

## Research



# Exposure of Small-Scale Gold Miners in Prestea to Mercury, Ghana, 2012

**Ebenezer Kofi Mensah<sup>1,2,&</sup>, Edwin Afari<sup>1</sup>, Frederick Wurapa<sup>1</sup>, Samuel Sackey<sup>1</sup>, Albert Quainoo<sup>3</sup>, Ernest Kenu<sup>1,2</sup>, Kofi Mensah Nyarko<sup>1,2</sup>**

<sup>1</sup>Ghana Field Epidemiology and Laboratory Training Programme, School of Public Health, University of Ghana, Legon, Ghana, <sup>2</sup>Ghana Health Service, <sup>3</sup>Ghana College of Physicians and Surgeons

**<sup>&</sup>Corresponding author:**

Ebenezer Kofi Mensah, Ghana Field Epidemiology and Laboratory Training Programme, Accra, Ghana

---

**Cite this:** The Pan African Medical Journal. 2016;25 (Supp 1):12.

**DOI:** 10.11604/pamj.supp.2016.25.1.6200

**Received:** 26/01/2015 - **Accepted:** 10/05/2016 - **Published:** 01/10/2016

**Key words:** Human-rabies, investigation, Post-exposure prophylaxis, animal-bite surveillance, Ghana

© **Kofi Afakye et al.** The Pan African Medical Journal - ISSN 1937-8688. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/2.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

**Corresponding author:** Kofi Afakye, Ghana Field Epidemiology and Laboratory Training Programme, Accra, Ghana ([kafakye@ug.edu.gh](mailto:kafakye@ug.edu.gh))

---

This article is published as part of the supplement **"Strengthening Surveillance, Outbreak Investigation and Response: the Role of Ghana FELTP"** sponsored by **GHANA Field Epidemiology and Laboratory Training Program**

**Guest editors:** Donne Kofi Ameme, Kofi Mensah Nyarko

**Available online at:** <http://www.panafrican-med-journal.com/content/series/25/1/12/full>

---

## Abstract

**Introduction:** Small-scale gold miners in Ghana have been using mercury to amalgamate gold for many years. Mercury is toxic even at low concentration. We assessed occupational exposure of small-scale gold miners to mercury in Prestea, a gold mining town in Ghana.

**Methods:** We conducted a cross-sectional study in which we collected morning urine samples from 343 small-scale gold miners and tested for elemental mercury. Data on small-scale gold miner's socio-demographics, adverse health effects and occupational factors for mercury exposure were obtained and analyzed using SPSS Version 16 to determine frequency and percentage. Bivariate analysis was used to determine occupational factors associated with mercury exposure at 95% confidence level.

**Results:** The mean age of the small-scale gold miners was 29.5 ±9.6 years, and 323(94.20%) were males. One hundred and sixty (46.65%) of the small-scale gold miners had urine mercury above the recommended exposure limit (<5.0ug/L). Complaints of numbness were significantly associated with mercury exposure among those who have previously worked at other small-scale gold mines ( $\chi^2=4.96$ ,  $p=0.03$ ). The use of personal protective equipment among the small-scale gold miners was low. Retorts, which are globally recommended for burning amalgam, were not found at mining sites.

**Conclusion:** a large proportion of small-scale gold miners in Prestea were having mercury exposure in excess of occupational exposure limits, and are at risk of experiencing adverse health related complications. Ghana Environmental Protection Agency should organize training for the miners.

## Introduction

Mercury is a chemical element commonly used in small-scale gold mining to amalgamate gold. It is estimated that there are between 10-15 million small-scale gold miners worldwide [1]. The small-scale gold mining sector contributes about 25% to total global gold production [2]. Small-scale gold mining serves as an important source of livelihood for many rural communities, and is also the world's fastest source of mercury contamination [3]. Mercury has effects on the nervous system as was seen in human poisoning in Japan and Iraq [4] and is toxic even at low concentrations [5]. Over one million Ghanaians are estimated to be working in the small-scale gold mining operations [6]. The bulk of small-scale gold mining is concentrated in the Western part of Ghana especially Prestea which is an old gold mining town. Small-scale gold mining activities in Ghana using mercury creates environmental problems such as land degradation, loss of natural resources and water pollution [7]. Small-scale gold miners in Prestea, Ghana handle mercury without appropriate respiratory and skin protection. In Ghana, small-scale gold miners add mercury to the gold containing ore and mix the two metals by hand without gloves to form an amalgam [8]. Subsequent burning of this amalgam over a charcoal fire releases mercury vapour. The released mercury vapour poses both an occupational and environmental threat, and those involved in small-scale gold mining activities as well as residents may inhale high levels of elemental mercury vapour. A study done in the Talensi-Nabdam District in the Upper East Region of Ghana, in 2009 reported high levels of urine mercury among small-scale gold miners [9]. Another study also found low urine mercury levels among small-scale gold miners in Dunkwa-on-Offin, in the Central Region of Ghana [10]. Small-scale gold miners in Prestea are at risk of mercury exposure, and there is paucity of information on their occupational exposure to mercury. We assessed occupational exposure of small-scale gold miners in Prestea to mercury.

## Methods

**Study design and setting:** we conducted a cross sectional study among small-scale gold miners in Prestea. Prestea is in the Prestea-Huni-Valley District of the Western Region of Ghana. Small-scale gold mining activities are widespread in the town employing more than 1000 people with some migrating from other towns in Ghana.

**Participant selection :** a minimum sample size of 334 was obtained; using a prevalence of 68% mercury exposure among small-scale gold miners in South-Western Ghana [11], and an allowable error of 5% at 95% confidence level. Three hundred and forty-three small scale gold miners were recruited into the study. Twenty out of the 25 small-scale gold mining sites scattered in Prestea were randomly selected. At each mining site, small scale gold miners were selected randomly, the total number selected per mining site was based on probability proportional to size.

**Data collection:** a pre-tested semi-structured questionnaire was administered to the small-scale gold miners to document their socio-demographics characteristics, occupational exposure and safety, and presence of signs and symptoms suggestive of mercury exposure. Work place assessments through direct observation and interviews were conducted at the small-scale gold mining sites and shops where amalgam burning takes place to assess occupational exposure.

**Urine collection and transportation:** we collected 30ml-50ml morning urine samples from each small-scale gold miner into polyethylene mercury free plastic bottles. All urine samples were kept in cold boxes containing ice packs with a thermometer to maintain a temperature between 20°C to 80°C in the field, and returned to a fridge at Prestea Government Hospital Laboratory each day at the same temperature range. For every 30ml of urine, 2ml of 5% volume by volume Nitric acid was added to digest mercury into its inorganic forms. To ensure anonymity, all urine containers bore only the identifying numbers of the small scale gold miners. Urine samples maintained at a temperature of 20°C to 80°C in cold boxes were sent to the Water Research Institute Laboratory in Accra, for mercury analysis.

**Urine mercury determination :** the Cold Vapour Atomic Absorption Spectrophotometer machine model AA240F was used for the urine

mercury analysis. Urine mercury determinations were calibrated to obtain a calibration curve by preparing three mercury standards (10ug/L, 20ug/L and 50ug/L) from a commercially prepared mercury stock standard of 1000ppm in 0.5M Nitric acid. These calibration standards were prepared fresh for each batch of 25 urine samples run daily; and run in parallel with the test urine samples and a commercially prepared quality control mercury sample. We defined occupational mercury exposure as urine sample containing mercury  $\geq 5.0\text{ug/L}$  [12].

**Data management and analysis:** data were coded, entered and analyzed using Statistical Package for Social Sciences (SPSS) Windows version 16. We summarised continuous variables as means and SD and categorical variable as proportions, and presented the results in graphs and tables. Pearson's Chi-square test was used to determine association between mercury exposure and any adverse health effects at 95% confidence level. Bivariate analysis was done to determine occupational factors associated with mercury exposure and to generate prevalence odd ratios (OR) at 95% confidence level.

**Ethical Consideration:** ethical clearance was obtained from Ghana Health Service Ethics Review Committee. We obtained informed consent from the small-scale gold miners.

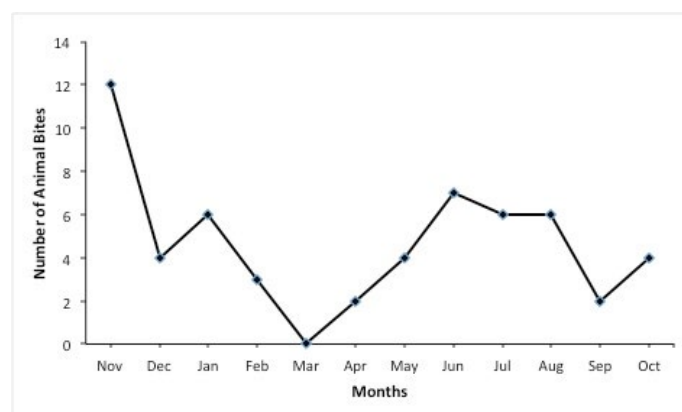
## Results

**Socio-demographic characteristics:** three hundred and forty three small-scale gold miners were recruited in this study. The ages of the small-scale gold miners ranged from 15-70 years with a mean age of  $29.46 \pm 9.64$  years. Majority, 154/343 (44.9%), of the small-scale gold miners were within the age 20-29 years, and 323/343 (94.2%) were males. Their duration of work ranged from 1-38 years with a mean occupational exposure of  $7.19 \pm 6.96$  years. Two hundred and nine, (60.9%) had primary education (Table 1).

**Table 1:** results of Blood Chemistry of 5-year old boy bitten by a dog two months earlier, Manya-Krobo district, September, 2012

Blood Indices	Value	Blood Indices	Value
White Blood Cells	$+ 17.9 \times 10^3 / \mu\text{L}$	Platelets	$393 \times 10^3 / \mu\text{L}$
Red Blood Cell	$5.44 \times 10^6 / \mu\text{L}$	Lymphocytes %	30.9%
Haemoglobin	12.9g/dL	Mid Cells %	1.3%
Haematocrit	36.1%	Neutrophils %	67.8%
Mean Cell Volume	-66.4fL	Lymphocytes #	$5.5 \times 10^3 / \mu\text{L}$
Mean Cell Haemoglobin	-23.7ps	Mid Cells #	$0.2 \times 10^3 / \mu\text{L}$
Mean Cell Haem. Conc.	35.7g/dL	Neutrophils #	$12.2 \times 10^3 / \mu\text{L}$

**Mercury exposure:** the study found 160 small-scale gold miners (46.65%) who were exposed to mercury. The exposure level range was between (5.00-50.50ug/L) of mercury with a mean of  $14.75 \pm 10.22\text{ug/L}$  (Figure 1).



**Figure 1:** reported animal-bites at government Hospital between Nov. 2011 and Oct. 2012, Manya Krobo District

**Signs and symptoms suggestive of mercury exposure:** an association was found between mercury exposure and complaints of skin rashes among the 343 small-scale gold miners; however, this finding (Table 2) was not statistically significant ( $\chi^2=3.49$ ,  $p=0.062$ ). Twenty-five out of the 343 small scale gold miners reported working previously at other small scale gold mining sites before migrating to work in Prestea. Among them complaints of numbness was significantly associated with mercury exposure ( $\chi^2=4.96$ ,  $p=0.026$ ) (Table 2). There was no statistically significant association between exposure to mercury and complaint of red eyes ( $\chi^2=3.22$ ,  $p=0.073$ ), medical taste ( $\chi^2=3.72$ ,  $p=0.054$ ) among the 25 small-scale gold miners (Table 2).

**Knowledge about mercury hazards and the use of personal protective equipment :** two hundred and thirty-six (68.8%) store mercury at home and 225(65.6%) had no knowledge about hazards associated with mercury use. Majority, 335(97.7%) had no occupational safety training in handling mercury. The use of personal protective equipment (PPE) among the small-scale gold miners was limited: 336(98.0%) did not use aprons, 315(91.8%) did not use face masks, 321(93.6%) did not use rubber gloves, 310(90.4%) did not use leather boots, and 314(91.5%) did not use head coverings, in their work. Some of the small-scale gold miners during this study were seen removing excess mercury from amalgam with their bare hands without gloves; whereas others sucked the mercury from the amalgam with their mouth for re-use.

**Occupational risk factors associated with mercury exposure at bivariate analysis:** none of the occupational risk factors in the small-scale gold mining was associated with high mercury exposure (Table 3).

that small-scale gold miners living in Prestea are potentially exposed to mercury. These small-scale gold miners are at risk of experiencing adverse health effects and mercury intoxication. Complaints of numbness were significantly associated with mercury exposure among small-scale gold miners who have previously worked at other small-scale gold mining sites before migrating to work in Prestea. This could be attributed to continuous, higher and longer period of occupational mercury exposure among this group of small-scale miners. Similar studies conducted in Ghana and Venezuela did not find any significant association between mercury exposure and frequency of reported symptoms of mercury among small-scale gold miners[9,13]. A recent study conducted in Burkina Faso found small-scale gold miners directly involved in gold mining activities reporting symptoms relating to mercury poisoning [15]. The low level education (primary) among the small-scale gold miners could explain the limited use of PPE among the study population. This low level use of PPE is consistent with other findings in Venezuela and Ghana [13,16]. Other possible explanation is their lack of knowledge and apathy towards mercury exposure. Our study did not find any significant association between occupational risk factors and mercury exposure; this is contrary to a study done in the Talensi-Nabdam District in the Upper East Region of Ghana where amalgam burners were found to have significantly higher urine mercury [9]. These study subjects may have been exposed to relatively higher and longer period of mercury vapour compared to those in this study. The inappropriate method of sucking mercury with the mouth, and the use of bare hands to squeeze mercury from the amalgam for re-use, could lead to mercury accumulating in their bodies causing symptoms such as dermatitis, cutaneous eruptions and numbness. Retorts which are globally recommended for burning gold amalgam [17] were not found at small-scale gold mining sites visited. However, a study done in Tanzania found some small-scale gold miners using retorts[18]. Studies have shown that it is possible to reduce mercury exposure at small-scale gold mining sites by using retorts [19,20].

**Limitation:** Due to the cross-sectional study design, we were unable to determine pre-occupational exposure to mercury before urine collection. Signs were elicited and symptoms self-reported; and these are subjective.

**Table 2:** characteristics of persons potentially exposed to rabies infectious material at Manya-Krobo district, 2012

Place exposure occurred	*Category I Exposure		#Category II Exposure		Total, n (%)
	Male	Female	Male	Female	
Child's Home	5	2	3	3	13 (39.3)
District Hospital	1	6	0	1	8 (24.3)
Regional Hospital	1	5	0	1	7 (21.2)
Dog's Home	1	1	1	2	5 (15.2)
Child's School	0	0	0	0	0 (0)
<b>Age Group exposure occurred</b>					
<5	1	0	0	0	1 (3.0)
5-15	5	1	3	2	11 (33.3)
16-30	0	6	0	1	7 (21.2)
30-59	2	7	1	3	13 (39.5)
>59	0	0	0	1	1 (3.0)
Total, n (%)	8(24.3)	14(42.4)	4(12.1)	7(21.2)	33 (100)
	22 (66.7)		11 (33.3)		

\* Touching, feeding of animals or licks on intact skin (no exposure therefore no prophylaxis if history reliable); # Minor scratches or abrasions without bleeding or and nibbling of uncovered skin (use vaccine alone)

## Conclusion

Some small-scale gold miners in Prestea were exposed to mercury levels in excess of occupational exposure limits. Complaints of numbness, metallic tastes, skin rashes and red eyes were elicited and reported by some small scale gold miners which might be related to mercury exposure. Environmental Protection Agency (EPA) of Ghana should organize training programmes in safety and hazards associated with handling of mercury among small-scale gold miners in Prestea to raise awareness concerning mercury exposure as well as ensuring that these PPEs are used appropriately. The District field officers of EPA should regularly monitor and supervise the activities of these small-scale gold miners to ensure that the environment is not destroyed through indiscriminate use of mercury. Ghana's Minerals Commission should contract local craft manufacturers to produce retorts at affordable prices for sale to the small-scale gold miners. They should also identify safe designated areas for the small-scale gold miners especially those working near human settlements in order to minimize environmental degradation as well as human exposure due to mercury use.

**Table 3:** number of reported animal bites by sex and age group, Manya-Krobo District, 2011/2012 (N=92)

Type of Facility	Sex	Age Group						Total, n (%)
		<5yrs	5-14yrs	15-17yrs	18-34yrs	35-59yrs	>59yrs	
Public Hospital	Male	1	11	4	4	1	3	24 (26)
	Female	2	6	1	13	5	1	32 (35)
Private Hospital	Male	5	4	2	8	3	0	22 (24)
	Female	1	4	0	4	2	7	14 (15)
Total, n (%)		9 (10)	25 (27)	7 (8)	29 (31)	11 (12)	11 (12)	92 (100)

## Discussion

This study found 46.65% of the small-scale gold miners occupationally exposed to mercury ( $\geq 5.0\mu\text{g/L}$ ) [12]. This finding is similar to studies conducted in South Africa, Venezuela and Brazil where estimated urine mercury concentrations among small-scale gold miners were 50%, 48.3% and 52% respectively above the recommended occupational exposure limits [12-14]. A study in Burkina Faso, however, reported 69% of small-scale gold miners having urine mercury levels above the recommended occupational exposure limit [15]. The findings in this present study show

## Competing interests

The authors declare no competing interest.

## Authors' contributions

All the authors contributed during the design of the study, data collection and interpretation, and approved the final version of the manuscript submitted.

## Acknowledgments

We acknowledge the Faculty members of Ghana Field Epidemiology and Laboratory Training Programme for their support during the study. Our appreciation also goes to the staff of Zonal Public Health Laboratory, Sekondi, Ghana and Prestea Government Hospital for their co-operation and assistance during the study. Special thanks to Mr. Emmanuel Benson of Takoradi Polytechnic, Ghana.

## References

1. Veiga MM, Baker RF, Fried MB, et al. Protocols for environmental and health assessment of mercury released by artisanal and small-scale gold miners. Vienna: Global Mercury Project, UNIDO 2004.
2. Cordy P, Veiga M, Crawford B, et al. Characterization, mapping, and mitigation of mercury vapour emissions from artisanal mining gold shops. *Environ Res.* 2013;125:82-91.
3. Swain EB, Jakus PM, Rice G, et al. Socioeconomic consequences of mercury use and pollution. *Ambio.* 2007;36(1):45-61.
4. Toxicological Effects of Methylmercury. <http://www.nap.edu/openbook.php?isbn=0309071402> (accessed 18 Sep2014).
5. Zahir F, Rizwi SJ, Haq SK, et al. Low dose mercury toxicity and human health. *Environ Toxicol Pharmacol.* 2005;20(2):351-60.
6. Hilson G. Challenges with eradicating child labour in the artisanal mining sector: A case study of the Talensi-Nabdam District, Upper East Region of Ghana. *Read Univ Read.* Published Online First: 2008. <http://www.yorku.ca/cerlac/EI/papers/Hilson.pdf> (accessed 17 Sep2014).
7. Hilson G. Harvesting mineral riches: 1000 years of gold mining in Ghana. *Resour Policy.* 2002;28(1-2):13-26.
8. Tschakert P, Singha K. Contaminated identities: Mercury and marginalization in Ghana's artisanal mining sector. *Geoforum.* 2007;38(6):1304-21.
9. Paruchuri Y, Siuniak A, Johnson N, et al. Occupational and environmental mercury exposure among small-scale gold miners in the Talensi-Nabdam District of Ghana's Upper East region. *Sci Total Environ.* 2010;408(24):6079-85.
10. Kwaansa-Ansah EE, Basu N, Nriagu JO. Environmental and occupational exposures to mercury among indigenous people in Dunkwa-On-Offin, a small scale gold mining area in the South-West of Ghana. *Bull Environ Contam Toxicol.* 2010;85(5):476-80.
11. Adimado AA, Baah DA. Mercury in Human Blood, Urine, Hair, Nail, and Fish from the Ankobra and Tano River Basins in Southwestern Ghana. *Bull Environ Contam Toxicol.* 2002;68(3):339-46.
12. Oosthuizen MA, John J, Somerset V. Mercury exposure in a low-income community in South Africa. *SAMJ South Afr Med J.* 2010;100(6):366-71.
13. Rojas M, Drake PL, Roberts SM. Assessing mercury health effects in gold workers near El Callao, Venezuela. *J Occup Environ Med Am Coll Occup Environ Med.* 2001;43(2):158-65.
14. Silbergeld EK, Nash D, Trevant C, et al. Mercury exposure and malaria prevalence among gold miners in Pará, Brazil. *Rev Soc Bras Med Trop.* 2002;35(5):421-9.
15. Tomicic C, Vernez D, Belem T, et al. Human mercury exposure associated with small-scale gold mining in Burkina Faso. *Int Arch Occup Environ Health.* 2011;84(5):539-46.
16. Hilson G, Hilson CJ, Pardie S. Improving awareness of mercury pollution in small-scale gold mining communities: Challenges and ways forward in rural Ghana. *Environ Res.* 2007;103(2):275-87.
17. Moher PB. Artisanal Gold Council: Mercury Recycling in Artisanal Gold Mining: The Good and the Bad. *Artis. Gold Council.* 2013. <http://artisanalgold.blogspot.com/2013/07/retorts-good-and-bad.html> (accessed 18 Sep2014).
18. Jønsson JB, Fold N. Handling uncertainty: Policy and organizational practices in Tanzania's small-scale gold mining sector. *Nat Resour Forum.* 2009;33(3):211-20.
19. Shandro JA, Veiga MM, Chouinard R. Reducing mercury pollution from artisanal gold mining in Munhena, Mozambique. *J Clean Prod.* 2009;17(5):525-32.
20. Jønsson JB, Fold N. Mining 'From Below': Taking Africa's Artisanal Miners Seriously: Africa's artisanal miners. *Geogr Compass.* 2011;5(7):479-93.

**PAMJ is an Open Access Journal published in partnership with the African Field Epidemiology Network (AFENET)**

