygiene. BF2_L7

On the other hand, they appreciated interventions to improve the infrastructure such as new toilets or the donation of potties or kettles donated.

Taken together, discussion around environmental impacts was heavily negative and linked with different diseases, while improved water and road infrastructures were perceived as relief for the communities and their health.

Economic determinants

The discussion around economic aspects was very dynamic and the different themes that emerged were related to participants' income. Most prominently, participants reported about the impact on their traditional income generating activities, such as farming and artisanal mining. Despite having undergone reallocation, people across several communities felt that their land for agriculture or areas for artisanal mining was taken by the mine, which forced them to stop these activities, or for the latter one, continue it illegally. In two study sites in Mozambique, similar issues were also reported related to fishing, where access to the ocean was restricted for local inhabitants after the mine became operational.

On the other hand, the mines provided new job opportunities. Mostly, participants reported unskilled labour work positions, such as construction workers and security guards. Opportunities inside the mine (e.g. gardeners) were also mentioned during the discussions. However, these opportunities were reported to be very limited and related to harsh working conditions and adverse health outcomes, such as back pain and loss of sight after having worked in the mine as reported by participants from Tanzania. In Burkina Faso, announced job opportunities turned out to be empty promises. While seeking employment and regular income and, thus, being able to provide the basic needs for the family, participants were frustrated about the unfair employment conditions, harsh working conditions and social insecurity.

I was working in the mining but later they discovered that I have sight problem and I was advised on what to do also investor was supposed to take care of me but at the end of the day he failed to do so. TZ1_L3

During the FGDs, unemployment was reported as a particular challenge in all countries. Therefore, they reported about their sometimes life-threatening attempts to collect stones (i.e. ore or gemstones) from the tailings of the mine for their own benefit or stealing other materials in the mine. Another strategy to generate income were sexual transactions, which were also linked to severe health consequences, including HIV. While this was reported in Mozambique and Tanzania, participants in Burkina Faso did not report on this topic. However, personal discussions of researchers and gatekeepers involved in the study indicated the same trend in Burkina Faso. Although it might particularly affect women, it is very likely that as married housewives, they did not feel comfortable talking about it.

In Mozambique and Tanzania, economic dynamics were also linked to the compensation payment of the land, when communities were resettled. However, most participants were not satisfied with this compensation or perceived it as insufficient and not adequate for what they had lost. In both countries it was reported that the received money was spent irresponsibly by men for personal amusement. Rising living costs were perceived as a challenge, especially for basic goods such as food or clean water. Particularly linked to most of the participants' poor economic situation, these impacts were related with poor health and well-being, described as stress, fatigue or weakness. Further, respondents were also concerned about not being able to afford health care, including testing and treating febrile illnesses or diarrheal diseases.

In few cases in Tanzania and Mozambique, participants also reported economic benefits for their community. For example in one study site in Tanzania, a certain share of the salaries of local security guards working for the mine were allocated for community development projects. Hence, participants felt relieved as they didn't have to contribute to the community fund. Similarly in Mozambique, participants acknowledged in-kind contribution from or interventions sponsored by the mine, as this allowed them to spend their money for personal needs, such as food and health care.

In sum, the overarching topic of having, generating or seeking income is a highly dynamic topic for communities living around industrial mines, particularly linked to the changes in local livelihoods. Although short windows of opportunities were linked to the mine, being able to afford basic needs for their health and well-being was a major concern and not always guaranteed.

Social services and social organisation

Perceived impacts on social services and social organisation embraced the following three heading themes: health care, community dynamics (including cultural aspects) and schooling.

In all study sites, except for one in Mozambique, interventions in the health sector sponsored by the mine led to a positive appraisal by community members. Participants mentioned different interventions, including the construction of new health care facilities, upgrading existing infrastructure, equipment and materials in health care facilities, implementation of mobile clinics or ambulance transportation, HIV testing and counselling, as well as treatment of other specific diseases. For instance, in Tanzania participants also acknowledged the support of the mines for open-cleft treatment for affected children. Despite these positively perceived health care interventions, a few participants also complained about long waiting hours and lack of services in health facilities. Further, they claimed that they had

to seek health care more often due to the increased burden of disease and the loss of traditional medicinal plants.

During analysis, positive and negative issues related to internal community dynamics emerged. During the FGDs, the introduction of the mine was associated with in-migration, which they linked to increased spread of HIV as well as HIV-related mortality. While participants from Mozambique had the same perception, they specifically stated that local people get infected when interacting with “white people”:

If we were among us there in the mine and not a foreigners, we would not say that it is full of diseases [...] now we are mixed up with each other's disease so diseases are growing more [...]. Now these people from outside who come with their diseases come here and contaminate us without knowing, the reason why the diseases are increasing more and more. MZ3_L9

Linked to these community dynamics, participants from all study sites perceived decreased cohesion of their family or community. For instance, young people left their family for education outside the village and men left their family with their freshly earned money or to seek other job opportunities. These dynamics were further linked to mistrust among community members. More extremely, community members felt less safe due to increased crimes among community members. For instance, a few stories of stealing were told during the FGDs. Beyond these community internal conflicts participants from one site in Mozambique anticipated the ongoing conflicts due to the natural resources. Hence, personal safety and security were particular concerns of participants, which they asserted by an increased number of deaths.

Regarding socio-cultural aspects, different spiritual conceptions and associated rituals came up during the discussions in the different countries. In Burkina Faso, different problems were linked to intrusion of mythic creatures (“*les génies et les démons*”) after the implementation of the mine. Participants believed that these creatures bring bad luck and causing malformations in new-borns or even miscarriages, as illustrated in the following quotation:

Before the mine was implemented, we had about two miscarriages per year. Nowadays, within one year we can register 20 cases of miscarriage. Women give birth to babies with malformations and we have the impression that these are geniuses and demons from the extractions, who are possessing the people and mainly the women BF1_L1

Further, participants were worried about the future of their children. According to them, they will not have land any more, which is a traditional gift for a marriage and in turn links the current and future generations to their ancestry. Similarly to this concept reported in Burkina Faso, participants in Mozambique were not satisfied after being resettled. They were concerned about both losing the ties with the land where their ancestors were originally buried and having to bury their relatives in a new location, as “home” is where one’s ancestors were born and buried. Described as concerns, worries, fear or stress during the FGDs, these changes particularly affected participant’s well-being.

More positively, participants appreciated the support for local associations, interest groups or community based organisations. In Tanzania, for example, local vegetable farmers were established and beekeepers received financial support from the mine.

Another ambiguous determinant discussed, was related to education. The new construction or upgraded infrastructure in and around schools by the mining companies has contributed to improved education quality and student’s attendance according to participants from all countries. On the other hand, early dropouts from school were mentioned to happen more frequently in relation to the mines in Tanzania. Participants described that this particularly affects girls when they get pregnant (from their relationships with workers from the mine). Interestingly, the topic of education was considerably less discussed in Burkina Faso, while it was mentioned in almost all discussions in Tanzania and Mozambique.

In sum, interventions to improve social services such as health care and education were common across the different settings, having potential to improve community health. On the other hand, impacts on the communities’ social organisations were perceived negatively for the well-being of local populations, including various country-specific cultural aspects.

Interlinkages between health determinants and health outcomes

While perceived impacts are reported above in distinct categories and sub-categories of the determinants of health, many impacts were closely interlinked within a specific category (e.g. water and air within the environmental determinants) or between categories (e.g. resettlement linked to environmental, social and economic determinants) as reported in this chapter.

Within the category of environmental impacts, air and water pollution were interlinked. For example, participants described the blasting as cause for air and rain water pollution at the same time. More specifically, they said that the dust released during blasting is transported through the air to their houses and then washed by the rain from the roofs directly into their water collection systems:

Dust from the mining comes to the community and sticks to the roof of our houses, so we are not using rainy water because of the chemical carried with dust which has stacked on the roof of our houses. Despite of the contamination some people are using rainy water but they are getting health effect. TZ2_L3

Different changes induced by the mine had intersecting implications regarding the wider determinants of health. Resettlement was linked with several changes, as reported by the participants: they lost their land for agriculture (environmental impact), received compensation payment (economic impact), had to incur household goods (economic impact) or did not feel home at the new place (social impact), which ultimately affected their health and well-being. Another example is the insecure household income: due to decreased agricultural land and restrictions in the areas for artisanal mining or fishing (environmental impact), community members are hoping for employment in the mine (economic impact), while thefts and sexual transactions increased (social impact). Another example related to in-migration is illustrated as follows:

Native youth who were doing small mining activities in that area were enforced to shift to other distant mining areas where they can continue to conduct small mining activities. This movement caused family separation because they didn't move out with their families and as human being they will start new relationship in that area and this will accelerate to transmission of diseases meaning that if he could have been living here he wouldn't have established new relationship. But living in another community for like one year without coming back home to his wife and children it is a problem and may be when they meet one of them is already infected. I am talking about diseases like HIV because of conducting unprotected sex. TZ2_L4

In light of this, only few diseases mentioned were linked to a single, specific cause. Mostly, health outcomes tended to be determined by a combination of factors, acting on different levels and changes induced by the mining project.

3.5 Discussion

Overall, impacts of mining projects on the wider determinants of health and related health outcomes were perceived similarly by affected communities in mining areas across the study countries. An increased burden or spread of diseases was mostly related to environmental pollution and social dynamics caused by the mining operations. Elevated mortality rate was related to accidents, crimes but also to HIV and chemical exposures. With the implementation

of the industrial mines, participants' perceived well-being decreased particularly through housing insecurity and changes in livelihoods. Although limited, perceived positive impacts on health and well-being were linked to upgraded infrastructure and social services such as water access points, roads, schools and health facilities, which were constructed or financially supported by the mining companies. Both positive and negative changes related to the mining projects were mostly linked to multiple determinants, and thus, closely inter-related to each other.

3.5.1 Differences across countries and mining settings

Besides similarities, we observed differences of perceived health impacts due to the extracting and processing methods of resources as well as the current stage of project life cycle. For instance, gold mining caused severe environmental health impacts due to the explosive blasting and toxic chemicals used for the extraction and processing. Heavy dust emissions were also reported around coal mines. Chemicals were less discussed around titanium, ruby and coal mines, where the extraction and processing are mostly physical. However, various perceived environmental, social and economic impacts and related health implications were not only linked to extraction activities per se. As suggested by our results, which also include data from one mining site under construction, the project implementation at large has implications for the health of surrounding communities by changes on the wider determinants. Overall, these perceived indirect health effects are also exemplified in several studies in the wider context of natural resource extraction, like poverty (Gamun et al., 2015), export activities and HIV (Oster, 2012), health impacts of resettlement (Dietler et al., 2020a), nightlight and security (Mamo et al., 2019) – to name a few.

Country specific aspects were primarily related to cultural beliefs and practices such as myths, rituals and traditions. Although less evident in our data, differences might also be linked to the role of the government and national regulations or laws related to the mining industry. For instance, different compensation mechanisms (e.g. providing job opportunities in Burkina Faso versus compensation payment in cash in Tanzania and Mozambique) indicated different national regulations on the local level (Owen et al., 2019). In Tanzania, new legislative measures have been introduced in 2017, aiming to maximise the countries benefits through a “new resource nationalism”, which promotes community development through mandatory investments by the mining companies (Jacob & Pedersen, 2018).

3.5.2 Complexity of health revealed through communities' perspective

Based on communities' perception, our study revealed various ways in which the health and well-being of local populations living and working in mining regions can be impacted. The current study provides particular insights into the complex interplay of determinants of health

and health outcomes as perceived by affected communities. For instance, our findings indicate health effects linked to the environmental pollution through the mine, which further induces a shift from crop to cash based economy. Ultimately, this can lead to food insecurity as well as deprived and socially disrupted communities, with poor health conditions. Our results further show that, despite several interventions implemented by the mine, perceived negative impacts on communities' health and well-being prevailed. Drawing on this comprehensive understanding of health retrieved from affected communities expands the existing quantitative literature pertained to health risk, health determinants or health outcomes of interest. Indeed, recurrent thematic aspects reported in our study have been studied in previous research, including environmental (Antabe et al., 2017; Porgo & Gokyay, 2017), social (Berman et al., 2017; Cronjé et al., 2013) or economic (Benshaul-Tolonena et al., 2019; Gamu et al., 2015; Von der Goltz & Barnwal, 2019) determinants of health. While several studies report potential health benefits (Anaf et al., 2019; Benshaul-Tolonena et al., 2019), negative aspects tend to prevail in studies synthesising health literature (Carney & Gushulak, 2016; Cronjé et al., 2013; Schrecker et al., 2018), which is in line with our findings. Similarly, a recent study have reported a positive trend of water infrastructure in mining regions but health benefits were less evident (Dietler et al., 2021).

Studies measuring health conditions of local communities (e.g. Akpalu & Normanyo, 2017; Anaf et al., 2019; Benshaul-Tolonena et al., 2019) might have missed important aspects for the health and well-being as perceived by affected populations themselves. For example, health effects caused by cracks in the houses related to blasting and cultural dimensions of health have to our best knowledge received little attention. All these dimensions, alongside broad social engagement, need to be carefully incorporated when assessing health impacts, particularly in the dynamic setting of industrial mining projects (Buse & Hawkes, 2015; Schrecker et al., 2018; Winkler et al., 2020a). A seminal study pertained to community health in mining regions monitored the health status of population in vicinity of a copper mine over time (Knoblauch et al., 2020). The researchers reported improvement of certain health conditions in mining communities compared to control groups, including reduced risk for malaria and less parasitic infections in children. However, this study result from a rather exceptional collaboration between the academic, health and extractive sector, which may serve as a best practice example for protecting and promoting community health in mining settings. Nonetheless, the promising findings from the comprehensive biomonitoring are in contrast with the perception of the community member participated in our study. This dissonance of quantitative measurement and observed perceptions underlines a clear need for improved management of health impacts by acting on the wider determinants of health.

3.5.3 Incorporating community perceptions in impact assessment

To address this need and prioritise community health in settings of industrial mining, there are several tools to mitigate risks and maximise benefits. For instance, impact assessment is a systematic approach to support decision-making prior project development. Impact assessment can be required by national regulations or as part of international standards or guiding principles of international organisations such as the International Finance Cooperation (IFC) or the Equator Principles (Winkler et al., 2013). At present, different types of impact assessment exist, including environmental, social, health or gender impact assessment (EIA, SIA, HIA and GIA, respectively) as well as integrated approaches, such as environmental, social and health impact assessment (ESHIA) (Esteves et al., 2012; Harris-Roxas et al., 2012; Hill et al., 2017; Morgan, 2012). HIA as stand-alone approach or integrated in other forms of impact assessment was endorsed by WHO in 1999 as holding particular promise in addressing health and its wider determinants, given its comprehensive understanding of health (Leuenberger et al., 2019; WHO European Centre for Health Policy, 1999; Winkler et al., 2020; Winkler et al., 2021). Additionally, democracy is a core value of HIA emphasising “the right of people to participate in the formulation and decision of proposals that affect their life” (Quigley et al., 2006). Placing local communities at centre and proactive inclusion of marginalised population during impact assessment may improve impact assessment by contributing context specific knowledge, which is needed for identifying and addressing communities’ needs appropriately (Den Broeder et al., 2017; O’Faircheallaigh, 2017). Although public participation has been reported as a major challenge in impact assessment and weak methodological guidance (Bawole, 2013; Den Broeder et al., 2017), community-based impact assessment approaches have been developed and successfully administered, including examples from sub-Saharan Africa (Aboagye et al., 2019; Cameron et al., 2011; Sandham et al., 2019; Thondoo et al., 2020).

HIA, which is poorly institutionalised in sub-Saharan African countries (Winkler et al., 2013), or the inclusion of health in other forms of impact assessment should go beyond a mechanism to obtain the mining licence and also encompass participatory monitoring and follow-ups (Harris & Viliiani, 2018; Thondoo & Gupta, 2020). As inclusive and participatory tool, HIA should inform community development initiatives including health interventions for local communities, and further contribute to sustained health improvements (Knoblauch et al., 2020). Meanwhile, this could strengthen Corporate Social Responsibility (CSR), which serves as umbrella term for various community development initiatives under the lead of the mining companies (Mzembe & Downs, 2014). By suggesting appropriate interventions, HIA could ensure “real benefits” of CSR for local communities, which have been questioned (Emel et al., 2012). Indeed, CSR holds promise to boost social and economic development of hosting countries and communities, yet more innovative solution with a broader focus on human

development are needed – including the communities' perspective on their health and well-being (Niederberger et al., 2016; Yakovlevaa et al., 2017).

Taken together, HIA adopted by the host countries and bringing in the voices of affected communities offers a unique opportunity to “think and act” toward sustainable development, including health equity (Gulis, 2019; O'Keefe & Scott-Samuel, 2010; Thondoo & Gupta, 2020). Beyond the global agenda for sustainable development this would also be in line with the continent's road map, aiming for increased ownership of the projects and a human-driven approach toward prosperous, integrated and peaceful Africa by 2063 (AUDA-NEPAD, 2015).

3.6 Limitations

The scope of our study is mainly limited by the following three characteristics. First, the qualitative cross-country study presents methodological, procedural as well as linguistic challenges. During data collection, a core research team was responsible for managing the fieldwork, including the training of interviewers and continuous quality control of interviews and transcription. During the initial analysis, subtle linguistic or cultural differences might have remained concealed, as the researchers were trying to find consensus rather than cultural diversity when developing the coding system. However, particular attention to differences was paid during late stage analysis, including the discussion meetings held with the international research team.

Secondly, different types of industrial mines at different stage of the project development were selected as study sites. In Burkina Faso and Tanzania, the study was conducted around three gold mines, while in Mozambique different types of mines were selected (i.e. ruby, titanium and coal). While the choice of different types of mining industries was not very well balanced between the different countries, including different mining types allowed us to compare perceived health impacts across different settings of natural resource extraction. Additionally, only one mine was being constructed during the data collection, while all other mines have been operating since several years.

Thirdly, the qualitative study was focused on the communities' perspective, yet it would have been interesting to triangulate the communities' perspective with voices from the mine or local governments. However, systematic selection of positively and negatively impacted communities together with purposive sampling of knowledgeable community members for the FGDs should have minimised the bias of respondents' potential negative attitudes toward the mine. Additionally, the consistency of our qualitative findings from the different study sites indicates rather systematic challenges across the countries and settings.

3.7 Conclusion

Globally, natural resources play a key role toward sustainable development, while their extraction has implications for health and well-being of local populations. Based on the perception of communities surrounding industrial mining sites in Burkina Faso, Mozambique and Tanzania, changes and health outcomes reported were consistent across the countries, whereas differences were mainly related to extraction or processing method of the resource extracted and socio-cultural aspects of health. Community perspectives revealed various impacts on the environmental, economic and social determinants of health and health outcomes related to morbidity, mortality and well-being. While negative aspects for health overweighed the positive changes, the latter were primarily related to interventions implemented by the mine. This comprehensive synthesis of perceived positive and negative impacts on health and well-being contributes to the existing literature, which is often investigating impacts on specific biomedically-oriented determinants of health or health outcomes and their quantification respectively. Importantly, community health and well-being should be addressed by acting on the wider determinants of health and including the voices of affected populations. This would further allow addressing their needs adequately, particularly those of most marginalised population groups. HIA with its potential to include and raise the voices of affected communities offers a unique opportunity for strengthening CSR related health interventions, but HIA must become adopted by hosting countries and producer regions. Compared to opportunistic health management, community-based health programs to protect and promote health and well-being in mining settings should become a priority in striving toward local, continental and global sustainable development.

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3.9 References

- Aboagye, D. C., Akuffo, K., & Khan, H. T. A. (2019). Community health impact assessment in Ghana: contemporary concepts and practical methods. *Inquiry*, 56, 0046958019845292. doi:10.1177/0046958019845292
- Aboka, Y. E., Cobbina, S. J., & Doke, A. D. (2018). Review of environmental and health impacts of mining in Ghana. *Journal of Health and Pollution*, 8(17), 43-52. doi:10.5696/2156-9614-8.17.43

- Akpalu, W., & Normanyo, A. K. (2017). Gold mining pollution and the cost of private healthcare: the case of Ghana. *Ecological Economics*, 142(2017), 104-112. doi:10.1016/j.ecolecon.2017.06.025
- Anaf, J., Baum, F., Fisher, M., & London, L. (2019). The health impacts of extractive industry transnational corporations: a study of Rio Tinto in Australia and Southern Africa. *Global Health*, 15(1), 13. doi:10.1186/s12992-019-0453-2
- Antabe, R., Atuoye, K. N., Kuuire, V. Z., Sano, Y., Arku, G., & Luginaah, I. (2017). Community health impacts of surface mining in the Upper West Region of Ghana: the roles of mining odors and dust. *Human and Ecological Risk Assessment*, 23(4), 798-813. doi:10.1080/10807039.2017.1285691
- AUDA-NEPAD. (2015). Agenda 2063 framework document. African Union Development Agency (AUDA). Addis Ababa, Ethiopia.
- Bawole, J. N. (2013). Public hearing or 'hearing public'? An evaluation of the participation of local stakeholders in environmental impact assessment of Ghana's Jubilee Oil Fields. *Environmental Management*, 52(2), 385-397. doi:10.1007/s00267-013-0086-9
- Benshaul-Tolonena, A., Punam, C.-P., Dabalamb, A., Kotsadamc, A., & Sanohb, A. (2019). The local socio-economic effects of gold mining: evidence from Ghana. *Extractive Industries and Society*, 6(4), 1234-1255. doi:10.1016/j.exis.2019.07.00
- Berman, N., Couttenier, M., Rohner, D., & Thoenig, M. (2017). This mine is mine! How minerals fuel conflicts in Africa. *American Economic Review*, 107(6), 1564-1610. doi:10.1257/aer.20150774
- Brisbois, B. W., Reschny, J., Fyfe, T. M., Harder, H. G., Parkes, M. W., Allison, S., Buse, C. G., Fumerton, R., & Oke, B. (2018). Mapping research on resource extraction and health: a scoping review. *Extractive Industries and Society*, 6(1), 250-259. doi:10.1016/j.exis.2018.10.017
- Britten, N. (1995). Qualitative interviews in medical research. *British Medical Journal*, 311(6999), 251-253. Retrieved from <http://www.jstor.org/stable/29728175>
- Buse, K., & Hawkes, S. (2015). Health in the Sustainable Development Goals: ready for a paradigm shift? *Globalization and Health*, 11(13). doi:10.1186/s12992-015-0098-8
- Cameron, C., Ghosh, S., & Eaton, S. L. (2011). Facilitating communities in designing and using their own community health impact assessment tool. *Environmental Impact Assessment Review*, 31(4), 433-437. doi:10.1016/j.eiar.2010.03.001
- Carney, J. G., & Gushulak, B. D. (2016). A review of research on health outcomes for workers, home and host communities of population mobility associated with extractive industries. *Journal of Immigrant and Minority Health*, 18(3), 673-686. doi:10.1007/s10903-015-0328-4
- Carvalho, F. P. (2017). Mining industry and sustainable development: time for change. *Food and Energy Security*, 6(2), 61-77. doi:10.1002/fes3.109
- Cronjé, F., Reyneke, S., & Van Wyk, D. (2013). Local communities and health disaster management in the mining sector. *Journal of Disaster Risk Studies*, 5(2), a78. doi:10.4102/jamba.v5i2.78
- CSDH, & WHO. (2008). Closing the gap in a generation: health equity through action on the social determinants of health. Geneva, Switzerland: Commission on Social Determinants of Health (CSDH), World Health Organization (WHO).
- Den Broeder, L., Uiters, E., ten Have, W., Wagemakers, A., & Schuit, A. J. (2017). Community participation in health impact assessment: a scoping review of the literature. *Environmental Impact Assessment Review*, 66, 33-42. doi:10.1016/j.eiar.2017.06.004

- Dietler, D., Farnham, A., de Hoogh, K., & Winkler, M. S. (2020a). Quantification of annual settlement growth in rural mining areas using machine learning. *Remote Sensing*, 12(2), 235. doi:10.3390/rs12020235
- Dietler, D., Farnham, A., Loss, G., Fink, G., & Winkler, M. S. (2021). Impact of mining projects on water and sanitation infrastructures and associated health outcomes in children: a multi-country analysis of demographic and health surveys in sub-Saharan Africa. *Globalization and Health*(17), 70. doi:10.1186/s12992-021-00723-2
- Dietler, D., Lewinski, R., Azevedo, S., Engebretsen, R., Brugger, F., Utzinger, J., & Winkler, M. S. (2020b). Inclusion of health in impact assessment: a review of current practice in sub-Saharan Africa. *International Journal of Environmental Research and Public Health*, 17(11), 4155. doi:10.3390/ijerph17114155
- Emel, J., Makene, M. H., & Wangari, E. (2012). Problems with reporting and evaluating mining industry community development projects: a case study from Tanzania. *Sustainability*, 4(2), 257-277. doi:10.3390/su4020257
- Esteves, A. M., Franks, D., & Vanclay, F. (2012). Social impact assessment: the state of the art. *Impact Assessment and Project Appraisal*, 30(1), 34-42. doi:10.1080/14615517.2012.660356
- Farnham, A., Cossa, H., Dietler, D., Engebretsen, R., Leuenberger, A., Lyatuu, I., Nimako, B., Zabre, H. R., Brugger, F., & Winkler, M. S. (2020). Investigating health impacts of natural resource extraction projects in Burkina Faso, Ghana, Mozambique, and Tanzania: protocol for a mixed methods study. *JMIR Research Protocols*, 9(4), e17138. doi:10.2196/17138
- Fraser, J. (2019). Creating shared value as a business strategy for mining to advance the United Nations Sustainable Development Goals. *Extractive Industries and Society*, 6(3), 788-791. doi:10.1016/j.exis.2019.05.011
- Gamu, J., Le Billon, P., & Spiegel, S. (2015). Extractive industries and poverty: a review of recent findings and linkage mechanisms. *Extractive Industries and Society*, 2(1), 162-176. doi:10.1016/j.exis.2014.11.001
- Gulis, G. (2019). Health impact assessment and the Sustainable Development Goals. *Health Promotion International*, 34(3), 373-375. doi:10.1093/heapro/daz052
- Harris-Roxas, B., Viliiani, F., Bond, A., Cave, B., Divall, M., Furu, P., Harris, P., Soeberg, M., Wernham, A., & Winkler, M. (2012). Health impact assessment: the state of the art. *Impact Assessment and Project Appraisal*, 30(1), 43-52. doi:10.1080/14615517.2012.666035
- Harris, P., & Viliiani, F. (2018). Strategic health assessment for large scale industry development activities: an introduction. *Environmental Impact Assessment Review*, 68, 59-65. doi:10.1016/j.eiar.2017.10.002
- Hill, C., Madden, C., & Collins, N. (2017). A guide to gender impact assessment for the extractive industries. Oxfam. Melbourne, Australia. Retrieved from: https://www.oxfam.org.au/wp-content/uploads/2017/04/2017-PA-001-Gender-impact-assessments-in-mining-report_FA_WEB.pdf
- IFC. (2009). *Projects and people: A handbook for addressing project-induced in-migration*. International Finance Corporation (IFC). Washington DC, USA. Retrieved from: http://www.ifc.org/wps/wcm/connect/Topics_Ext_Content/IFC_External_Corporate_Site/Sustainability-At-IFC/Publications/Publications_Handbook_Inmigration__WCI__1319576839994
- Jacob, T., & Pedersen, R. H. (2018). New resource nationalism? Continuity and change in Tanzania's extractive industries. *Extractive Industries and Society*, 5(2), 287-292. doi:10.1016/j.exis.2018.02.001

- Karakaya, E., & Nuur, C. (2018). Social sciences and the mining sector: some insights into recent research trends. *Resources Policy*, 58, 257-267. doi:10.1016/j.resourpol.2018.05.014
- Knoblauch, A. M., Farnham, A., Zabre, H. R., Owuor, M., Archer, C., Nduna, K., Chisanga, M., Zulu, L., Musunka, G., Utzinger, J., Divall, M. J., Fink, G., & Winkler, M. S. (2020). Community health impacts of the Trident Copper Mine Project in northwestern Zambia: results from repeated cross-sectional surveys. *International Journal of Environmental Research and Public Health*, 17(10), 3633. doi:10.3390/ijerph17103633
- Knoblauch, A. M., Hodges, M., Bah, M., Kamara, H., Kargbo, A., Paye, J., Turay, H., Nyorkor, E., Divall, M., Zhang, Y., Utzinger, J., & Winkler, M. (2014). Changing patterns of health in communities impacted by a bioenergy project in northern Sierra Leone. *International Journal of Environmental Research and Public Health*, 11(12), 12997-13016. doi:10.3390/ijerph111212997
- Leuenberger, A., Farnham, A., Azevedo, S., Cossa, H., Dietler, D., Nimako, B., Adongo, P. B., Merten, S., Utzinger, J., & Winkler, M. S. (2019). Health impact assessment and health equity in sub-Saharan Africa: a scoping review. *Environmental Impact Assessment Review*, 79, 106288. doi:10.1016/j.eiar.2019.106288
- Mactaggart, F., McDermott, L., Tynan, A., & Whittaker, M. (2018). Exploring the broader health and well-being outcomes of mining communities in low- and middle-income countries: a systematic review. *Global Public Health*, 13(7), 899-913. doi:10.1080/17441692.2016.1240821
- Mamo, N., Bhattacharyya, S., & Moradi, A. (2019). Intensive and extensive margins of mining and development: evidence from sub-Saharan Africa. *Journal of Development Economics*, 139, 28-49. doi:10.1016/j.jdeveco.2019.02.001
- Marmot, M. (2005). Social determinants of health inequalities. *Lancet*, 365(9464), 1099-1104. doi:10.1016/S0140-6736(05)71146-6
- Mays, N., & Pope, C. (1995). Rigour and qualitative research. *BMJ*, 311(6997), 109-112. doi:10.1136/bmj.311.6997.109
- Moretti, F., van Vliet, L., Bensing, J., Deledda, G., Mazzi, M., Rimondini, M., Zimmermann, C., & Fletcher, I. (2011). A standardized approach to qualitative content analysis of focus group discussions from different countries. *Patient Education and Counseling*, 82(3), 420-428. doi:10.1016/j.pec.2011.01.005
- Morgan, R. K. (2012). Environmental impact assessment: the state of the art. *Impact Assessment and Project Appraisal*, 30(1), 5-14. doi:10.1080/14615517.2012.661557
- Mzembe, A. N., & Downs, Y. (2014). Managerial and stakeholder perceptions of an Africa-based multinational mining company's corporate social responsibility (CSR). *Extractive Industries and Society*, 1(2), 225-236. doi:10.1016/j.exis.2014.06.002
- Niederberger, T., Haller, T., Gambon, H., Kobi, M., & Wenk, I. (2016). *The open cut: mining, transnational corporations and local populations*. Zürich: Lit Verlag.
- 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: Planning, Administration, Evaluation*, 40(2), 339-345. doi:10.2190/HS.40.2.o
- O'Faircheallaigh, C. (2017). Shaping projects, shaping impacts: community-controlled impact assessments and negotiated agreements. *Third World Quarterly*, 38(5), 1181-1197. doi:10.1080/01436597.2017.1279539

- Oster, E. (2012). Routes of infection: exports and HIV incidence in sub-Saharan Africa. *Journal of the European Economic Association*, 10(5), 1025-1058. doi:10.1111/j.1542-4774.2012.01075.x
- Owen, J. R., Vivoda, V., & Kemp, D. (2019). Country-level governance frameworks for mining-induced resettlement. *Environment, Development and Sustainability*, 22(5), 4907-4928. doi:10.1007/s10668-019-00410-8
- Poland, B. D. (2016). Transcription quality as an aspect of rigor in qualitative research. *Qualitative Inquiry*, 1(3), 290-310. doi:10.1177/107780049500100302
- Pope, C., & Mays, N. (1995). Reaching the parts other methods cannot reach: an introduction to qualitative methods in health and health services research. *BMJ*, 311(6996), 42-45. doi:10.1136/bmj.311.6996.42
- Porgo, M., & Gokyay, O. (2017). Environmental impacts of gold mining in Essakane site of Burkina Faso. *Human and Ecological Risk Assessment*, 23(3), 641-654. doi:10.1080/10807039.2016.1263930
- Quigley, R., den Broeder, L., Furu, P., Bond, A., Cave, B., & Bos, R. (2006). Health impact assessment international best practice principles. International Association for Impact Assessment. Retrieved from http://www.iaia.org/uploads/pdf/SP5_3.pdf
- Sandham, Chabalala, & Spaling. (2019). Participatory rural appraisal approaches for public participation in EIA: lessons from South Africa. *Land*, 8(10), 150-166. doi:10.3390/land8100150
- Schrecker, T., Birn, A.-E., & Aguilera, M. (2018). How extractive industries affect health: political economy underpinnings and pathways. *Health and Place*, 52, 135-147. doi:10.1016/j.healthplace.2018.05.005
- Standard & Poor Global. (2020). Market Intelligence Platform. Retrieved from <https://www.spglobal.com/marketintelligence/en/solutions/market-intelligence-platform>
- Thondoo, M., & Gupta, J. (2020). Health impact assessment legislation in developing countries: a path to sustainable development? *Review of European, Comparative and International Environmental Law*, 00, 1-11. doi:10.1111/reel.12347
- Thondoo, M., Mueller, N., Rojas-Rueda, D., de Vries, D., Gupta, J., & Nieuwenhuijsen, M. J. (2020). Participatory quantitative health impact assessment of urban transport planning: a case study from Eastern Africa. *Environment International*, 144, 106027. doi:10.1016/j.envint.2020.106027
- Tong, A., Sainsbury, P., & Craig, J. (2007). Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care*, 19(6), 349-357. doi:10.1093/intqhc/mzm042
- USGS. (2019). 2015 Minerals Yearbook United States Geological Survey (USGS). Retrieved from: <https://prd-wret.s3-us-west-2.amazonaws.com/assets/palladium/production/atoms/files/myb3-sum-2015-africa.pdf>
- Uttinger, J., Wyss, K., Moto, D., Tanner, M., & Singer, B. (2004). Community health outreach program of the Chad-Cameroon petroleum development and pipeline project. *Clinics in Occupational and Environmental Medicine*, 4(1), 9-26. doi:10.1016/j.coem.2003.09.004
- Von der Goltz, J., & Barnwal, P. (2019). Mines: The local wealth and health effects of mineral mining in developing countries. *Journal of Development Economics*, 139, 1-16. doi:10.1016/j.jdeveco.2018.05.005
- WHO European Centre for Health Policy. (1999). Gothenburg Consensus Paper. World Health Organization Regional Office for Europe. Brussels, Belgium.

- Winkler, M. S., Adongo, P. B., Binka, F., Brugger, F., Diagbouga, S., Macete, E., Mungambe, K., & Okumu, F. (2020a). Health impact assessment for promoting sustainable development: the HIA4SD project. *Impact Assessment and Project Appraisal*, 3(8), 225-232. doi:10.1080/14615517.2019.1694783
- Winkler, M. S., Furu, P., Viliiani, F., Cave, B., Divall, M., Ramesh, G., Harris-Roxas, B., & Knoblauch, A. M. (2020b). Current global health impact assessment practice. *International Journal of Environmental Research and Public Health*, 17(9), 2988. doi:10.3390/ijerph17092988
- Winkler, M. S., Krieger, G. R., Divall, M. J., Cissé, G., Wielga, M., Singer, B. H., Tanner, M., & Utzinger, J. (2013). Untapped potential of health impact assessment. *Bulletin of the World Health Organization*, 91(4), 298-305. doi:10.2471/BLT.12.112318
- Winkler, M. S., Viliiani, F., Knoblauch, A. M., Cave, B., Divall, M., Ramesh, G., Harris-Roxas, B., & Furu, P. (2021). Health impact assessment international best practice principles. International Association for Impact Assessment. Fargo, USA. Retrieved from: https://www.iaia.org/uploads/pdf/SP5%20HIA_21_5.pdf
- Wong, L. P. (2008). Focus group discussion: a tool for health and medical research. *Singapore Medical Journal*, 49(3), 256-261. Retrieved from <https://www.ncbi.nlm.nih.gov/pubmed/18363011>
- World Bank. (2017). The growing role of minerals and metals for a low carbon future. World Bank. Washington, D.C., USA.
- Yakovleva, N., Kotilainen, J., & Toivakka, M. (2017). Reflections on the opportunities for mining companies to contribute to the United Nations Sustainable Development Goals in sub-Saharan Africa. *Extractive Industries and Society*, 4(3), 426-433. doi:10.1016/j.exis.2017.06.010
- Yakovlevaa, N., Kotilainenb, J., & Toivakkab, M. (2017). Reflections on the opportunities for mining companies to contribute to the United Nations Sustainable Development Goals in sub – Saharan Africa. *The Extractive Industries and Society*, 4, 426-433. doi:0.1016/j.exis.2017.06.010

3.10 Supplementary files

S1: Outcome of participatory focus group discussions

The picture shows the perceived impacts (written in Swahili on paper cards), which were categorized by the participants on the wider determinants of health (A4 sheets) and ultimately ranked with bottle lids.



S2: Excerpt from the codebook

Thematic codes for the perceived impacts on the wider determinants of health, description of the themes and exemplary quotes extracted from the transcripts of the FGDs.

Name	Description	Exemplary quotations*
Perceived environmental impacts		
Environmental	Statements related to environmental conditions in general such as geographical situation, environmental degradation or climate conditions	<ul style="list-style-type: none"> - Les dégâts environnementaux seront énorme - As condições climáticas desta comunidade costuma estar ao contrário - As you can see near that pit there is a mountain that when it rains the mud from the mountain can collapse
Air pollution	Statements related to air pollution or dust in general or not specified (with one of the child nodes)	<ul style="list-style-type: none"> - La poussière nous dérange beaucoup - Defecamos fezes com cor preta por causa de poeira - Air that we breathe is not clean
Bad smell	Statements about odour or bad smell (around the mine or along a mining pipe)	<ul style="list-style-type: none"> - L'odeur empeste tout le village - Sai um cheiro mau, e nos faz sentir mal aquele cheiro - The smell of chemicals here are strong - This bad smell is emitted by a pipe, it goes straight on air
Blasting - dust from inside the mine	Statements about dust coming from inside the mine, dust from the mining activities	<ul style="list-style-type: none"> - Quand ils écrasent leur or, il y a la poussière qui se repend dans le village et on ne peut plus regarder - Consegue ver as poeiras saindo das minas para dentro da vila. O ar que temos respirado, é poluído - The blasting they do here releases dust into the atmosphere - The blasting pollutes the air that we breathe - There is a dust coming from inside the mining
Traffic - dust	Statement about dust related to traffic on unpaved roads	<ul style="list-style-type: none"> - Esses carros deles quando estiverem a passar costumam nos sujar com poeira também - I want to add something about dusts, mining company is using big trucks when passing to our community dust comes to our houses
Water	Statements related to water in general, i.e. when participants were speaking simply about "water" without specifying the source or issue related to it	<ul style="list-style-type: none"> - On demande qu'ils nous aident avec de l'eau - Água conseguimos mas o governo e a Kenmare não nos abastece água - Water is life and our health depends on water, if water is not safe then our health is also not safe.

		<ul style="list-style-type: none"> - We get diseases like chest pain, stomach pain and other diseases and the main cause of these diseases is the water we are using
Burst of mining dam - water flow from the mine	Statements related to the burst of the tailing dam (in the mine) or when (contaminated) water was flowing from the tailing dam to the communities.	<ul style="list-style-type: none"> - En saison pluvieuse il y'a des coulée qui contamine les eaux de surface que les animaux boivent - Sai água dali [da empresa] que vai aqui na comunidade e essa água misturasse com a água que nós bebemos - Last year the dam was full of water then it broke, water flowed to rice plants which dried because of the chemicals. - They are constructing dams but when the dams are full water flows outside then poison which is in the water flows to another dam
Ponds as breeding sites	Ponds or surface water related to vector breeding	<ul style="list-style-type: none"> - Lugares que tem charcos ou mesmo dentro de casa quando tiver água na bilha que leva muito tempo dentro de casa isso provoca mosquitos acaba picando as crianças mesmos adultos - Here are ponds where mosquito breeds and spread malaria - The stagnant water behind our homes to breed mosquitoes
Type of water source	To specify type of water source with the given sub-nodes or to code segments were multiple water sources are mentioned	
Dams - ponds - rivers	Natural water bodies, surface water	<ul style="list-style-type: none"> - L'eau du barrage de la mine affecte nos retenues d'eau en brousse - A água que cartamos no rio Zambeze apenas bebemos, a água não é tratada - On the dam which was constructed for animals to get drinking water but water has poisons - When it rains water from the mining flows to the river then to our village
Piped - drilled water points - taps	Water infrastructure for water supply	<ul style="list-style-type: none"> - Certaines personnes partent jusqu'à Sabcé acheter l'eau à la borne fontaine - Nous avons eu à réparer notre seule pompe du village - Montaram aquela bomba para poder nos ajudar quando lá no rio a água ficar suja - We should request to put pipes to distribute water to this community - they brought water services and all these water taps
Rain water	Rain water, rain water collection systems	<ul style="list-style-type: none"> - Cette eau des toits est devenue gluante - Avant nous recueillons les eaux de pluie qui coulaient des toits de nos maison - Pode a chuva cair não vem boa água - Quando estiver a chover caí água suja de carvão na chapa

		<ul style="list-style-type: none"> - We cannot even dare to fetch rainy water for drinking
Wells	Natural wells, unprotected wells, open wells	<ul style="list-style-type: none"> - [La mine] est entrain de contaminer notre eau des forages - Nous nous inquiétons de la potabilité de ces eaux de puits - Costuma estar difícil, porque todos nos cartamos água no pequeno poço - We are using open natural wells
Water access	Statements related to physically being able to access water or when they are referring to the distance of the water source, also when they cannot access water for free	<ul style="list-style-type: none"> - La distance lointaine de l'eau rend certaines choses difficiles - A água estamos a pagar muito carro - Essa água não estão nos a dar, estamos a pagar - Agua está distante - It is located far away from the community, so people are choosing to fetch water from the nearby well instead of going there
Water as habitat	Water as habitat for any kind of animals	<ul style="list-style-type: none"> - Quando vamos cartar a água não enche uma lata e está cheio de areia, abelhas e sapos - Quando vamos no rio, somos pegues com crocodilo - Water had poison because leaders from the mining visited us and I was there, fish and other living organism died
Water availability	Statements about the availability of water and water access points	<ul style="list-style-type: none"> - L'eau ne suffit pas - On veut aussi qu'il ait beaucoup de pompes pour qu'on gagne assez d'eau - Não temos água - We also have shortage of clean water - They constructed wells for us
Water quality	Descriptions about the water quality (colour, taste or smell, appearance/composition) as well as the measurement of the water quality	<ul style="list-style-type: none"> - L'eau est trouble, la couleur de l'eau change - La mine fait des prélèvements d'eau à des fins d'analyse - Nós a bebermos água suja - Depois essa água está contaminada - There is a dangerous poison in water
Sanitation	General statements about sanitation and sanitary infrastructure such as toilets	<ul style="list-style-type: none"> - La majorité des latrines de la cité sont pleines - Aqui na comunidade não habituamos latrinas, estamos habituados a ir fazer (cocô) ai no mato mesmo - We have worked so hard to push them to construct sewage system
Hygiene	Personal hygiene (bathing, showering, washing hands) and household hygiene (food hygiene, cleaning the house, washing clothes)	<ul style="list-style-type: none"> - On dit qu'il y a la santé parce que si tu es une femme et que tu assainis ton milieu - Tomamos banho uma vez por dia - You can see we are living closer to this road and there is dust everywhere

		even on the food
Open defecation	Descriptions of defecation and urination of employees of the mine or community members	<ul style="list-style-type: none"> - Il[s] [les agents de la mine] défèque[nt] dans les champs - Outras vezes encontra enquanto cagaram (refere-se a defecar) lá na sua machamba - Security guards working outside the mining are making our environment dirty because they don't have toilets
Waste management	Waste management of the community and the mine	<ul style="list-style-type: none"> - Parfois jette les restes de repas pourri dans nos [champs] - Temos uma lixeira que não esta protegida, só o lixo e deitado (o lixo é despejado ao relento) - Those chemicals are dangerous to health of human being if are not handled properly, this means people living in the community surrounding the mining can be affected too - There is no damping place to dispose rubbish
Soil and land	Heading category for issues related to soil and land (general statement or when it is not clearly linked to a child-node in the subcategory)	
Agriculture	General statements related to agriculture and the productivity of agriculture (increase or decrease), therefore when the reason for the change in productivity is not clearly stated and the quotation cannot be coded by a following child-node. Agriculture considered as subsistence work or income generating activity.	<ul style="list-style-type: none"> - De nos jours c'est très difficile de cultiver ici et pas de rendement. - A Mineradora estragou as nossas terras, porque antes cultivávamos bem - Agriculture production is very poor
Destruction of fields	Physical destruction of agricultural fields by machines or other activities of the mine	<ul style="list-style-type: none"> - Porque encontram sua machamba eles pisam, estragam seus produtos, isso tudo provoca-nos fome, a senha para receber sementes não dão
Food	Agriculture as food production; cultivating and harvesting crops and vegetables; quantity and quality of food (from the fields)	<ul style="list-style-type: none"> - Les champs qu'on a demandé ce sont de petits champs et quand on récolte ça nous suffira pas jusqu'à la saison prochaine - <i>Carakata</i> (farinha de mandioca) está toda estragada - It doesn't matter how hard you will try to cultivate but you won't get enough food - Dusts affect us so much because of eating poison

Land taken	Loss of agricultural land or fields	<ul style="list-style-type: none"> - C'est le blanc là [from the mine] qui a fait qu'on n'a plus d'argent parce qu'il a pris nos terres où on se débrouillait. - As machambas levaram com a empresa; levaram sim com a empresa e não nos deram nada - To be honest by taking our land they have killed us
Less rainfall	Reduced production (agricultural or fishing) due to less rainfall	<ul style="list-style-type: none"> - We were getting a lot of crops but since they started doing mining activities rate of crops has dropped because we don't get enough amount of rainfall - Não há chuvas, até peixe já não temos
Resettled	Size of land or soil fertility in the new area, distance of resettled fields	<ul style="list-style-type: none"> - C'est parce que les champs sont très éloignés de nous maintenant - A empresa [...], indemnizou a todos que eles atingiram para que pudessem abandonar as suas machambas e procurou machambas para a população afetada. - When we moved out we left our fertile farms and productive then we moved to new area where the farms are not fertile. - They shift me and take me to another place where there is no manure, so everything that I cultivate in a new farm doesn't give me a good outcome
Soil pollution - drought	Drought or polluted soil (through air, water or soil) and related consequences for the growing plants	<ul style="list-style-type: none"> - Amendoim é amargam muito, quando plantas não cresce porque ai a terra já não esta boa - Poison water flowed to rice farms and plants were burnt and since then plants are not growing in those farms because the land is affected. - We are not safe because when it rains water comes from the dam to our crops, when that happens our crops get dry
De-forestration	Cutting down trees or forest, clearing of woods and loss of herbs (inside the woods) and firewood as well as related interventions (replanting trees)	<ul style="list-style-type: none"> - La mine a détruit tous les arbres qui existaient - Eles [the company] até vieram distribuir plantas numa das reuniões que tiveram com a população. Eles deram plantas que não tem interesse, não são plantas frutíferas. - Ai na mata eles estragam tudo, partem as árvores e deixam ai mesmo de qualquer maneira - Because clearing of the forest has let to shortage of rainfall in our country - We had certain trees that we used for traditional medicines but we don't get those trees anymore
Land accessibility	Physically being able (or not) to access the land, physical barriers	<ul style="list-style-type: none"> - Parce qu'ils ont clôturé les lieux avec le grillage - Nem pisamos na mata, costumam nos proibir, até colocaram guardas com armas só para nós não entrar, fizeram uma vala grande para nós não conseguir atravessar, porque quem tenta atravessar a vala morre logo

Pastoralism - animals	Statement related to domestic and wild animals, domestic and income-generating activities with animals, ONE health aspects (interaction of animals and humans which are relevant for their health)	<ul style="list-style-type: none"> - Ils avaient promis nous donner des animaux à élever - L'élevage à aussi beaucoup de pans: il y'a l'élevage des montons; des poulets; des bœufs - Até mesmo animais, há dias atrás morreram por ai 4 cabeças de Gado Bovino, estava doente. Quando morreu abrimos a barriga e vimos que toda a barriga estava escura, devido a esta água - Animals are drinking water which has poison and eat grasses which have poison
Housing	Heading category about housing and living conditions, comprises general statements, which cannot be specified by the following child-nodes (e.g. statement related to interventions on the housing communities or when reason for improvement or impediment are not specified)	<ul style="list-style-type: none"> - On y trouve maintenant de belles constructions de maisons - They gave houses to people but the houses have even broken down, they were not of good quality
Blasting - vibration - cracks	Statements related to the effects of blasting on the houses or living area or cracks in the houses	<ul style="list-style-type: none"> - Depuis que la mine est installée, on constate les fissures des maisons - Rachas nas casas. Quando eles explodem Os dinamites, primeiro a terra treme depois as chapas de casa se levantam, quando estiver a chover caí água suja de carvão na chapa. - Blasting comes with vibration which causes cracks on our houses - At that time there was blasting at the mining, there was very strong land vibration.
Electricity	Statements related electricity	<ul style="list-style-type: none"> - Costumo colocar painel solar para poder carregar meu telefone - The electricity passes to our farms and inter in the mining but we don't have electricity. So we would like to ask that if there is a possibility, they should bring us electricity - At night this community is in darkness, no electricity
Land - resettlement	Owning land and land rights, resettlement of home or land for living (compared to land for agriculture), construction of new houses	<ul style="list-style-type: none"> - C'est la société minière qui nous a dit de choisir un lieu dans nos domaines afin qu'elle construise les maisons pour nous - Parce que quand tu n'a pas les documents d'une parcelle, alors tu es en insécurité foncière - Sans ces documents, nous ne sommes pas propriétaire de ces maison - O importante, é que sejamos reassentados num outro local que não tenha mineradoras

		<ul style="list-style-type: none"> - The pit they dug was right in front of our house so they relocated us to a new house - We don't know whether we live near the mining or we live within the mining area because their beacons are here - By law we are not supposed to be here
Noise – noise pollution	Acoustic effects of blasting or machines used in the mines, potentially also traffic noise	<ul style="list-style-type: none"> - Quand tu es couché au petit matin tu as peur du bruit - Tu perds par moment le sommeil à cause du bruit «kouououooooo» des engins lourds - Não apanho sono, quando explodem até fico assustada - We don't get used to the blasting sound people are shocked whenever they do blasting
Roads	Statements related to the road network in the communities or the quality of the road and implication for the mobility of the communities	<ul style="list-style-type: none"> - Ils nous ont promis construire une grande route - As estrada estão todas esburacadas desde que chegaram e começaram a trabalhar ainda não arranjaram - They came to level[ed] our roads - Construction of this road to town has made movements to the community and outside the community to be easy.
Traffic - trucks - accidents	Statements about the traffic in the community and related consequences for the safety of the communities	<ul style="list-style-type: none"> - Quand ils passent avec leur véhicule ils tuent (cognent) nos animaux (les poules et les chèvres meurent) de plus la poussière nous donne des maladies. - Lá na cidade sempre tem havido acidentes, quase todos dias, principalmente, nos finais de semana - Heavy trucks passing on the road which causes vibration which affects our houses - This road is used frequently there are so many trucks taking things to the mining and out of the mining.
Perceived impact on social services and organization		
Social	Heading category for issues related to social services (such as education and health care services) and social organisation of the community	
Education - schooling	General statements related to education or when not specified for one of the given child-nodes (not including higher education or educational programmes)	<ul style="list-style-type: none"> - Escola construíram, construíram escola industrial só as pessoas daqui é que não estudam - Education is the source of better life for our children in the future

Attendance - accessibility	Being physically able to go to school and attend the classes (or not attend)	<ul style="list-style-type: none"> - La mine a fait installer un grillage, lequel grillage a augmenté la distance entre koussaro et le collège puisqu'elle barre l'ancienne voie - Temos escola industrial, só não frequentamos, lá tem coisas, as crianças não vão só fizeram mas não vão. - Now our school can manage to take many students - Children will be stressed they cannot even go to school because they are thinking of how can he/she help his old father
Buildings - infrastructure	School buildings and infrastructure in and around the classrooms	<ul style="list-style-type: none"> - Ils ont construit des salles de classes - Construíram duas escolas que leciona até Oitava classe (8ª Classe) aqui na CFM e me disseram que a [empresa] que construíram? - They have supported construction of two secondary schools - They brought iron sheets, wood and color but they didn't gave money to build the school instead they gave those things to village government. - They built classrooms here [in the village], also teachers' houses and toilets
School fees	Financial aspects related to education, being able to pay or get support for paying school fees	<ul style="list-style-type: none"> - Aucun des parents n'a de l'argent pour payer la scolarité - Tinham dito para entramos na escola e estudar, mas na escola nos pedem dinheiro - They are giving support to orphans children in this community to get education - They confirm that there are some children who are poor and they are being sponsored by the mining in their education
Health care services	General statements related to health care or health care services or when not specified for the given child-nodes	<ul style="list-style-type: none"> - Os médicos vão dizer que não acusou nada nos testes e análises feitos no hospital - There is reduction of maternal and infant deaths in the community - There is no improvement on health services
Accessibility	Statement related to physically being able to access health care or distance that they have to travel to access health care	<ul style="list-style-type: none"> - Le centre de santé dans lequel nous nous rendons en cas de maladie est éloigné de notre zone - Se tivéssemos um hospital perto estaria a nos ajudar a tratar das nossas doenças e as pessoas não estariam a morrer descontroladamente. - Now it is easy to go for delivery for us women - So when mining built this health center here we feel good, we get treatment near our homes
Affordability	Financial aspect of accessing health care services including transport costs to get there	<ul style="list-style-type: none"> - Si tu es malade pour te soigner il faut de l'argent pour les soins sans argent la maladie va s'aggravé jusqu'à ce que tu vas trépasser - Nós pagamos ambulância para levarem nosso doente ao hospital em Maputo para ser operada

		<ul style="list-style-type: none"> - Because people financial situation is poor, they cannot afford to pay for the health services even when someone is in need of it - We don't waste transport fee as we used to do before
Availability	Availability of health care facilities, for example when new health facilities were constructed	<ul style="list-style-type: none"> - Ils ont construit un dispensaire - Lamentamos por causa de não ter hospital? - We don't have even a dispensary in this community
Capacity	Capability to receive or treat people (number of beds or waiting time)	<ul style="list-style-type: none"> - Apenas é um hospital somente e as pessoas são muitas? - The waiting time to get services is shorter [...] you don't spend the whole day waiting to get treatment - The [XX] health centre has helped in decreasing the crowd of people at [XX] district hospital
Readiness	preparedness of the health facilities for treatment, available equipment or availability of tests and medicines,	<ul style="list-style-type: none"> - La mine avait appuyé le CSPS en médicaments pour les enfants - Disseram que não temos outros comprimidos a não ser aspirina? - You can have a building of dispensary but it is not full equipped for it to provide services to community members - After the mining renovated health centres, hospital buildings, providing medical tools and other things
Seeking health care	Frequency of seeking health care, description of reasons for seeking health care and places where they are seeking care (hospitals, traditional healers, pharmacies)	<ul style="list-style-type: none"> - Les gens achètent un comprimé appelé F sur la place du marché qui les soulagent - Quando podemos temos ido ao hospital, mas não está a resultar, é preciso que tenhamos o hospital aqui perto - Now majority are going at the health facility to do checkup before using medicines while in the past people went straight pharmacy to buy medicines - Currently majority are going hospital when they are sick not to traditional healers as it was in the past
Specific services	specific health care services provided, treatments offered or health care infrastructure constructed	<ul style="list-style-type: none"> - Ils nous ont promis une ambulance - Quando vão fazer parto no hospital, e se ser difícil o parto muitas mulheres levam cesariana e voltam com duas crianças mas isso há muito tempo não acontecia - They have educated people and there is testing of HIV frequently in our community - They have provided two important services, children with open-cleft and children who had fire scars they took them somewhere and treat them - Also they built a mortuary

Community dynamics	General statements about the community dynamics or when not able to specify with one of the following child nodes	
Community conflicts - inequities	Conflicts and tensions among community members or subgroups, when not everyone is benefitting equally and certain people are privileged compared to others	<ul style="list-style-type: none"> - L'arrivée de la mine a été bénéfique pour certains et une perte pour d'autre - Nossos dirigentes tem muita "doença" (problemas ou desentenenmentos) com a comunidade de [XX], não querem nos ver a trabalhar - The mining paid the money with agreement but the leaders did not educate the community or they were forcing people to sell their farms - Few opportunities are offered to the point it brings conflicts to community members. - She has a referee. (<i>She knows someone in the mining who has connected them to get employment opportunity at the mining</i>)
Crimes	Committed crimes like robberies, stealing and thefts within the community or in the mine, also crimes related to ongoing conflicts	<ul style="list-style-type: none"> - Si les voleurs n'avaient pas volé nos animaux, ont pouvais vendre quelques animaux pour acheter les condiments - Não estamos bem, temos medo por causa de assassinatos; não sabemos de onde vem essas coisas, estamos ouvir <i>Al Shabaab</i> - They are stealing our properties in the community - When the mining started operating they remain jobless and that is why they started stealing in the mining
Culture - beliefs - future	Statement related to the culture (like rituals), beliefs (like myths or religion) or anticipation of effects in the future (for the future generation)	<ul style="list-style-type: none"> - Ils sont venus nous dire de faire l'élevage des porcs nous on a dit que nous sommes des musulmans et que nous ne pouvons pas le faire - La présence de la mine a chassé les génies et les démons de la brousse et ils ont habité les gens maintenant - As pessoas pensão que agora tem má sorte, eles abrem furos e sai azar dai mesmo - We are living by God's grace and protection - So what will support my children in the future?
Direct contact contamination	Transmission or spread of diseases through physical or sexual contact of people	<ul style="list-style-type: none"> - Ficam cheio de doenças e as nossas filhas dormem com esses Sul-africanos, esses de Maputo; está a ver, são dominadas assim apanham SIDA amanha morrem - Então essas nossas filhas que dormem com esses Sul-africanos dizem que são dois, mas esses dois são muitos, nossas filhas morrem, as mães morrem
Family - cohesion	Family or community spirit of feeling connected or belonging together, as well as trusting and respecting each other,	<ul style="list-style-type: none"> - Les femmes se frappent souvent au niveau des pompes

	respectively when this is all not given anymore	<ul style="list-style-type: none"> - Crianças não tem medo, encontram um adulto passam mas antigamente as crianças se ajoelhavam <i>ruwa</i>, <i>ruwa</i> ali diziam que filho de fulano sim tem respeito - Há muito tempo era normal você, a andar no bairro, encher um saco plástico de amendoim de oferta; as pessoas oferecerem-te só, mas agora isso não existe; ninguém dá o outro, se você não tem estás mal - When they take the money they run away from their families - They get involved in adultery and end up getting infection
In-migration	Migration to the communities, increase in population, mine as pull-factor	<ul style="list-style-type: none"> - La population de la cité à fait accroitre la population qui existait de [XX] - E essa vinda de pessoas de outras regiões, faz com que surjam novas doenças na comunidade - Many people are coming here looking for employment opportunities in the large mining
Security	Feelings about safety and security (positive and negative)	<ul style="list-style-type: none"> - Partout où tu passes en brousse on te chasse - They were also announcing on radio that no farmer should use their lands not even for the slightest activity otherwise when a mining soldier sees you, he/she can arrest you - After the phase out of mining activities the pits will be very dangerous to the living things that is human being and animals - This has cause the area to like a forest and people are raped and sometimes killed because the area has been left idle - As villagers we are benefiting due to the security services provided by these youth, they are our guards so in one way or another we are benefiting from them
Sports teams - interests groups	Formation of or (financial) support for local groups or associations (e.g. sports team, beekeepers, vegetable gardeners)	<ul style="list-style-type: none"> - On a créé aussi un groupe de femmes qui creuse le zaï - Eu quero pedir a [empresa] temos desporto em particular futebol - They sponsor football teams - They tried to educate people on the modern agriculture, we have groups where we are being educated on how to perform modern agriculture - We have introduced women groups which basically support each other financially
Perceived economic impacts		
Economic	Heading category for issues related to economic aspects or general statements about economics that cannot be	<ul style="list-style-type: none"> - Our economy here might be a lie

	specified with one of the following child nodes	
Compensation	Compensation payment for resettlement, relocation of land or house as well as indications about how this money was spent	<ul style="list-style-type: none"> - Ils ont donné de l'argent à ceux qu'ils ont pris les terres. - Quand on déménageait dans la cité, dans chaque concession ils ont donné la somme de 200000F CFA - Mas a empresa já nos dominou nos arrancou nossas machambas os que tiveram a sorte de serem indemnizados uma machamba grande cheia de produtos só lhe davam 10 a 20 milho meticais - Native who got paid had a lot of money, they used the money for drinking, seducing students and marry other women - People were paid and shifted then they used money badly
Economic benefits	other economic benefits (not related to income generating activity)	<ul style="list-style-type: none"> - Dizem que cumpriram dar pensão aos idosos - Omem outras pessoas (presumivelmente quis dizer que "outras pessoas é que tem o beneficio da riqueza que a região possui") [...] esta é a comunidade que tem recursos minerais e não acreditar porquê do jeito como está não espelha a realidade - That 10,000 from security guard is for street [community] development - I didn't use my money to contribute on the building of classrooms and teacher's houses, they helped us on that
Income generating activities	Means of livelihoods, subsistence work or businesses driven by community members (compared to employment by the mine), such as artisanal mining, farming, fishing, prostitution	<ul style="list-style-type: none"> - Le marché ne donne plus, tu vas cultiver mais pour vendre, tu ne trouves pas le marché - On faisait l'orpaillage et on avait toujours l'argent - Demain chez vais préparer mon dolo (bière de mil) pour vendre et avoir de l'argent - As pessoas saiam de outros pontos para virem comprar mandioca fresca aqui mas nesses dias não - Ficamos toda hora no rio ir pescar peixe porque há falta de emprego. - People are selling their bodies (<i>prostitution</i>) to satisfy their needs - Youth are going steal some abandoned stones in the mining so that they can come and process it and get small amount of money for their needs
Living costs	Expenses for living and domestic activities, sometimes specified goods that they have to incur now, as they are not available anymore naturally because of the mine	<ul style="list-style-type: none"> - Acheter l'eau à la borne fontaine - Nous ne disposons pas de moyens pour les réparer - On avait les amandes de karité que nous ramassions pour faire du savon et depuis que nous sommes ici, nous n'avons rien et si tu as besoin du savon il faut en acheter - A realidade do povo que não conseguem comer arroz porque custa 2 milhão e

		<p>500mt</p> <ul style="list-style-type: none"> - When you get money you go and buy food, you won't buy manure - Where will you get money for medication? - Life running costs increased - We don't get firewoods so we are enforced to buy charcoal
Poverty	Poor economic status, poverty	<ul style="list-style-type: none"> - La paupérisation de la population - Só sabem trazer pobreza e fome para as nossas comunidades e não temos o que comer - People financial situation is poor
Unemployment	Not being employed by the mine or not having work at all	<ul style="list-style-type: none"> - Pas d'embauche à la mine - Está tudo estragado e não apanhamos emprego, e nossos familiares não apanham emprego também - Aqui não há emprego para nós, quem apanha emprego são pessoas que vem de [the city], são as pessoas que conseguem trabalho na fábrica - We are starving out of unemployment - Due to lack of employment our children turn to robbers
Working conditions and job opportunities (at the mine)	Job opportunities offered by the mine (employment conditions) and working conditions when employed by the mine such as salary, type of contract or occupational health issues	<ul style="list-style-type: none"> - Il y a aussi certains qui mangent la bonne nourriture à la mine - Les gens arrivent à entretenir leurs enfants par rapport à avant, car ils y'a des parents qui travaillent à la mine - Pode passar muito tempo, eles não lhe ajudam com a sua doença e se você está doente e trabalha lá e se você não for ao trabalho, logo acabas por perder emprego - They are not giving natives long term employment although we are grateful natives have been given security guard posts - The mining provided employment through the government and the government employed security guards and that is where we get that money that we are discussing - Most of mining employees get sick due to the dust in the mining, - We are short term employees at [the mine] - Employment opportunities which are offered to natives is <i>sungusungu</i> (local security guards), it is kind of employment which we are not happy with because it is the lowest posts at the mining

* Participants speaking in the third person plural (they, their, them), they usually refer to the mine; before and after refers to before or after the implementation of the mine. Square brackets ([...]) are used to indicate changes made from the original transcript (e.g. to censor proper names or places).

S3: Original quotations of coded health outcomes

Complementary table to Table 3 with statements in original languages of selected quotations including of positive and negative health outcomes, categorized by morbidity, mortality, well-being as of the coding system.

	Positive	Negative
Morbidity		
Diseases	<ul style="list-style-type: none"> - On dépose le savon au bord des toilettes pour qu'après les selles on se lave les mains afin d'éviter les maladies (BF2_L2) - Agradecemos essa rede que trazem porque reduz um pouco a picada do mosquito (MZ2.2_L1) - Agradecemos porque vamos ao hospital porque [...] vamos para receber medicamentos e essas da [empresa] dão e tomamos (MZ2.2_L7) - Now due to the presence of a dispensary children are taken there for testing and if they diagnosed with malaria they are given medicines (TZ3_L2) - There is testing of HIV frequently in our community (TZ2_L3) 	<ul style="list-style-type: none"> - C'est depuis l'implantation de la mine que nous tombons malade (BF2_L7) - A empresa provoca muitas doenças (MZ2.2_L1) - We were using unprotected wells, they had no much effect but after the mining [...], now there are many diseases and we think it is caused by water (TZ2_L7) - Dust is produced when they are grinding stones and this dust is spreading to the community where people are living. As a result people are getting cough (TZ2_L3) - Also there is an increase of HIV transmission because many people from different regions came to work in the mining (TZ2_L1)
Accidents and injuries	n/a	<ul style="list-style-type: none"> - Les accidents de circulation qu'on y rencontre de la part des véhicules et de leurs camions (BF1_L4) - [Um carro] da empresa Kenmare quase que me atropelava (MZ2.1_L1) - If adult caught for stealing Magwangala [ore in the mine] are beaten so badly because you are matured enough to know what you are doing is wrong (TZ3_L7)
Disabilities	<ul style="list-style-type: none"> - We have good cooperation with the NREP [natural resource extraction project] we are allowed to employ this woman who is a cripple (TZ1_L6) - The mining sponsors for medical treatment for children who have midomo ya sungura [open-cleft] (TZ3_L3) 	<ul style="list-style-type: none"> - Ils sont venus tout fouiller avec leur machines font que ces génies étaient tranquille commence à ce mélanger au humains ce qui fait que certaines femmes mettent des enfants bizarre au monde (BF1_L3) - Essas doenças é que estão mais cheias agora diferente de antigamente aqui, esse assunto de Romatismo é criando por causa da poeira (MZ2.1_L2) - I was working in the mining but later they discovered that I have sight problem (TZ1_L3)

Mortality

- Nós agradecemos essa rede que nós dão [...] Se não fosse **rede** ninguém ia sobreviver aqui na comunidade (MZ2.2_L11)
 - We were travelling long distance to **get health services** so it was costful also we losted our beloved ones a mother or child because of delivering on the way to the health facility and some women decided to deliver at home because they couldn't afford the cost to go to the health center all these led to maternal deaths in our community but now situation has been improved (TZ1_L2)
 - Ceux qui souffrent là risque de mourir dans leur maisons car ils n'ont plus **rien a mangé** (BF1_L2)
 - Depuis que la mine est arrivée vraiment il n'y a plus la santé et les gens **ne vivent plus longtemps** (BF3_L1)
 - Tem muitas doenças que **nós mata** (MZ2.2_L2)
 - Aqueles que têm coragem vão lá mesmo no mato, mesmo que **possam ser mortos**, para tentar cava (MZ3_L7)
 - When the houses have cracks the vibrations may cause the house to fall down and **you will all die** in there (TZ3_L3)
 - Going to steal remaining of the processed stones called "magwangala", so **the security guard kills them** for self-defence (TZ3_L1)
 - The use of unsafe water is what causes **miscarriage** (TZ2_L2)
 - If you consider all these factors the answer is people from [our village] are **the living dead** (they are expecting to die) because they are using things which are not safe (TZ3_L7)
-

Well-being

- Les gens arrivent à **entretenir** leurs enfants par rapport à avant, car ils y'a des parents qui travaillent à la mine (BF3_L5)
- Drilled well has improved **healthy** because water is safe (TZ1_L6)
- The ENREP [natural resource extraction project] has constructed school, classrooms and toilets which has improved our **well-being** (TZ2_L5)
- So when mining built this health center here we **feel good**, we get treatment near our homes and we don't waste transport fee as we used to do before (TZ2_L7)
- Nous n'avons **plus une bonne qualité de vie**, c'est pas facile de vivre permanant «en bas de la poussière» (BF2_L8)
- Il n'y a pas d'eau, pas de travail, c'est la **misère** (BF1_L2)
- Quand ils font le dynamitage, on sursaute de **peur** à chaque moment (BF1_L4)
- Comemos mal, **dormimos a maneira**, as nossas machambas já reduziam até 50 metros e o resto são desses brancos (MZ2.2_L3)
- People are currently living with **fear** because boundaries between the community and mining are not clear (TZ1_L5)
- We **do not trust** the water that we use (TZ1_L5)
- We are in a very **difficult situation** because the poisons they using are dangerous (TZ3_L4)
- We have been **weak** due to lack of money from mining jobs (TZ2_L2)

4. Gendered health impacts of industrial gold mining in northwestern Tanzania: perceptions of local communities

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4.1 Abstract

Mining projects affect the health of surrounding communities by inducing environmental, economic, social and cultural changes in different population groups. Health impact assessment (HIA) offers an opportunity to manage these impacts. This paper aims to explore gender differences of impacts on the wider determinants of health as described by communities impacted by industrial gold mining and consider the implications for impact assessment. We conducted 24 gender-separated, participatory focus group discussions at three study sites in northwestern Tanzania. Participants reported on a broad range of impacts on the wider determinants of health. Based on a thematic analysis, we identified gendered health impacts on men and women; in addition, children and adolescent boys and girls emerged as differently affected subpopulation groups. Located in the theory of the 'triple role of women', we suggest that different gender needs should be addressed more explicitly by HIA. Increased use of mitigation measures that recognise and address impacts on women's engendered roles, and their health, through addressing women's strategic gender needs, would strengthen HIA as a tool towards sustainable development.

4.2 Introduction

Natural resource extraction projects (NREPs), such as industrial gold mines, may have transformative potential for sustainable development, encompassing the health-related targets of the Sustainable Development Goals (SDGs) (Yakovleva et al. 2017, Winkler et al. 2020a). This includes both positive and negative implications for local communities and their health. On the one hand, NREPs have the potential to strengthen health systems through partnership arrangements and improve people's health through specific disease prevention and health promotion measures (Knoblauch et al. 2014, 2020). Further, NREPs can contribute to health and well-being through improved socio-economic status or upgraded infrastructure and public services, such as education and access to clean water, sanitation and hygiene (Admiraal et al. 2017; Winkler et al. 2012). On the other hand, environmental degradation, exacerbating poverty and social disruption associated with NREPs often lead to adverse health outcomes in impacted communities (Winkler et al. 2012; Carney and Gushulak 2016; Aboka et al. 2018; Dietler et al. 2020a).

Due to their different social roles, men and women do not equally experience the benefits and trade-offs of NREPs. Previous research suggests that women are disproportionately affected by the negative impacts (Eftimie et al. 2009b; Muchadenyika 2015; Sulle and Dancer 2019; see also Hill et al. 2021, Kimotho and Ogot 2021, this volume). Evidence also shows that particularly in terms of socio-economic impacts (e.g. employment), women are left behind if no specific measures to promote their inclusion are put in place (Adusah-Karikari 2015; Knoblauch et al. 2018). This paper builds on this body of research by focusing on the gendered health impacts of large NREPs, based on the example of industrial gold mining in Tanzania.

Gender can be defined as a social construct referring to the conventions, roles, behaviours, rights, and decision-making power of men and women in society (Krieger 2003). As such, gender is also considered as a structural determinant of health, together with social class and ethnicity (WHO 2010). Gender thus intersects with other factors, such as age, education, income, ethnicity, sexual orientation and place of residence, and the impact of gender on health and any mitigating interventions must be considered in the context of these other factors (Bates et al. 2009; Hankivsky 2014; O'Neill et al. 2014). As a powerful determinant for health and well-being, achieving gender equity is also an important step towards a more equitable world as stated in the imperative of the 2030 Agenda for Sustainable Development to 'Leave no one behind' (UNGA 2015; George et al. 2019).

Mining companies, financial institutions, and international civil society organisations have developed tools, measures and strategies to reduce gender inequities and prevent potential adverse health impacts. For example, the international mining company Rio Tinto (2009), has published a resource guide emphasising the importance of gender and diversity in local

communities; the World Bank and the International Finance Corporation (IFC) have provided guidance documents pertaining to gender aspects in risk mitigation and project development potential in affected communities (IFC 2009, 2018; Eftimie et al. 2009a; World Bank 2016, 2018); and the civil society organisation Oxfam has produced a gender impact assessment (GIA) guidance (Hill et al. 2017). Impact assessments are commonly carried out at different stages of NREP development, to systematically identify and mitigate potential negative impacts along with maximising potential positive impacts – and as such present an opportunity for operationalising such tools. Guidance for health impact assessment (HIA) has also been developed (e.g. ICMM, 2010; IPIECA, 2016). When it comes to the application of these guides and tools, however, there is a significant gap between theory and practice (see also Götzmann and Bainton 2021, this volume). This holds particularly true for sub-Saharan Africa where research has demonstrated that HIA practice comes with many challenges (Leuenberger et al. 2019; Dietler et al. 2020b; Winkler et al. 2020b).

While several papers have investigated economic or social gender impacts in industrial mining areas in Africa, gender-specific health impacts have not yet been researched (Jenkins 2014; Adusah-Karikari 2015; Muchadenyika 2015). Additionally, while many studies on gender issues in NREP settings have focused on women, far fewer have engaged deeply with men's gender roles as part of scrutinising the complexity of gender issues (Hankivsky 2012). Therefore, this paper explores local perspectives on how NREPs impact on gender roles as related to health. More specifically, our research seeks to understand how NREPs influence the wider determinants of health and how the respective health outcomes are distributed in communities, with a focus on the differences between men and women. The 'wider determinants of health' can be defined as a diverse range of environmental, economic and social factors which impact on people's health; where it is recognised that such factors are influenced by the distribution of power and resources that shape the conditions of everyday life (WHO 2010). Our research was guided by the following three research questions: How do affected communities perceive impacts of large NREPs on the wider determinants of health? How are these impacts distributed among key population subgroups? How are the differences between men and women explained?

The paper proceeds as follows. We first present the methodology and findings from our qualitative field study conducted in Tanzania and contextualise the gendered health impacts with the theory of the 'triple role of women' (Moser 1989, 1995). We then discuss the implications of the results for promoting HIA as a unique opportunity to more explicitly address strategic gender needs in NREP settings.

4.3 Methods

This study was conducted as part of a larger research project, including the necessary ethics approvals, aiming to generate scientific evidence about health impacts in mining settings to strengthen HIA in sub-Saharan Africa (Farnham et al. 2020; Winkler et al. 2020a).

4.3.1 Study area

The study was conducted in northwestern Tanzania, where several industrial gold mines have been implemented in the last two decades, including the three gold mines investigated. Data was collected in communities surrounding the Geita, Bulyanhulu and Buzwagi gold mines (see **Figure 11**). In these rural areas, agriculture is the main occupational activity, while artisanal mining was observed around all three industrial mines (Ministry of Health Zanzibar and Office of Chief Government Statistician Zanzibar 2016). With the implementation of the large-scale gold mines, the livelihoods of local populations have changed, which can be closely linked to the associated loss of land and rapid urbanisation (Bainton et al. 2020; Dietler et al. 2020a).

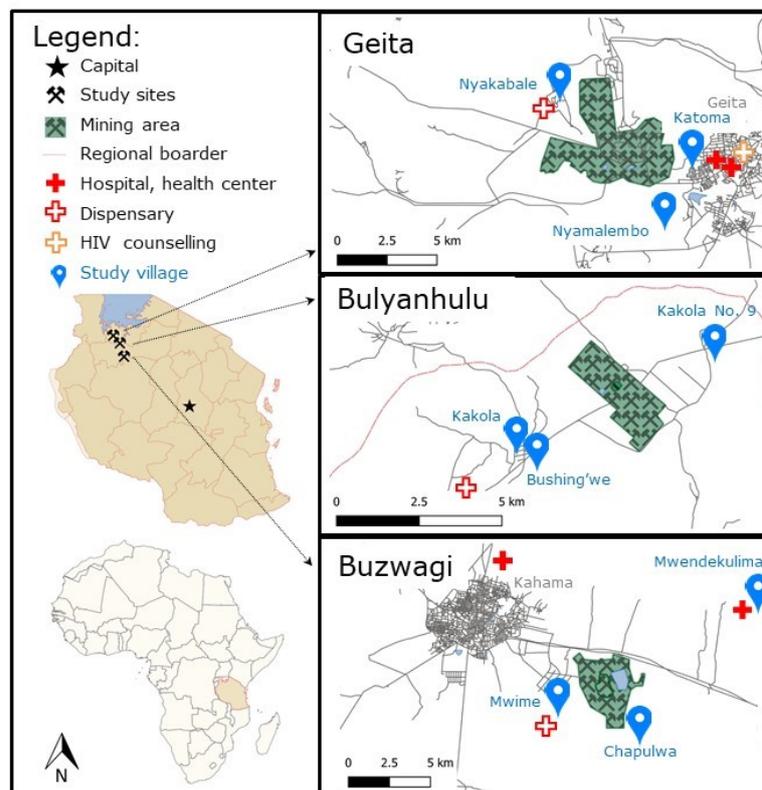


Figure 11: Map of study area and study sites with indicated study villages, where data has been collected in Tanzania, 2019.

4.3.2 Sampling and interviewees

At each study site, we collaborated with local coordinators from the respective health district. Based on a transect walk under the guidance of the local coordinator, we identified highly impacted communities in proximity of the mine and identified community members for focus group discussions (FGDs). In the selected villages and with the assistance of community

leaders or health workers, gender-separated FGDs were held with purposively sampled community members.

Overall, 183 community members participated (94 men, 89 women), with an average of eight community members per FGD (see **Table 4**). On average, participants were 44.5 years old (median: 42 years), had lived for 20 years in their communities (median: 18 years) and had attended few years of formal education. Agriculture was the main occupation reported, but artisanal mining was also mentioned as a common income-generating activity at all study sites. Furthermore, about a third ($n = 27$) of all participating women were running their own business, and a minority ($n = 3$) of them considered being a housewife as their main occupation. At the time of the data collection, none of the participants reported being employed by the mining companies. Notably, unskilled labour work, such as a local security guard ('sungusungu' in Swahili) at the mines, was not considered by participants to constitute 'proper employment'. About a third ($n = 58$) of all respondents (but relatively more women, $n = 35$, 60.3%) were actively engaged in community-based organisations, such as 'savings and borrowings' ('vikoba') or the association of vegetable gardeners.

Table 4: Socio-demographic characteristics of study participants from all 24 focus group discussions conducted in the three study sites in northwestern Tanzania.

	Women	Men	Total
Total number of participants	94	89	183
Age			
Average (in years)	41.5	47.6	44.5
Range (in years)	20-77	19-77	19-77
Marital status			
Married	75	85	160
Single	17	4	21
Widowed	2	0	2
Education			
None	8	3	11
Primary incomplete	1	6	7
Primary completed (Standard VII)	66	62	128
Secondary incomplete	1	1	2
Secondary completed (Form IV)	15	14	29
Higher education (Diploma, University)	3	3	6
Occupation			
Farmer	58	70	128
Entrepreneur	27	9	36
Others	9	10	19
Community based organizations			
Member	35	23	58
Leading role (chair or assistant chair)	13	8	21

4.3.3 Data collection and preparation

Fieldwork was conducted from March to May 2019. As shown in **Figure 12**, a participatory tool to collect, categorise and rank impacts on the wider determinants of health was used to facilitate the FGDs. All discussions were moderated and audio-recorded in Swahili by an experienced social sciences researcher (female, Tanzanian) and assisted by another researcher (female, Swiss). At all three study sites, four FGDs were conducted with men and four with women (24 FGDs in total), each of which lasted on average 91 minutes and was followed by a team debriefing. Swahili audio-files were transcribed verbatim into English.

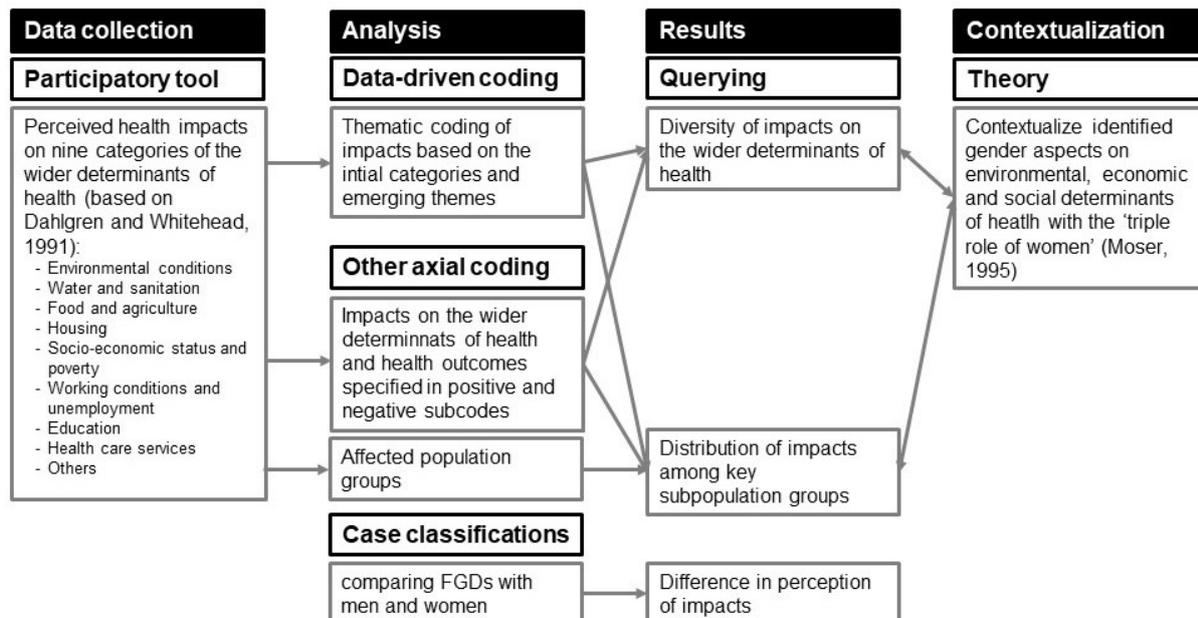


Figure 12: Flowchart indicating methodological aspects of different phases of the study from data collection, to analysis, results and contextualisation (FGD: focus group discussion).

4.3.4 Data analysis and theoretical framing

As indicated in **Figure 12**, the aim of the analysis was threefold: (1) to explore the communities' perceptions of impacts on the wider determinants of health; (2) to compare the differences in how women and men perceived these impacts; and (3) to understand how men and women, adolescents and children are differently impacted as key subpopulation groups with regard to gender. The initial analysis, which included data from all three study sites, was mainly driven by the first author using Nvivo Pro (QSR International Pty Ltd, Victoria, Australia).

Rooted in thematic data analysis, the categories applied during the data collection process (see **Figure 12**) were used as initial coding structure and emerging themes (i.e. sanitation and community dynamics) were incorporated during the analysis (Braun and Clarke 2006; DeCuir-Gunby et al. 2010). Beyond the thematic structure of the different impacts (e.g. air pollution), the data was coded along other axes, such as related health outcomes (e.g. cough, flu) and population groups affected (DeCuir-Gunby et al. 2010). Based on the axial

coding and case classifications, queries were run in Nvivo to analyse the data and to create the matrices (see **Figure 13** and **Figure 14**).



Figure 13: Negative (red) and positive (green) impacts on the wider determinants of health classified by data sources (i.e. FGDs with men, FGDs with women and pooled analysis); colour gradient indicates relative coding frequency.



Figure 14: Distribution of negative (red) and positive (green) impacts on the wider determinants of health among key subpopulation groups (children, boys, girls, men and women) based on axial coding; colour gradient indicates coding frequency.

To interpret our findings with a gender lens, we draw on the concept of the 'triple role of women' (Moser 1989, 1995). This concept is a key element of Moser's gender analysis and planning framework, in which mapping the gendered labour divisions is a core element for planning development interventions. Based on the recognition of the interplay between the different roles Moser identifies women's work to be threefold: (1) women take care of the child-

rearing and household work (reproductive work); (2) women are responsible for creating a secondary income for the household (productive work); and (3) women are engaged in the community (community managing work). The male role, in contrast, is considered as primary income-generator (productive role). Although men play an active role in reproductive work, expectations are not as clearly defined compared to women, and men continue to be seen as key decision-makers in all domains, according to Moser and others (Balgah et al. 2019). While the triple role concept has been criticised, including on the basis that it can obscure the distinction between an activity and an outcome (e.g. Kabeer 2015), we find that the concept provides a useful entry point for analysing our findings of environmental, economic and social impacts of NREPs through the reproductive, productive and community managing gender roles; as well as to locate our findings beyond gender roles, in practical and strategic gender needs. Practical needs evolve from concrete experiences, and thus from women's engendered role in the sexual division of labour. Strategic gender needs originate from an analytical perspective of the subordinated position of women (Moser 1989). Addressing strategic gender needs potentially translates to a transformative gender approach with the ultimate objective of shifting unequal gender relations (Kågesten and Chandra-Mouli 2020). If more cognisant of these different types of needs, HIA, we suggest, provides a unique opportunity to contribute to realising gender equality through identifying and addressing strategic gender needs more explicitly in NREPs settings.

4.4 Limitations

While aiming for rigour in research, the scope of our methodology is limited by the following three characteristics. Firstly, although highly impacted villages were systematically chosen based on a transect walk, it is probable that the mines' impacts reach far beyond the villages sampled. Several other studies have investigated impacts of industrial NREPs on their broader environment, including the closest towns and their inhabitants, suggesting that we chose an appropriate radius for our impacted villages (Jackson 2018; Dietler et al. 2020a). Secondly, this study purely reflects the perspectives of the community members. Further research would benefit from including voices from the health district officials or employees of the mining companies. To minimise the risk of an unbalanced sample of participants in terms of their attitudes towards the mining projects, we targeted knowledgeable community members from systematically selected villages, which were positively and negatively impacted. Thirdly, the analysis and contextualisation of this qualitative gender paper focusses mainly on differences between men and women. The categorisation of gender as social roles assigned to men and women is used in this paper as a transversal category, while it does not reflect the full diversity of a community in terms of other social, economic and cultural aspects (Bates et al. 2009; Hankivsky 2014; see also Levac et al. 2021, this volume). While touching on some

intersectional elements (i.e. age), applying a more comprehensive intersectional analysis was beyond the scope of the current study.

4.5 Results

In all FGDs, a broad range of impacts on the wider determinants of health was observed. Based on the coding frequency, Figure 3 visualises how often the different topics were discussed, disaggregated by gender. Figure 4 shows how the impacts are distributed among key subpopulation groups, as identified based on the communities' perception (i.e. men, women, adolescent boys and girls, and children). A more detailed overview of positive and negative impacts and related health outcomes is given in the Annex (see Supplementary Material). In the following sections, we focus on specific gender impacts and analyse how these key subpopulation groups are differently affected by impacts on environmental, economic and social determinants of health.

4.5.1 Environmental impacts, gender and health

Overall, discussions about environmental issues were profoundly negative, and consisted mainly of the environmental hazards and degradation caused by the mines. The main concern of respondents was the unsafe and insecure housing situation caused by cracks in the houses due to mining-related blasting, potential or actual resettlement, and increased traffic. Cracks in the house were mentioned in all FGDs and described by one participant as follows:

Blasting causes strong vibrations, which cause cracks on many houses in the community ... Triiiiiiiiiiii (sound of vibration) it is like the sound of the train. (BUZWAGI, L4)

Consequently, community members were fearful that their house would fall down while they were sleeping. According to some participants, this fear particularly affects women and children, as they spend more time at home compared to men. However, cracks in the house also affect men, as they are usually responsible for repairing the house.

The next most frequently mentioned topics were related to soil and land. Participants noted a decrease in agriculture due to less productive or polluted soil and loss of land. The communities reported being affected by chemicals coming from the mines to the agricultural fields, expressing that this polluted their crops and caused skin rashes. In some extreme cases, participants associated this exposure with miscarriages. Further, due to the reduced agricultural production, providing food for the family was reported as a challenge for men, but also for women who had to find alternative means to feed the family. Deforestation emerged as another theme in the category of soil and land. This affected women in particular, as they had to walk further to collect firewood for cooking. In case no firewood was available,

participants reported buying charcoal as an alternative, which was an additional burden on the men who were considered primarily responsible for providing for these additional funds. Although women's health and their different domestic tasks were heavily impacted, men mentioned topics related to soil and land more frequently, especially as related to loss of agricultural land and their role as landowners.

The third major environmental theme discussed was water. Participants reported pollution of different water bodies and decreased availability of water. They stated that the dust from the blasting in the mines had contaminated their (unprotected) wells, dams and rivers, as well as leaving them unable to drink the rainwater they traditionally collect as drinking water. They also perceived that chemicals from the tailings dam had penetrated their water sources. Consequently, reaching a clean water source was difficult and fetching water, which was in general reported as one of women's domestic tasks, was more time-intensive. Because of the 'unsafe water', as participants often referred to poor water quality, they stated that children were getting intestinal diseases more frequently.

Fourthly, air pollution was a recurrent theme with different causes. Participants mentioned the dust from the mining activities, the passing mining trucks on the unpaved roads and bad odour next to the mines. According to the participants, the whole community was exposed to air pollution, but children were particularly at risk. They mentioned frequent respiratory ailments and diseases, such as cough and flu and linked it to the children's immature immune system.

Taken together, the environmental degradation caused by the mines affected women in particular in their domestic tasks as mothers and housewives, as well as having particular impacts on children as they fall sick more often. Participants, however, also acknowledged positive effects of the mining industry, such as new roads and water access points constructed by the mining companies. The improved road network allowed community members to more quickly reach health facilities. New water access points were – when functional – perceived as a relief, particularly for women due to the culturally constructed gender expectation that fetching water is the role of women.

4.5.2 Economic impacts, gender and health

Overall, the topic of having, generating or seeking an income is a highly dynamic topic for communities around industrial gold mines and clearly a key concern for their health as a means to be able to afford food and health care. The link between their poor economic situation and health was explained as follows:

There is [a] decrease of the economic status of people living in this community ... To be healthy you must have enough income which will

enable you to get requirements needed for yourself and your family. But if you don't have enough money then you will not manage to provide for your family or even to access health services when necessary.

(BUZWAGI, L4)

Most prominently in this category, participants discussed the impact on their traditional income-generating activities, such as farming and artisanal gold mining. Despite compensation payments or reallocation, in several villages participants felt that their land for agriculture or areas for artisanal mining had been taken by the mine. This forced them to stop these activities, or for the latter one, continue it illegally:

We are practicing agriculture and pastoralism but we are mostly dependent on small mining in certain areas that's why when the mining company took this area we were affected a lot because we don't have another area to do our work. (BULYANHULU, L7)

As a consequence, new gender-specific strategies to generate income were developed and reported at all study sites. Boys and young men risk their life to illegally access the tailings in the mine to 'steal precious stones', as they described it. Once caught by guards inside the mine ('ukorokoron'), they are reportedly heavily beaten. Adult men who committed the same crime were even subject to fatal consequences, according to participants. Adolescent girls and adult women reportedly became involved in 'prostitution', including sexual transactions as well as commercial sex work, through either seeking income or being seduced by in-migrants. As a result, girls and young women have to deal with early pregnancies and often drop out of school. Human Immunodeficiency Virus (HIV) was reported as another lethal health outcome related to these community dynamics. These high-stakes gendered health impacts indicate the important role that boys and young men, as well as girls and young women, play in their family, especially in settings with unsecured household income.

The industrial mining operations provided new job opportunities – but mainly for men. Participants reported limited opportunities for local community members, as they were not qualified for specialised jobs. Therefore, men were mostly involved in unskilled labour work, such as construction works, local security guards ('sungsusungsu') and only a few opportunities such as being a gardener inside the mine were mentioned. However, negative outcomes for their health due to the harsh working conditions and losing their job after a short time outweighed these opportunities. Additionally, salaries of these job opportunities were reported to be low and with these jobs alone men could rarely fulfil their role as 'breadwinners' of their family.

In contrast to the new job opportunities for men, being unemployed was perceived by women to be a major issue, as they need money to raise the children:

They are not giving employment opportunities to women but women are the ones raising children. Some employed men are spending money on alcohol but women who are employed are spending their money to buy food and take good care of their families. (BULYANHULU, L6)

The opportunity for women to be employed by one of the mining companies are lower, based on their statements. Although they were willing to pursue unskilled work like cleaning or cooking, women reported that these tasks were subcontracted to external companies. Regarding other jobs offered to local residents, they were afraid of the hard working conditions, for example, night shifts as a local security guard. In the absence of other opportunities, adolescent girls and women seeking an income become involved in sexual transactions and commercial sex relationships. As a result, the communities noticed an increase in HIV infections, which particularly affected women, who were perceived to be more susceptible than men due to their alleged involvement in prostitution. Participants also reported impacts that were initially perceived as positive, but were not sustainable. At one study site, the mining company staff educated women in 'modern' agriculture and bought their vegetables to prepare food for mining employees. This was acknowledged as a helpful contribution to women's income, but men and women were disappointed once this collaboration was suspended and only few community members continued to benefit.

Other economic factors were identified as a minor theme, such as embracing the compensation payment for land or being resettled, as well as the increase of living costs. Men, as landowners and heads of families, negotiated with the companies about their land and compensation payments. For men, suddenly having a lot of money and the freedom to spend it without the need of consulting other family members, had ambiguous results. As both men and women reported, it should allow men to provide for their children and the family (such as paying school fees), but in practice, this money was on some occasions spent on alcohol, tobacco or sexual transactions. In one case reported, there was no money left to buy new land, with negative implications for the entire household. Some men were overwhelmed by the amount of money received and wished to be educated about keeping or investing money:

People had farms to cultivate but when the investors came they negotiated and paid. But the problem is I have never had a lot of money since I was born so having a lot of money at once made people misuse money and continued to be poor to date. (BUZWAGI, L4)

The increased living costs are particularly challenging for women, who have to pay for certain key household goods, such as food. Satisfying the basic needs for their family without having a reliable source of income was perceived as a major challenge.

Taken together, both men and women struggle to fulfil the economic needs for their families. Some examples indicate windows of opportunities for men to benefit economically, but in the end, negative consequences for their health and well-being often prevailed.

4.5.3 Social service, social organization, gender and health

The category of social services and social organisation, which embraces the topics of health care, schooling and social dynamics, was reported by participants as being highly dynamic in positive and negative aspects.

The topic of health care was mostly positively perceived, especially in relation to the newly constructed health care facilities and the provision of specific services such as ambulances, HIV testing and counselling, as well as disease-specific medical treatment. At most study sites, the upgraded or even newly constructed dispensaries and health centres reportedly benefitted women, and pregnant women in particular. These positive experiences are illustrated as follows:

The presence of that dispensary has helped us, first as women we get health services, for example, in the past when you needed family planning services you must go [to] Geita town but now there are health service providers here at our dispensary, we get that service here. Even delivery services, we give birth here ... unlike in the past where we used a lot of money to go to Geita town. (GEITA, L2)

Although positive perceptions dominated in terms of health care, participants also reported that their needs are not fully satisfied. Overcrowded hospitals and long waiting times, as well as unavailable services or equipment, were still issues of concern.

In relation to education, which is 'key for their health' according to different respondents, positive and negative aspects were reported. On the positive side, construction of teacher houses, school buildings and renovation of toilets contributed to improving the quality of education by promoting ready availability of teachers at school, increasing student enrolment and improving student attendance. On the negative side, the presence of the mine has caused people to drop out of school early, according to participants. It was reported that girls dropped out because of unexpected pregnancies, and boys because of seeking employment elsewhere.

Positive and negative themes also emerged in relation to social dynamics. Respondents valued the formation of specific interest groups such as vegetable gardeners or beekeepers, and the financial support of the mining companies to these groups. In contrast, the introduction of the mines was associated with in-migration, crime and incoherent family structure. Participants linked these impacts to an increased spread of HIV, increased HIV-mortality, and ultimately to an increase in orphans. In response, an orphanage was constructed at one study site and participants reported financial support for orphans from the mining company. Further, community leaders who acted in some villages as liaison officers between the mine and the community became more powerful. For example, they were responsible for distributing job opportunities among community members. These changes in power led to stories about bribing that were narrated during the FGDs.

Taken together, the mining projects served as a strong pull factor for migration, causing different negative impacts on social services and the social organisation of the communities. But related interventions implemented by the mining company were common at all study sites, while new health facilities contributed in particular to improved community health.

4.6 Discussion

As demonstrated by the above findings, local communities experience multiple and dynamic impacts by industrial gold mines on the wider determinants of health, as well as resulting consequences for their health. Our findings also show that the distribution of these impacts differed between specific groups in the population according to age and sex. Particularly adult men and women are impacted differently. This can be explained by their different exposure resulting from their gender-differentiated roles as men and women in reproductive work, productive work (income generation), and community management, as conceptualised by Moser's (1989, 1995) concept of the triple role of women.

4.6.1 Extractive industries, gender roles and gender needs

Settings of NREPs are highly dynamic and changes in traditional livelihoods, such as the shift from subsistence towards a more cash-oriented economy, have implications for different gender roles (see also Hill et al. 2021, this volume). **Figure 15** shows the alignment of gendered health impacts with environmental, economic and social determinants of health as influenced by gender roles (Moser 1995). The triple role of women and the related division of labour as suggested in Moser's theory, was the dominant gender-role model at our study sites. Overall, women's triple role as mothers and housewives, as secondary income generators and with their low-prestige community engagement, contrasted with men's role as primary income generator and decision-maker.

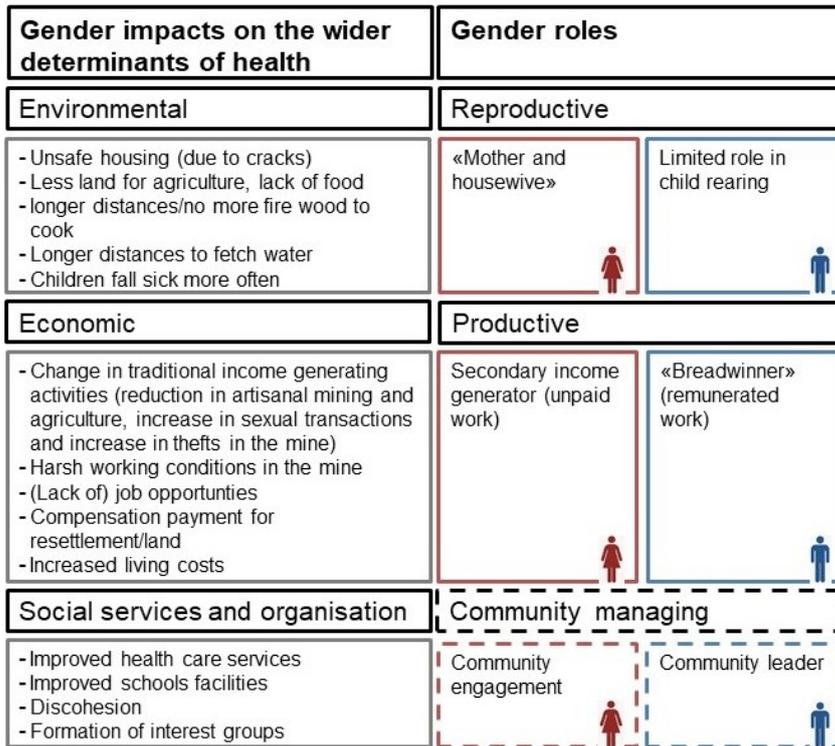


Figure 15: Alignment of gender impacts on the wider determinants of health induced by industrial gold mines and gender roles as of Moser's theory (dashed lines indicate weak evidence based on our data).

The manifold environmental degradation caused by the mines particularly challenged the agricultural and domestic subsistence work, which was found to be primarily the responsibility of women. In addition, women take care of the children, who were reported to fall sick more often since the commencement of mining activities. Consequently, women's workload as mothers and caregivers increases in such dynamic environments, while there is less time to invest in paid work (Adusah-Karikari 2015). In contrast to women, men are considered responsible for the financial and physical aspects of maintaining the household, such as paying school fees of the children and the repair of the cracks in the house. While their role in reproductive work of child rearing was found to be limited, men may only partly be able to meet these financial expectations, shifting the overall burden of the negative impacts towards women.

Regarding economic impacts, only few men and women benefit from the establishment of the mines. Women particularly struggle to ensure the economic well-being of the household as their time and opportunities to create an income are more restricted after the development of the mine. It is worth mentioning that although Moser and other researchers consider women as secondary income generator, they all agree that women's work often provides the actual income for the family (Adusah-Karikari 2015; Balgah et al. 2019; Bryceson 2019). In comparison, men focus on doing remunerated work and this is consistent with them being primary income generators. If men can get a job in the mine, they still face difficulties to fulfil

their role as 'breadwinners' given the low salaries for unskilled labour work. In addition, these opportunities are also closely linked to harsh working conditions and health risks. As landowners, they negotiate about resettlement and receive the compensation payment for land. Despite these potential windows of opportunities for men, only few are able to benefit in the long run. In the context of NREPs, where traditional income-generating activities are changing and new jobs are available mainly for highly skilled external workers, both women and men have to find new ways to create an income. According to the narratives from our study, new income-generating activities can be hazardous and even life-threatening for men and women. In accordance with the work from Whitehead and Kabeer (2001), our data further indicate that women spend their income on the health and well-being of the family, hence fulfilling their reproductive role, while some men tend to spend their money for their own purposes.

Our study also identified gendered impacts on social services and organisation, but the link to the community managing role is less evident. For example, improved health care services, are highly beneficial for women because of their role in reproduction and as caregivers. In this sense, women's engagement in community-based organisations, which allows them to share their interests and support each other, is in line with their gendered role in the community. According to Moser, men, as community leaders, also have a role in the community. However, in contrast to women, this role is usually related to an increase in social status and political power. In settings of NREPs, this role can be further strengthened when community leaders become liaison officers between the company and the community, widening the gender gap within the community.

Overall, the triple role of women and the gendered impacts in the three categories increase women's workload and constrain them from actively participating in the labour force. While men are to a certain extent involved in the mining industry, job opportunities are nonetheless scarce and paid salaries are low. Although increasingly challenging, subsistence work remains an important part of the household's productive work, while women continue to depend financially upon men. While more research is needed on the dynamics of natural resource extraction and its impacts on traditional gender roles in society, our findings indicate how gender roles are interlinked with structural inequalities. Further, gender roles and gendered impacts indicate an unequal distribution of power and resources between men and women, reflecting the subordinated position of women in society (Moser 1995; Bryceson 2019). Consequently, men and women, as well as other population groups, have different strategic needs to address these power dynamics, which need to be made explicit in HIA.

In our context and in line with Moser's theory, interventions for basic services, such as new water access points and improved health care services, address the practical needs of

women. Indeed, such interventions satisfy women's concerns and contribute to the improved health of the community. However, they help to maintain the view that women are subordinate to men, and may preserve engendered roles. As such, new health facilities might mitigate negative impacts but women remain financially dependent on their male partner to seek health care. In contrast, few interventions mentioned during the FGDs recognised women's productive role in income generation. For example, educating women in alternative farming practices or supporting them in vegetable gardening and marketing holds promise in transforming practical needs into strategic needs. While both men and women in mining communities face health effects, our data indicates that women are particularly adversely affected in patriarchal societies. Therefore, a gender transformative approach is needed in HIA practice to reduce gender inequalities and challenge the sexual division of labour (Sharma and Rees 2007; Kågesten and Chandra-Mouli 2020).

4.6.2 Solutions to gender-based needs from HIA

This paper reflects on community perception of gender-related impacts of mining on health within the framework of a larger research project focused on HIA in sub-Saharan Africa (Farnham et al. 2020; Winkler et al. 2020a). Our findings suggest that negative impacts outweigh positive impacts, with men and women, as well as children, boys and girls, experiencing adverse consequences for their health. Hence, our study provides evidence and fuels the need for improved identification and management of gendered health impacts.

With regard to gender and health, GIA and HIA arguably have great potential to prospectively identify and address gender-based inequities around mine implementation. The Oxfam guide for GIA holds promise to address strategic gender needs by evaluating the possession of and control over assets, as well as decision-making power (Hill et al. 2017). Beyond the differences between men and women, the guide also highlights the differences within these population groups and considers other factors determining effects on different subpopulation groups, such as age and place of residence. Unlike GIA, HIA is primarily focused on contributing to health and well-being of impacted communities. With equity as a core value, HIA holds promise to address inequities, yet the specific experiences of impacts of different subpopulation groups, need to be considered more systematically (Leuenberger et al. 2019; Winkler et al. 2021). Evidence shows that rigorously conducted HIA contributes to better health of impacted communities, and in some cases also particularly to women's health (Knoblauch et al. 2014, 2018, 2020). Further, equity-focused HIA, a specific and more advanced HIA methodology, holds promise to specifically address communities' needs in order to achieve more equitable outcomes (Harris-Roxas et al. 2004; Heller et al. 2014).

Although our findings are specific to our study, we can conclude that more thoroughly considering the gender roles and dynamics in NREP settings is key to understanding inequalities and developing strategies for mitigation (see also Hill et al. 2021, Kimotho and Ogol 2021, this volume). Given the above-mentioned potential of HIA, it could be further improved by more systematically considering the gendered division of labour and addressing strategic gender needs more explicitly. For example, comprehensive HIA should aim for minimising the negative impacts on subsistence (i.e. agricultural production for home production) and reproductive work, and strengthening the economic and social development of impacted communities, while considering mitigation strategies for negative gender-based impacts. As emphasised in the new gender guidelines published by IFC, special attention should be drawn to women's conflicting responsibilities and their subordinate position, as they play a central role in the health of the community as well as its development (Sen and Hausman 2007; IFC 2018). Hence, HIA offers a great opportunity to contribute to fostering sustainable development by promoting community health and simultaneously contributing to shifting gender norms and reducing gender inequities (UNGA 2015; Gupta et al. 2019). Finally, solutions to improve health should be gender sensitive by creating inclusive approaches for decision-making as well as gender transformative by challenging imbalanced power structures in society (WHO 2011). Yet, HIA is underutilised in sub-Saharan Africa and continued efforts are needed to strengthen HIA in contexts of natural resource development.

4.7 Conclusion

Large NREPs, such as industrial gold mines, have transformative potential for sustainable development. For local communities, risks might outweigh the opportunities, with women being disproportionately affected, which in turn calls for thorough and inclusive management. Particularly in sub-Saharan Africa, current measures for the health and well-being of impacted communities are weak and approaches such as HIA or environmental, social and health impact assessments, need to be more rigorously promoted. In this qualitative, gender-focused study, we demonstrate the diversity of impacts on the wider determinants of health based on communities' perceptions in the context of industrial gold mining and we describe how these impacts are distributed among key subpopulation groups. We observed gender impacts across environmental, economic and social determinants of health. Linked to women's triple role, specific gender impacts were observed across all three categories, with the most substantial impacts in their productive and reproductive role. In contrast, specific gender impacts for men were mostly related to economic determinants of health, linked to their primary role as 'breadwinners'. Clearly, men and women, due to their different roles, have different needs. Indeed, HIA and other forms of impact assessment should explicitly address these gender needs, while considering how health and health care may be affected if women

are more strongly included in the economy and therefore suggesting gender-transformative solutions to improve community health. As a tool for achieving equity and sustainability, HIA offers a particular opportunity to integrate strategic interventions that create equal opportunities for good health and well-being for all.

4.8 References

- Aboka, Y. E., Cobbina, S. J., & Doke, A. D. (2018). Review of environmental and health impacts of mining in Ghana. *Journal of Health & Pollution*, 8(17), 43-52. <https://doi.org/10.5696/2156-9614-8.17.43>
- Admiraal, R., Sequeira, A. R., McHenry, M. P., & Doepel, D. (2017). Maximizing the impact of mining investment in water infrastructure for local communities. *The Extractive Industries and Society*, 4(2), 240-250. <https://doi.org/10.1016/j.exis.2017.01.014>
- Adusah-Karikari, A. (2015). Black gold in Ghana: Changing livelihoods for women in communities affected by oil production. *The Extractive Industries and Society*, 2(1), 24-32. <https://doi.org/10.1016/j.exis.2014.10.006>
- Balgah, R. A., Amungwa, F. A., & Egwu, B. M. J. (2019). A gender analysis of intra-household division of labor in Cameroon using Moser's triple roles framework. *Asian Journal of Agricultural Extension, Economics & Sociology*, 1-12. <https://doi.org/10.9734/ajaees/2019/v29i430095>
- Bates, L. M., Hankivsky, O., & Springer, K. W. (2009). Gender and health inequities: A comment on the Final Report of the WHO Commission on the Social Determinants of Health. *Social Science and Medicine*, 69(7), 1002-1004. <https://doi.org/10.1016/j.socscimed.2009.07.021>
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101. <https://doi.org/10.1191/1478088706qp063oa>
- Bryceson, D. F. (2019). Gender and generational patterns of African deagrarianization: Evolving labour and land allocation in smallholder peasant household farming, 1980–2015. *World Development*, 113(2019), 60-72. <https://doi.org/10.1016/j.worlddev.2018.08.021>
- Carney, J. G., & Gushulak, B. D. (2016). A review of research on health outcomes for workers, home and host communities of population mobility associated with extractive industries. *Journal of Immigrant and Minority Health*, 18(3), 673-686. <https://doi.org/10.1007/s10903-015-0328-4>
- DeCuir-Gunby, J. T., Marshall, P. L., & McCulloch, A. W. (2010). Developing and using a codebook for the analysis of interview data: An example from a professional development research project. *Field Methods*, 23(2), 136-155. <https://doi.org/10.1177/1525822x10388468>
- Dietler, D., Farnham, A., de Hoogh, K., & Winkler, M. S. (2020a). Quantification of annual settlement growth in rural mining areas using machine learning. *Remote Sensing*, 12(2), 235. <https://doi.org/10.3390/rs12020235>
- Dietler, D., Lewinski, R., Azevedo, S., Engebretsen, R., Brugger, F., Utzinger, J., & Winkler, M. S. (2020b). Inclusion of health in impact assessment: A review of current practice in sub-Saharan Africa. *Int J Environ Res Public Health*, 17(11). <https://doi.org/10.3390/ijerph17114155>
- Eftimie, A., Heller, K., & Strongman, J. (2009a). Mainstreaming gender into extractive industries projects. *The World Bank*. http://siteresources.worldbank.org/EXTOGMC/Resources/eifd9_gender_guidance.pdf

- Eftimie, A., Heller, K., & Strongman, J. (2009b). Gender dimensions of the extractive industries: Mining for equity. The World Bank. https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/publications/publications_report_genderdimensionsofextractiveindustries__wci__1319576704143
- Farnham, A., Cossa, H., Dietler, D., Engebretsen, R., Leuenberger, A., Lyatuu, I., Nimako, B., Zabre, H. R., Brugger, F., & Winkler, M. S. (2020). Investigating health impacts of natural resource extraction projects in Burkina Faso, Ghana, Mozambique, and Tanzania: Protocol for a mixed methods study. *JMIR Research Protocols*, 9(4), e17138. <https://doi.org/10.2196/17138>
- George, A. S., Amin, A., García-Moreno, C., & Sen, G. (2019). Gender equality and health: Laying the foundations for change. *The Lancet*, 393(10189), 2369-2371. [https://doi.org/10.1016/s0140-6736\(19\)30987-0](https://doi.org/10.1016/s0140-6736(19)30987-0)
- Götzmann N, Bainton N. 2021. Embedding gender-responsive approaches in impact assessment and management. *Impact Assess Project Appraisal*. 39(3):171–182. doi:10.1080/14615517.2021.1904721.
- Gupta, G. R., Oomman, N., Grown, C., Conn, K., Hawkes, S., Shawar, Y. R., Shiffman, J., Buse, K., Mehra, R., Bah, C. A., Heise, L., Greene, M. E., Weber, A. M., Heymann, J., Hay, K., Raj, A., Henry, S., Klugman, J., & Darmstadt, G. L. (2019). Gender equality and gender norms: Framing the opportunities for health. *The Lancet*, 393(10190), 2550-2562. [https://doi.org/10.1016/s0140-6736\(19\)30651-8](https://doi.org/10.1016/s0140-6736(19)30651-8)
- Hankivsky, O. (2012). Women's health, men's health, and gender and health: Implications of intersectionality. *Social Science and Medicine*, 74(11), 1712-1720. <https://doi.org/10.1016/j.socscimed.2011.11.029>
- Hankivsky, O. (2014). Intersectionality 101. The Institute for Intersectionality Research & Policy.
- Harris-Roxas, B., Simpson, S., & Harris, L. (2004). Equity-focused health impact assessment: A literature review. Australasian Collaboration for Health Equity Impact Assessment (ACHEIA). [http://hiaconnect.edu.au/old/files/Harris-Roxas_B_\(2004\)_Equity_Focused_HIA.pdf](http://hiaconnect.edu.au/old/files/Harris-Roxas_B_(2004)_Equity_Focused_HIA.pdf)
- Heller, J., Givens, M. L., Yuen, T. K., Gould, S., Jandu, M. B., Bourcier, E., & Choi, T. (2014). Advancing efforts to achieve health equity: Equity metrics for health impact assessment practice. *International Journal of Environmental Research and Public Health*, 11(11), 11054-11064. <https://doi.org/10.3390/ijerph111111054>
- Hill, C., Madden, C., & Collins, N. (2017). A guide to gender impact assessment for the extractive industries. Oxfam. https://www.oxfam.org.au/wp-content/uploads/2017/04/2017-PA-001-Gender-impact-assessments-in-mining-report_FA_WEB.pdf
- ICMM. (2010). Good practice guidance on health impact assessment. International Council on Mining and Metals (ICMM). <https://www.icmm.com/website/publications/pdfs/health-and-safety/792.pdf>
- IFC. (2009). Women in mining. International Finance Cooperation (IFC). https://www.ifc.org/wps/wcm/connect/a3e296da-ffd8-40b3-a4d3-254fdc1d5231/IFC-LONMIN_WomenInMining_Manual.pdf?MOD=AJPERES&CVID=jaDDmao
- IFC. (2018). Unlocking Opportunities for women and business: A Toolkit of Actions and Strategies for Oil, Gas, and Mining Companies. International Finance Cooperation (IFC). https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/gender+at+ifc/resources/unlocking-opportunities-for-women-and-business

- IPIECA. (2016). Health impact assessment - a guide for the oil and gas industry. International Petroleum Industry Environmental Conservation Association (IPIECA). <https://www.ipieca.org/resources/good-practice/health-impact-assessment-a-guide-for-the-oil-and-gas-industry/>
- Jackson, R. T. (2018). Migration to two mines in Laos. *Sustainable Development*, 26(5), 471-480. <https://doi.org/10.1002/sd.1892>
- Jenkins, K. (2014). Women, mining and development: An emerging research agenda. *The Extractive Industries and Society*, 1(2), 329-339. <https://doi.org/10.1016/j.exis.2014.08.004>
- Kabeer, N. (2015). Gender, poverty, and inequality: a brief history of feminist contributions in the field of international development. *Gender & Development*, 23(2), 189-205. <https://doi.org/10.1080/13552074.2015.1062300>
- Kågesten, A., & Chandra-Mouli, V. (2020). Gender-transformative programmes: Implications for research and action. *The Lancet Global Health*, 8(2), e159-e160. [https://doi.org/10.1016/s2214-109x\(19\)30528-5](https://doi.org/10.1016/s2214-109x(19)30528-5)
- Kimotho W, Ogol D. 2021. Exploring the drivers of gendered grievance mechanisms: examples from the agribusiness, extractive and wind power sectors in Kenya. *Impact Assess Project Appraisal*. 39(3):240–250. doi:10.1080/14615517.2021.1906020.
- Knoblauch AM, Divall MJ, Owuor M, Musunka G, Pascall A, Nduna K, Ng'uni H, Utzinger J, Winkler MS. 2018. Selected indicators and determinants of women's health in the vicinity of a copper mine development in northwestern Zambia. *BMC Women's Health*. 18(1):62. doi:10.1186/s12905-018-0547-7.
- Knoblauch AM, Farnham A, Zabre HR, Owuor M, Archer C, Nduna K, Chisanga M, Zulu L, Musunka G, Utzinger J, et al. 2020. Community health impacts of the trident copper mine project in northwestern Zambia: results from repeated cross-sectional surveys. *Int J Environ Res Public Health*. 17(10):3633. doi:10.3390/ijerph17103633
- Knoblauch AM, Hodges M, Bah M, Kamara H, Kargbo A, Paye J, Turay H, Nyorkor E, Divall M, Zhang Y, et al. 2014. Changing patterns of health in communities impacted by a bioenergy project in northern Sierra Leone. *Int J Environ Res Public Health*. 11(12):12997–13016. doi:10.3390/ijerph111212997
- Krieger, N. (2003). Genders, sexes, and health: What are the connections—and why does it matter? *International Journal of Epidemiology*, 32(4), 652-657. <https://doi.org/10.1093/ije/dyg156>
- Leuenberger, A., Farnham, A., Azevedo, S., Cossa, H., Dietler, D., Nimako, B., Adongo, P. B., Merten, S., Utzinger, J., & Winkler, M. S. (2019). Health impact assessment and health equity in sub-Saharan Africa: A scoping review. *Environmental Impact Assessment Review*, 79, 106288. <https://doi.org/10.1016/j.eiar.2019.106288>
- Levac L, Stinson J, Manning SM, Stienstra D. 2021. Expanding evidence and expertise in impact assessment: informing Canadian public policy with the knowledges of invisible communities. *Impact Assess Project Appraisal*. 39(3):218–228. doi:10.1080/14615517.2021.1906152
- Ministry of Health Zanzibar, National Bureau of Statistics, & Office of Chief Government Statistician Zanzibar. (2016). Tanzania Demographic and Health Survey and Malaria Indicator Survey 2015-2016. ICF International. <http://dhsprogram.com/publications/publication-FR321-DHS-Final-Reports.cfm>
- Moser, C. (1989). Gender planning in the Third World: Meeting practical and strategic gender needs. *World Development*, 17(11), 1790-1825. <https://www.sciencedirect.com/science/article/abs/pii/0305750X89902015>

- Moser, C. (1995). Evaluating gender impacts. *New Directions for Evaluation*, 1995(67), 105-117. <https://doi.org/10.1002/ev.1009>
- Muchadenyika, D. (2015). Women struggles and large-scale diamond mining in Marange, Zimbabwe. *The Extractive Industries and Society*, 2(4), 714-721. <https://doi.org/10.1016/j.exis.2015.08.003>
- O'Neill, J., Tabish, H., Welch, V., Petticrew, M., Pottie, K., Clarke, M., Evans, T., Pardo Pardo, J., Waters, E., White, H., & Tugwell, P. (2014). Applying an equity lens to interventions: Using PROGRESS ensures consideration of socially stratifying factors to illuminate inequities in health. *Journal of Clinical Epidemiology*, 67(1), 56-64. <https://doi.org/10.1016/j.jclinepi.2013.08.005>
- Rio Tinto. (2009). Why gender matters: A resource guide for integrating gender considerations into communities work at Rio Tinto. The University of Queensland. http://www.riotinto.com/documents/ReportsPublications/Rio_Tinto_gender_guide.pdf
- Sen, A., & Hausman, D. M. (2007). Capability and well-being (The Philosophy of Economics (pp. 270-294)). <https://doi.org/10.1017/cbo9780511819025.019>
- Sharma, S., & Rees, S. (2007). Consideration of the determinants of women's mental health in remote Australian mining towns. *Australian Journal of Rural Health*, 15(1), 1-7. <https://doi.org/10.1111/j.1440-1584.2007.00842.x>
- Sulle, E., & Dancer, H. (2019). Gender, politics and sugarcane commercialisation in Tanzania. *The Journal of Peasant Studies*, 1-20. <https://doi.org/10.1080/03066150.2019.1632294>
- UN. (2015). Transforming our world: The 2030 Agenda for Sustainable Development. United Nations (UN). <https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf>
- Whitehead, A., & Kabeer, N. (2001). Living with uncertainty: Gender, livelihoods and pro-poor growth in rural sub-Saharan Africa. *IDS Working Papers*, 134. <https://opendocs.ids.ac.uk/opendocs/bitstream/handle/20.500.12413/3896/Wp134.pdf>
- Winkler, M. S., Adongo, P. B., Binka, F., Brugger, F., Diagbougba, S., Macete, E., Munguambe, K., & Okumu, F. (2020a). Health impact assessment for promoting sustainable development: The HIA4SD project. *Impact Assessment and Project Appraisal*, 3(8), 225-232. <https://doi.org/10.1080/14615517.2019.1694783>
- Winkler, M. S., Furu, P., Viliiani, F., Cave, B., Divall, M., Ramesh, G., Harris-Roxas, B., & Knoblauch, A. M. (2020b). Current global health impact assessment practice. *International Journal of Environmental Research and Public Health*, 17(9), 2988. <https://doi.org/10.3390/ijerph17092988>
- Winkler MS, Krieger GR, Divall MJ, Singer BH, Utzinger J. 2012. Health impact assessment of industrial development projects: a spatio-temporal visualization. *Geospat Health*. 6(2):299–301. doi:10.4081/gh.2012.148
- Winkler MS, Viliiani F, Knoblauch AM, Cave B, Divall M, Ramesh G, Harris-Roxas B, Furu P. 2021. Health impact assessment international best practice principles. International Association for Impact Assessment
- World Bank. (2016). Addressing Risks and Impacts on Disadvantaged or Vulnerable Individuals or Groups (<https://policies.worldbank.org/sites/ppf3/PPFDocuments/e5562765a5534ea0b7877e1e775f29d5.pdf>)
- World Bank. (2018). Good Practice Note on Addressing Sexual Exploitation and Abuse and Sexual Harassment in Investment Project Financing involving Major Civil Works. The World Bank

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- WHO (2010). A conceptual framework for action on the social determinants of health: debates, policy & practice, case studies. World Health Organization (WHO). Geneva, Switzerland. [accessed 2020 April 10]. http://apps.who.int/iris/bitstream/10665/44489/1/9789241500852_eng.pdf
- WHO (2011). Gender mainstreaming for health managers: a practical approach. World Health Organization (WHO). Geneva, Switzerland. [accessed 2020 April 10]. https://apps.who.int/iris/bitstream/handle/10665/44516/9789241501071_eng.pdf?sequence=1
- Yakovleva, N., Kotilainen, J., & Toivakka, M. (2017). Reflections on the opportunities for mining companies to contribute to the United Nations Sustainable Development Goals in sub-Saharan Africa. *The Extractive Industries and Society*, 4(3), 426-433. <https://doi.org/10.1016/j.exis.2017.06.010>

4.9 Supplementary file

Themes of positive and negative impacts and related health outcomes that emerged during the analysis of the 24 focus groups discussion with communities impacted by industrial gold mining in north-western Tanzania, categorized by environmental, economic and social determinants of health

Health determinant (category)	Negative impacts (themes)	Negative health outcomes (themes)	Positive impacts (themes)	Positive health outcomes (themes)
Environmental				
Housing	<ul style="list-style-type: none"> - Cracks in the houses due to the blasting in the mine - Resettlement, loss of land rights - More traffic, heavy trucks passing 	<ul style="list-style-type: none"> - Fear, stress, shock - High blood pressure - Fainting - Injuries 	<ul style="list-style-type: none"> - New or improved roads 	-
Soil and land	<ul style="list-style-type: none"> - Loss of land - Soil pollution (through water and air) - Deforestation, loss of medicinal plants - Pastoralism: animals drinking polluted water 	<ul style="list-style-type: none"> - Malnutrition, hunger - Contaminated food - Skin infections 	<ul style="list-style-type: none"> - Wild animals chased away 	-
Water	<ul style="list-style-type: none"> - Pollution of water bodies (wells, rivers, dams) - Rain water pollution - Decreased water availability, dried up wells - Burst of mining dam - Vector breeding sites (ponds in the roads) 	<ul style="list-style-type: none"> - Urinary tract infections - Diarrheal diseases - Skin rashes - Malaria 	<ul style="list-style-type: none"> - New water access points 	<ul style="list-style-type: none"> - Safety for children (reduced distances)
Air	<ul style="list-style-type: none"> - Dust from the mine (blasting) - Road dust - Odour 	<ul style="list-style-type: none"> - Cough - Flu - Pneumonia - Tuberculosis - Eye infections 	-	-
Sanitation	<ul style="list-style-type: none"> - Open defecation (lack of toilets) - Waste management 	<ul style="list-style-type: none"> - Urinary tract infection - Diarrhoea - Stomach diseases 	-	-

Economic

Income generating activities	<ul style="list-style-type: none"> - Loss/prohibition of small-scale mining - Stealing in the mine - Prostitution (sexual transaction, commercial sexual relationships) 	<ul style="list-style-type: none"> - Injuries - Beaten, death - HIV - Stress, high blood pressure - Hunger 	<ul style="list-style-type: none"> - Market (minerals and vegetables) 	<ul style="list-style-type: none"> - Afford food and basic needs (for the family)
Working conditions in the mine	<ul style="list-style-type: none"> - Type of work/position - Low salaries - Unfair conditions for employment (temporary contract, few opportunities for women) 	<ul style="list-style-type: none"> - Physical unfit - Back pain - Bad eyes - Chest pain - Sexual dysfunction - Injuries 	<ul style="list-style-type: none"> - Income - Community fund 	<ul style="list-style-type: none"> - Afford food and health care - Construction of health care facilities
Unemployment	<ul style="list-style-type: none"> - Lack of job opportunities in the mine - Loss of temporary job 	<ul style="list-style-type: none"> - Weakness, tiredness - HIV - Injuries and deaths - Conflict 	-	-
Other economic dynamics	<ul style="list-style-type: none"> - Compensation payment for resettlement/land - High living costs 	<ul style="list-style-type: none"> - Substance abuse (alcohol, tobacco) - HIV 	<ul style="list-style-type: none"> - Increased cash flow 	-

Social services and organisation

Health care	<ul style="list-style-type: none"> - Lack of health care services (affordability, accessibility, availability) - Lacking capacity (overcrowded) 	<ul style="list-style-type: none"> - Death on the way to the hospital 	<ul style="list-style-type: none"> - Improved health care services (availability, accessibility, affordability, capacity, specific services) 	<ul style="list-style-type: none"> - Reduced maternal and child mortality rate - Improved diagnostics and adequate treatment - Service delivery - Afford food and health care
Schooling	<ul style="list-style-type: none"> - Drop out of school - Limited capacity 	<ul style="list-style-type: none"> - (Early) pregnancies - HIV 	<ul style="list-style-type: none"> - Construction and renovation of school buildings and infrastructure - Financial support 	<ul style="list-style-type: none"> - Safety of children - Good learning environment - Afford food and health care
Social dynamics	<ul style="list-style-type: none"> - In-migration - Adultery, separation, men leaving - Orphans - Bribe 	<ul style="list-style-type: none"> - HIV 	<ul style="list-style-type: none"> - In-migration - Formation of community based organizations 	-

5. *“It is like we are living in a different world”*: health equity in communities around industrial mining sites in Burkina Faso, Mozambique and Tanzania

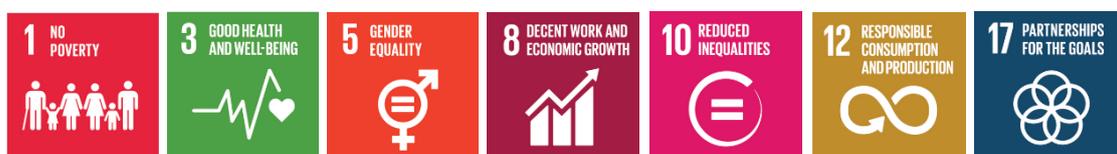
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5.1 Abstract

Background: Health equity features prominently in the 2030 Agenda for Sustainable Development, yet there are wide disparities in health between and within countries. In settings of natural resource extraction (e.g., industrial mines), the health of surrounding communities is affected through myriad changes in the physical, social, and economic environment. How changes triggered by such projects translate into health inequities is poorly understood.

Methods: This qualitative study explores potential layers of inequities by systematically coding perceived inequities of affected communities. Drawing on the framework method, we thematically analyzed data from 83 focus group discussions, which enrolled 791 participants from 10 study sites in Burkina Faso, Mozambique, and Tanzania.

Results: Participants perceived inequities related to their individual characteristics, intermediate factors acting on the community level, and structural conditions. Due to environmental pollution and land loss, participants were concerned about unsecured livelihoods. Positive impacts, such as job opportunities at the mine, remained scarce for local communities and were claimed not to be equally distributed among community members.

Conclusion: Extractive industries bear considerable risks to widen existing health gaps. In order to create equal opportunities among affected populations, the wider determinants of health must be considered more explicitly in the licensing process of resource extraction projects.

5.1 Introduction

Many low- and middle-income countries (LMICs) are rich in natural resources, which encompasses both opportunities and risks for sustainable development. Indeed, natural resource extraction projects act on several of the Sustainable Development Goals (SDGs), including various health-related targets (Fraser, 2019; Winkler et al., 2020a). At the global level, it has been emphasized that extractive industries will contribute to achieving the 2030 Agenda for Sustainable Development (Fraser, 2019; Hussain et al., 2020; RMF & CCSI, 2020). In the strive toward a low-carbon future, the demand for metals and minerals is rising (World Bank, 2017). At the national level, sectors engaged in natural resource extraction (e.g., mining, oil, and gas) are important partners for economic development (UNECA, 2011). Fiscal revenues and public–private partnerships hold promise to improve public services, such as education and health care (Asante & Zwi, 2007; Viliiani et al., 2017). At the local level, industrial mining companies are becoming more and more engaged in community development through corporate social responsibility (CSR) programs, including health-related interventions (Knoblauch et al., 2020; Utzinger et al., 2004).

Prospects for development that go hand-in-hand with the implementation and operation of natural resource extraction projects are opposed by potential negative consequences for health and wellbeing in surrounding communities. Affected communities face particular challenges related to environmental pollution, social disruption, or increased poverty (Anaf et al., 2019; Gamu et al., 2015; Schrecker et al., 2018). Consequently, in communities living next to mining areas, an increased burden of diseases and poor wellbeing has been reported (Hendryx, 2015; Leuenberger et al., 2021b). Due to conflicting interests of mining companies and local stakeholders, local communities might not benefit as much as reported (Emel et al., 2012). Further, CSR has been described as an elusive concept, with varying perceptions of the effectiveness of CSR among different stakeholders (Mzembe & Downs, 2014). Against this background, the question arises whether profit organizations are undermining health equity (Asante & Zwi, 2007).

Creating equal opportunities to achieve good health and wellbeing is a core element of the 2030 Agenda for Sustainable Development (Buzeti et al., 2020; Spencer et al., 2019). To reduce health inequities and act toward a more equitable world, there is a pressing need to address the root causes (Hussain et al., 2020; Irwin et al., 2006; Marmot, 2007). Particularly in sub-Saharan Africa, where many countries are lagging behind in terms of health-related targets of the SDGs, acting on the social determinants of health is closely linked to poverty reduction (GBD 2016 SDG Collaborators, 2017; Worku & Woldesenbet, 2015).

The social determinants of health are defined as the conditions in which people are born, grow, live, and work, which has been conceptualized in various models (CCSDH, 2015; WHO,

2020). Most models consider multiple layers, including individual and intermediate factors and structural conditions, which all affect people's health and wellbeing (WHO, 2010). Social exclusion and intersectoral action have been identified as key barriers hampering health equity (CCSDH, 2015; WHO Task Force on Research Priorities for Equity in Health & WHO Equity Team, 2005). Despite the increasing recognition of social determinants in global development, societal-level factors, such as power, among other structural drivers of inequities, tend to be omitted (Lucyk & McLaren, 2017; Navarro, 2009). Especially in settings of industrial mining, which are often located in remote areas, these dynamics are major drivers for the social fabric of local communities (Borde & Hernandez, 2019). Clearly, there is a need to ensure equal opportunities in order to achieve good health and wellbeing in mining settings and toward sustainable development, while paying particular attention to the most marginalized population groups (Carvalho, 2017; Leuenberger et al., 2019). Yet, pathways of health impacts and related health inequities induced by natural resource extraction projects are poorly understood. Previous studies have been investigating specific factors that are closely linked to health and equity (Adusah-Karikari, 2015; Akpalu & Normanyo, 2017; Von der Goltz & Barnwal, 2019). However, studies addressing health comprehensively, including its underlying causes, remain scarce in the context of natural resource extraction in LMICs. To address this issue, particularly qualitative studies that incorporate the voices of affected communities, are needed to deepen the understanding of local perceptions and beliefs of health and wellbeing (Briggs, 2008; Cortes-Ramirez et al., 2019; Karakaya & Nuur, 2018). Based on the perception of affected communities, the underlying values of health inequity can be made more explicit (Abrams et al., 2020; Pope & Mays, 1995). Qualitative research holds promise to advance equity [41], which is an essential feature for the achievement of the 2030 Agenda for Sustainable Development (Buse & Hawkes, 2015).

The overarching goal of this study was to deepen the understanding of health equity in communities living in close proximity to industrial mining projects. We addressed the following research questions: (i) What are perceived inequities induced by industrial mining projects in sub-Saharan Africa? (ii) How do the perceived inequities relate to different wider determinants of health? (iii) How do perceived inequities translate into health inequities?

5.3 Materials and methods

5.3.1 Study set-up

This paper is embedded in a large research project pertaining to health impact assessment (HIA) of natural resource development and management (Farnham et al., 2020; Winkler et al., 2020a). Within this frame, a qualitative study was conducted in rural communities surrounding industrial mining sites (Farnham et al., 2020). The current piece includes data from study sites

in Burkina Faso, Mozambique, and Tanzania, which are all partner countries of the framing research project and extracting natural resources for several decades. **Figure 16** shows the study sites. A detailed description of the overall research project and the individual study sites is available elsewhere (Farnham et al., 2020; Leuenberger et al., 2021b).

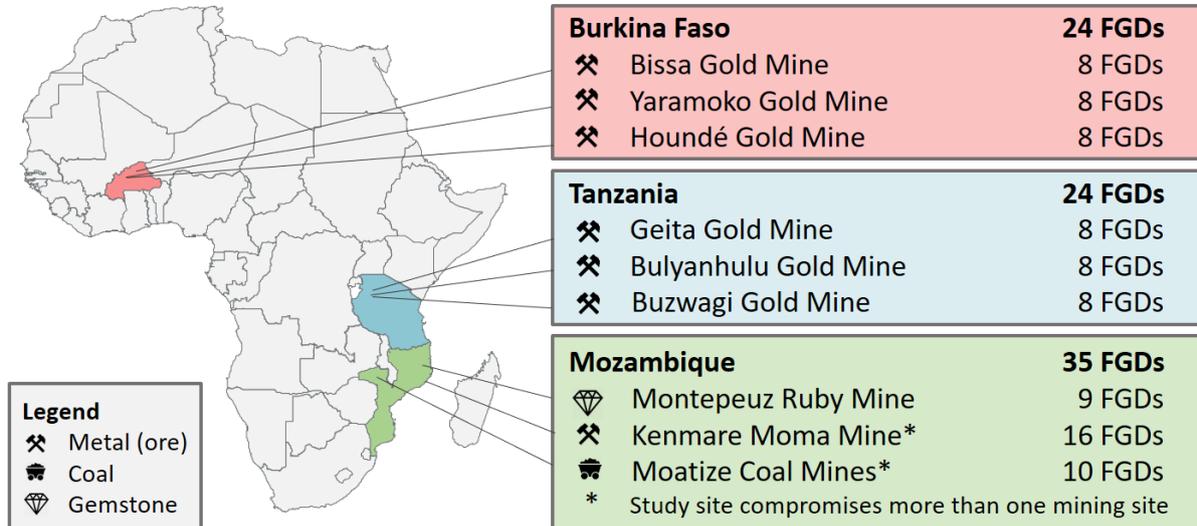


Figure 16: Overview of study sites in three African countries, indicating location, the type of mining project, and the number of focus group discussions (FGDs) conducted.

5.3.2 Ethical approval

Ethical approval was obtained from national and institutional review boards in the three project countries and in Switzerland. In brief, the study was approved by the Ethics Committee for Health Sciences in Burkina Faso (no. 2019-013), the Institutional Committee on Bioethics in Health at Manhica Health Research Centre (CISM) in Mozambique (no. CIBS-CISM/048/2018), the Institutional Review Board of the Ifakara Health Institute (IHI) (no. 32-2018) and the National Institute for Medical Research (NIMR) in Tanzania (no. 2969), and the Ethics Committee of Northwestern and Central Switzerland (EKNZ) (no. 2018-00386).

5.3.3 Recruitment and study population

Under the guidance of a local study coordinator (i.e., local health care professional or government officer), a transect walk was conducted in each study site at the beginning of the field work. This allowed identification of communities that are positively (e.g., community development initiatives) and negatively (e.g., environmental degradation or social disruption) impacted by the mine and subsequent recruitment of study participants. With the assistance of community leaders, adult community members (aged ≥ 18 years) were invited to participate in the study. Preferably, people who were familiar with the community and its dynamics in relation to the development of the mine were selected. All participants were informed about the purpose and procedures of the study and provided written informed consent prior to data

collection. Participants were reimbursed for travel expenses or provided with snacks and refreshments according to local research standards and requirements.

5.3.4 Data collection and analysis

Focus group discussions (FGDs) were moderated by trained research assistants in the local languages. Sessions were held in gender-separated groups to minimize gender-based power relations that might impede participants to talk freely. Using a participatory approach, participants listed, categorized, and ranked perceived impacts of mining on community health. The individual part of the participatory approach facilitated engaged discussions with every participant, while particularly integrating also rather shy participants. All FGDs were audio-recorded and transcribed verbatim into French (Burkina Faso), Portuguese (Mozambique), or English (Tanzania).

Data analysis was done by two researchers, namely A.L. (English and French transcripts) and O.C. (English and Portuguese transcripts) employing Nvivo (Nvivo 12 Pro, QSR International; Melbourne, Australia). Therefore, an overarching “inequity” code was utilized to capture perceived inequities in an initial step, which was subsequently analyzed in depth for emerging themes. Specifically, when participants opposed positive attributes to negative consequences in the same phrase or participants compared themselves to others getting better or worse in response to the developments induced by the extractive industry, this was coded as inequity. For example: “They have water in the mining, the water ends there at the fence, why is it impossible to bring it to us here?”

For in-depth analysis of the inequity data, we created a specific coding system based on the wider determinants of health (Dahlgren & Whitehead, 1991). In brief, all statements in the initially created and overarching “inequity” node were re-coded by drawing on the framework method for qualitative data analysis (Gale et al., 2013). The different layers of the health determinants were utilized as initial categories for the coding and complemented with emerging themes. An overview of the different categories, along with indicative quotes, is given as Annex (Table A1).

The original “rainbow” model of the social determinants of health consists of five basic layers, namely (i) personal factors; (ii) individual lifestyle factors; (iii) social and community networks; (iv) living and working conditions; and (v) general socioeconomic, cultural, and environmental conditions. Grounded on the same layers, a more recent model of the World Health Organization (WHO) emphasizes different topics of the living and working conditions and specifically link them to the SDGs (WHO, 2019). In the current study, we applied the basic layers of original model of Dahlgren and Whitehead (Dahlgren & Whitehead, 1991) as analytical device and to situate our findings.

5.4 Results

5.4.1 Study sites and participants

The study was conducted in communities around nine industrial mining sites in Burkina Faso, Mozambique, and Tanzania (**Figure 16**). The core resources extracted in these mining sites are gold (in six sites), and coal, ruby, and titanium (in one site each). Except for one study site in Mozambique, all mines have been operating for several years. In total, 83 FGDs were conducted with 791 participants (406 females, 385 males), who have been living in the impacted communities since, on average, more than 25 years. The characteristics of study participants are summarized in **Table 5**. The typical participants had less than four years of formal education. Participants were mostly farmers or running their own small businesses. Of note, artisanal mining was also reported as important income-generating activity during the discussions.

Table 5: Characteristics of study participants. Number of study participants and sociodemographic characteristics by country and in total (FGD: focus group discussion).

	Burkina Faso (24 FGDs)	Mozambique (35 FGDs)	Tanzania (24 FGDs)	Total (83 FGDs)
Number of study participants (and relative frequency in %)				
Male	115 (49.8%)	181 (48.0%)	89 (48.6%)	385 (48.7%)
Female	116 (50.2%)	196 (52.0%)	94 (51.4%)	406 (51.3%)
Total	231	377	183	791
Average number of participants per FGD (and range)				
Male	10 (6–10)	11 (6–12)	8 (6–8)	9 (6–12)
Female	10 (7–10)	11 (8–13)	8 (6–10)	9 (6–13)
Total	10 (6–10)	11 (6–13)	8 (6–10)	9 (6–13)
Average age in years (and age range)				
Male	42 (23–71)	45 (19–89)	48 (19–77)	45 (19–89)
Female	31 (18–49)	44 (29–83)	42 (20–77)	39 (18–83)
Total	37 (18–71)	44 (19–89)	45 (19–77)	42 (18–89)
Average years living in the community (and range)				
Male	26 (3–67)	37 (3–89)	22 (2–66)	30 (2–89)
Female	13 (1–44)	36 (1–83)	19 (1–77)	25 (1–83)
Total	20 (1–67)	37 (1–89)	21 (1–77)	28 (1–89)
Average number of years of school attended (and range)				
Male	2.7* (0–10)	3.8 (0–12)	7.4 (0–14)	4.4 (0–14)
Female	1.2* (0–10)	1.4 (0–12)	7.3 (0–14)	2.9 (0–14)
Total	1.9* (0–10)	2.6 (0–12)	7.4 (0–14)	3.6 (0–14)

* Data from two FGDs with male participants and two FGDs with female participants missing.

5.4.2 Perceived inequities

Perceived inequities were linked to a broad range of factors, which are closely interrelated. The complexity of the perceived inequities are illustrated by the following quote:

Since [the mine] came to [our region] here, they have brought many problems to the people. By taking our land, they have brought many palaver between us. They have flatten us, as they have taken us to the mine and only employed us for six months and then left us again. Yet, you didn't have your fields for cultivation anymore. Really, this is what causes problems. It can lead to crimes and thefts. (BF3_L1)

Despite this intersection of social, environmental, and economic changes, we present our findings in the following section layer by layer as adapted based on our findings. By referring to specific examples from the FGDs, we describe the perceived inequities, how these are interpreted as health inequities, and how they are located in the different layers of health determinants.

Personal factors: place of origin or residence, gender and age

During the FGDs, people's place of origin or residence was linked most often to perceived inequities. For example, they complained that autochthonous people ("natives" or "locals") fail to get employed in the mine. One participant said:

People living near the mine are not getting permanent employment opportunities, which have high salary. Getting high salary could enable us to provide for our families instead people coming from other regions are the ones getting good employment posts. (TZ1_L5)

In Emakuwa (the local language in the northern part of Mozambique), "the white [foreign person]" also means boss. People refer to a person with more power and money as a white man, which does not necessarily mean the skin color. This perception is in line with the concept of "white-collar workers", indicating the clear distinction to manual workers in industrial capitalism (Prinz, 2001).

Gender and age were other personal factors that emerged related to perceived inequities. Participants' statements suggested that females are disproportionately affected due to their subordinated position in the domestic and work environment. Moreover, males were more likely to benefit from the mining operations, particularly in terms of job opportunities. Impacts on men's and women's engendered roles and implications on gender and health equity are discussed in more detail elsewhere (Leuenberger et al., 2021a). During the FGDs different age groups were mentioned. It was emphasized that children and adolescents are particularly vulnerable to the impacts of the mine and related consequences for their health.

Personal resources

This category embraced individual, socially determined factors, including educational attainment and socioeconomic status. Education was a key issue as community members felt left behind due to their low education **Table 5**. Having attended few years of formal education was often perceived as disadvantage compared to formal employees of the mines. Hence, the community members' educational background was reported as the main reason for not getting employment in the mine. This is illustrated in the following quote:

Neither for jobs nor for anything they say that jobs already have owners [...] the ones who know how to write and they used say that 'you don't know how to write', but a long time ago they moralized us with jobs.
(MZ2.1_L6)

Personal monetary resources and particularly the lack or depletion thereof, was a major concern among participants in relation to the development of the mining projects. The following quote underscores this point:

We are very poor now it is because of these whites. In the past we were not that poor. (MZ1_L4)

Community members explained that their financial situation worsened since the mine started to operate, due to the loss of their agricultural land or artisanal mining areas, which used to be reliable sources of income. Participants also mentioned that they are spending money increasingly for various goods or services such as food or health care. They asserted that since the operation of the mine, they are not able to produce food themselves anymore and they need to seek health care more often. In Tanzania and Mozambique, money was also needed to obtain a certain job position, such as a local security guard of the mine. Nevertheless, participants from Tanzania also reported about the support from the mine granted to the community fund to realize community projects, such as construction of new water systems or strengthening of health facilities. These contributions were particularly acknowledged, as they could use their own money for personal needs, including food and health care. Cash compensation for being resettled were short windows of opportunities, but respondents were not able to benefit in the longer term.

Despite potential benefits, study participants were most concerned about fulfilling their personal needs and the needs of their family based on their limited resources. This was reported to be exacerbated by the implementation of the mines. The "lifestyle" of participants was marked by surviving with limited resources, which contrast to lifestyle factors based on free choices as indicated by Dahlgren and Whitehead (Dahlgren & Whitehead, 1991). Participants reported to be particularly constrained in terms of their financial resources due to the implementation of the mine. Except for rare occasions to become employed, individuals

were hardly able to benefit from the industrial mining projects. These findings indicate the aggravation of their poor economic conditions.

Social and community network

During the FGDs, inequities related to social and community network were closely linked to the social disruption of local communities. Participants primarily reported that not everyone is equally benefitting from potential positive impacts. For example, access to interventions implemented in distant communities, job opportunities offered or the support of selected local associations or community-based organizations were not equally distributed among communities and community members. According to their statements, the unequal distribution caused tensions or even conflicts among the community members, which were absent before implementation of the mines. In several study sites, community members perceived that certain community leaders are benefitting disproportionately. Especially those who were selected by the mining companies to become liaison officers between the mine and the community. Participants linked this increase in power relations also to physical and material benefits, such as houses or vehicles for leaders. Moreover, power exacerbation through illicit charging or other forms of corruption was reported as recurrent theme related to the unequal distribution of benefits. Taken together, the social cohesion among the community declined as expressed by a participant from Mozambique:

The government is the one who causes the struggle, for you to be community leader you need to pay someone, now people are fighting to be community leader, those who had no decent house have built it [...]. Those who never had a car now have a car, and so they are fighting to be community representatives, nowadays people have already opened their eyes, no one is robbed only the farmers who go to the fields all the time. (MZ2.1_L4)

Beside community internal dynamics, participants also reported the poor relationship between them and the mining companies. Community members claimed empty promises, such as job opportunities or wealth, or were not satisfied with the reallocation compensation payment and felt that their problems were ignored. This was perceived to be particularly frustrating for the local communities, as the mining companies were located on and benefitting from their land. In-migration was also reported to affect the social dynamics negatively and was perceived to increase the risk of infection with human immunodeficiency virus (HIV) through commercial sex work. While participants mentioned positive aspects related to in-migration, such as the possibility to generate an income through sexual transactions, negative aspects prevailed. Participants mentioned explicitly that they are more likely to be HIV positive

because of foreign people working in the mine, with women and adolescent girls being particularly affected.

Social and community networks emerged as a central aspect of inequities, which is consistent with the concept introduced by Dahlgren and Whitehead (Dahlgren & Whitehead, 1991). In the setting of industrial mining, the rapid influx of people, the gain of power of selected community leaders, and the unequal distribution of benefits particularly influenced the social dynamics in affected communities, which had negative consequences for their health and wellbeing.

Living environment and subsistence work

Changes in the natural environment, which were induced by the mining projects, heavily affected the daily lives and work of communities and certain inequities emerged, including issues related to land, water, health care, roads, and electricity. Most importantly, the loss of land was a particular issue for subsistence farming, meaning the agricultural production to eat as well as sell goods. Participants reported that their access to land (for agriculture, herding, or housing), water (for fishing), or mining areas (for artisanal mining) was restricted by the mining companies. Despite being resettled or compensated for the land, participants were not satisfied as new areas were smaller than expected and the soil reported as infertile. Hence, creating an income in their traditional way was a struggle for communities surrounding industrial mining sites. Regarding their housing situation, participants mentioned that they did not only lose their land, but also their rights to possess the land. In Burkina Faso and Tanzania, they reported that the mines are owning large areas beyond the actual fence line, including the living areas of some communities. Consequently, they were not able to buy new land for housing and felt disenfranchised as their land certificates were of no value as many participants reported. Because of the explosions in the mine, many houses were reported to be cracked, and people expressed a need to move or construct new houses. Participants felt disempowered, as they were constrained to construct new buildings but also no longer allowed to dig holes for latrines or to bury their close relatives. Particularly in the dynamic setting of resource extraction, land-use conflicts, and the insecure housing situation are major issues, also for their health and wellbeing, as illustrated in the following quote:

The areas that everyone of us has exploited, were our property. In contrast, the area of the mine, which we are occupying today, is the property of these "white" [from the mine]. Why [?] Because the certificate for residential area as promised by the responsible from the mine, we did not receive it [...]. Because you are not the owner of something, you are always living with fear. This problem affects our sleep. (BF1_L5)

Respondents complained about polluted water sources and reduced water availability due to the extraction activities. If respondents observed mining employees drinking bottled water, this further enhanced their perception. New water sources were installed by the mining companies to make up for the problem. However, participants' needs for clean water were not met, as new water access points were reported to be crowded or located far away. With regard to their health, FGD participants noted an increase in water-borne diseases.

Similarly, inequities related to food production emerged. Agricultural fields and crops were reported to be polluted by toxic dust or water released by the mine or not growing on the polluted soil. Hence, food insecurity and hunger related to the implementation of the mines were an issue raised during the FGDs. These statements were opposed by an observation from a participant in Burkina Faso that mining employees get served a lot of meat.

Another topic discussed was health care services and thus, directly related to health equity. Accessibility and affordability of health care were key concerns among community members from all sites. Newly constructed or improved health care facilities through the support of the mining companies were acknowledged as a positive development by the participants. At the same time, they also felt that they had to seek health care more often because of the various health impacts induced by the mining operations. Some participants felt deceived by the mining companies:

The presence of dispensary is not for the intention of saving our lives but to destroy us because if it wouldn't have been their mining activities, we wouldn't have been getting sick frequently. (TZ3_L4)

Some inequities were also perceived in relation to the road network. Indeed, accessibility of the mine is key for the development of the mine and for transporting extracted material. Hence, improved roads were mentioned to be helpful for the mobility communities, especially with regard to reaching health facilities in due time. However, many more remote villages were not benefitting from these infrastructure developments. In Mozambique, for example, participants reported that new roads and bridges were not constructed as promised at the beginning of project development.

Another difference between people living in the community and the mines was access to the power grid. Participants in Tanzania mentioned a lack of electricity, while witnessing the power line for the mine passing their village. The same community was located next to the mining site, which was surrounded with an electric fence (personal observation). Respondents stated that electricity could be particularly helpful to have night-lights as an intervention to increase safety in their villages by reducing crimes and robberies.

Taken together, communities revealed inequities by comparing their basic living standards in and with the natural and physical environment with the modernity and prosperity of mining employees. They lost their natural resources for living and, hence, also their source of income to pay for basic needs, and thus their subsistence farming. Despite positive contributions of the mines to public infrastructure, negative perceptions prevailed and decreased the health and wellbeing of affected communities. Adapted to the communities' situation, we comprised various aspects of the daily life and self-sustained work in this layer. Distinct from their living conditions and subsistence work, respondents reported about job opportunities in the mines.

Job opportunities and working conditions

Based on the FGDs, the theme of job opportunities and working conditions for local residents in the mine emerged as a major theme of perceived inequities. With the construction and operation of the mining projects, participants were—based on the announcement of mining companies—hoping for new job opportunities and having a regular income. However, unemployment was a major concern and participants expressed their frustration about unkept promises, not being qualified for jobs offered, and a limited number of jobs. Consequently, many participants struggled with generating an income despite the project development, as they reported:

They are employing chef who gets high salary while that job can be done by one of us from this community. When they were introducing the mining company they said natives will benefit a lot from the mining but we are only getting temporary employment for two weeks or two months or three. (TZ2_L1)

Available job opportunities were related to harsh working conditions, low salaries, or socially unprotected employment. The few job opportunities, such as local security guards, ended usually after a few months. Although participants acknowledged this source of income, they were disappointed that they did not benefit from certain standards provided for formal employees of the mining companies, such as high salaries, health care, and decent housing. Having an income is important for the communities to be able to afford basic needs such as food, education, and health care services.

Although “work environment and unemployment” are included in the original model, we used a separate layer for “job opportunities and working conditions in the mine”. The separate layer indicates that the concept of employment for local communities was rather new, as they traditionally are subsistence farmers or entrepreneurs **Table 5**. Notably, a separate layer illustrates the widening of inequities related to positive and negative aspects coming with these

works. Moreover, it demonstrates the key role of the inclusion of local communities in economic activities to foster sustainable development while reducing inequities (Whitehead & Kabeer, 2001).

General socioeconomic conditions and political context

The general socioeconomic conditions and political context were referred to by statements about the role and (expected) responsibilities of the government. General socioeconomic conditions included statement about the governments' management of economic benefits of the mines or investment to community development. In Mozambique, participants explicitly mentioned the lack of investment for safeguarding people's health and wellbeing. Participants criticized that revenues from the mining companies were not re-invested to benefit affected communities, as promised prior the project development. General political context referred to the relationship of the state with the multi-national mining companies or related regulations and laws. Participants in Burkina Faso and Mozambique felt unsupported by the government regarding their health. This was particularly frustrating for participants, after having voted for the government, as they narrated:

In any case, the authorities must know that their power come from the people and without the people there is no power. In this regard, the government has the obligation to surveil the health of the population.
(BF1_L5)

In Tanzania, as in Burkina Faso, several community development projects were implemented and acknowledged by the respondents in relation to a law. The regulations require that a certain share of the companies' revenue must be invested in community development projects.

Despite the important role of mining companies for the national economies, as repeatedly recognized by the participants, their statements indicate the lack of sustained improvements in affected communities, including health and wellbeing. In our context, general conditions were mostly shaped by the role of the governments and national regulations. Socioeconomic or political conditions were revealed, indicating the challenge to manage multi-national partnerships and ensure benefits also on the local level.

5.4.3 Consistency of findings across countries

As shown in **Figure 17**, similar patterns of inequities were observed in the three study countries. In all sites, perceived inequities related to job opportunities and working conditions in the mine as well as living environment and subsistence work were mentioned most frequently. Perceived inequities related to personal factors (e.g., place of residence or origin,

gender, and age), personal resources (educational attainment and financial resources), social and community network, and general conditions were revealed as secondary themes in all countries.

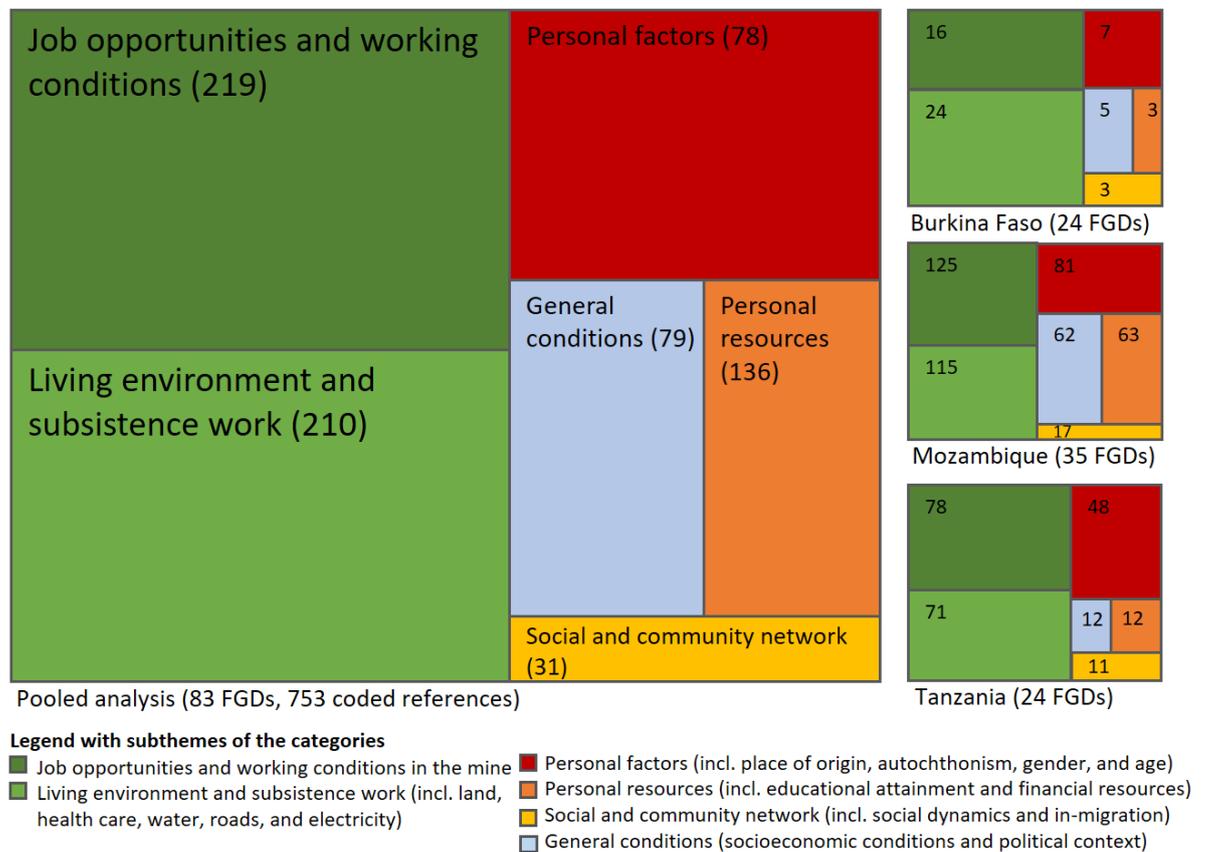


Figure 17: Qualitative tree maps indicating the proportion of coded references (and absolute number in brackets) of perceived inequities and the consistency of findings across countries (FGD: focus group discussion).

5.5 Discussion

We conjecture that natural resource extraction will play a role in sustainable development with health equity being a critical issue. This paper sought to deepen the understanding of health inequities in mining regions in different parts of sub-Saharan Africa, by exploring the perception of affected communities. The study revealed that operation of the mining projects, brought to light several inequities, as expressed in various statements of local communities highlighting “different worlds”. Based on the perception of local community members, our findings indicate that there is a clash of rural, economically, and socially disadvantaged communities living in close proximity to extractive industries in LMICs. Both positive and negative changes induced by the mines resulted in increased perceived inequities. Positive changes related to interventions or job opportunities that were not distributed equally among and within communities. Negative changes unsecured the livelihoods of communities investigated and, hence, decreased their socioeconomic status. Despite improved health care services, communities’ opportunities to achieve good health and wellbeing were reported to

be impeded by the construction and operation of the mine. Hence, this community-centred study indicates that the gap in health equity is widening in a highly dynamic and complex setting of industrial mining projects.

5.5.1 Complexity of health inequities

Many of the specific issues faced by the communities in relation to health equity have been studied before, including community dynamics (Dietler et al., 2020a; Issah & Umejesi, 2018), resettlement (Vanclay, 2017), environmental degradation (Buse et al., 2019), water infrastructure (Admiraal et al., 2017), land-use conflicts (Hilson, 2002) and poverty (Gamu et al., 2015). Based on the emic perspective, our findings revealed that the participants perceive the situation as a complex interplay of different factors and that different layers were closely intersecting with each other. Especially due to the multi-dimensionality of the perceived inequities, communities reported them as particular challenges for their health. In the three study countries, respondents spoke about how the operation of the mines were responsible for social and environmental problems leading to an increased burden of diseases and ill health in the local communities. Being at the same time impacted by economic dynamics, affected communities who have been living in remote areas could not afford health services, let alone the transportation costs to reach them. Ultimately, the combination of different factors extracted from the individual layers draw a picture of unequal opportunities for health and wellbeing and, hence, show that there are important health inequities (Whitehead, 1991).

5.5.2 Locating our findings in a model of health determinants

By referring to statements describing “different worlds” and the reported changes induced by the mining operations, we located the perceived inequities in the layers of wider determinants of health. As shown in **Figure 18**, the basic layers as suggest by Dahlgren and Whitehead (Dahlgren & Whitehead, 1991), were useful to position the perception of local communities. However, our analysis pertained to perceived inequities revealed specific themes and sub-themes different from the original layers. For example, regarding personal factors in the central layer, place of origin or residence were (besides gender and age) important underlying factors for affected communities to feel excluded (e.g., job opportunity). The second layer embraces personal resources (including their educational background and financial resources), which is in contrast to the “lifestyle factors” proposed in the original framework. The participants’ way of living was mostly determined by their limited resources, which were reported to become aggravated by the changes induced through the construction and operation of the mine. Social dynamics within the communities were influenced by the mines through the unequal distribution of benefits and gains and exploitation of power relations of some community members. Hence, additional factors emerged related to individual layers of health inequities,

which indicates that the implementation of the industrial mining projects widens the equity gap in local communities. Moreover, our findings suggest that the original layer of “living and working conditions” can be divided into two separate layers, namely “living environmental and subsistence work” and “job opportunities and working conditions in the mine”. **Figure 18** also reveals that adding a separate layer for the employment in the mine further illustrates an increase in inequities within affected communities. A recent study observed a similar trend by researching the “resource curse” and “resource blessing” in local communities in areas of oil and gas exploration (Byakagaba et al., 2019).

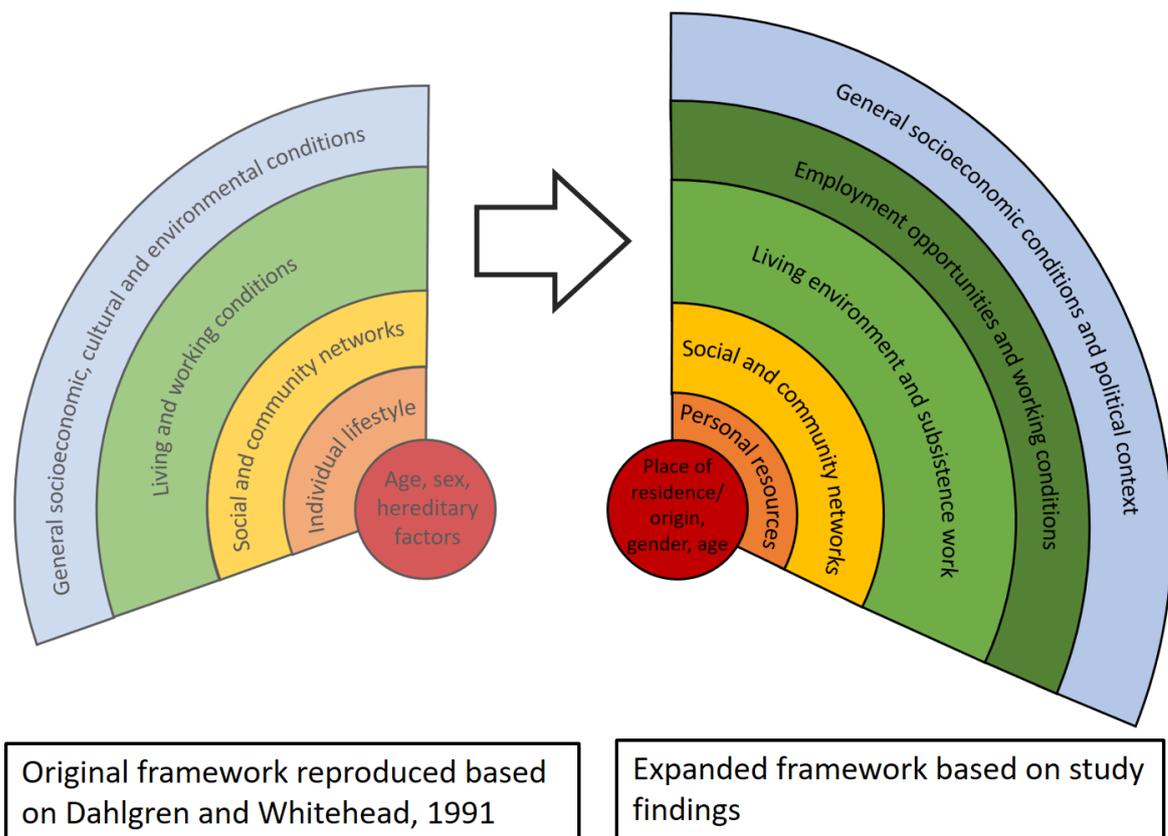


Figure 18: Layers of social determinants of health. Contrasting layers of inequities from the original model (Dahlgren and Whitehead, 1991; left) and expanded model based on the perception of communities affected by industrial mining projects (our own data; right).

5.5.3 Addressing health inequities

Addressing health inequities needs holistic health policies, which are acting on different layers and, hence, including the root causes, such as social and economic drivers of health inequities (Dahlgren & Whitehead, 1991; Llop-Girones & Jones, 2020). This is in line with the current “Health in All Policies” debate governed by WHO, which emphasizes that health is largely determined outside the health sector (Lin & Kickbusch, 2017). Similarly, the intersectionality theory addresses inequities comprehensively by considering multiple, intertwined factors,

including people's social location, power relations and experiences (Hankivsky, 2014). Using an intersectionality perspective for investigating health inequities also includes social stratification of populations and, thus, considers different population groups and subgroups (Hankivsky, 2012). For instance, considering differential impacts between females and males, including girls and boys, due to their engendered roles is key to effectively address the root causes of health inequities (Leuenberger et al., 2021a). To address inequities, particularly socially disadvantaged groups must be educated and empowered, as they are likely to be affected most negatively (Whitehead, 2007). Strengthening community networks as mitigation strategy for social impacts can empower socially disadvantaged population groups, which usually have a poor social network, and low social status, and, hence, is critical to reduce inequities (Dahlgren & Whitehead, 1991; Whitehead, 2007). In this regard, supporting community funds is a promising contribution of the mines, as it allows the communities to address their needs by participating in the decision-making process. As expected, education emerged as an important factor for inequities in our study. It follows that education warrants to be considered more prominently in mitigation strategies.

Although potentially unintended, the communities perceived various impacts especially in contrast of the mine, including implications for their health. Importantly, negative impacts on local communities, but also the unequal distribution of potential benefits, resulted in perceived inequities. This predominately negative perception of surrounding communities is in contrast with recent findings about objective health indicators, indicating positive effects of extractive industries on health outcomes and health determinants. For instance, increase in life expectancy and improved access to drinking water in producer regions were reported. However, such observations should be made available for communities for preventing misperceptions. Thus, community engagement is essential as perceived impacts may be even more important than objectively measured impacts and to address their needs adequately. Overall, improved management of impacts is clearly needed for tackling perceived inequities, especially to “leave no one behind” as promulgated by the 2030 Agenda for Sustainable Development (Fraser, 2019; Winkler et al., 2020a).

5.5.4 Addressing health inequities in the context of extractive industries

Impact assessments are in most countries routinely conducted as part of the licensing process, embracing environmental (Morgan, 2012), social (Esteves et al., 2012; Vanclay, 2003) and, more recently, also health aspects (Winkler et al., 2021). HIA is a process, which systematically judges the potential, and sometimes unintended, effects of a project on the health of a population and the distribution of those effects within the population (Quigley et al., 2006; Winkler et al., 2021). Equity—as a guiding principle of HIA—underlines the importance of considering particularly most vulnerable population groups (e.g., women, adolescents, and

children) (Quigley et al., 2006; WHO European Centre for Health Policy, 1999). Against this theoretical background, as well as confirmed by few existing case studies (Knoblauch et al., 2017; Knoblauch et al., 2018), HIA holds promise to address health inequities in settings of natural resource extraction in LMICs (Leuenberger et al., 2019).

To unfold the potential of HIA for health equity, the HIA approach has been complemented with specific guidelines for “health equity impact assessment” or “equity-focused health impact assessment” (Mahoney et al., 2004; Ontario Ministry of Health and Long-Term Care, 2012; Salcito et al., 2015). To reduce inequities, these guidelines emphasize the need of assessing negative consequence of unintended impacts, considering differential impacts on people or population subgroups and reducing avoidable and unfair factors determining potential inequitable impacts. Another key strategy for integrating equity measures in impact assessment is community empowerment (Buse et al., 2019; SOPHIA Equity Working Group, 2016). Therefore, researchers have suggested the increased use of participatory assessments in comparative settings and to ensure the inclusion of communities in solution-finding and decision-making processes (Addo-Atuah et al., 2020; Cameron et al., 2011; Sandham et al., 2019).

There remains a gap between theory and practice as HIA is currently under-used in LMICs (Dietler et al., 2020b; Leuenberger et al., 2019; Winkler et al., 2020b). In order to maximize the untapped potential of HIA (Winkler et al., 2013), awareness must rise and HIA needs to be strengthened and institutionalized in LMICs (Thondoo & Gupta, 2020). Moreover, HIA must include community members to address their needs adequately. In line with “Health in All Policies” and the call for equity promoting policies (WHO, 2013b; WHO Task Force on Research Priorities for Equity in Health & WHO Equity Team, 2005), anchoring community-based HIA in policies should be considered as a first step toward more equitable outcomes (WHO, 2013a).

5.6 Limitations

Our study has several limitations. First, the procedures, methods, and analysis of the research undertaken in the three countries with different languages was challenging. The close collaboration of the international team allowed us to collect and analyze the data from the different settings in a standardized manner. Data collection was facilitated by a core research team in each country, who was in charge of training moderators of the FGDs and continuously assuring the quality of the transcription. The varying number of coded references, reflect differences in the data quality and quantity across sites and countries with potential bias for inter-rater reliability. Notably, the analysis was performed by researchers from the core study team, who were familiar with the entire data set and the research context. Regular meetings

and exchanges among researchers ensured comprehensive understanding of the data from the different study sites as well as a gradual calibration in the interpretation of the data. The Nvivo project was constantly updated, allowing researchers to learn from each other and harmonize as the coding tree evolved.

Second, the current paper is based on findings retrieved from a suite of FGDs determining perceived health impacts and not health equity per se. Our analysis builds on an initially created node and, hence, country- or site-specific aspects may have remained concealed.

Third, all selected study sites were active mining sites for several years and, hence, not comparable with non-mining sites. It is conceivable that similar patterns can be observed in settings of “natural” urbanization, which is another key issue in the discussion about social determinants of health (WHO, 2020). However, our study conducted in a host of mining sites in three African countries resulted in consistent evidence of the particular dynamic induced by the project developments. Focusing on perceived inequities, we could yet not assess differences between the mining sites in the current study. This was, however, done in broader papers published under the framing research project (Farnham et al., 2020; Leuenberger et al., 2021a; Leuenberger et al., 2021b).

Fourth, our study is purely reflecting the perspective of affected communities. While it would have been interesting integrating voices from local governments or those operating the mines, this has been addressed in a separate study (Himmelsbach, 2021). Such kind of data triangulation could especially contribute to discuss the roles of governments and mining companies in more detail, which remained limited based on the communities’ perspectives only. To address the potential negative attitude of participants toward the mine, the informed and trained research assistants stated the neutrality of the research at the beginning of the sessions and probed for positive and negative impacts induced by the mine during the FGDs. As we observed similar issues across the sites and countries, perceived inequities are likely to be linked to structural problems.

5.7 Conclusions

The 2030 Agenda for Sustainable Development stipulates “to leave no one behind”. As shown in this study, extractive industries can contribute to the attainment of the SDGs, including the development of surrounding communities; yet negative changes predominate the perception of surrounding communities. With regard to health equity, limited job opportunities and loss of subsistence work caused social instability and increased ill-health among local communities, as they reported. Positioning our findings against the wider determinants of health indicates that the implementation of the mines widened the equity gap. Given the fact that both perceived positive and negative impacts resulted in unequal opportunities for health across

settings and countries, there is a pressing need for action to reduce inequities. In order to leave no one behind, impact mitigation must minimize negative consequences of potential unintended impacts and ensure equal opportunities to benefits from positive impacts. Therefore, including a strong equity and community participation component in HIA practice presents an opportunity for addressing the equity gaps identified. Hence, alongside evidence-based policies, the institutionalization of HIA in producer regions is needed to reduce inequities in contexts of natural resource extraction and for striving toward sustainable development in LMICs and beyond.

5.8 Acknowledgements

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5.9 References

- Abrams, J. A., Tabaac, A., Jung, S., & Else-Quest, N. M. (2020). Considerations for employing intersectionality in qualitative health research. *Soc. Sci. Med.*, *258*(2020), 113138. doi:10.1016/j.socscimed.2020.113138.
- Addo-Atuah, J., Senhaji-Tomza, B., Ray, D., Basu, P., Loh, F. E., & Owusu-Daaku, F. (2020). Global health research partnerships in the context of the Sustainable Development Goals (SDGs). *Research in Social and Administrative Pharmacy*, *16*(11), 1614-1618. doi:10.1016/j.sapharm.2020.08.015.
- Admiraal, R., Sequeira, A. R., McHenry, M. P., & Doepel, D. (2017). Maximizing the impact of mining investment in water infrastructure for local communities. *Extractive Industries and Society*, *4*(2), 240-250. doi:10.1016/j.exis.2017.01.014.
- Adusah-Karikari, A. (2015). Black gold in Ghana: changing livelihoods for women in communities affected by oil production. *Extractive Industries and Society*, *2*(1), 24-32. doi:10.1016/j.exis.2014.10.006.
- Akpalu, W., & Normanyo, A. K. (2017). Gold mining pollution and the cost of private healthcare: the case of Ghana. *Ecological Economics*, *142*(2017), 104-112. doi:10.1016/j.ecolecon.2017.06.025.
- Anaf, J., Baum, F., Fisher, M., & London, L. (2019). The health impacts of extractive industry transnational corporations: a study of Rio Tinto in Australia and Southern Africa. *Global Health*, *15*(1), 13. doi:10.1186/s12992-019-0453-2.
- Asante, A. D., & Zwi, A. B. (2007). Public-private partnerships and global health equity: prospects and challenges. *Indian Journal of Medical Ethics*, *4*(4), 176-180. doi:10.20529/IJME.2007.070.

- Borde, E., & Hernandez, M. (2019). Revisiting the social determinants of health agenda from the global South. *Global Public Health*, 14(6-7), 847-862. doi:10.1080/17441692.2018.1551913.
- Briggs, D. J. (2008). A framework for integrated environmental health impact assessment of systemic risks. *Environ. Health*, 7, 61. doi:10.1186/1476-069X-7-61.
- Buse, C. G., Lai, V., Cornish, K., & Parkes, M. W. (2019). Towards environmental health equity in health impact assessment: innovations and opportunities. *International Journal of Public Health*, 64(1), 15-26. doi:10.1007/s00038-018-1135-1.
- Buse, K., & Hawkes, S. (2015). Health in the Sustainable Development Goals: ready for a paradigm shift? *Globalization and Health*, 11(13). doi:10.1186/s12992-015-0098-8.
- Buzeti, T., Madureira Lima, J., Yang, L., & Brown, C. (2020). Leaving no one behind: health equity as a catalyst for the Sustainable Development Goals. *Eur. J. Public Health*, 30(Supplement_1), i24-i27. doi:10.1093/eurpub/ckaa033.
- Byakagaba, P., Mugagga, F., & Nnakayima, D. (2019). The socio-economic and environmental implications of oil and gas exploration: perspectives at the micro level in the Albertine region of Uganda. *Extractive Industries and Society*, 6(2), 358-366. doi:10.1016/j.exis.2019.01.006.
- Cameron, C., Ghosh, S., & Eaton, S. L. (2011). Facilitating communities in designing and using their own community health impact assessment tool. *Environmental Impact Assessment Review*, 31(4), 433-437. doi:10.1016/j.eiar.2010.03.001.
- Carvalho, F. P. (2017). Mining industry and sustainable development: time for change. *Food and Energy Security*, 6(2), 61-77. doi:10.1002/fes3.109.
- CCSDH. (2015). *A review of frameworks on the determinants of health*: Canadian Council on Social Determinants of Health (CCSDH).
- Cortes-Ramirez, J., Sly, P. D., Ng, J., & Jagals, P. (2019). Using human epidemiological analyses to support the assessment of the impacts of coal mining on health. *Reviews on Environmental Health*, 34(4), 391-401. doi:10.1515/reveh-2019-0033.
- Dahlgren, G., & Whitehead, M. (1991). *Policies and strategies to promote social equity in health*. Institute for Futures Studies. Stockholm, Sweden. Retrieved from: <https://core.ac.uk/download/pdf/6472456.pdf>
- Dietler, D., Farnham, A., de Hoogh, K., & Winkler, M. S. (2020a). Quantification of annual settlement growth in rural mining areas using machine learning. *Remote Sensing*, 12(2), 235. doi:10.3390/rs12020235.
- Dietler, D., Lewinski, R., Azevedo, S., Engebretsen, R., Brugger, F., Utzinger, J., & Winkler, M. S. (2020b). Inclusion of health in impact assessment: a review of current practice in sub-Saharan Africa. *International Journal of Environmental Research and Public Health*, 17(11), 4155. doi:10.3390/ijerph17114155.
- Emel, J., Makene, M. H., & Wangari, E. (2012). Problems with reporting and evaluating mining industry community development projects: a case study from Tanzania. *Sustainability*, 4(2), 257-277. doi:10.3390/su4020257.
- Esteves, A. M., Franks, D., & Vanclay, F. (2012). Social impact assessment: the state of the art. *Impact Assessment and Project Appraisal*, 30(1), 34-42. doi:10.1080/14615517.2012.660356.
- Farnham, A., Cossa, H., Dietler, D., Engebretsen, R., Leuenberger, A., Lyatuu, I., Nimako, B., Zabre, H. R., Brugger, F., & Winkler, M. S. (2020). Investigating health impacts of natural resource extraction projects in Burkina Faso, Ghana, Mozambique, and Tanzania: protocol for a mixed methods study. *JMIR Research Protocols*, 9(4), e17138. doi:10.2196/17138.

- Fraser, J. (2019). Creating shared value as a business strategy for mining to advance the United Nations Sustainable Development Goals. *Extractive Industries and Society*, 6(3), 788-791. doi:10.1016/j.exis.2019.05.011.
- Gale, N. K., Heath, G., Cameron, E., Rashid, S., & Redwood, S. (2013). Using the framework method for the analysis of qualitative data in multi-disciplinary health research. *BMC Medical Research Methodology*, 13, 117. doi:10.1186/1471-2288-13-117.
- Gamu, J., Le Billon, P., & Spiegel, S. (2015). Extractive industries and poverty: a review of recent findings and linkage mechanisms. *Extractive Industries and Society*, 2(1), 162-176. doi:10.1016/j.exis.2014.11.001.
- GBD 2016 SDG Collaborators. (2017). Measuring progress and projecting attainment on the basis of past trends of the health-related Sustainable Development Goals in 188 countries: an analysis from the Global Burden of Disease Study 2016. *Lancet*, 390(10100), 1423-1459. doi:10.1016/S0140-6736(17)32336-X.
- Hankivsky, O. (2012). Women's health, men's health, and gender and health: implications of intersectionality. *Soc. Sci. Med.*, 74(11), 1712-1720. doi:10.1016/j.socscimed.2011.11.029.
- Hankivsky, O. (2014). *Intersectionality 101*. Vancouver, Canada: The Institute for Intersectionality Research & Policy.
- Hendryx, M. (2015). The public health impacts of surface coal mining. *Extractive Industries and Society*, 2(4), 820-826. doi:10.1016/j.exis.2015.08.006.
- Hilson, G. (2002). An overview of land use conflicts in mining communities. *Land Use Policy*, 19(1), 65-73. doi:10.1016/S0264-8377(01)00043-6.
- Himmelsbach, G. (2021). *Exploring the impact of mining on health and health service delivery: perceptions of key informants involved in three different gold mining communities in Burkina Faso*. (Master thesis). Swiss Federal Institute of Technology (ETH Zürich), Zürich, Switzerland.
- Hussain, S., Javadi, D., Andrey, J., Ghaffar, A., & Labonte, R. (2020). Health intersectoralism in the Sustainable Development Goal era: from theory to practice. *Globalization and Health*, 16(1), 15. doi:10.1186/s12992-020-0543-1.
- Irwin, A., Valentine, N., Brown, C., Loewenson, R., Solar, O., Brown, H., Koller, T., & Vega, J. (2006). The Commission on Social Determinants of Health: tackling the social roots of health inequities. *PLoS Med*, 3(6), e106. doi:10.1371/journal.pmed.0030106.
- Issah, M., & Umejesi, I. (2018). Uranium mining and sense of community in the Great Karoo: insights from local narratives. *Extractive Industries and Society*, 6, 9. doi:10.1016/j.exis.2018.09.01.
- Karakaya, E., & Nuur, C. (2018). Social sciences and the mining sector: some insights into recent research trends. *Resources Policy*, 58, 257-267. doi:10.1016/j.resourpol.2018.05.014.
- Knoblauch, A. M., Divall, M. J., Owuor, M., Archer, C., Nduna, K., Ng'uni, H., Musunka, G., Pascall, A., Utzinger, J., & Winkler, M. S. (2017). Monitoring of selected health indicators in children living in a copper mine development area in northwestern Zambia. *International Journal of Environmental Research and Public Health*, 14(3), 315. doi:10.3390/ijerph14030315.
- Knoblauch, A. M., Divall, M. J., Owuor, M., Musunka, G., Pascall, A., Nduna, K., Ng'uni, H., Utzinger, J., & Winkler, M. S. (2018). Selected indicators and determinants of women's health in the vicinity of a copper mine development in northwestern Zambia. *BMC Women's Health*, 18(1), 62. doi:10.1186/s12905-018-0547-7.

- Knoblauch, A. M., Farnham, A., Zabre, H. R., Owuor, M., Archer, C., Nduna, K., Chisanga, M., Zulu, L., Musunka, G., Utzinger, J., Divall, M. J., Fink, G., & Winkler, M. S. (2020). Community health impacts of the Trident Copper Mine Project in northwestern Zambia: results from repeated cross-sectional surveys. *International Journal of Environmental Research and Public Health*, 17(10), 3633. doi:10.3390/ijerph17103633.
- Leuenberger, A., Farnham, A., Azevedo, S., Cossa, H., Dietler, D., Nimako, B., Adongo, P. B., Merten, S., Utzinger, J., & Winkler, M. S. (2019). Health impact assessment and health equity in sub-Saharan Africa: a scoping review. *Environmental Impact Assessment Review*, 79, 106288. doi:10.1016/j.eiar.2019.106288.
- Leuenberger, A., Kihwele, F., Lyatuu, I., Kengia, J. T., Farnham, A., Winkler, M. S., & Merten, S. (2021a). Gendered health impacts of industrial gold mining in northwestern Tanzania: perceptions of local communities. *Impact Assessment and Project Appraisal*, 39(3), 183-195. doi:10.1080/14615517.2021.1904697.
- Leuenberger, A., Winkler, M. S., Cambaco, O., Cossa, H., Kihwele, F., Lyatuu, I., Zabré, H. R., Eusebio, M., & Munguambe, K. (2021b). Health impacts of industrial mining on surrounding communities: local perspectives from three sub-Saharan African countries. *PLoS ONE*, e0252433. doi:10.1371/journal.pone.0252433.
- Lin, V., & Kickbusch, I. (2017). *Progressing the Sustainable Development Goals through Health in All Policies: case studies from around the world*. Geneva, Switzerland: Government of South Australia and World Health Organization (WHO).
- Llop-Girones, A., & Jones, S. (2020). Beyond access to basic services: perspectives on social health determinants of Mozambique. *Critical Public Health*, 1-15. doi:10.1080/09581596.2020.1769838.
- Lucyk, K., & McLaren, L. (2017). Taking stock of the social determinants of health: a scoping review. *PLoS ONE*, 12(5), e0177306. doi:10.1371/journal.pone.0177306.
- Mahoney, M., Simpson, S., Harris, E., Aldrich, R., & Stewart Williams, J. (2004). *Equity-focused health impact assessment framework*. Newcastle, Australia: Australasian Collaboration for Health Equity Impact Assessment (ACHEIA).
- Marmot, M. (2007). Achieving health equity: from root causes to fair outcomes. *Lancet*, 370(9593), 1153-1163. doi:10.1016/S0140-6736(07)61385-3.
- Morgan, R. K. (2012). Environmental impact assessment: the state of the art. *Impact Assessment and Project Appraisal*, 30(1), 5-14. doi:10.1080/14615517.2012.661557.
- Mzembe, A. N., & Downs, Y. (2014). Managerial and stakeholder perceptions of an Africa-based multinational mining company's corporate social responsibility (CSR). *Extractive Industries and Society*, 1(2), 225-236. doi:10.1016/j.exis.2014.06.002.
- Navarro, V. (2009). What we mean by social determinants of health. *Int. J. Health Serv.*, 39(3), 423-441. doi:10.2190/HS.39.3.a.
- Ontario Ministry of Health and Long-Term Care. (2012). *Health Equity Impact Assessment (HEIA) Workbook*. Ontario Ministry of Health and Long-Term Care. Toronto, ON, Canada.
- Pope, C., & Mays, N. (1995). Reaching the parts other methods cannot reach: an introduction to qualitative methods in health and health services research. *BMJ*, 311(6996), 42-45. doi:10.1136/bmj.311.6996.42.
- Prinz, M. (2001). *History of white-collar workers*. Orlando, FL, U.S.A.: Elsevier.
- Quigley, R., den Broeder, L., Furu, P., Bond, A., Cave, B., & Bos, R. (2006). Health impact assessment international best practice principles. *International Association for Impact Assessment*. Retrieved from http://www.iaia.org/uploads/pdf/SP5_3.pdf.

- RMF, & CCSI. (2020). *Mining and the SDGs a 2020 status update*. Responsible Mining Foundation (RMF), Nyon, Switzerland; Columbia Center on Sustainable Investment (CCSI), New York, U.S.A.
- Salcito, K., Utzinger, J., Krieger, G. R., Wielga, M., Singer, B. H., Winkler, M. S., & Weiss, M. G. (2015). Experience and lessons from health impact assessment for human rights impact assessment. *BMC International Health and Human Rights*, 15(1), 24. doi:10.1186/s12914-015-0062-y.
- Sandham, Chabalala, & Spaling. (2019). Participatory rural appraisal approaches for public participation in EIA: lessons from South Africa. *Land*, 8(10), 150-166. doi:10.3390/land8100150.
- Schrecker, T., Birn, A.-E., & Aguilera, M. (2018). How extractive industries affect health: political economy underpinnings and pathways. *Health and Place*, 52, 135-147. doi:10.1016/j.healthplace.2018.05.005.
- SOPHIA Equity Working Group. (2016). *How to advance equity through health impact assessments*. Society of Practitioners of Health Impact Assessment (SOPHIA). Toronto, ON, Canada.
- Spencer, G., Corbin, J. H., & Miedema, E. (2019). Sustainable Development Goals for health promotion: a critical frame analysis. *Health Promotion International*, 34(4), 847-858. doi:10.1093/heapro/day036.
- Thondoo, M., & Gupta, J. (2020). Health impact assessment legislation in developing countries: a path to sustainable development? *Review of European, Comparative and International Environmental Law*, 00, 1-11. doi:10.1111/reel.12347.
- UNECA. (2011). *Minerals and Africa's development*. United Nations Economic Commission for Africa. Addis Ababa, Ethiopia.
- Utzinger, J., Wyss, K., Moto, D., Tanner, M., & Singer, B. (2004). Community health outreach program of the Chad-Cameroon petroleum development and pipeline project. *Clinics in Occupational and Environmental Medicine*, 4(1), 9-26. doi:10.1016/j.coem.2003.09.004.
- Vanclay, F. (2003). International principles for social impact assessment. *Impact Assessment and Project Appraisal*, 21(1), 5-12. doi:10.3152/147154603781766491, Review AL.
- Vanclay, F. (2017). Project-induced displacement and resettlement: from impoverishment risks to an opportunity for development? *Impact Assessment and Project Appraisal*, 35(1), 3-21. doi:10.1080/14615517.2017.1278671.
- Viliani, F., Edelstein, M., Buckley, E., Llamas, A., & Dar, O. (2017). Mining and emerging infectious diseases: results of the infectious disease risk assessment and management (IDRAM) initiative pilot. *Extractive Industries and Society*, 4(2), 251-259. doi:10.1016/j.exis.2016.08.009.
- Von der Goltz, J., & Barnwal, P. (2019). Mines: The local wealth and health effects of mineral mining in developing countries. *J. Dev. Econ.*, 139, 1-16. doi:10.1016/j.jdeveco.2018.05.005.
- Whitehead, A., & Kabeer, N. (2001). Living with uncertainty: gender, livelihoods and pro-poor growth in rural sub-Saharan Africa. *IDS Working Papers*, 134. Retrieved from <https://opendocs.ids.ac.uk/opendocs/bitstream/handle/20.500.12413/3896/Wp134.pdf>.
- Whitehead, M. (1991). The concepts and principles of equity and health. *Health Promotion International*, 6(3), 217-228. doi:10.1093/heapro/6.3.217.
- Whitehead, M. (2007). A typology of actions to tackle social inequalities in health. *J Epidemiol Community Health*, 61(6), 473-478. doi:10.1136/jech.2005.037242.

- WHO. (2010). *A conceptual framework for action on the social determinants of health: debates, policy & practice, case studies*. Geneva, Switzerland: World Health Organization (WHO).
- WHO. (2013a). *Closing the health equity gap: policy options and opportunities for action*. Geneva, Switzerland: World Health Organization (WHO).
- WHO. (2013b). *Health in all policies: report on perspectives and intersectoral actions in the African Region*. Geneva, Switzerland: World Health Organization (WHO).
- WHO. (2019). *Addressing the Social Determinants of Health at WHO headquarters*. World Health Organization (WHO). Geneva, Switzerland. Retrieved from: https://www.who.int/social_determinants/2_HQ_Address-SDH-at-WHO-headquarters.pdf?ua=1
- WHO. (2020). About social determinants of health Retrieved from https://www.who.int/social_determinants/sdh_definition/en/
- WHO European Centre for Health Policy. (1999). *Gothenburg Consensus Paper*. World Health Organization Regional Office for Europe. Brussels, Belgium.
- WHO Task Force on Research Priorities for Equity in Health, & WHO Equity Team. (2005). Priorities for research to take forward the health equity policy agenda. *Bulletin of the World Health Organization*, 83(12), 948-953. doi:/S0042-96862005001200018.
- Winkler, M. S., Adongo, P. B., Binka, F., Brugger, F., Diagbouga, S., Macete, E., Munguambe, K., & Okumu, F. (2020a). Health impact assessment for promoting sustainable development: the HIA4SD project. *Impact Assessment and Project Appraisal*, 3(8), 225-232. doi:10.1080/14615517.2019.1694783.
- Winkler, M. S., Furu, P., Viliani, F., Cave, B., Divall, M., Ramesh, G., Harris-Roxas, B., & Knoblauch, A. M. (2020b). Current global health impact assessment practice. *International Journal of Environmental Research and Public Health*, 17(9), 2988. doi:10.3390/ijerph17092988.
- Winkler, M. S., Krieger, G. R., Divall, M. J., Cissé, G., Wielga, M., Singer, B. H., Tanner, M., & Utzinger, J. (2013). Untapped potential of health impact assessment. *Bulletin of the World Health Organization*, 91(4), 298-305. doi:10.2471/BLT.12.112318.
- Winkler, M. S., Viliani, F., Knoblauch, A. M., Cave, B., Divall, M., Ramesh, G., Harris-Roxas, B., & Furu, P. (2021). *Health impact assessment international best practice principles*. International Association for Impact Assessment. Fargo, USA. Retrieved from: https://www.iaia.org/uploads/pdf/SP5%20HIA_21_5.pdf
- Worku, E. B., & Woldesenbet, S. A. (2015). Poverty and inequality – but of what - as social determinants of health in Africa? *African Health Sciences*, 15(4), 1330-1338. Retrieved from <https://www.ajol.info/index.php/ahs/article/view/128506>.
- World Bank. (2017). *The growing role of minerals and metals for a low carbon future*. World Bank. Washington, D.C., USA.

5.10 Annex

Table A1: Exemplary quotes for the different layers of inequities (including a code indicating the source, BF: Burkina Faso, MZ: Mozambique, TZ: Tanzania).

Theme	Quotation
Personal factors	
Place of origin and residence	<i>They haven't employed many people from our community. They employ staff from other elsewhere. Men from [this region] and the youth are unemployed. BF3_L2</i>
Gender	<i>The women, they are most affected because although men are eaming money by working, they do not take care of their women. They will go drinking and run after women with the money, but when women are working, the children remain their concern. When the women is [are] working, the children are no longer suffering. BF1_L4</i> <i>Doing cleanness, cutting trees, that does not need education, there are many women there who are not [local] residents are doing those jobs, so it is like [the mining company] has abandoned women form [our village]. TZ2_L2</i> <i>Women are not given a job, when you ask why they don't have a job they say to take care of the house [cough], the person weeding in his land/farm does not grow at all and suffers alone, we have no children to study for say you are going to work there, here we only stay on the field only. MZ2.2_L7</i>
Ethnicity	<i>In [our village] it is like were [we] are in prison, you cannot go at the bank to request a loan because they will say you are living in the area, which has license of white people [mining company owned by Wazungu therefore you cannot do anything TZ3_L8</i>
Age	<i>Our youth are not getting employment. What will they work on, if they are taking our land? Hence, the mine has to find work for them. BF1_L6</i> <i>We young people are sitting at home, and they are taking people from outside to work for them. MZ1_L6</i>
Personal resources	
Educational background	<i>Neither for jobs nor for anything they say that jobs already have owners [...] the ones who know how to write and they used [to] say that 'you don't know how to write', but a long time ago they moralized us with jobs. MZ2.1_L6</i> <i>There is no employment because let us say we are not educated, OK we are not educated but what about our children? They are educated but why don't they get those jobs? TZ2_L2</i>
Monetary	<i>We will be flattened and compensated; the compensation will be hardly beneficial for us. BF1_L6</i> <i>At this time to work you need money, if I had money this time I would be working, because you must have a godfather nowadays to have a job, since that time I came I was told to take money, money to be introduced and start working and I have no money. MZ2.1_L1</i> <i>Yes, there is employment opportunities but we don't see them announcing in the community, people are getting employment by giving bribe [...]. For natives to get employment one must give bribe [to community leaders]. TZ1_L3</i> <i>If we are very poor now it is because of these whites. In the past we were not that poor. MZ1_L4</i>
Social and community network	
Social status	<i>Coming of the [mining project] has brought sadness in our community [...]. There are so many people have not been paid after being evicted to give space to implement mining activities [...]. Leaders are not ready to help community</i>

	<i>members instead they are standing with the ENREP may be it is because they are getting envelopes [bribe] from the mining and at the end of the day leaders are choosing to wear sunglasses. TZ2_L3</i>
Relationship to the mine	<i>The mine will use certain people for in its own way. During the meetings there is always a risk for quarreling. This is new. The dis-cohesion, we haven't known it before. BF1_L5</i>
In-migration	<i>Nowadays people come from afar and have sex with native people and infect them. MZ2.1_L4</i> <i>I have to say, is that these whites [coughs] are here with us, because when they arrived they built the houses and were not expelled, if they were expelled we would stay with the houses they had built, they were not expelled and they stayed here to destroy things of the people. MZ2.1_L4</i>
Living environment and subsistence work	
Land	<i>There is an impact because they have taken our land and there is no fertile land. Also, the mine did not employ all those whose land they have taken. BF3_L7</i> <i>When you grow vegetables community relation officers [from the mine] are cutting all because it is within mining area. TZ3_L8</i> <i>One day you will get call informing you that small miners were evicted from the area as monkeys [by force with no dignity]. TZ1_L7</i> <i>These whites were too smart, they took good farming land, fertile land and left us with a space of stones only. MZ1_L8</i> <i>Because they take our fishing nets and the company said that anyone whose fishing net gets stuck in the river, the person has to write to the company to inform what happened so they can take it out. MZ2.1_L4</i>
Housing	<i>The areas that everyone of us has exploited, were our property. In contrast, the area of the mine, which we are occupying today it the property of these "white" [from the mine]. Why, because the certificate for residential area as promised by the responsible from the mine, we did not receive it [...]. Because you are not the owner of something, you are always living with fear. This problem affects our sleep. BF1_L5</i> <i>They brought a brigade that destroyed the whole village [...] with a cold hand, burned all those houses and as a solution to this they said they would organize the houses of those affected and so far nothing has happened. MZ3_L3</i> <i>We are living as slaves and we don't know when we will be free or when we will get help [...] may be we will get solution to this problem, may be they will say hey this is a place you can go live there. We can finally leave this slavery kingdom. TZ3_L8</i> <i>We are not allowed to dig over three meters or three feet from the surface [...]. If it is more than that you must get a permission from investor. They are saying basing to laws you are supposed to get permit but people are just digging because you need it. If they will find out that it is over three feet it is a violation because this area belongs to another person and we are tenants. TZ3_L8</i> <i>In short they put beacons and limitation that you are not allowed to do any development activities in the area, this affects us and at the same time they don't want to reallocate us. You are not allowed to build permanent house or do any development activity, they put beacons but they don't want to reallocate us, so by doing so they are making us poor because they have stopped us to do development activities. TZ3_L8</i>
Health care	<i>The presence of dispensary is not for the intention of saving our lives but to destroy us because if it wouldn't have been their mining activities we wouldn't have been getting sick frequently, we wouldn't have been getting those scabs</i>

	<p><i>but they did that because they know we will be getting sick because we are like the future dead people. TZ_L4</i></p> <p><i>When they are doing blasting they are wearing special PPE [personal protective equipment] and they are closing everything, also after certain period of time staffs are given medicines to remove poison and I heard their bosses are getting holidays after every three months, they are going back to their home countries and definitely they are getting money for treatment, so what about us poor people. TZ3_L8</i></p>
Road network	<p><i>Also they use their own money to renovate a road from [the town] to [the mine] because they use that road to transport most of their commodities. TZ3_L3</i></p>
Electricity	<p><i>Yes, the main power station of this mining is in [this community] but they direct some power poles and take electricity to [the town] but in [our community], who guards the power poles we don't benefit with that electricity TZ2_L8</i></p> <p><i>For example the building electricity business, there is no outlet in this village. There are only a few here who are using solar energy, they need an installation, if it only were here [in our village]. BF1_L8</i></p>
Job opportunities and working conditions	
Job opportunities	<p><i>What I would like regarding the exploitation of the mine, if the people from the mine can employ our men and even the women, this would be good. When we are talking about employment, they say that if you cannot read and write, it is difficult to become employed. But in this case, if we are not told, we will not eat? There are also small jobs that also illiterate can do. We can clean or do the shopping. All these are jobs, but they don't want to do it. They just have to apologize and see our situation, we need to eat, we are suffering too much. BF2_L5</i></p> <p><i>People living near the mining are not getting employment opportunities. Small companies, which are getting tender to work in the mining are coming with their workers, by doing so natives are not benefiting. TZ1_L1</i></p> <p><i>They are employing chef who gets high salary while that job can be done by one of us from this community. When they were introducing the mining company they said natives will benefit a lot from the mining but we are only getting temporary employment for two weeks or two months or three. TZ2_L1</i></p>
Working conditions	<p><i>The workers of the mine are not coming from here. Those who were employed were fired again after three months. BF1_L5</i></p> <p><i>It has never happened someone from this community to get employment posts inside the mining, we only get security posts and we are staying outside the mining. TZ1_L7</i></p> <p><i>It is labour work not employment. TZ3_L2</i></p>
General socio-economic political conditions	
Socio-economic	<p><i>They took machambas [land/farms] of people but they still haven't finished paying people, they still haven't said anything yet, dust hasn't left, we are not receiving anything and they who are winning are suffering and winning diseases. MZ1_L3</i></p> <p><i>Another thing that causes poverty is [...] the situation of someone not being capable to take a loan because the area you are living is under license of another person that means you will not be allowed by government or [the mine]. GEITA_L8</i></p> <p><i>This government hasn't done anything, [...] they don't want to answer something, they don't want to make [this community] a good place, they don't want to build good schools, but they brought good ones teachers, but the government didn't build a good school like in other places. MZ2.1_L5</i></p>

Political	<p><i>We have no power over them; on the other hand, they have power to do what they want, because the authorities let them do. Instead of preserving our health. In any case, the authorities must know that their power come from the people and without the people there is no power. In this regard, the government has the obligation to surveil the health of the population. BF1_L5</i></p> <p><i>Because if the government thought of us, [the mining company] would do good things. MZ2.2_L2</i></p>
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6. Water infrastructure and health in mining settings in sub-Saharan Africa: a mixed-methods geospatial visualization

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Video clip: <https://youtu.be/4EcJ2rDQEuU>

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6.1 Manuscript

6.1.1 Abstract

Industrial mining transforms local landscapes, including important health determinants like clean water and sanitation. In this paper, we combine macro-level quantitative and micro-level qualitative data to show how mining projects affect water infrastructures and ultimately health of affected communities. Although we observed a positive trend of improved water infrastructure in mining settings, surrounding communities are also characterized by water scarcity and water quality degradation. The video at the core of this publication showcases inter-linkages of the findings obtained at the macro- and micro-level and embeds our results in their geospatial context. Our study shows that while mining projects can have positive impacts on development of local water infrastructure, improved management of negative impacts of mining projects is needed for promoting “Good health and well-being” and “Clean water and sanitation” as promulgated by the Sustainable Development Goals of the 2030 Agenda.

6.1.2 Background

Water security is one of the key public health issues of the 21st century (Boretti and Rosa, 2019). The importance of water is also reflected in the 2030 Agenda for Sustainable Development, aiming for “universal and equitable access to safe and affordable drinking water for all” under the sixth Sustainable Development Goal (SDG) (United Nations, 2015). Access to water is intrinsically linked to the attainment of good health and well-being – prominently featured in the 2030 Agenda for Sustainable Development under SDG 3. Achieving these ambitious goals requires collaboration between different sectors – including extractive industries.

Large resource extraction projects, such as industrial mines, are an important economic driver in many of the countries where water scarcity is an acute problem (Admiraal et al., 2017). The implementation of mining projects can have a positive effect on local water infrastructures through direct investments and local economic growth (von der Goltz and Barnwal, 2019). On the other hand, mining activities can increase the demand of local water resources or cause water pollution, and therefore, negatively affect access to clean water in local communities (Kemp et al., 2010; Schrecker et al., 2018). Rapid in-migration of job seekers to the often remote and rural areas can additionally strain the often weak water infrastructures and limited water resources (Pelders and Nelson, 2018). Hence, as a key determinant of health, changes on local water resources are closely interlinked with the health and well-being of affected populations (Marcantonio et al., 2021).

To assess these positive and negative impacts of large infrastructure projects on water resources and health, environmental impact assessments (EIAs) are conducted in virtually all countries in the world (Morgan, 2012). EIAs aim to determine how to mitigate potential negative environmental impacts along with maximising potential benefits for society prior to project development (Morgan, 2012). Hence, impact assessment can serve as a tool to engage mining companies toward the attainment of the 2030 Agenda for Sustainable Development (Winkler et al., 2020).

To inform impact assessment practice, it is important to better understand in which direction and to what extent water infrastructures are impacted in mining settings and ultimately how this affects the health of surrounding communities. To date, studies on the impacts of mining projects on water often focus on environmental effects, while the inclusion of health implications for surrounding communities remains weak. Particularly, research triangulating qualitative and quantitative data at both supra-national and local level data is scarce. In this paper, we utilized a mixed-methods approach to better understand how mining affects access to safe and affordable water and how this affects the health status of local communities in sub-Saharan Africa.

6.1.3 Methods

In the frame of a multi-country research project, we combined quantitative and qualitative data (**Figure 19**) (Farnham et al., 2020; Winkler et al., 2020). Quantitative data were used to analyse the trends in access to different water sources (i.e. piped water, wells, surface water) from a macro-level perspective. Based on qualitative data, water reliability and quality were described on a micro-level as perceived by affected community members. Together with insights from EIA reports, we triangulated all our findings to present a comprehensive overview of the complex and dynamic relationship between mining projects, water infrastructures and community health. The video at the core of this publication allowed us to embed our results in their geospatial context and to showcase linkages of the findings obtained at the different levels.

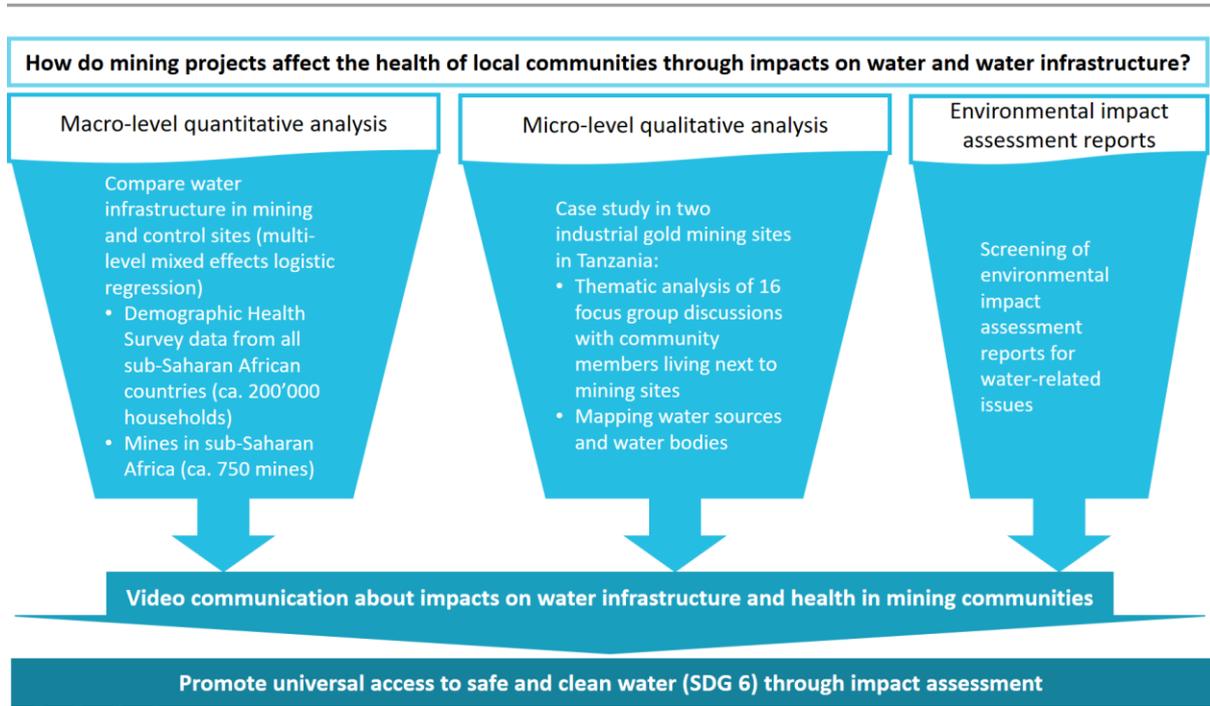


Figure 19: Overview of methodological approach to map water infrastructure and related health impacts in communities affected by mining projects (SDG: Sustainable Development Goal).

Macro-level: regional trends on water infrastructure around industrial mining sites

For quantifying the impacts of the mines on water infrastructure at the national and supra-national level, data from all Demographic and Health Surveys (DHS) conducted in 34 sub-Saharan African countries were combined (Dietler et al., 2021). DHS data is generated through repeated standardized household surveys, allowing for comparison of access to water in mining areas both across and within countries over time.

The Standard & Poor’s Global Market Intelligence Mining Database featuring all large mines in Africa was used to select the more than 189,992 DHS households located within a 100 km distance of an industrial mine (Dietler et al., 2021). The households were grouped depending on their distance to the mining site. Households located within a radius of 5 km from a mining project were classified as impacted. Households at a distance of 50-100 km from the closest mine were used as comparison group. Households located in larger cities were excluded from analyses. Using multi-level multinomial logistic regression models, the impact of proximity to a mine on access to water infrastructures and diarrheal incidence in the two weeks prior to the survey was analysed.

Micro-level: perceived impacts on water and health of communities living around industrial mining sites

For better understanding the impacts of mining companies on local water infrastructure, we collected primary data in two industrial gold mining sites in north-western Tanzania. More precisely, we engaged with communities around the Buzwaji and Bulyanhulu Gold mine.

Rooted in “Qualitative GIS” (qualitative geographic information system), we first conducted focus group discussions (FGDs), followed by a thematic analysis to extract statements related to water. Subsequently, we geo-referenced the water sources mentioned during the discussions (Lechner et al., 2019; Leuenberger et al., 2021).

Data triangulation and visualization

Based on the individual quantitative and qualitative research related to this work, we identified, extracted and combined findings on emerging water and health issues for this data triangulation. Additionally, we contextualised the findings with insights from EIA reports of the two mines in the selected study sites, which were systematically screened for water-related issues. We visualised our findings from the different data sources and levels of data analysis, including spatial components in a short video clip. This approach allowed us to contrast and contextualise our findings from the different levels by portraying the situation on the ground. The main purpose of our visualization was to create a tangible communication tool to present our mixed methods research approach and findings to a broad audience.

6.1.4 Results

Based on the quantitative data, we found that across all included countries in sub-Saharan Africa, households located closer to a mine were almost 4-times more likely to have access to modern drinking water sources, such as piped water, while relying less on surface water. However, stratified analyses revealed that mainly the wealthier households profited from these overall positive trends in mining regions (Dietler et al., 2021).

These findings from the DHS data analysis were mirrored by the qualitative data collected in two mining areas in north-western Tanzania (Leuenberger et al., 2021). In both study sites, the mine supported the construction of water access points, such as taps, pumps or drilled wells for surrounding communities. However, FGDs participants raised concerns about water accessibility. Additionally, we observed several abandoned or not operational pumps, which were originally implemented by mining companies. This confirms participants’ notion on the lack of sustained improvements water infrastructure. Besides technical aspects, participants from both study sites reported negative impacts of the mining operations on the availability and quality of drinking water from traditional water sources, such as open wells and rain water collection systems. Further, they linked the scarcity of water and poor water quality with adverse effects on their health status. For example, some participants perceived an increase in diarrhoeal diseases due to the polluted water. On the other hand, quantitative data on the incidence of childhood diarrhoea shows no association between the location of the mines and incidence of diarrhoeal diseases (Dietler et al., 2021). This may be explained by the diversity

of factors influencing diarrhoea incidence, including nutritional status, personal hygiene and access to safe drinking water and food.

Screening of the impact assessment reports of the two mining projects revealed that besides various community development initiatives, interventions related to water infrastructures were considered in both mining sites. Both reports included aspects related to water quality and availability in surrounding communities. However, the planned interventions to mitigate these impacts around the Buzwagi mine were more comprehensive compared to the Bulyanhulu mining project. Despite these mitigation plans, our results from the micro-level analyses suggest that communities around Bulyanhulu benefited more from investments in water infrastructure compared to the communities around Buzwagi. This indicates a potential gap between mitigation plans and actual implementations.

6.1.5 Conclusion and outlook

By combining quantitative and qualitative data, this study highlights differences in impacts of mining companies on water infrastructure and related health effects from a macro- and micro-level perspective. The triangulation of these different perspectives allowed us to identify pockets in society that did not profit from the overall positive impacts by the mines on water infrastructure. These developments could potentially be driven by direct investments by the mine, but also be the result of overall economic development and increased engagement of the local government in the water sector (Admiraal et al., 2017). Yet, more research is needed to better understand how positive impacts can be maximized and focussing on exposure pathways of local communities to these chemicals. Nevertheless, our results show that mines play a major role for both positive and negative impacts on water availability and quality for local communities and their health.

This data triangulation was realized within the frame of a larger research project, aiming to generate sound scientific evidence to promote the use of Health Impact Assessment (HIA) in sub-Saharan Africa (Farnham et al., 2020; Winkler et al., 2020). This visualization along with other audio-visual material was produced to communicate the multi-layered research results to a broad audience and facilitate an informed and effective policy dialogue. In particular, this vHealth communication can increase accessibility and raise awareness of public health science in traditionally non-health sectors. Reducing the barriers between different sectors and disciplines can foster intersectoral collaboration. This type of intersectoral collaboration between public health practitioners and researchers, international policymakers and local communities is key to achieving SDG 3 “Good health and well-being for all” and SDG 6 “Clean water and sanitation” by 2030.

Box 1: Motivation

- Create a tangible communication tool to present our mixed methods research approach and resulting findings to a broad audience
- Visualize and integrate different data sources and levels of data analysis, including geospatial aspects
- Show the different types of water infrastructures commonly found in mining areas on the African continent

Box 2: Software used

- Content visualization and animations: Microsoft Power Point 2016 (Microsoft Corporation, Edmond; WA, USA)
- Three-dimensional fly troughs: Google Earth Pro version 7.3.14507 (Google, Inc., Mountain View, CA, USA)
- Video editing: DaVinci Resolve 15 (Blackmagic Design, free download available here)

6.1.6 References

- Admiraal, R., Sequeira, A. R., McHenry, M. P., & Doepel, D. (2017). Maximizing the impact of mining investment in water infrastructure for local communities. *Extractive Industries and Society-an International Journal*, 4(2), 240-250. doi:10.1016/j.exis.2017.01.014
- Boretti, A., & Rosa, L. (2019). Reassessing the projections of the World Water Development Report. *NPJ Clean Water*, 2(1). doi:10.1038/s41545-019-0039-9
- Dietler, D., Farnham, A., Loss, G., Fink, G., & Winkler, M. S. (2021). Impact of mining projects on water and sanitation infrastructures and associated health outcomes in children: A multi-country analysis of demographic and health surveys in sub-Saharan Africa. (submitted)
- Farnham, A., Cossa, H., Dietler, D., Engebretsen, R., Leuenberger, A., Lyatuu, I., Nimako, B., Zabre, H. R., Brugger, F., & Winkler, M. S. (2020). Investigating health impacts of natural resource extraction projects in Burkina Faso, Ghana, Mozambique, and Tanzania: Protocol for a mixed methods study. *JMIR Research Protocols*, 9(4), e17138. doi:10.2196/17138
- Kemp, D., Bond, C. J., Franks, D. M., & Cote, C. (2010). Mining, water and human rights: making the connection. *Journal of Cleaner Production*, 18(15), 1553-1562. doi:10.1016/j.jclepro.2010.06.008
- Lechner, A. M., Owen, J., Ang, M., & Kemp, D. (2019). Spatially integrated social sciences with qualitative GIS to support impact assessment in mining communities. *Resources*, 8(1), 47. doi:10.3390/resources8010047
- Leuenberger, A., Winkler, M. S., Cambaco, O., Cossa, H., Kihwele, F., Lyatuu, I., Zabré, H. R., Eusebio, M., & Munguambe, K. (2021). Health impacts of industrial mining on surrounding communities: Local perspectives from three sub-Saharan African countries. (submitted)

- Marcantonio, R.A., Field, S.P., Sesay, P.B. & Lamberti, G.A. (2021). Identifying human health risks from precious metal mining in Sierra Leone. *Regional Environmental Change* 21(2). doi:10.1007/s10113-020-01731
- Morgan, R. K. (2012). Environmental impact assessment: The state of the art. *Impact Assessment and Project Appraisal*, 30(1), 5-14. doi:10.1080/14615517.2012.661557
- Pelders, J., & Nelson, G. (2018). Living conditions of mine workers from eight mines in South Africa. *Development Southern Africa*, 36(3), 265-282. doi:10.1080/0376835x.2018.1456909
- Schrecker, T., Birn, A.-E., & Aguilera, M. (2018). How extractive industries affect health: political economy underpinnings and pathways. *Health and Place*, 52, 135-147. doi:10.1016/j.healthplace.2018.05.005
- United Nations. (2015). *Transforming our world: the 2030 Agenda for Sustainable Development*. New York, NY, USA: United Nations
- von der Goltz, J., & Barnwal, P. (2019). Mines: The local wealth and health effects of mineral mining in developing countries. *Journal of Development Economics*, 139, 1-16. doi:10.1016/j.jdeveco.2018.05.005
- Winkler, M. S., Adongo, P. B., Binka, F., Brugger, F., Diagbouga, S., Macete, E., Munguambe, K., & Okumu, F. (2020). Health impact assessment for promoting sustainable development: the HIA4SD project. *Impact Assessment and Project Appraisal*, 3(8), 225-232. doi:10.1080/14615517.2019.1694783

6.2 Story grid

#	Text	Image
1	Whenever large infrastructure projects, such as mines, are developed in a rural area, like <i>Buzwagi</i> , local communities experience changes in their social and physical environments. Positively, the mine can boost the local economy, or contribute to community development overall. Such changes could potentially improve community health and well-being in the long term.	<ul style="list-style-type: none"> - Picture of market/gold seller - Nice housing
2	Negatively, the arrival of a mine can also increase contamination of air, water and soil. This, and a rapid influx of people can add to the strain on often weak and overburdened public infrastructures. When infrastructures are under strain, diseases spread more.	<ul style="list-style-type: none"> - Mine (GGM) - School with many children (e.g. BF)
3	One factor large mines can positively and negatively affect is local water infrastructure. Clearly, safe and clean water is key to good health and well-being. Before such big projects are developed, their potential impacts should be assessed. So called “impact assessments” identify positive and negative impacts, including health aspects. The final impact assessment report includes a mitigation plan. The aim of such a mitigation plan is to minimize negative impacts and maximize potential benefits for local communities.	<ul style="list-style-type: none"> - Woman pumping water in BF
4	Where natural resources are extracted assessments show if the impact on the water infrastructure is positive or negative and how big these positive and negative impacts are. Ultimately, the impact assessment shows how the new mine affects the local water and how this affects the health of communities. To understand these connections, we combine quantitative and qualitative data.	<ul style="list-style-type: none"> - Water/dam where kids are playing - Top box of methods overview figure
5	With the quantitative data we analyze the settings from a macro-level. This is complemented by micro-level qualitative data. To quantify the mines' impacts on water infrastructure at the national and supra-national levels, we combined data from all Demographic and Health Surveys, short DHS, in sub-Saharan Africa.	<ul style="list-style-type: none"> - Rest of methods overview figure animated
6	We then used another dataset, featuring all large mines in Africa to select approximately 200'000 households located in proximity to a mine. Using regression models, we analyzed the impact of having a mine nearby.	<ul style="list-style-type: none"> - Rest of methods overview figure animated
7	To better understand the impacts of mining projects on local water infrastructure, we visited two industrial gold mining sites in northwestern Tanzania. In villages around the Buzwagi and Bulyanhulu Gold mines, we engaged with community members.	<ul style="list-style-type: none"> - Research team in a car (on a shaky road)
8	One year later, we visited the villages again to map and observe water sources and water bodies mentioned by the community members.	<ul style="list-style-type: none"> - Figure: Methods overview

9	Additionally, we screened Environmental Impact Assessment reports for water related issues.	- Figure: Methods overview
10	The quantitative data showed that the mines had a positive impact on water infrastructure across all included countries in sub-Saharan Africa. The closer the households were to a mine the more improved water sources, such as piped water, were available. Overall, the households in the first 5 kilometers from a mine were around 4-times more likely to have access to piped water than households further away. However, these benefits were not distributed equally, with poorer households profiting less.	- Far-away GE imagery highlighting the countries that were covered with DHS data - (pop-up) Graph showing percentages of different water sources by distance
11	The same pattern exists when focusing only on Tanzania.	- Zoom to Tanzania (whole country) on GE
12	These findings from the DHS data were mirrored by the qualitative data from our visits to Buzwagi and Bulyanhulu. In both sites the mine installed or financially supported many different water access points for surrounding communities. These included taps and pumps. Zooming to the two sites, we see the locations of some of these investments.	- Zoom to Buly+Buzwagi, potentially explaining the colours and symbols in the narration
13	Community members living around the Bulyanhulu mine said how important new and reliable drinking water sources, such as taps and drilled wells, were.	- Bulyanhulu taps
14	For example, one participant told us: <i>there is a drilled well also constructed by the mining company and we are using water from this well for drinking. Also the well is fenced and there is a tap, it is a modern one.</i>	- Bugando source video with quotation showing up
15	Around the Buzwagi mine, more than a dozen new pumps were installed in several villages. However, participants reported that some pumps are not operational and we found several pumps abandoned.	- Buzwagi and Iboja Pump (Buzwagi site)
16	Besides technical aspects, participants from both sites reported negative impacts on the water availability and quality. They described that their wells are dried-up and suspected the reason was that the mine needs more water. More importantly, they complained about the poor water quality. They said the water in their wells is smelly, salty or oily. According to the participants, chemicals get into their unprotected wells through the air or penetrate their water sources underground.	- Julius well
17	They said: <i>Through blasting activities where the water from the poison dams can penetrate underground and enter in our water sources.</i>	- Same as above: video continues, quotation showing up

18	Also, local residents were afraid to use the rain water, which they traditionally collect as drinking water. Blasting in the mines sends black particles into the air that land on their roofs. This dust is washed directly into their water collecting systems.	- Rainwater collection system (Chapulwa Primary School)
19	In the words of a participant from Kakola Number 9: <i>You cannot fetch rainy water because it is black because of the dust stacked on the roof, you cannot drink it.</i>	- Quotation showing up
20	Further, participants linked these problems with the water to their health. As another participants said: <i>The water is not safe [...]. That water causes miscarriage, causes diseases like urinary tract infections and stomach diseases, so we do not trust the water that we use.</i>	- More images from water sources/water fetching - Same as above: video continues, quotation showing up
21	We then wanted to know if better results can be explained by better mitigation plans in impact assessment. But when we looked at the impact assessment reports of the two mining projects we saw that this was not the case. Both reports included aspects related to water quality and quantity. But the outcome in Bulyanhulu was better even though the mitigation plan in the Bulyanhulu report covered less than the Buzwagi-report.	- Methods figure - Tap with woman Acacia
22	To sum up, this study combined quantitative and qualitative data, and offered macro- and micro-level perspectives. The findings indicate different impacts of mining companies on water infrastructure and on health. From the macro-perspective, we found overall positive impacts of mines on local water infrastructure. So, water infrastructure around mining projects is more developed compared to non-mining regions. On the other hand, both the macro and the micro-level analysis showed that there are pockets in society that do not profit from these positive impacts.	- Figure: methods – now with visuals from findings (graph, wells)
23	Although the mines build new water access points, availability and access to clean water is still a major issue. Particularly when the mine uses chemicals that pollute the environment, this is a major concern for the residents of the surrounding communities. Taken together, we can conclude that mines play a big part in both positive and negative impacts on water for local communities and their health.	- Dirty dam
24	Impact assessment could be a promising tool to manage these impacts. Our results point out that this tool should be used to address communities' needs in an equitable manner – this includes the health and well-being of the most vulnerable populations. Most importantly, anticipating future impacts is not	- ASGM community meeting Ghana

	enough. In addition, ongoing and collaborative management and monitoring are essential to ensure any positive effects.	
25	In the spirit of the 2030 Agenda for Sustainable Development – “leave no one behind” - inclusive impact assessment of mining projects together with community liaison activities could make it possible to strive toward universal access to water for all as a key element for health and well-being.	<ul style="list-style-type: none"> - Woman riding off with jerry can on her bike - SDG Wheel

7. Digital storytelling

The following table (**Table 6**) gives an overview of the video clips produced within the frame of the digital storytelling project. While the direct links to each video is given in the table, the clips are available online in the Youtube channel of the r4d programme.

Title	Spotlight	Main SDGs	Link	Filmmaker(s)	
How could we improve community health around large gold mines? - Community voices	Insights from the field work in Tanzania	 3 GOOD HEALTH AND WELL-BEING	 6 CLEAN WATER AND SANITATION	https://bit.ly/39VSvUy	Andrea Leuenberger
How could we improve community health around large gold mines? – Executive summary	Summary of insights from the field work in Tanzania	 3 GOOD HEALTH AND WELL-BEING	 6 CLEAN WATER AND SANITATION	https://bit.ly/2Xm2TQa	Andrea Leuenberger
A multidisciplinary approach to researching health impacts of large mines	HIA4SD project	 3 GOOD HEALTH AND WELL-BEING		https://bit.ly/3i30JNd	Dominik Dietler and Andrea Leuenberger

Table 6: Overview the outputs from the digital storytelling project (HIA4SD: Health impact assessment for sustainable development, SDG: Sustainable Development Goal)



8. Discussion

The overarching goal of this PhD thesis was to better understand how large NREPs affect the health of local communities, placing particular emphasis on the social determinants of health and health equity. The generated evidence will be used to facilitate a policy dialogue toward the institutionalization of HIA in sub-Saharan Africa. This chapter brings together the different components and situates the work in a broader public health context. It starts with its contribution to the three Swiss TPH pillars (innovation, validation and application). It continues with methodological reflections of the individual objectives, which are followed by a synthesis of key findings of the different study components. Next, the current work is located in the frame of the (i) the HIA4SD project; (ii) Africa's continental Agenda 2063; and (iii) the global Agenda 2030 for Sustainable Development. After a concluding section, recommendations for research and practice are formulated.

8.1 Thesis contributions to innovation, validation and application

This PhD thesis was conducted at the Swiss Tropical and Public Health Institute (Swiss TPH). The three pillars of innovation, validation and application build the main foundation for the institute's value chain and serve as strategic nexus for excellence in global health. The contributions of this work to the three domains are summarized in **Table 7**.

Table 7: Overview of contributions of the PhD thesis to the three main pillars of Swiss TPH (innovation, validation and application) (FGD: Focus group discussion; HIA: Health impact assessment; SDG: Sustainable Development Goal)

Chapter	Innovation	Validation	Application
2: Literature review	Health equity in impact assessment in sub-Saharan Africa	Scrutinizing health and health equity aspects in impact assessment guidelines and compare it with research practice (published research)	Findings informing a policy dialogue to strengthen community-based HIA in sub-Saharan Africa
3: Perceived health impacts across countries	Comparative qualitative study based on participatory FGDs across countries		
4: Gendered health impacts	Participatory FGDs to study health impacts and their distribution among affected communities	Scrutinizing health impacts from a gender lens	
5: Perceived inequities	Comparative qualitative study based on participatory FGDs across countries		Open access video communication to disseminate our findings to a broad audience, including stakeholders
6: Water infrastructure and health in mining regions	Integrating findings from geo-referenced qualitative and quantitative data into a video communication		

Chapter	Innovation	Validation	Application
			involved in the policy dialogue
7: Digital Storytelling	Producing short video clips to communicate science and its contribution to the SDGs		Open access video clips to share the projects connections and contributions to the SDGs to a broad audience and various stakeholders
Annex A1: New SDG Reporting Scheme	Launching new SDG reporting scheme in <i>Tropical Medicine and International Health</i> to report and monitor contributions of published research to the SDGs	SDG tagging by core team, validation through authors of the publications	Participatory tagging tool: authors tag their research independently; potentially yearly evaluation of progress toward the SDGs

8.2 Reflections on the methods and results of the individual objectives

8.2.1 Literature review

As an entry point into this PhD thesis, the literature review aimed to obtain an overview of the current HIA literature and how the social determinants of health are included. The search was initially focusing on HIA only and only a few HIA papers were identified, with almost none from authors outside of the HIA research group at Swiss TPH. In order to retrieve a representative sample of the ongoing impact assessment research potentially addressing health, we expanded the final search strategy and included EIA and SIA literature as well. Impact assessment reports were scrutinized in a separate study within the HIA4SD project (Dietler et al., 2020).

For the analysis, the original plan was to systematically investigate, how the social determinants of health are addressed in current HIA literature and guidelines. However, identifying and interpreting “key social determinants of health” was a major challenge due to the scope and complexity of the factors determining health. In the literature and guidelines retrieved, health determinants were often not mentioned explicitly or included in a rather vague list of various determinants and not further explained. Meanwhile, considering so-called “differential impacts”, emerged as key strategy to address the health of various population subgroups, which are determined by social determinants of health. Finally, this led to analyzing the distribution of health impacts among population subgroups, as suggested in the EFHIA framework (Mahoney et al., 2004). This shift from investigating the social determinants of

health by looking in to differential health impacts and thus, health equity, was a turnaround in the study and echoes the close interplay of the two concepts.

8.2.2 Perceived health impacts across countries

Based on the qualitative study conducted in the partner countries, this paper aimed to compare the perceived health impacts in the different countries and settings. The following sections reflect about methodological challenges, advantages and limitations related to the qualitative work undertaken.

A first major challenge that we faced in the field was the systematic selection of the study villages. Following the data collection manual, we aimed to identify villages that were “highly negatively” impacted and “highly positively and negatively” impacted by extraction projects. “Highly negatively” impacted villages were defined as not having benefited from any interventions implemented by the mines. On the other hand, “highly positively and negatively” impacted villages, were defined as villages, where interventions were implemented. Indeed, the closer the villages were to the mining area, the more exposed they were to the negative environmental effects. However, both negative impacts (e.g. water or air pollution) as well as interventions (e.g. new health centers) seemed to be rather systemic and often affecting multiple villages. Therefore, identifying purely negatively impacted villages was difficult. The transect walk in each study site allowed us to map the different impacts and select the study villages to enclose a broad range of negative and positive impacts. Once the study villages were selected, we closely collaborated with village representatives or community health workers. This was particularly helpful to get further insights about the impacts and related dynamics affecting the communities and allowed us to delegate the recruitment of study participants.

At the heart of the data collection were participatory FGDs with men and women from affected communities. During the discussions, health impacts were collected (by writing them on cards), categorized into social determinants of health (assigning the cards to sheets) and ranked (with lids or stones) by the participants. This participative methodology allowed all participants to contribute to a lively discussion, interacting with each other and kept the whole group engaged until the end, which can be a challenge in “traditional” FGDs (Kitzinger, 1994). Through the reiteration of the different impacts during one discussion participants could reflect and moderators probe about different aspects of the mentioned impacts. Additionally to the in-depth discussions, the participatory tool created a summary table of all mentioned impacts and their perceived importance - compared to a 20 up to 50 pages of transcription per discussion. This overview was helpful (i) to understand the data, particularly when I did not speak the language of the discussion or did not take part in the data collection; (ii) to compare

the findings from the different discussions at hand; and (iii) to master the huge amount of data from the different countries. Overall, the method chosen was reproducible in the different countries allowing for reliable data collection while exploring of the epistemological nature of the research. In particular the community-based approach was revealing to study the social determinants of health (Bach et al., 2017). Despite these advantages of using a “smart tool” (meaning the low costs and few materials needed, flexible for the different countries and possibility for rapid appraisal compared to complex biomonitoring or health survey studies as example), scientific rigor is essential to create sound and trustworthy qualitative evidence (Pope et al., 2000). Hence, trained research assistants (moderators, transcribers and translators) and thorough documentation of the data collected are key to be able comparative and collaborative analysis and ultimately raise the voices of the communities by disseminating the findings (Grieb et al., 2015).

For this study, we only included data from affected communities, which could be subjected to be biased, as we purposively sampled community members from highly impacted villages. Additionally, the presence of an international research team may have affected the discussions. In the frame of the qualitative field work there were certain elements to minimize this potential bias. With the assistance of a local study coordinator, we conducted a transect walk in each study site to obtain an overview of positive and negative impacts of the mines. During daily debriefing sessions, field teams were encouraged to exchange about new observations or findings from KIIs or FGDs and update the initial map. This allowed the moderators to probe accordingly during the discussions, for instance about specific interventions implemented by the mines in case they have not been mentioned by the participants. Through the close collaboration with village leaders or community health care workers and multiple visits in the villages prior data collection, we have established a rapport, which was helpful to create a faithful atmosphere for the FGD. Further, at the beginning of each FGD, the purpose of the study was introduced. Worth mentioning, FGDs were always moderated by trained research assistants from the respective countries and held in the local languages.

The comparative analysis of the data was conducted as collaborative work with two researchers and one supervisor in Mozambique. This collaboration enabled me to include the data from Mozambique (in Portuguese). Moreover, the joint development of the coding system reduced the personal bias related to my familiarity with the data from Tanzania (Pope et al., 2000). Additionally, the insights in to the field work in Burkina Faso (discussions, pictures, videos) and the field experience in Ghana were helpful to see the ample similarities of the settings. Importantly, during regular team meetings and discussions we validated the codes and exchanged about the most striking narratives from the different countries, which was an

essential element for the rigor of the study (Milford et al., 2017). All together, these experiences and collaborations were a major contribution for successful development of this manuscript.

8.2.3 Gendered health impacts

Beyond the collection of the health impacts during the FGDs, we also asked participants about the distribution in their communities, which was the foundation for this paper. The question “which subpopulation groups were affected by the impacts” served as entry point for this manuscript. Yet, most often participants in Tanzania replied that “the whole community” (“*jamii yote*” in Swahili) is affected. This fact is particularly interesting, since it contradicts the findings from the literature review, where we concluded that the systematic stratification of subgroups is key to address health equity in HIA.

Based on an in-depth analysis of the transcripts, gender and age were identified as key characteristics determining sub-population groups among the communities. Major differences were reported between men and women and primarily linked to their engendered roles. In light of this, we chose Moser’s framework to contextualize our findings (Moser, 1989, 1995). Although the framework was developed in the late 1990s, it allowed us to discuss practical and strategic gender needs, as important factors to address gender and health equity.

Although the study shows how gender and health equity are linked and that the inclusion of women is critical as they play a central role in community health, it is important to mention that we analyzed our data with a gender lens and this was not a gender study by design. While our research gives insight into how health impacts are distributed among communities, more research is needed to deepen the understanding of gendered aspects in health impacts. Regarding the differences between men and women, it would be important to better understand the traditional gender roles and how these are potentially changing through the implementation of the mines. This would allow to design gender-transformative interventions for the given context. Beyond the differences between men, women as well as boys, girls and children, a gender-focused study would be able to identify differences within these population groups but also other population groups. This would be particularly helpful to identify key factors for social stratification, which could be used to further develop the HIA tools and methods with a strong equity focus.

8.2.4 Perceived inequities

During the field work in Tanzania and Ghana, I got the chance to visit three mines. Indeed, seeing the open mining pits, driving through the underground extraction site and walking through the processing plants were very impressive moments. The environment was special and the health and safety of employees and visitors were a top priority. I remember the

thorough security check to enter the mining area, obligation to fasten the seat belt, the designated walking areas, the many installed alcohol tests, and the mandatory dressing code (solid and closed shoes, long trousers and long sleeves shirt). Posters reminded the employees and us that “every person going home safe & healthy every day”. I was also impressed by the infrastructure and high standards in the offices: modern printers, whiteboards and markers, computers, Wi-Fi and air-conditioning in the offices – and modern flush toilets. I haven’t seen such commodities in other offices from high-level governmental officials that we visited during the fieldwork. Most striking however was the short tour in the health department in one of the mines. I was stunned by the specific X-ray and sonography room, a small but well-equipped operating theater, a room for physiotherapy, two modern labs as well as a highly sterile emergency room – all under the lead of five physicians.

Going back to the villages on the next day, the participants’ concerns resonated differently in me and I realized how strikingly different the worlds are and how the two realities clash against each other. Various aspects of these “different worlds” were highlighted by participants as their statements opposed potential benefits with disadvantages. Beyond the different layers of inequities (which were reported in the equity paper, Chapter 5), statements often indicated a sense of power, indicating the subordinated position of the communities. For example, when they reported lack or loss of power through land disentanglement, or allocation of restricted areas for artisanal mining or fishing. Communities constantly expressed a general feeling of disenfranchisement.

Similarly to the limitations in the comparative study a purposely selected sample and cultural biases could have affected this study. To address this bias, it would be particularly interesting to triangulate the community perspectives with different qualitative findings or quantitative findings. For example, KIIs with community leaders, health care workers or even community relation officers of the mine could provide additional insights about the relationship of the mine and the communities (Carter et al., 2014). Applying a mixed methods approach, for example with national routine health survey data, would allow for an even more thorough exploration and explanation of the data (Pluye & Hong, 2014).

8.2.5 Water infrastructure and health in mining regions

This last component, pertained to impacts of mining projects on water infrastructure and health. It is innovative in terms of methodology and output. Using a mixed-methods approach, we triangulated findings retrieved from DHS data and qualitative investigation of water sources from communities in proximity of gold mines. The mixed-methods approach enabled us to detect impacts on water infrastructures at the macro-level while allowing for more in-depth considerations on the changes among local residents. The triangulation, including the geo-

spatial components, offers new perspectives on the complex dynamics related to the project development and outweighs strengths and limitations of quantitative and qualitative research (Pope et al., 2016).

The results of this co-creation are presented as video publication. By underlining our findings with visualizations, we intend to increase the impact of our research and reach a broader audience inside and outside academia. We particularly hope that it will be used as a communication tool to facilitate the policy dialogue and ultimately improves the health and well-being of affected communities.

8.3 Synthesizing key findings

Besides achieving the individual objective, there are three transversal findings stemming from this PhD project.

Firstly, the “pathway of health impacts” became evident and is illustrated in **Figure 20**. Based on the community perceptions, we found that changes on the environmental, social and economic determinants of health, which were induced by the mine, ultimately had consequences on the perceived health and well-being of study participants. In response, several interventions were implemented by the mines. Although in most study sites health care was improved, the management of the health impacts was rather opportunistic. Upgraded or newly constructed health care facilities help to treat diseased people, but often do not address the root causes of the ill health, which are the social determinants of health.

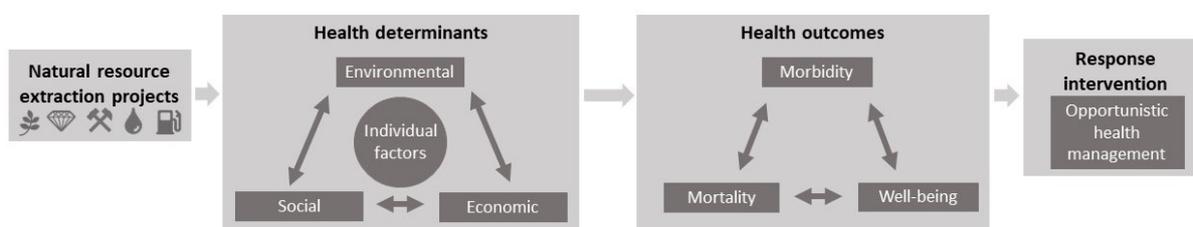


Figure 20: Schematic illustration of pathway of health impacts.

Secondly, this PhD thesis elucidates the ample interlinkage of the social determinants of health and health equity. Two papers are focusing on specific determinants of health (i.e. gender and water and sanitation) and related implications for health. Compared to this focused approach, the diverse aspects of the wider determinants of health was represented in the comparative paper, with particular emphasis on the complex interplay of environmental, social and economic determinants of health. The social determinants of health are not only closely interlinked to each other, but often also intersecting. This means that socially disadvantaged population groups tend to be affected by multiple aspects at the same time (Dahlgren & Whitehead, 1991; Marmot, 2005). The so called social gradient of health, suggests that particularly those with a low socio-economic status or those who are unemployed, are more

likely to suffer from ill health – which was also shown in our context (Marmot, 2007). The unequal distribution of these underlying factors, driven by the distribution of power, money and resources, results in different opportunities for health and thus, health inequities. In light of this, it becomes evident that action on the social determinants of health is needed to reduce health inequities and large NREPs hold theoretically potential to do so.

Thirdly, looking at the different components of the current study (i.e. literature review and qualitative studies), this PhD thesis illustrates the gap between theory and practice of HIA in sub-Saharan Africa. Based on current literature and guidelines investigated in the literature review (see Chapter 2), we found that HIA holds promise to address inequities. Comprehensive studies were conducted to monitor and evaluate HIA, with a specific focus on women and children (Knoblauch et al., 2017; Knoblauch et al., 2018; Knoblauch et al., 2020). These desktop-based research findings are in contrast with the perception of communities living in proximity to industrial mining projects (see Chapter 3-6). The findings based on the qualitative data indicate a lack of impact mitigation in mining regions. Although several interventions were implemented by the mine, perceived negative aspects for their health outweighed. Potential benefits linked to the implementation of the mining projects were not accessible for everyone and often unequally distributed. Of note, major concerns of communities were related to environmental health aspects (water, soil and air pollution; cracks in the houses due to blasting). Hence, even if there were “only” EIAs conducted for the mining projects investigated, which do not address health issues *per se*, these findings highlight the need of improved impact management and mitigation, particularly for the health of affected population (Dietler et al., 2020). This should be addressed by strengthening HIA in the countries hosting the extractive industries and putting the theory into practice.

8.4 Relevance of this PhD thesis for the HIA4SD project

8.4.1 First phase of the project (2017-2020): generating scientific evidence

This work is embedded in the HIA4SD project and thus not an isolated PhD project (Farnham et al., 2020). Given the various topics included in the project (**Figure 1**), the project addresses health extensively. Indeed, health is a complex and cross-cutting issue, which became also evident during the FGDs conducted for this PhD thesis. **Figure 21** shows selected quotations from the FGDs illustrating the link to the five other PhD topics investigated in the frame of the HIA4SD project. This PhD thesis particularly raises the voices of communities, which is an important contribution to the existing literature pertained to community health in mining regions.



Figure 21: Exemplary quotations retrieved from the focus groups discussions with affected community members, showing the thematic intersection with other PhD theses conducted under the frame of the HIA4SD project (HIA4SD: Health impact assessment for sustainable development).

To further increase the impact of the research, the community-centered results could be strengthened with methodological and thematically triangulation. Methodological triangulation could combine different qualitative data (e.g. FGDs and KIIs) but also qualitative and quantitative data (Carter et al., 2014; Pluye & Hong, 2014). The former approach would be particularly insightful for expanding the studies about health equity and could further increase the validity so far community-centered qualitative findings. Similar to the v-Health publication pertained to water infrastructure, it would be highly interesting to triangulate also other findings in a mixed-methods approach. For example, scrutinizing the housing situation or comparing the community perceptions of increased burden of diseases with actual numbers from routine health data as well as analyzing out-of-pocket expenditure. This would not only allow to raise the community voices in different topics but also increase the understanding of health impacts and potentially allow to generalize the community perceptions (Pope & Mays, 2009). Combining the power of stories and numbers could maximize the impacts and lead to better uptake of the research findings in the policy dialogue (Pluye & Hong, 2014). The data at hand and the knowledge acquired in the course of this project offers a great opportunity, which must not remain missed.

8.4.2 Second phase of the project (2020-2023): from evidence to policy

The generated evidence during the first phase of the project will be used to produce country-specific HIA-related public policy recommendations. Drawing on the findings from this research, strengthening HIA in sub-Saharan Africa should integrate the following two aspects. First, new HIA-related policies should emphasize the integration of local communities, as

empowering local communities is a key strategy to act toward equity (Heller et al., 2014). Engaging with directly affected communities is a necessity to come up with effective interventions, that are accessible and beneficial for all (Maalim, 2006). Second, HIA should be promoted as long term activity, compared to a mechanism for obtaining the mining license. In the best case, a new policy conveys a framework that holds mining operators accountable during the different project phases and ensures good health and well-being of surrounding communities in the long run (O'Keefe & Scott-Samuel, 2010).

Based on the generated evidence, restructuring the governance architecture toward the institutionalization of HIA – including local communities – could contribute to close the critical gap between researchers and policies (McKee, 2019; Thondoo & Gupta, 2020). Although translating research findings into a policy dialogue has been reported as major challenge among researchers, the HIA4SD as multidisciplinary project is likely to create beyond the academic impact also a societal impact for sustainability (Erismann et al., 2021, under review; Newig et al., 2019).

8.5 Situating this thesis in the frame of development agendas

8.5.1 Agenda 2063

The Agenda 2063 has been considered as continental action plan, toward an “integrated, prosperous and peaceful Africa” and is closely related to the development potential due to the continent’s vast amount of endowed natural resources (AUDA-NEPAD, 2015). Most importantly, the Agenda 2063 emphasizes the need of increased ownership of extractive industries and that the transformation of the continent should be people-driven. Both aspects are aligned with the current work.

Increased ownership of the project is related to the objective of the framing project of this PhD thesis, to promote the use and uptake of HIA by engaging the extractive industries. Importantly, increased ownership of the project should also include public health considerations. Therefore, the HIA4SD project with its various stakeholders and exhaustive health research approach offers a great opportunity to infuse this public health perspective into traditional non-health sectors, like the extractive sector. This would further help to protect the health of most marginalized communities and to reach not only a prosperous, but also an integrated and peaceful Africa with healthy citizens (AUDA-NEPAD, 2020).

The “people-driven” approach pursued by the agenda is related to the community-centered research presented in the current work (see Chapters 3-6) as well as to “democracy” as core value of HIA (Quigley et al., 2006). Listening to the voices of affected communities demonstrated the need of improved management of health impacts. To address the needs of the communities effectively, HIA offers an opportunity particularly through public participation.

Although reported as major challenge (Bawole, 2013; Den Broeder et al., 2017), innovative approaches have been developed and successfully implemented (Sandham et al., 2019).

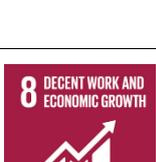
Taken together, the Agenda 2063 offers an opportunity for structural transformation on regional level, and thus, creates an additional momentum toward to the institutionalization of HIA (Baek, 2019). In order “to ensure healthy lives of citizens”, HIA could and should not only contribute to surmount negative impact and enhancing benefits of development projects, but also to include and empower most marginalized population groups (O’Keefe & Scott-Samuel, 2010).

8.5.2 Agenda 2030 for Sustainable Development

As shown in this current study, large NREPs offer certain opportunities to contribute to sustainable development. At the same time the implementation of industrial mining projects may impede the attainment of the SDGs. A summary of the opportunities and risks, based on findings from affected communities is given in **Table 8**. The table further indicates how HIA could contribute to the achievement of the different SDGs.

Table 8: Summary of perceived risks and opportunities of large natural resource extraction projects (NREPs) for local communities and potential contribution of health impact assessment (HIA) by Sustainable Development Goal (SDG).

SDG	Related targets	Perceived risks of NREPs for local communities	Perceived opportunities of NREPs for local communities	Potential contribution of HIA
	1.6, 1.7, 1.8, 1.9, 1.10, 1.b	<ul style="list-style-type: none"> - Loss of artisanal mining areas as traditional source for income - shift from crop to cash-based economy, while local communities are staying behind, bribing 	<ul style="list-style-type: none"> - Increased trade 	<ul style="list-style-type: none"> - Contribute to improved health as aspect of poverty as multidimensional issue
	2.1, 2.3	<ul style="list-style-type: none"> - Lack of agricultural fields - Food contamination 	<ul style="list-style-type: none"> - Introducing new agricultural methods 	<ul style="list-style-type: none"> - Ensure well-nourished citizens
	3.1, 3.3, 3.6, 3.7, 3.8, 3.9, 3.b, 3.c, 3.d	<ul style="list-style-type: none"> - Environmental, social and economic risks for health 	<ul style="list-style-type: none"> - Improved health care services 	<ul style="list-style-type: none"> - Disease prevention and health promotion, health education

SDG	Related targets	Perceived risks of NREPs for local communities	Perceived opportunities of NREPs for local communities	Potential contribution of HIA
 4 QUALITY EDUCATION	4.1, 4.3, 4.5, 4.6, 4.7	- Early drop out of schools linked to poor economic situation (early pregnancies from sexual transactions, child labor)	- New schools, vocational training for young boys	
 5 GENDER EQUALITY	5.4, 5.5, 5.a	- Unequal distribution of (health) impacts between men and women	- Support of local (women's) associations	- Include gender-sensitive and gender-transformative interventions, include women in decision-making
 6 CLEAN WATER AND SANITATION	6.1, 6.2, 6.3, 6.4, 6.6, 6.a, 6.b	- Poor water quality and availability - Loss of water-related ecosystems - Poor hygienic conditions (caused by dust load and open-defecation)	- New water access points	- Universal access to water
 8 DECENT WORK AND ECONOMIC GROWTH	8.3, 8.5, 8.6, 8.8	- High rates of unemployment - Socially insecure job opportunities in the mine	- New job opportunities in the mines	- Ensure healthy working conditions for local communities
 10 REDUCED INEQUALITIES	10.2	- Unequal distribution of benefits		- Include local communities in decision making process of developing interventions - Empower local communities and particularly most marginalized population groups - Ensure equal benefits among community subgroups
 11 SUSTAINABLE CITIES AND COMMUNITIES	11.1, 11.2	- Cracks - Land disentanglement	- Resettlement	- Sustainable and resilient buildings and living areas

SDG	Related targets	Perceived risks of NREPs for local communities	Perceived opportunities of NREPs for local communities	Potential contribution of HIA
	12.4, 12.8	- Environmental degradation		- Environmental sound management to minimize adverse health impacts
	16.1, 16.5, 16.6, 16.7	- Crimes - Conflicts - Corruption, bribery	- Local security guards	- Accountable and transparent institutions - Participatory decision making
	17.6, 17.14, 17.16, 17.17	- Focus on economic benefits may subordinate sustainable thinking - Corruption	- Community funds to realized joint development projects	- Cross-sectoral collaboration - Bring in public health perspective into traditional non-health sectors

“Sustainable mining” is coined by corporate social responsibility (CSR), which encompasses various community development projects initiated by the mining companies (Vintro & Comajuncosa, 2009). Many interventions observed in the study regions and reported during the FGDs were implemented under this umbrella, including new health interventions, schools or wells. Indeed and as acknowledged by the participants from our study, such interventions are important to provide basic needs such as access to health care, education and water and therefore help to achieve the SDGs (SDG 3, 4 and 6 respectively). This positive contribution was underlined by the quantitative findings included in this work, suggesting improved water infrastructure of households in proximity to an industrial mining site (SDG 6), with water as key element for good health and well-being (Admiraal et al., 2017; Boelee et al., 2019). Beyond the co-benefits of SDG 3 and SDG 6, there is a synergetic effect of attaining “good-health and well-being for all” (SDG 3), with various other SDGs, including no poverty (SDG 1), quality education (SDG 4), gender equality (SDG 5), reduced inequalities (SDG 10) (Pradhan et al., 2017), whereas mining projects have the potential to positively contribute to all of them (RMF & CCSI, 2020).

This “SDGs optimism” with its conduciveness for health and well-being is however opposed by pitfalls (De Neve & Sachs, 2020). On the local level and as shown in this present study, the benefits are in dissonance with the predominating negative perception of affected communities. Despite interventions implemented in response to their needs, negative impacts for local communities overweighed the positive effects, indicating opportunistic health

management for the treatment of diseases or occurring cases. A reason for this could be the economic development paradigm, primarily aiming for prosperity and thus, sacrificing social responsibility and sustainability (Mzembe & Downs, 2014). Interestingly, this paradigm could further be linked to trade-off between SDG 3 and 12, which has been reported as a major negative correlation between the SDGs (Pradhan et al., 2017). Although the material footprint of many African countries is low (SDG 12), most countries are lagging behind in terms of health-related SDG targets (GBD 2016 SDG Collaborators, 2017). To address major health challenges and particularly protecting most marginalized people, including communities affected by large NREPs, they can contribute to multiple SDGs - if health is managed with a priority throughout the entire project life-cycle. Therefore, the HIA4SD project aims to engage extractive industries in HIA to advance sustainable development, with health as central issue (Winkler et al., 2020).

Adopted by the countries' legislation, commissioned by the extractive industries and driven by the citizens, HIA should play a key role to leverage the attainment of the SDGs (see **Figure 22**). Participatory HIA would ensure "that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature" as aimed for in SDG 12. As decision-support tool implemented prior project implementation, HIA can foster strategic health management, including diseases prevention and promoting health of local communities (Quigley et al., 2006). In best case, a mitigation plan should besides ensuring health care for all also strongly focus on the action on the wider determinants of health, including, but not limited to water, housing and livelihoods. By considering and integrating different population groups throughout the whole process, HIA could navigate positive and negative health impacts toward the reduction of health inequities (Buse et al., 2019). Ultimately, minimizing the negative impacts and maximize the benefits can serve a promising strategy to overcome trade-offs and further advance SDG co-benefits (Gulis, 2019). Hence, as shown in **Figure 22**, HIA holds potential to contribute to the successful implementation of the SDGs by acting on the wider determinants of health.

To realize this, many efforts are needed from different stakeholders and different sectors, which will become engaged in the frame of the HIA4SD project. By demonstrating the potential of HIA for health equity and raising the voice of affected communities, this PhD thesis lays an important foundation for the upcoming policy-dialogue toward sustainable development in producer regions of natural resources in sub-Saharan Africa.

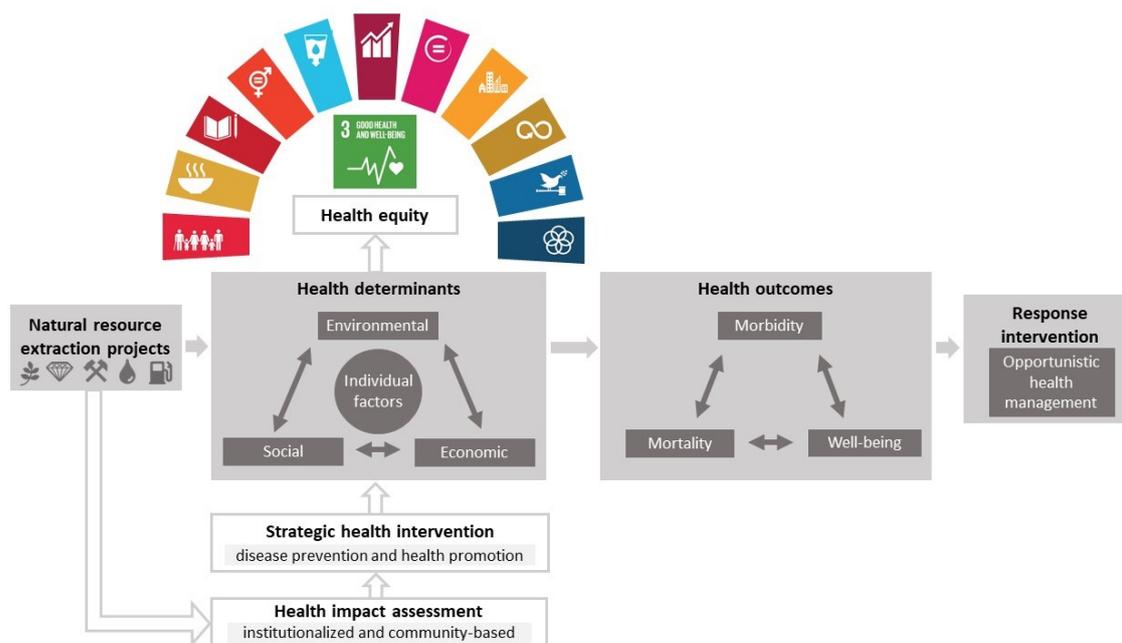


Figure 22: Potential action of natural resource extraction projects to leverage the Sustainable Development Goals through the application of health impact assessment.

8.6 Conclusion

This PhD thesis gives insights into the complex nexus of mining project and health as well as health equity as central issues for sustainable development. We found that HIA holds promise to address health equity in mining regions. However, regarding the health of local communities negative impacts related to environmental, social and economic determinants of health tend to dominate, with women being affected disproportionately. Positive impacts related to upgrade of public services and infrastructure were secondary and economic benefits related to new job opportunities or compensation for resettlement were often not distributed equally among communities. Based on similar qualitative findings from different study sites in different sub-Saharan African countries, there is a pressing need to consider community health more prominently. Particular attention should be drawn to create equal opportunities for good health and well-being for all. To ensure effective interventions, affected populations and population subgroups should become active stakeholders. Community-based HIA offers a unique opportunity to inform strategic health management in producer regions, with particular emphasis on disease prevention and health promotion. In order to be able to put the promising theory into practice, the application of HIA must be promoted in producer regions, especially in the strive toward the 2030 Agenda for Sustainable Development. The findings of this PhD thesis, including the videos produced, will enable facilitating an informed policy dialogue toward the institutionalization of HIA in sub-Saharan Africa.

8.7 Open research needs and recommendations

Based on the findings presented in the current work, underlining the big gap between theory and practice of HIA in settings of large NREPs in sub-Saharan Africa, the following research needs and recommendations arise:

- (i) Advancing the HIA toolbox toward a more equity-focused methodology for the specific context of natural resource extraction in sub-Saharan Africa, particularly including systematic stratification, gender-transformative approaches and public participation.
- (ii) Thematic and methodological triangulation of study results derived from the different components of the HIA4SD project at large could further strengthen the scientific evidence being generated.
- (iii) Synthesis of findings of from the different components of the HIA4SD project at large, including the discussion of potential contradictory findings.
- (iv) Disseminate findings through approachable means of communication to reach also non-academic stakeholders or stakeholders outside the health sector by engaging in an intersectoral policy dialogue.
- (v) Ensuring that impact assessments, including HIA, become frameworks that hold accountable throughout the project development (compared to a mechanism to obtain the mining license) in order to ensure community health and well-being in the long run.

8.8 References

- Admiraal, R., Sequeira, A. R., McHenry, M. P., & Doepel, D. (2017). Maximizing the impact of mining investment in water infrastructure for local communities. *Extractive Industries and Society*, 4(2), 240-250. doi:10.1016/j.exis.2017.01.014.
- AUDA-NEPAD. (2015). *Agenda 2063 framework document*. African Union Development Agency (AUDA). Addis Ababa, Ethiopia.
- AUDA-NEPAD. (2020). *Agenda 2063 implementation report*. African Union Development Agency (AUDA). Addis Ababa, Ethiopia.
- Bach, M., Jordan, S., Hartung, S., Santos-Hovener, C., & Wright, M. T. (2017). Participatory epidemiology: the contribution of participatory research to epidemiology. *Emerging Themes in Epidemiology*, 14, 2. doi:10.1186/s12982-017-0056-4.
- Baek, S. J. (2019). Viewpoint: Cooperating in Africa's sustainable structural transformation: policymaking capacity and the role of emerging economies. *International Development Planning Review*, 41(4), 419–434. doi:10.3828/idpr.2019.21.
- Bawole, J. N. (2013). Public hearing or 'hearing public'? An evaluation of the participation of local stakeholders in environmental impact assessment of Ghana's Jubilee Oil Fields. *Environmental Management*, 52(2), 385-397. doi:10.1007/s00267-013-0086-9.
- Boelee, E., Geerling, G., van der Zaan, B., Blauw, A., & Vethaak, A. D. (2019). Water and health: from environmental pressures to integrated responses. *Acta Trop.*, 193, 217-226. doi:10.1016/j.actatropica.2019.03.011.

- Buse, C. G., Lai, V., Cornish, K., & Parkes, M. W. (2019). Towards environmental health equity in health impact assessment: innovations and opportunities. *International Journal of Public Health, 64*(1), 15-26. doi:10.1007/s00038-018-1135-1.
- Carter, N., Bryant-Lukosius, D., DiCenso, A., Blythe, J., & Neville, A. J. (2014). The use of triangulation in qualitative research. *Oncology Nursing Forum, 41*(5), 545-547. doi:10.1188/14.ONF.545-547.
- Dahlgren, G., & Whitehead, M. (1991). *Policies and strategies to promote social equity in health*. Institute for Futures Studies. Stockholm, Sweden. Retrieved from: <https://core.ac.uk/download/pdf/6472456.pdf>
- De Neve, J. E., & Sachs, J. D. (2020). The SDGs and human well-being: a global analysis of synergies, trade-offs, and regional differences. *Scientific Reports, 10*(1), 15113. doi:10.1038/s41598-020-71916-9.
- Den Broeder, L., Uiters, E., ten Have, W., Wagemakers, A., & Schuit, A. J. (2017). Community participation in health impact assessment: a scoping review of the literature. *Environmental Impact Assessment Review, 66*, 33-42. doi:10.1016/j.eiar.2017.06.004.
- Dietler, D., Lewinski, R., Azevedo, S., Engebretsen, R., Brugger, F., Utzinger, J., & Winkler, M. S. (2020). Inclusion of health in impact assessment: a review of current practice in sub-Saharan Africa. *International Journal of Environmental Research and Public Health, 17*(11), 4155. doi:10.3390/ijerph17114155.
- Erismann, S., Pesantes, M. A., Beran, D., Leuenberger, A., Farnham, A., Berger Gonzalez de White, M., Labhardt, N. D., Tediosi, F., Akweongo, P., Kuwawenaruwa, A., et al. (2021). How to bring research evidence into policy? Synthesizing strategies of five research projects in low-and middle-income countries. *Health Research Policy and Systems, 19*(1), 29. doi:10.1186/s12961-020-00646-1.
- Farnham, A., Cossa, H., Dietler, D., Engebretsen, R., Leuenberger, A., Lyatuu, I., Nimako, B., Zabre, H. R., Brugger, F., & Winkler, M. S. (2020). Investigating health impacts of natural resource extraction projects in Burkina Faso, Ghana, Mozambique, and Tanzania: protocol for a mixed methods study. *JMIR Research Protocols, 9*(4), e17138. doi:10.2196/17138.
- GBD 2016 SDG Collaborators. (2017). Measuring progress and projecting attainment on the basis of past trends of the health-related Sustainable Development Goals in 188 countries: an analysis from the Global Burden of Disease Study 2016. *Lancet, 390*(10100), 1423-1459. doi:10.1016/S0140-6736(17)32336-X.
- Grieb, S. D., Eder, M. M., Smith, K. C., Calhoun, K., & Tandon, D. (2015). Qualitative research and community-based participatory research: considerations for effective dissemination in the peer-reviewed literature. *Progress in Community Health Partnerships: Research, Education, and Action, 9*(2), 275-282. doi:10.1353/cpr.2015.0041.
- Gulis, G. (2019). Health impact assessment and the Sustainable Development Goals. *Health Promotion International, 34*(3), 373-375. doi:10.1093/heapro/daz052.
- Heller, J., Givens, M. L., Yuen, T. K., Gould, S., Jandu, M. B., Bourcier, E., & Choi, T. (2014). Advancing efforts to achieve health equity: equity metrics for health impact assessment practice. *International Journal of Environmental Research and Public Health, 11*(11), 11054-11064. doi:10.3390/ijerph111111054.
- Kitzinger, J. (1994). The methodology of focus groups: the importance of interaction between research participants. *Soc. Health Illness, 16*(1), 103-121. doi:10.1111/1467-9566.ep11347023.
- Knoblauch, A. M., Divall, M. J., Owuor, M., Archer, C., Nduna, K., Ng'uni, H., Musunka, G., Pascall, A., Utzinger, J., & Winkler, M. S. (2017). Monitoring of selected health indicators

- in children living in a copper mine development area in northwestern Zambia. *International Journal of Environmental Research and Public Health*, 14(3), 315. doi:10.3390/ijerph14030315.
- Knoblauch, A. M., Divall, M. J., Owuor, M., Musunka, G., Pascall, A., Nduna, K., Ng'uni, H., Utzinger, J., & Winkler, M. S. (2018). Selected indicators and determinants of women's health in the vicinity of a copper mine development in northwestern Zambia. *BMC Women's Health*, 18(1), 62. doi:10.1186/s12905-018-0547-7.
- Knoblauch, A. M., Farnham, A., Zabre, H. R., Owuor, M., Archer, C., Nduna, K., Chisanga, M., Zulu, L., Musunka, G., Utzinger, J., Divall, M. J., Fink, G., & Winkler, M. S. (2020). Community health impacts of the Trident Copper Mine Project in northwestern Zambia: results from repeated cross-sectional surveys. *International Journal of Environmental Research and Public Health*, 17(10), 3633. doi:10.3390/ijerph17103633.
- Maalim, A. D. (2006). Participatory rural appraisal techniques in disenfranchised communities: a Kenyan case study. *International Nursing Review*, 53(3), 178-188. doi:10.1111/j.1466-7657.2006.00489.x.
- Mahoney, M., Simpson, S., Harris, E., Aldrich, R., & Stewart Williams, J. (2004). *Equity-focused health impact assessment framework*. Newcastle, Australia: Australasian Collaboration for Health Equity Impact Assessment (ACHEIA).
- Marmot, M. (2005). Social determinants of health inequalities. *Lancet*, 365(9464), 1099-1104. doi:10.1016/S0140-6736(05)71146-6.
- Marmot, M. (2007). Achieving health equity: from root causes to fair outcomes. *Lancet*, 370(9593), 1153-1163. doi:10.1016/S0140-6736(07)61385-3.
- McKee, M. (2019). Bridging the gap between research and policy and practice - Comment on "CIHR health system impact fellows: reflections on 'driving change' within the health system". *International Journal of Health Policy and Management*, 8(9), 557-559. doi:10.15171/ijhpm.2019.46.
- Milford, C., Kriel, Y., Njau, I., Nkole, T., Gichangi, P., Cordero, J. P., Smit, J. A., & Steyn, P. S. (2017). Teamwork in qualitative research. *International Journal of Qualitative Methods*, 16(1), 1-10. doi:10.1177/1609406917727189.
- Moser, C. (1989). Gender planning in the Third World: meeting practical and strategic gender needs. *World Development*, 17(11), 1790-1825. doi:10.1016/0305-750X(89)90201-5.
- Moser, C. (1995). Evaluating gender impacts. *New Directions for Evaluation*, 1995(67), 105-117. doi:10.1002/ev.1009.
- Mzembe, A. N., & Downs, Y. (2014). Managerial and stakeholder perceptions of an Africa-based multinational mining company's corporate social responsibility (CSR). *Extractive Industries and Society*, 1(2), 225-236. doi:10.1016/j.exis.2014.06.002.
- Newig, J., Jahn, S., Lang, D. J., Kahle, J., & Bergmann, M. (2019). Linking modes of research to their scientific and societal outcomes: evidence from 81 sustainability-oriented research projects. *Environmental Science and Policy*, 101, 147-155. doi:10.1016/j.envsci.2019.08.008.
- 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: Planning, Administration, Evaluation*, 40(2), 339-345. doi:10.2190/HS.40.2.o, .
- Pluye, P., & Hong, Q. N. (2014). Combining the power of stories and the power of numbers: mixed methods research and mixed studies reviews. *Annual Review of Public Health*, 35(1), 29-45. doi:10.1146/annurev-publhealth-032013-182440.

- Pope, C., & Mays, N. (2009). Critical reflections on the rise of qualitative research. *BMJ*, 339(2), b3425-b3425. doi:10.1136/bmj.b3425.
- Pope, C., Mays, N., & Popay, J. (2016). How can we synthesize qualitative and quantitative evidence for healthcare policy-makers and managers? *Healthcare Management Forum*, 19(1), 27-31. doi:10.1016/s0840-4704(10)60079-8.
- Pope, C., Ziebland, S., & Mays, N. (2000). Qualitative research in health care: analysing qualitative data. *BMJ*, 320(7227), 114-116. doi:10.1136/bmj.320.7227.114.
- Pradhan, P., Costa, L., Rybski, D., Lucht, W., & Kropp, J. P. (2017). A systematic study of Sustainable Development Goal (SDG) interactions. *Earth's Future*, 5(11), 1169-1179. doi:10.1002/2017EF000632.
- Quigley, R., den Broeder, L., Furu, P., Bond, A., Cave, B., & Bos, R. (2006). Health impact assessment international best practice principles. *International Association for Impact Assessment*. Retrieved from http://www.iaia.org/uploads/pdf/SP5_3.pdf.
- RMF, & CCSI. (2020). *Mining and the SDGs a 2020 status update*. Responsible Mining Foundation (RMF), Nyon, Switzerland; Columbia Center on Sustainable Investment (CCSI), New York, U.S.A.
- Sandham, Chabalala, & Spaling. (2019). Participatory rural appraisal approaches for public participation in EIA: lessons from South Africa. *Land*, 8(10), 150-166. doi:10.3390/land8100150.
- Thondoo, M., & Gupta, J. (2020). Health impact assessment legislation in developing countries: a path to sustainable development? *Review of European, Comparative and International Environmental Law*, 00, 1-11. doi:10.1111/reel.12347.
- Vintro, C., & Comajuncosa, J. (2009). Corporate social responsibility in the mining industry: Criteria and indicators. *DYNA*, 77(161), 31-41. Retrieved from <http://www.scielo.org.co/pdf/dyna/v77n161/a03v77n161.pdf>.
- Winkler, M. S., Adongo, P. B., Binka, F., Brugger, F., Diagboug, S., Macete, E., Munguambe, K., & Okumu, F. (2020). Health impact assessment for promoting sustainable development: the HIA4SD project. *Impact Assessment and Project Appraisal*, 3(8), 225-232. doi:10.1080/14615517.2019.1694783.



Annex

A1. *Tropical Medicine and International Health* and the 2030 Agenda for Sustainable Development

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Editorial

Tropical Medicine and International Health and the 2030 Agenda for Sustainable Development

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keywords 2030 Agenda for Sustainable Development, health and well-being, inequity, partnership, Sustainable Development Goal

Sustainable Development Goals (SDGs) SDG 1 (no poverty), SDG 2 (zero hunger), SDG 3 (good health and well-being), SDG 4 (quality education), SDG 5 (gender equality), SDG 6 (clean water and sanitation), SDG 7 (affordable and clean energy), SDG 8 (decent work and economic growth), SDG 9 (industry, innovation and infrastructure), SDG 10 (reduced inequalities), SDG 11 (sustainable cities and communities), SDG 12 (responsible consumption and production), SDG 13 (climate action), SDG 14 (life below water), SDG 15 (life on land), SDG 16 (peace, justice and strong institutions), SDG 17 (partnerships for the goals)

Introduction

In September 2015, at the general assembly of the United Nations, all 193 member states approved the 2030 Agenda for Sustainable Development – the 2030 Agenda in short [1]. At the heart of the 2030 Agenda are 17 Sustainable Development Goals (SDGs) with 169 targets. The 2030 Agenda provides a negotiated and undisputed framework with a normative vision for humanity. It should serve as a shared compass to transform our world into a better, more equitable and solidary place for current and future generations [1,2]. Academia and the scientific community are pressed to pay their share and lead the way towards achieving the SDGs. Indeed, researchers from all disciplines, together with other stakeholders and civil society, are invited to co-create and test new approaches to advance sustainable development [3]. Importantly, the newly generated knowledge must be transformed into actionable and scalable solutions to address the wicked problems that are inherent to sustainable development in a globalised world [4–6].

Monitoring progress towards the SDGs and its targets is critical, and the urgency of taking action from the current unsustainable path to the desired sustainable

development cannot be emphasised enough [7]. This calls for academia and the scientific community to act expediently and all over the world. While new journals have been launched (e.g. *Nature Sustainability*; see: <https://www.nature.com/natsustain/>) and special issues have been published in multi-, inter- and trans-disciplinary journals (e.g. *GAIA*, June 2019 issue; see: <https://www.oekom.de/zeitschrift/gaia-2/>), a systematic classification of scientific outputs in the peer-reviewed literature according to their contribution to the SDGs is called for but currently missing [8]. We take this issue forward and propose a subtle yet significant transformation of how research is being reported and disseminated in *Tropical Medicine and International Health*.

Introducing a new SDG reporting scheme in *Tropical Medicine and International Health*

As of January 2020, *Tropical Medicine and International Health* adds a novel feature to original research articles, reviews and editorials. As part of the submission process, prospective authors must specify the contribution of their research to one or several of the SDGs. This information will increase the visibility of the journal's contribution towards the SDGs and allows for monitoring short-, mid- and long-term trends of dynamically shifting research

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foci. The SDG(s) addressed will appear on the title page, just after the abstract (if any) and the keywords. This novel reporting feature will help promote the 2030 Agenda and encourage authors and readers to become more cognizant about the SDGs and their interconnectedness. In turn, the new reporting feature might foster innovative solutions towards achieving the 2030 Agenda. Moreover, the reporting scheme will allow for a regular and quantitative appraisal of the different SDGs targeted by research published in *Tropical Medicine and International Health*.

Apart from SDG 3 ('Ensure healthy lives and promote well-being for all at all ages'), other SDGs are directly or indirectly interacting with health and thus promote or

jeopardise health and well-being [9]. The complex interlinkages of the SDGs can be visualised and novel solutions sought at the interface of SDGs.

SDGs addressed in previous research published in *Tropical Medicine and International Health*

To assess the specific contributions of recently published articles in *Tropical Medicine and International Health* to the 2030 Agenda, we systematically screened the titles and abstracts of the 216 articles published between January 2018 and July 2019. First, SDGs were independently assigned by two of the authors (AG and AL), using the SDG targets as main reference (Appendix). In this short-

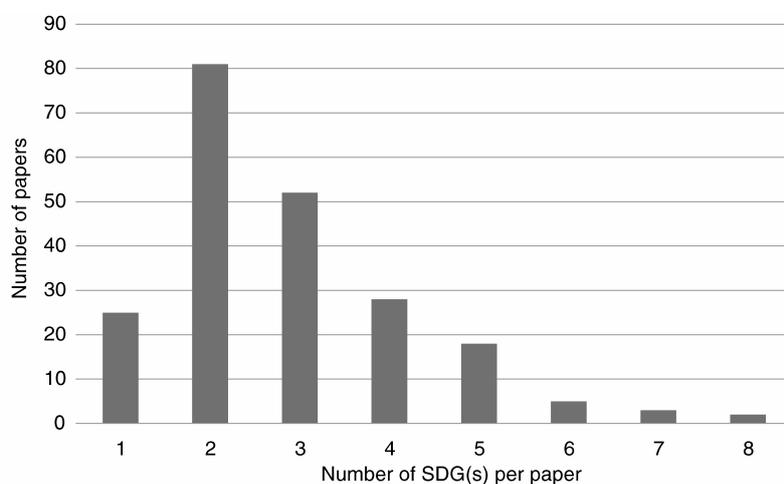


Figure 1 Frequency of numbers of SDG(s) addressed in 216 papers published in *Tropical Medicine and International Health* between January 2018 and July 2019.

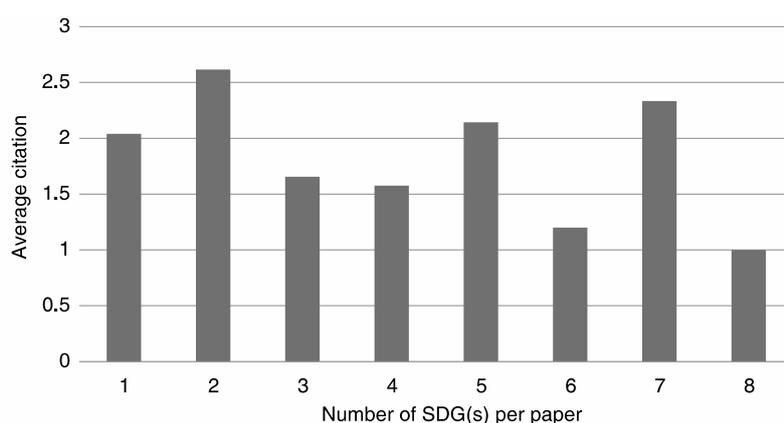


Figure 2 Average citation by number of SDG(s) addressed per paper in 216 papers published in *Tropical Medicine and International Health* between January 2018 and July 2019 (average time since manuscript publication 15 months).

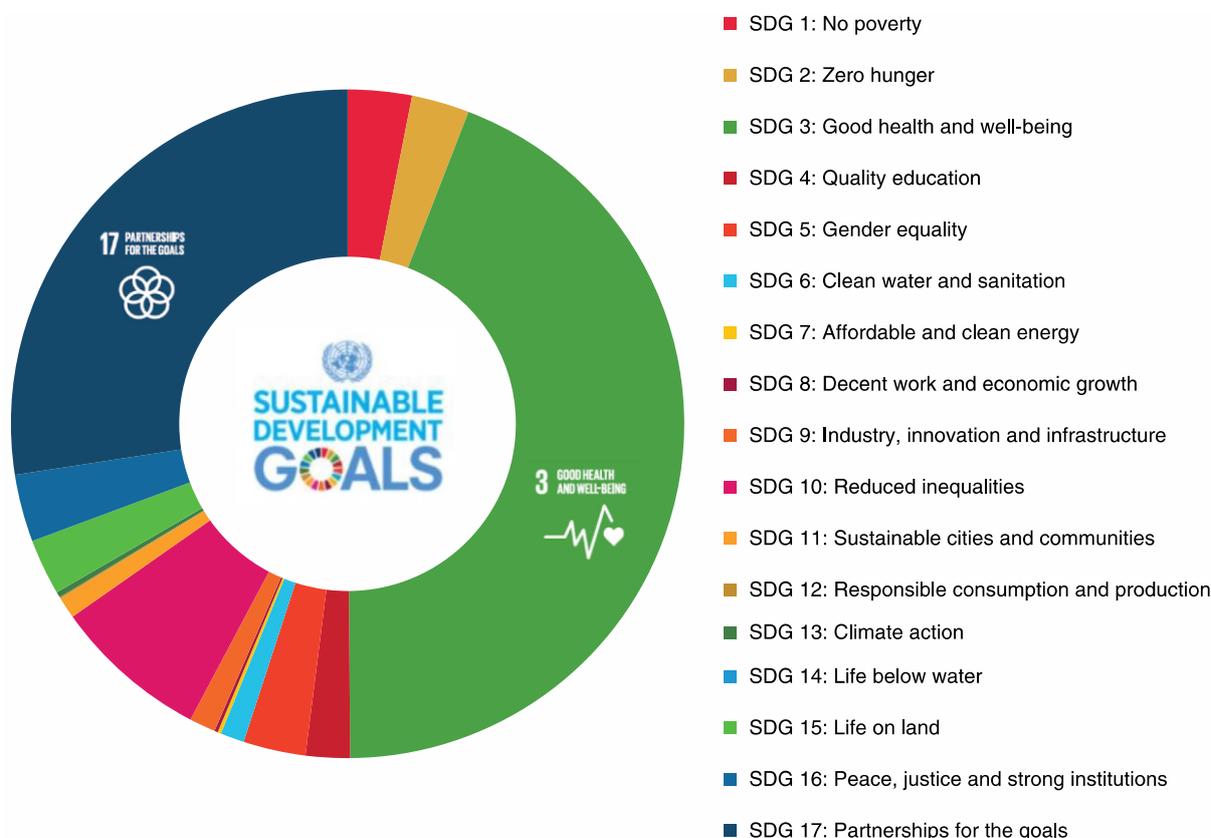


Figure 3 Doughnut chart indicating frequencies of SDGs addressed by 216 papers published in *Tropical Medicine and International Health*, between January 2018 and July 2019 weighted by the number of SDGs assigned per paper.

term analysis the mean time from publication to citation sampling was 15 months (range 5–23 months). To assign SDG 17 (‘Strengthen the means of implementation and revitalize the global partnership for sustainable development’), authors’ affiliations were scrutinised for collaboration across countries and disciplines. Second, after assigning SDGs independently for the first 20 papers, discrepancies were discussed to generate a mutual understanding of the criteria. Third, one author (AG) continued assigning SDGs to the remaining 196 papers and discussed uncertainties with a second author (AL). Finally, a second independent screening of 10 randomly selected papers confirmed the consensus about assigning SDGs and thus assured internal consistency of our database.

For subsequent analyses, the assigned SDGs were weighted by the total number of SDGs addressed by individual papers: if a single SDG was addressed, it received a weight of 1; if two SDGs were addressed, each received a weight of 0.5, and so on. Additionally, manuscript citation scores were sampled for each manuscript from

online.wiley.com in mid-December 2019. Citation rates between papers targeting different SDGs or different numbers of SDGs were compared by one-way ANOVA.

Results

The number of SDGs addressed in our sample of 216 papers published in *Tropical Medicine and International Health* between January 2018 and July 2019 ranged from one to eight [10,11]. More than a third of the papers ($n = 81$, 37.5%) targeted two SDGs (Figure 1). There was no difference in manuscript citation rate by number of SDGs targeted, indicating that addressing multiple SDGs does not penalise citation rate in the short term (Figure 2).

The SDG most often addressed was SDG 3, followed by SDG 17 and SDG 10 (‘Reduce inequality within and among countries’). None of the papers screened was classified as having addressed SDG 14 (‘Conserve and sustainably use the oceans, seas and marine resources for

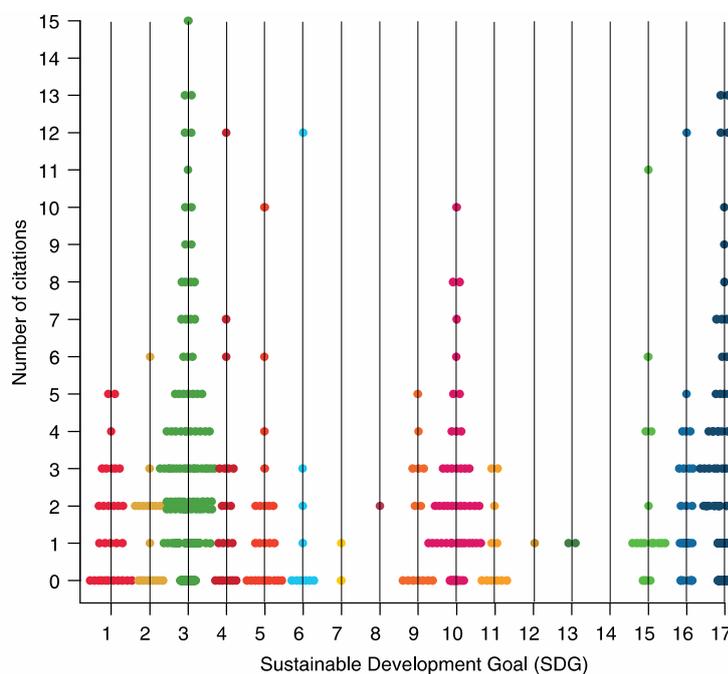


Figure 4 Citation of papers published in *Tropical Medicine and International Health* between January 2018 and July 2019, as of mid-December 2019 (average time since manuscript publication 15 months), stratified by SDG.

sustainable development’ (Figure 3). There were no significant differences in manuscript citation rate across the different SDGs addressed (Figure 4).

SDGs where *Tropical Medicine and International Health* has particular visibility, as measured by manuscript citation rate, include SDG 4 (‘Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all’), SDG 5 (‘Achieve gender equality and empower all women and girls’), SDG 15 (‘Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss’) and SDG 16 (‘Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels’). Common themes emerged in publications addressing SDG 3 (good health and well-being), along with other SDGs. For example, research that also tackled SDG 4 (quality education) predominately focused on assessing the effectiveness of public health interventions delivered through the education sector. For SDG 5 (gender equality), research focused on maternal health or explored gender differences in disease susceptibility or treatment response. For SDG 15 (life on

land), research predominantly focused on the impact of land use on insect vectors and the transmission of vector-borne disease. SDG 16 (peace, justice and strong institutions) explored the delivery of health care to poor, marginalised or stigmatised populations.

Figure 5 shows the connections between different SDGs in our sample of 216 papers published in *Tropical Medicine and International Health* over an 18-month period starting in January 2018. Given the fact that SDGs 3, 10 and 17 were the most prominent ones, a triangle emerges. Further strong relationships between SDG 1 (‘End poverty in all its forms everywhere’) and SDG 10 (reduced inequalities), between SDG 5 (gender equality) and SDG 17 (partnerships for the goals), between SDG 4 (quality education) and SDG 17 (partnerships for the goals) and between SDG 3 (good health and well-being) and SDG 16 (peace, justice and strong institutions) become apparent.

Based on our experiences from assigning SDGs to already published articles, a method to assign SDGs for papers that will be published in future issues of *Tropical Medicine and International Health* is provided in Box 1. Prospective authors will be guided to this box, so that they

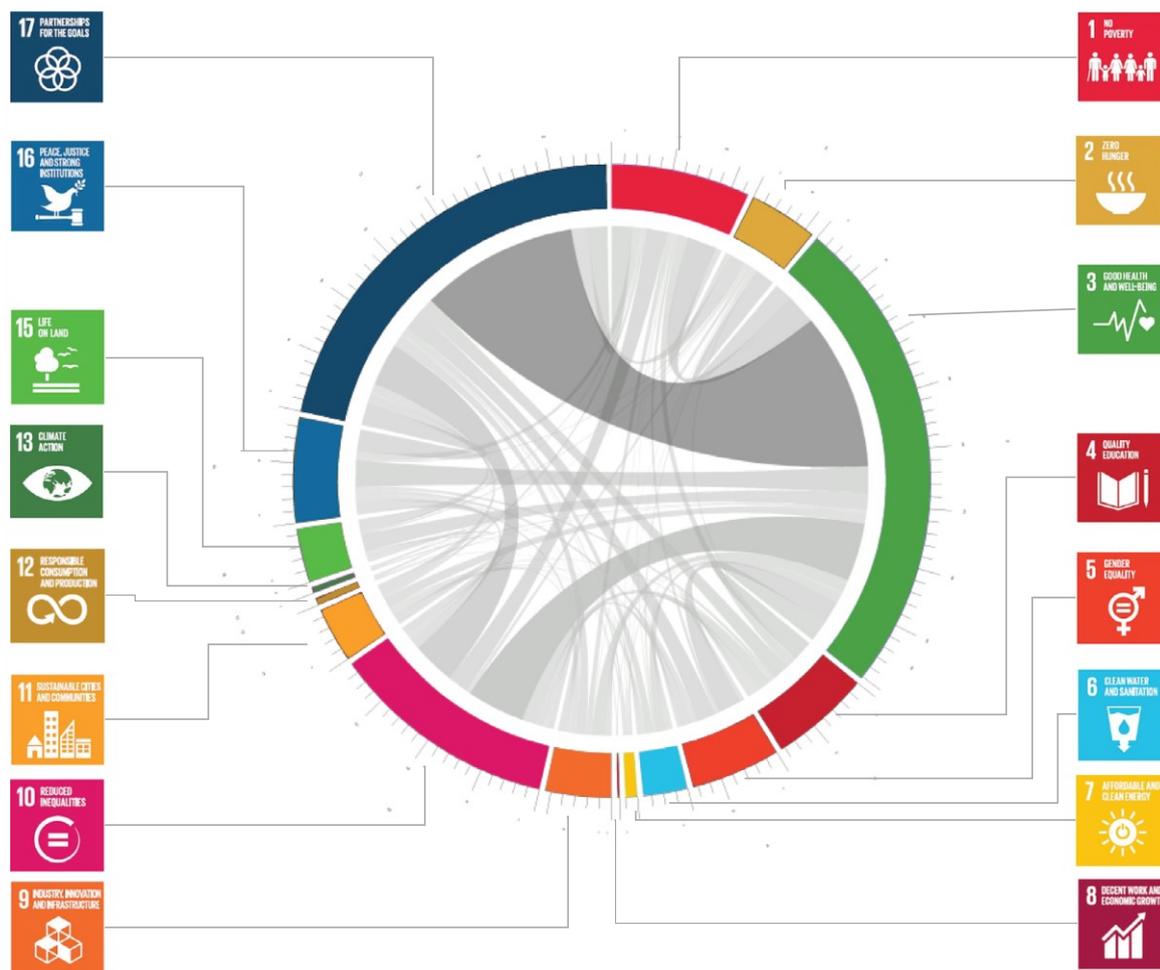


Figure 5 Circular plot indicating frequencies and interactions of SDGs assigned from 216 papers published in *Tropical Medicine and International Health* between January 2018 and July 2019.

can readily assign relevant SDGs to their forthcoming publications. The editors will assist should challenges arise.

Discussion

The observation that SDGs 3 and 17 (good health and well-being and partnerships for the goals) were the most prominent SDGs in recently published articles in *Tropical Medicine and International Health* is not surprising. The predominance of SDG 3 reflects that *Tropical Medicine and International Health* is a journal in the health area, with an emphasis on (i) tropical medicine and (ii) public, environmental and occupational health.

Moreover, this finding sheds light on the journal's policy to welcome particularly authors from low- and middle-income countries, and hence, to strengthen research partnerships.

The strong connection between SDGs 10 and 17 (reduced inequalities and partnerships for the goals), obvious in Figure 5, indicates their essential interlinkage in striving for sustainable development and reduced poverty. Hence, a pathway originating in improving health may be extended through partnerships that consequently could reduce inequalities and poverty. Our screening of more than 200 published articles in *Tropical Medicine and International Health*, revealed

Box 1 Guideline for *Tropical Medicine and International Health* authors: How to assign SDGs to their work

- 1 Look at the SDG keyword list derived from the 169 SDG targets (see Appendix) and identify the SDGs addressed in your paper.
- 2 The topics of the SDGs addressed have to be mentioned in your text. You can either aim for them with your research or report on them as outcomes of your research. E.g.
 - If you investigate water and sanitation, add SDG 6.
 - If you found that hookworm-infected children cannot attend school regularly, add SDG 4.
- 3 Look at the author affiliations. If your authors come from more than one country or from institutions in different disciplines (e.g. health research institute and ministry of environment), add SDG 17.
- 4 Select all identified SDGs from the drop-down menu in the online submission system.

quantitative evidence of such interlinkages, highlighting the importance of equitable partnerships in achieving the SDGs.

We see no significant difference in manuscript citation rate by SDG addressed or by the total number of SDGs addressed, indicating that work which tackles a diversity of SDGs does not suffer a penalty in citation rate. However, in this short-term analysis the mean time since publication was only 15 months (range 5–23 months). Tracking manuscript citation rate over longer time frames for the SDGs will provide a measure of the visibility and reach of SDG-focused research as we approach 2030.

Prior research has investigated the interlinkages and synergies between the SDGs [4,9]. For example, SDG 3 (good health and well-being) has strong synergies with SDGs 1 (no poverty), 4, 5, 6, 9, 10 and 11 [4,9]. These interactions are clearly reflected in the recent body of publications in *Tropical Medicine and International Health*. The interlinkages between SDG 3 and others underline the importance of fostering co-benefits through inter- and transdisciplinary research partnerships [12,13].

An additional strength of *Tropical Medicine and International Health* is research on SDG 15 (life on land), in particular the impact of land use on insect vectors and the transmission of vector-borne disease and SDG 16 (peace, justice and strong institutions) exploring the delivery of health care to poor, marginalised or stigmatised populations. These interlinkages between SDGs 3, 15 and 16 have not been highlighted in previous analyses of health

research but reflect the aim of *Tropical Medicine and International Health*, which welcomes diverse research and research led by authors from low- and middle-income countries.

Conclusion

In order to achieving sustainable development in its three dimensions – economic, social and environmental – in a balanced and integrated manner, research on SDGs needs to be more easily identifiable to inform governments, business and civil society [14]. The unique and participatory reporting scheme of *Tropical Medicine and International Health* will reveal the contribution of the health and life sciences to the achievement of the 2030 Agenda and will allow for monitoring the thematic focus of *Tropical Medicine and International Health*, within the SDG framework.

References

1. UN. *Transforming Our World: The 2030 Agenda for Sustainable Development*. United Nations: Geneva, 2015.
2. Oberlack C, Breu T, Giger M *et al.* Theories of change in sustainability science: understanding how change happens. *GAIA* 2019; **28**: 106–111.
3. Schwan G. Sustainable development goals: a call for global partnership and cooperation. *GAIA* 2019; **28**: 73.
4. ISC. *A Guide to SDG Interactions: From Science to Implementation*. International Science Council: Paris, 2017.
5. Adler C, Hirsch Hadorn G, Breu T, Wiesmann U, Pohl C. Conceptualizing the transfer of knowledge across cases in transdisciplinary research. *Sustain Sci* 2018; **13**: 179–190.
6. Black PF, Butler CD. One Health in a world with climate change. *Rev Sci Tech* 2014; **33**: 465–473.
7. Yonehara A, Saito O, Hayashi K, Nagao M, Yanagisawa R, Matsuyama K. The role of evaluation in achieving the SDGs. *Sustain Sci* 2017; **12**: 969–973.
8. Capua I, Giovannini E. Tag research geared towards SDGs. *Nature* 2019; **572**: 178.
9. Pradhan P, Costa L, Rybski D, Lucht W, Kropp JP. A systematic study of Sustainable Development Goal (SDG) interactions. *Earth's Future* 2017; **5**: 1169–1179.
10. Yan LD, Mwale J, Straitz S *et al.* Equity dimensions of the availability and quality of reproductive, maternal and neonatal health services in Zambia. *Trop Med Int Health* 2018; **23**: 433–445.
11. Htet S, Ludwick T, Mahal A. Targeting subsidised inpatient services to the poor in a setting with limited state capacity: proxy means testing in Myanmar's hospital equity fund scheme. *Trop Med Int Health* 2019; **24**: 1042–1053.
12. Dietler D, Leuenberger A, Bempong NE *et al.* Health in the 2030 Agenda for Sustainable Development: from framework

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- to action, transforming challenges into opportunities. *J Global Health* 2019; 9: 020201.
13. Saric J, Blaettler D, Bonfoh B *et al.* Leveraging research partnerships to achieve the 2030 Agenda: experiences from North-South cooperation. *GAIA* 2019; 28: 143–150.
14. Sachs JD, Schmidt-Traub G, Mazzucato M, Messner D, Nakicenovic N, Rockström J. Six transformations to achieve the Sustainable Development Goals. *Nat Sustain* 2019; 2: 805–814.

Appendix**Keyword list to assign SDGs**

SDG	Title	Keywords from the targets to assign SDGs
	End poverty in all its forms everywhere	<ul style="list-style-type: none"> • Eradicate extreme poverty • Social protection systems • Coverage of the poor and the vulnerable • Equal rights to economic resources • Equal rights to access to basic services • Equal rights to ownership and control over land and other forms of property • Equal rights to inheritance • Equal rights to natural resources • Equal rights to appropriate new technology • Equal rights to financial services including microfinances • Build resilience of the poor • Reduce exposure and vulnerability to climate-related extreme events • Reduce exposure and vulnerability to economic, social and environmental shocks and disasters • Development cooperation
	End hunger, achieve food security and improved nutrition and promote sustainable agriculture	<ul style="list-style-type: none"> • End hunger • Access to safe, nutritious and sufficient food all year round • End all forms of malnutrition (also stunting and wasting) • Address nutritional needs of adolescent girls, pregnant and lactating women and elderly • Agricultural productivity and incomes • Equal access to land and other productive resources • Sustainable food production • Resilient agricultural practices increasing productivity and production • Strengthen capacities for adaption to climate change • Progressively improve land and soil quality • Maintain genetic diversity of seeds, plants and animals • Seed and plant banks • Equitable sharing of benefits from utilization of genetic resources and associated traditional knowledge • Functioning food community markets • Limit extreme food price volatility

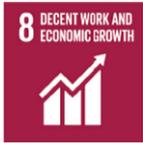
Appendix (Continued)

SDG	Title	Keywords from the targets to assign SDGs
	Ensure healthy lives and promote well-being for all at all ages	<ul style="list-style-type: none"> • Reduce global maternal mortality • End preventable deaths of new-borns and children under 5 years • Reduce neonatal mortality • End epidemics of AIDS, tuberculosis and neglected tropical diseases • Combat hepatitis, water-borne diseases and other communicable diseases • Reduce premature mortality from non-communicable diseases • Promote mental health and well-being • Prevention and treatment of substance abuse (narcotics and alcohol) • Reduce deaths and injuries from road traffic accidents • Universal access to sexual and reproductive health-care services (including family planning) • Achieve universal health coverage • Financial risk protection • Access to quality essential health-care services • Access to safe, effective, quality and affordable essential medicines and vaccines • Reduce deaths/illness due to hazardous chemicals and air, water and soil pollution and contamination • Tobacco control • Research and development of vaccines and medicines • Access to medicines for all • Strengthen health financing • Strengthen health workforce • Early warning systems for national and global health risks
	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	<ul style="list-style-type: none"> • Free, equitable and quality primary and secondary education (girls and boys) • Access to pre-primary education and early childhood development and care • Access to affordable and quality technical, vocational and tertiary education, including universities for men and women • Increased number of youth and adults with relevant skills • Eliminate gender disparities in education • Access to all levels of education also for the vulnerable (persons with disabilities, indigenous peoples and children in vulnerable situations) • Achievement of literacy and numeracy • Build and upgrade education facilities • Expand number of scholarships for enrolment in higher education • Supply of qualified teachers

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SDG	Title	Keywords from the targets to assign SDGs
	Achieve gender equality and empower all women and girls	<ul style="list-style-type: none"> • Eliminate all forms of discrimination against all women and girls everywhere • Eliminate violence against all women and girls (including trafficking and sexual and other types of exploitation) • Eliminate harmful practices (child, early and forced marriage and female genital mutilation) • Recognize and value unpaid care and domestic work • Promotion of shared responsibility within the household • Women's full and effective participation • Equal opportunities for leadership • Universal access to sexual and reproductive health • Reproductive rights • Equal rights for women to economic resources • Access for women to ownership and control over land/property • Access for women financial services • Access for women to inheritance • Access for women to natural resources • Use of enabling technology promoting empowerment of women
	Ensure availability and sustainable management of water and sanitation for all	<ul style="list-style-type: none"> • Access to safe and affordable drinking water • Access to sanitation and hygiene • End open defecation • Improve water quality (reduction of pollution, elimination of dumping and the release of hazardous chemicals and materials, reduction of untreated waste water, improve recycling) • Increase water-use efficiency • Address water scarcity • Reduce water scarcity • Implement integrated water resource management • Protect and restore water-related ecosystems • Expand international cooperation and capacity building in water- and sanitation-related activities • Strengthen participation of local communities in water and sanitation management
	Ensure access to affordable, reliable, sustainable and modern energy for all	<ul style="list-style-type: none"> • Universal access to affordable, reliable and modern energy services • Increase share of renewable energy • Improvement in energy efficiency • Access to clean energy research and technology • Expand infrastructure and upgrade technology for modern and sustainable energy

Appendix (Continued)

SDG	Title	Keywords from the targets to assign SDGs
	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	<ul style="list-style-type: none"> • Sustain per capita economic growth • Higher levels of economic productivity (diversification, technological upgrading and innovation) • Policies supporting productive activities • Policies supporting decent job creation • Policies supporting entrepreneurship • Policies supporting creativity and innovation • Policies supporting growth of micro-, small and medium-sized enterprises • Improve global resource efficiency • Decouple economic growth from environmental degradation • Achieve full and productive employment and decent work for all (women, men, young people, persons with disabilities) • Equal pay for work of equal value • Reduce proportion of youth not in employment, education or training • Eradicate forced labour • End modern slavery and human trafficking • End child labour • End recruitment and use of child soldiers • Protect labour rights • Promote safe and secure working environments • Promote sustainable tourism • Capacity strengthening of domestic financial institutions • Access to banking, insurance and financial services for all • Aid for trade support for developing countries • Develop global strategy for youth employment
	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	<ul style="list-style-type: none"> • Develop quality, reliable, sustainable and resilient infrastructure • Access for all to the infrastructure • Inclusive and sustainable industrialization • Significantly raise industry's share of employment and gross domestic product • Access to financial services for small-scale industrial and other enterprises • Affordable credit • Integration into value chains and markets of small-scale industrial and other enterprises • Upgrade infrastructure and retrofit industries • Increase resource-use efficiency • Adoption of clean and environmentally sound technologies • Enhance scientific research and upgrade the technological capabilities of industrial sectors • Encourage innovation • Increase number of research and development workers • Facilitate sustainable and resilient infrastructure development • Support domestic technology development, research and innovation in developing countries • Significantly increase access to information and communications technology • Universal access to the Internet

Appendix (Continued)

SDG	Title	Keywords from the targets to assign SDGs
	Reduce inequality within and among countries	<ul style="list-style-type: none"> • Income growth of the bottom 40% of the population • Empower and promote the social, economic and political inclusion of all • Ensure equal opportunity • Eliminate discriminatory laws, policies and practices • Promote appropriate legislation, policies and action • Adopt policies, especially fiscal, wage and social protection policies leading to greater equality • Improve the regulation and monitoring of global financial markets and institutions • Enhance representation and voice for developing countries in decision-making in global international economic and financial institutions • Regular and responsible migration and mobility of people through well-managed migration policies • Special and differential treatment for developing countries • Encourage official development assistance and financial flows, including foreign direct investment • Reduce the transaction costs of migrant remittances
	Make cities and human settlements inclusive, safe, resilient and sustainable	<ul style="list-style-type: none"> • Access for all to adequate, safe and affordable housing and basic services • Upgrade slums • Access to safe, affordable, accessible and sustainable transport systems • Improve road safety • Expand public transport • Inclusive and sustainable urbanization • Protect world's cultural and natural heritage • Reduce deaths and people affected by decrease of economic losses caused by disasters • Reduce the adverse per capita environmental impact of cities • Pay attention to air quality in cities • Pay attention to municipal and other waste management • Safe, inclusive and accessible, green and public spaces • Links between urban, per-urban and rural areas • Build sustainable and resilient buildings utilizing local materials
	Ensure sustainable consumption and production patterns	<ul style="list-style-type: none"> • Sustainable consumption and production • Sustainable management and efficient use of natural resources • Reduction of per capita global food waste at the retail and consumer levels • Reduction of food losses along production and supply chains • Manage chemicals and all wastes throughout their life cycle • Reduce release of chemicals and wastes to air, water and soil • Reduce impact of chemicals and wastes on human health and environment • Reduce waste generation through prevention, reduction, recycling and reuse • Encourage companies to adopt sustainable practices • Encourage companies to integrate sustainability information into their reporting cycle • Promote sustainable public procurement practices • Ensure information and awareness for sustainable development for all people • Strengthen the scientific and technological capacity to achieve sustainable patterns of consumption and production • Monitor sustainable development impacts for sustainable tourism • Rationalize inefficient fossil-fuel subsidies

Appendix (Continued)

SDG	Title	Keywords from the targets to assign SDGs
	Take urgent action to combat climate change and its impacts	<ul style="list-style-type: none"> • Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters • Integrate climate change measures into national policies, strategies and planning • Improve education and awareness-raising on climate change (mitigation, adaptation, impact reduction and early warning) • Effective climate change-related planning and management in least developed countries
	Conserve and sustainably use the oceans, seas and marine resources for sustainable development	<ul style="list-style-type: none"> • Reduce marine pollution • Protect marine and coastal ecosystems • Strengthen the resilience of marine and coastal ecosystems • Minimize and address the impacts of ocean acidification • End overfishing, illegal, unreported and unregulated fishing and destructive fishing practices • Implement science-based fishing management plans • Sustainable management of fisheries, aquaculture and tourism • Increase scientific knowledge and technology to improve ocean health and marine biodiversity • Provide access for small-scale artisanal fishers to marine resources and markets
	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	<ul style="list-style-type: none"> • Conservation and restoration of terrestrial and inland freshwater ecosystems and their services (forests, wetlands, mountains and drylands) • Halt deforestation • Restore degraded forests • Combat desertification • Restore degraded land and soil • Ensure the conservation of mountain ecosystems • Halt the loss of biodiversity • Prevent the extinction of threatened species • Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources • End poaching and trafficking of protected species • Address both demand and supply of illegal wildlife products • Prevent the introduction of invasive alien species (plants and animals) • Control or eradicate the priority alien species • Integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts • Mobilize financial resources for the conservation of biodiversity and ecosystems • Combat poaching • Vector ecology

Appendix (Continued)

SDG	Title	Keywords from the targets to assign SDGs
	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	<ul style="list-style-type: none"> • Reduce all forms of violence and related death rates • End abuse, exploitation, trafficking and all forms of violence against and torture of children • Equal access to justice for all • Reduce illicit financial and arms flows • Combat all forms of organized crime • Reduce corruption and bribery • Develop effective, accountable and transparent institutions at all levels • Ensure responsive, inclusive, participatory and representative decision-making at all levels • Strengthen the participation of developing countries in the institutions of global governance • Provide legal identity for all, including birth registration • Ensure public access to information • Protect fundamental freedoms • Prevent violence and combat terrorism and crime • Promote and enforce non-discriminatory laws and policies
	Strengthen the means of implementation and revitalize the global partnership for sustainable development	<ul style="list-style-type: none"> • Collaboration across nations (authors should come from at least two countries) • Collaboration across disciplines (different disciplines within the medical field are not considered as transdisciplinary; cooperation of ministries or governmental institutions with academics are considered as transdisciplinary) • Finance (domestic resource mobilization and help financing developing countries) • Technology (cooperation: north-south, south-south or triangular; spread environmentally sound technologies; technology in least developed countries) • Capacity building (capacity building in developing countries through above mentioned cooperations) • Trade (universal trading system; increase exports of developing countries; duty-free and quota-free market access) • Systemic issues (global partnerships for sustainable development; macroeconomic stability; partnerships across public; private and civic society sectors)

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Curriculum vitae

Personal Information

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Date of birth	28.12.1991
Place of birth	Basel (BS)
Place of origin	Huttwil (BE)
Nationality	Swiss

Education

09.2017 – 11.2020	PhD in Epidemiology, Swiss Tropical and Public Health Institute, Basel, Switzerland
09.2014 - 09.2016	Master in Health Sciences and Technology, Swiss Federal Institute of Technology, Zurich, Switzerland <i>Specialization:</i> Health, Nutrition and Environment
09.2011 - 02.2015	Bachelor in Health Sciences and Technology, Swiss Federal Institute of Technology, Zurich, Switzerland
09.2010 - 02.2011	Course de Civilisation et Langue Française de la Sorbonne, Paris, France
08.2005 - 06.2010	High School Bäumlhof Gymnasium, Basel, Switzerland

Professional experience

09.2017 - 12.2020	PhD in Epidemiology, Swiss TPH, Switzerland <i>Research topics:</i> Health impact assessment, health equity, sub-Saharan Africa, Sustainable Development <i>Courses:</i> Qualitative and mixed-methods, statistics, social sciences, environmental epidemiology <i>Field work:</i> Tanzania, Ghana (qualitative data collection) and Mozambique (collaborative data analysis)
09.2017 - 11.2020	Co-Coordination of post-graduate courses, Swiss TPH, Switzerland
08. - 10.2018	Salmonella Outbreak Investigation, Swiss Centre for International Health, Swiss TPH, Switzerland
05. - 06.2017	Research Internship, Functional Biomechanics, University Hospital of Basel, Switzerland <i>Research topic:</i> Evaluation of gait analysis measurement tool (RehaGait)
02. - 07.2016	Master's Thesis, Swiss TPH, Switzerland <i>Thesis Title:</i> Schoolchildren environment and health: assessing dietary diversity of schoolchildren in two regions of Burkina Faso <i>Field work:</i> Data collection (health survey) in Burkina Faso
09. - 11.2015	Research Internship, Swiss TPH, Switzerland <i>Research topic:</i> Evaluation of diagnosis tool for soil-transmitted helminths <i>Field work:</i> Data collection (lab work) in Tanzania (Ifakara Health Institute)
10.2012 - 03.2013	Co-project leader in the "OpenSunday" project, IdéeSport, Switzerland

Selected publications

- Erismann, S., Pesantes, M.A., Beran, D., Leuenberger, A., Farnham, A., White, M.B.G.D., Labhardt, N.D., Tediosi, F., Akweongo, P., Kuwawenaruwa, A., Zinsstag, J., Brugger, F., Somerville, C., Wyss, K., and Prytherch, H. (2020). **How to bring research evidence into policy in the drive toward Universal Health Coverage? Synthesizing strategies of five research projects in low-and middle-income countries.** *Health Research Policy and Systems*. <https://doi.org/10.1186/s12961-020-00646-1>
- Farnham, A., Cossa, H., Dietler, D., Engebretsen, R., Leuenberger, A., Lyatuu, I., Nimako, B., Zabre, H. R., Brugger, F., & Winkler, M. S. (2020). **Investigating health impacts of natural resource extraction projects in Burkina Faso, Ghana, Mozambique, and Tanzania: protocol for a mixed methods study.** *JMIR Research Protocols*, 9(4), e17138. <https://doi.org/10.2196/17138>
- Galli, A.*, Leuenberger, A.*, Dietler, D.*, Fletcher, H. A., Junghanss, T., & Utzinger, J. (2020). **Tropical Medicine and International Health and the 2030 Agenda for Sustainable Development.** *Tropical Medicine and International Health*, 25(1), e1-e13. <https://doi.org/10.1111/tmi.13368>
- Dietler, D.*, Leuenberger, A.*, Bempong, N. E., Campbell-Lendrum, D., Cramer, C., Eggen, R. I. L., Erismann, S., Ferazzi, S., Flahault, A., Fletcher, H. A., Fuhrer, B., Fuhrmann, S., Greter, H., Heerdegen, A. C., Leach, M., Leissing, A., Lilje, J., Penny, M. A., Prytherch, H., Staudacher, P., Vounatsou, P., Weiss, F., Wiedemann, R., Winkler, M. S., Zhou, X. N., & Utzinger, J. (2019). **Health in the 2030 Agenda for Sustainable Development: from framework to action, transforming challenges into opportunities.** *Journal of Global Health*, 9(2), 020201. <https://doi.org/10.7189/jogh.09.020201>
- Leuenberger, A., Farnham, A., Azevedo, S., Cossa, H., Dietler, D., Nimako, B., Adongo, P. B., Merten, S., Utzinger, J., & Winkler, M. S. (2019). **Health impact assessment and health equity in sub-Saharan Africa: a scoping review.** *Environmental Impact Assessment Review*, 79, 106288. <https://doi.org/10.1016/j.eiar.2019.106288>
- Byrnes, S.K., Nüesch, C., Loske, S., Leuenberger, A., Schären, S., Netzer, C. & Mündermann, A. **Inertial sensor-based gait and attractor analysis as clinical measurement tool: functionality and sensitivity in healthy subjects and patients with symptomatic lumbar spinal stenosis.** *Frontiers in Physiology*, 2018;9. doi:10.3389/fphys.2018.01095.
- Erismann, S., Diagbouga, S., Schindler, C., Odermatt, P., Knoblauch, A.M., Gerold, J., Leuenberger, A., Shrestha, A., Tarnagda, G., Utzinger, J. & Cissé, G. **School children's intestinal parasite and nutritional status one year after complementary school garden, nutrition, water, sanitation, and hygiene interventions in Burkina Faso.** *The American Journal of Tropical Medicine and Hygiene*, 2017;97:904–13. doi:10.4269/ajtmh.16-0964.
- Erismann, S., Sandaogo, M., Leuenberger, A., Bhandari, K. **Kulga rêve d'un jardin des légumes.** Basel: Swiss TPH; 2016.
- Leuenberger, A., Nassoro, T., Said, K., Fenner, L., Sikalengo, G., Letang, E., Montresor, A., Zhou, X., Steinmann, P., Marti, H. Utzinger, J. and Knopp, S. **Assessing stool quantities generated by three specific Kato-Katz thick smear templates employed in different settings.** *Infectious Diseases of Poverty*, 2016;5(1):58. doi:10.1186/s40249-016-0150-9.

Volunteering

2016 - 2020	Head of the organisation team "Explorer Belt" <i>Facilitating advanced trekking expeditions in remote areas</i> <i>Coaching and preparing participants</i>
2011 - 2020	Leading various education courses for future scout leaders and youth work experts <i>Teaching the organisation of scouts camps and educational courses</i> <i>Coordination of teamwork and feedback techniques</i>
2008 - 2017	Leader and head of the scout group in Riehen, Basel (150 participants)

Language proficiency

German	Mother tongue
French	Advanced
English	Advanced
Swahili	Basic