

ORIGINAL RESEARCH

Global Burden of Disease of Mercury Used in Artisanal Small-Scale Gold Mining



Nadine Steckling, PhD, Myriam Tobollik, MSc, Dietrich Plass, PhD, Claudia Hornberg, PhD, Bret Ericson, MSc, Richard Fuller, BE, Stephan Bose-O'Reilly, MD
Bielefeld, Munich, and Berlin, Germany; Hall in Tirol, Austria; and New York, New York

Abstract

BACKGROUND Artisanal small-scale gold mining (ASGM) is the world's largest anthropogenic source of mercury emission. Gold miners are highly exposed to metallic mercury and suffer occupational mercury intoxication. The global disease burden as a result of this exposure is largely unknown because the informal character of ASGM restricts the availability of reliable data.

OBJECTIVE To estimate the prevalence of occupational mercury intoxication and the disability-adjusted life years (DALYs) attributable to chronic metallic mercury vapor intoxication (CMMVI) among ASGM gold miners globally and in selected countries.

METHODS Estimates of the number of artisanal small-scale gold (ASG) miners were extracted from reviews supplemented by a literature search. Prevalence of moderate CMMVI among miners was determined by compiling a dataset of available studies that assessed frequency of intoxication in gold miners using a standardized diagnostic tool and biomonitoring data on mercury in urine. Severe cases of CMMVI were not included because it was assumed that these persons can no longer be employed as miners. Cases in workers' families and communities were not considered. Years lived with disability as a result of CMMVI among ASG miners were quantified by multiplying the number of prevalent cases of CMMVI by the appropriate disability weight. No deaths are expected to result from CMMVI and therefore years of life lost were not calculated. Disease burden was calculated by multiplying the prevalence rate with the number of miners for each country and the disability weight. Sensitivity analyses were performed using different assumptions on the number of miners and the intoxication prevalence rate.

FINDINGS Globally, 14-19 million workers are employed as ASG miners. Based on human biomonitoring data, between 25% and 33% of these miners—3.3-6.5 million miners globally—suffer from moderate CMMVI. The resulting global burden of disease is estimated to range from 1.22 (uncertainty interval [UI] 0.87-1.61) to 2.39 (UI 1.69-3.14) million DALYs.

CONCLUSIONS This study presents the first global and country-based estimates of disease burden caused by mercury intoxication in ASGM. Data availability and quality limit the results, and the total disease burden is likely undercounted. Despite these limitations, the data clearly indicate that mercury intoxication in ASG miners is a major, largely neglected global health problem.

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From the Bielefeld University, School of Public Health, Department Environment & Health, Bielefeld, Germany (NS, MT, CH); University Hospital Munich, WHO Collaborating Centre for Occupational Health, Institute and Outpatient Clinic for Occupational, Social and Environmental Medicine, Unit Paediatric Environmental Epidemiology, Munich, Germany (NS, SB-O); Department of Public Health and Health Technology Assessment, University for Health Sciences, Medical Computer Science and Technology, Hall in Tirol, Austria (NS, SB-O); German Environment Agency, Section Exposure Assessment and Environmental Health Indicators, Berlin, Germany (MT, DP); Pure Earth, formerly Blacksmith Institute, New York, NY (BE, RF). Address correspondence to N.S. (nadine.steckling@uni-bielefeld.de).

KEY WORDS artisanal small-scale gold mining, burden of disease, disability-adjusted life year, global, DALY, mercury, mercury intoxication

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INTRODUCTION

Artisanal small-scale gold mining (ASGM) is the largest consumer of mercury worldwide and the largest anthropogenic source of mercury emissions in the environment.¹ In ASGM, gold is extracted using rudimentary techniques, including the use of mercury to bind the gold contained in the ore.² Smelting the amalgam releases mercury and leaves gold.³ The occurring mercury vapor contaminates the environment and affects miners as well as residents living nearby.⁴ In these groups, large quantities of mercury are measurable in human specimens and various health problems, such as neurological disorders (eg, tremor) and kidney effects, occur.^{5,6}

Because the amount of gold produced in ASGM is still increasing worldwide,^{7,8} a rising health burden can be assumed. However, data scarcity restricts the quantification of this disease burden. ASGM is mostly not regulated^{9,10} and it is an informal or even illegal activity. Thus, data collection on the health situation at mining sites is difficult, which probably leads to an underestimation of the corresponding disease burden.^{11–13}

Some preliminary work has been done to show the extent of this public health issue. Recent reviews summarize studies presenting mercury concentrations in human specimens of miners and residents as well as their related health effects.^{5,6} A combination of both human biomonitoring (HBM) and health data was used in a diagnostic algorithm to identify cases of chronic mercury intoxication.¹⁴ This diagnostic tool was applied in several field studies^{14–18} and used to calculate preliminary estimates of the burden of disease (BoD) as a result of the use of mercury in ASGM in Zimbabwe. The burden was estimated at about 95,400 disability-adjusted life years (DALYs) using an incidence-based approach and a approximative disability weight (DW).¹⁸ Pure Earth and Green Cross Switzerland¹⁹ assumed a global ASGM BoD of 1.5 million DALYs as a rough estimate. Besides the generally limited database, a missing DW, a factor needed for DALY quantification, hampered the calculation of more

valid estimates. Recently, DWs for chronic mercury intoxication as a result of metallic mercury vapor were derived to improve the input data for DALY quantifications.²⁰ The DWs were based on detailed case descriptions of moderate and severe chronic metallic mercury vapor intoxication (CMMVI),²¹ which is assumed to be the main health outcome resulting from exposure to mercury in ASGM.

There is an urgent need to quantify the health burden of mercury used in ASGM to raise awareness and to foster actions targeting a reduction of disease burden. An established method should therefore be used to quantify the burden, so that it can be compared with other risk factors and health conditions. The objective of this project is a rough estimate of the number of DALYs attributable to chronic metallic mercury vapor intoxication in gold miners caused by the use of mercury in ASGM on a global level and for a set of selected countries.

METHODS

DALYs are the sum of years of life lost (YLLs) and years lived with disability (YLDs).²² YLLs are the product of disease-specific death cases multiplied by a remaining life expectancy at age of death. Prevalence-based YLDs are the product of the number of prevalent cases of a given disease multiplied by its corresponding DW.²³ The DW represents the severity of a disease anchored on a scale between 0 (perfect health) and 1 (a health state comparable to death). The DW is the key element to be able to sum up the time lost due to premature death and time lived in a state of reduced health.²⁴ DALY quantifications were performed without age weighting and time discounting.²⁵ Assuming no fatal effects of CMMVI, the DALYs in our estimates only represent the morbidity component YLDs.

Available data on key parameters were used to calculate DALYs resulting from the use of mercury in ASGM. All model components, underlying concepts, and assumptions are described below and summarized in [Table 1](#).

Subgroup of Interest. The estimation focuses on artisanal small-scale gold miners. This includes all

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