problems_in_artisanal_gold_in_Makassar_city__1__21910308_-_1.pdf

by

FILE	PROBLEMS_IN_ARTISANAL_GOLD_IN_MAKASSAR_CITY__1__21910308_-_1.PDF (161.36K)		
TIME SUBMITTED	13-OCT-2020 01:29PM (UTC+0700)	WORD COUNT	3165
SUBMISSION ID	1413733681	CHARACTER COUNT	17711

IMPACT FACTOR

2.429

Reviews on Environmental Health
Editor In Chief: David O. Carpenter and Peter Sly

Edited by: Tahir Rafique and Lucia Fazzo

Volume 35 (2020): Issue 3 (Sep 2020): Special Issue: Assessing and mitigating environmental exposures in early life; Issue Editors: Sharon Brabon and Zahir Islam

ORIGINAL ARTICLES

The relationship of mercury exposure with neurological problems in artisanal gold in Makassar city

Reni Suhelmi, Hasnawati Amqam, Ridwan M. Thaha, Anwar Mallongi, Anwar Daud, and Hasanuddin Ishaq

Article Category: Research Article | Pages: 265–269 | Published online: 27 Jul 2020

Original Article

Reni Suhelmi, Hasnawati Amqam*, Ridwan M. Thaha, Anwar Mallongi, Anwar Daud and Hasanuddin Ishaq

The relationship of mercury exposure with neurological problems in artisanal gold in Makassar city

https://doi.org/10.1515/reveh-2020-0034
Received March 14, 2020; accepted June 4, 2020; published online xxx

Abstract

Objectives: This research aims to analyse the relationship between urine mercury levels and neurological problems.

Methods: This research is an observational study with a cross-sectional approach. There are 44 goldsmiths in the gold jewellery small scale industry involved in this study. Urine mercury levels were measured using an atomic absorption spectrophotometer. Neurological problems were assessed by a medician. Data collected includes age, time of exposure, work duration, smoking behaviour and nutrition status of the goldsmiths which were obtained by interview.

Results: The results showed that the concentration of mercury in the goldsmith's urine was around 0.93–64.59 µg/L. The analysis showed that there were 63% of goldsmiths experiencing neurological problems, such as tremors (9.1%) and knee pass reflex (6.8%). The bivariate analysis showed that there is no significant relationship between the concentration of mercury (p=0.133), age (p=0.155), time of exposure (p=0.702), time of working (p=0.354), smoking behaviour (p=0.169) and nutrition status (p=0.541) with neurological problems.

Conclusions: The goldsmiths who had high levels of mercury in urine samples were diagnosed with at least one of the neurological symptoms. It is recommended that the goldsmith use personal protective equipment during work such as mask, glasses and gloves.

Keywords: biomarkers; goldsmith; health effect; Hg; worker.

***Corresponding author: Hasnawati Amqam**, Environmental Health Department, Public Health, Universitas Hasanuddin, Makassar, Indonesia, E-mail: hasnawati.amqam@unhas.ac.id
Reni Suhelmi: Environmental Health Department of Universitas Muhammadiyah Kalimantan Timur, Samarinda, Indonesia
Ridwan M. Thaha: Health Promotion and Behavioral Science Department, Public Health, Universitas Hasanuddin, Makassar, Indonesia
Anwar Mallongi, Anwar Daud and Hasanuddin Ishaq: Environmental Health Department, Public Health, Universitas Hasanuddin, Makassar, Indonesia

Introduction

Mercury exposure induces numerous occupational diseases since mercury has been used in various industrial applications [1]. It is utilized in the dental filling, lamp manufacture, artisanal gold production, etc. Mining workers are the most studied subjects with regard to occupational mercury exposure in developing countries [2]. Meanwhile, gold artisans involved in gold jewellery production are still rarely included in the study while they are also closely related to mercury exposure. A large number of them work in artisanal gold small scale enterprises where personal protection is not a concern.

The gold artisans and their families who live around production sites are at higher risk of having health problems [3]. In Africa, exposure to mercury was mostly experienced by workers in gold production [4]. While in Ecuador, the concentration means of mercury in whole blood of gold miners was 5.2 µg/L [5]. Furthermore, 55 and 62% goldsmiths in Sulawesi and Kalimantan respectively had mercury exposure in their work environment [6]. Also, in South Sulawesi, almost all the goldsmiths had exposure to mercury [7]. The research in Southeast Sulawesi [8] and Cisarua [9] showed the level of mercury in hair of goldsmiths were 12.82 µg/g and 5.54 ppm, respectively. Other research showed that the level of mercury in urine was >7 – 273.3 µg/l and in hair was >1 – 12.93 µg/l [10].

The neurotoxicity of mercury had been confirmed since the central nervous system (CNS) is the critical organ for exposure to mercury [11, 12]. In adults, symptom onset starts with sensory disturbance followed by visual field

constriction, ataxia, cognitive decline and death [13]. The neuropathology indicates that the occipital cortex and cerebellum are the most affected organs [14].

There have been numerous studies about the effect of mercury exposure to the nervous system in mining workers [4, 15]. Blueline in gums, dysmetria, tremor and ataxia have been recorded as symptoms related to nervous disruption experienced by gold miners [16, 17]. The incidence of tremor was the highest in some researches, such as in Chile (71%) [18], in Peru (13%) [19], in Indonesia (76.5%) [6] and in Aceh-Indonesia (10.3%) [20].

Makassar City is one of the highest gold production areas in Indonesia, and it is famous with the high quality of gold jewellery. A gold jewellery trade centre has been available to distribute the products. The production involved modern and traditional methods. Most of the gold artisans are still use mercury in the production. It is applied to extract the gold from the mixtures of other metals. They prefer to use mercury as an extractor due to the lower price. This research aims to know the relationship between Hg in urine, age, time of exposure, time of working, and nutritional status with neurological problems in goldsmith in Makassar city, Indonesia.

Methods

Research site

This research was located in Makassar city, Indonesia, in two artisanal gold small scale industry areas called Wajo and Manggala subdistricts. The gold craft industries are located in the middle of residential areas. The gold artisans work in their house using the traditional method to produce the crafts, such as ring, necklace and bracelet.

Sample

Forthy-four gold artisan agreed to involve in this study. They were interviewed about their age, time of exposure, time of working, smoking behaviour and nutrition status by means of a questionnaire. For ethical consideration, informed consent was obtained from all of the participants involved in this study before the interview.

Neurological symptoms observation

To explore neurological symptoms experienced by the goldsmiths, a doctor observed them whether or not they experience the symptoms according to poisoning indicators in neurological examination [21]:

(1) Signs of bluish discolouration of gums
(2) Rigidity and ataxia (walking or standing)
(3) Test of alternating movements or test for dysdiadochokinesia
(4) Irregular eye movements or nystagmus
(5) Visual constriction of visual fields (Test of the field of vision)
(6) Patellar reflexes: Knee jerk reflex and biceps reflex
(7) Pathological reflexes: Babinski reflex and labial reflex
(8) Salivation and dysarthria
(9) Sensory examination
(10) Tremor

Hg measurement

Mercury exposure was measure through urine mercury level. The participants were asked to fill a polyethylene container with their 25 mL first-morning urine. After collecting the filled container, 1/10% preservative Natrium Azida was added to the urine then transported to the laboratory for analysis.

A urine specimen was poured into Erlenmeyer flask, and then added by 10 mL of concentrated HNO3. The urine mixture was heated until the steam was not brown then cooled for 10 min. Furthermore, the urine specimen mixture was diluted with distilled water to reach 100 mL. The diluted specimen was filtered using whatmann 42 filter paper. The specimen was then analysed *Atomic Absorption Flame Emission Spectrophotometer* AA-6200. Mercury level was counted using the following formula:

$$\text{Hg} = \frac{\text{Hg concentration} - \text{Blank}/1000}{\text{sample Volume}} \times \text{FinalVolume}$$

Mercury concentration was in µg/ml.

Results

The characteristic of the workers involved in this study is presented in Table 1. The most prevalent neurological problem was gums discolouration (31.8%). Other neurological symptoms that experienced by gold workers were a tremor, patellar reflex and nystagmus, with the incidence of 9.1, 6.8 and 2.3%, respectively. The current study also found that there were 11.4% of gold workers experience two neurological symptoms simultaneously: gums discolouration and patellar reflex as well. Average of total mercury concentration in goldsmiths was 12.92 µg/L. The mean productive age was 32 years old. The nutritional status showed that the highest body mass index was 37.60. The relationships between the concentrations of urine mercury with neurological symptoms were determined using the chi-square test. The data shows that the mercury level had no significant association with neurological problems.

Discussion

The results showed that all goldsmiths were exposed to mercury. The average mercury concentration in urine was 12.92 µg/L. This concentration is higher than the research in

Table 1: The characteristic of artisanal gold workers in Makassar City.

Variables	Value
Neurological symptom (%, n=44)	
No symptoms	36.3
Gums discolouration	31.8
Tremor	9.1
Patellar reflex	6.8
Nystagmus	2.3
Gums discolouration and tremor	2.3
Gums discolouration and patellar reflex	11.4
Hg in urine (µg/L ,n=44)	
Mean	12.92
Median	6.5
Minimum	0.93
Maximum	64.59
Age (year,n=44)	
Mean	32.75
Minimum	15
Maximum	53
Duration of exposure (Hours/day,n=44)	
Mean	10.50
Median	10.50
Minimum	4
Maximum	16
Working time (Year, n=44)	
Mean	12.80
Minimum	1
Maximum	30
Body mass index (kg/m^2)	
Mean	22.66
Median	22.45
Minimum	16.00
Maximum	37.60

Table 2: The relationship between independent variables to neurological symptom.

Variables n = 44	Neurological problems experience n (%)		p-Value*
	Yes	No	
Hg in urine			
≥4 µg/L	4 (40.0)	10 (29.4)	0.133
<4 µg/L	24 (70.6)	16 (60.0)	
Age			
High-risk	20 (71.4)	8 (28.6)	0.155
Low-risk	8 (50.0)	8 (50.0)	
Time of Exposure			
High-risk	23 (65.7%)	12 (34.3)	0.702
Low-risk	5 (5.6)	4 (44.4)	
Time of working			
High-risk	18 (69.2)	8 (30.8)	0.354
Low-risk	10 (55.6)	8 (44.4)	
Nutritional status			
Not Normal	20 (66.7%)	10 (33.3)	0.541
Normal	8 (57.1)	6 (42.9)	

*chi-square test.

Equador that found 3.3 µg/kreatinin mercury in the urine of gold workers [22].

There was no significant relationship between the levels of Hg in urine with neurological problems (p=0.133). This research showed that 71.4% of respondents had experienced neurological symptoms. Study in Chile found that the average age of goldsmith of 48.3 that experiencing health impact. It is not in line with the research in Gorontalo, Indonesia, that found a positive relationship between age and mercury exposure [23].

The effects of mercury exposure on the central nervous system are influenced by age, sex and length of time of exposure [24]. The neurological symptoms were observed according to neurological evaluations [18]. Chronic neurological diseases due to mercury poisoning can be experienced by the communities [4]. Mercury enters the body through inhalation will be inducted into the brain through reactive oxygen species (ROS). This ROS will change the antioxidants of the cell defence system. There is a detoxification process of mercury in the body involving glutathione [9]. The involvement of ROS can cause damage or DNA changes and enzyme imbalances [10].

The trade of gold jewellery in Makassar city has been operated for over 40 years. Designing and decorating of the jewellery from gold bars are the tasks of the goldsmith. These activities are usually carried out inside their houses in a group of 3–4 people without proper ventilation. Goldsmiths do not use any personal protective equipment.

Goldsmith usually finishes one jewellery within a week to a month, depending on the type and model of gold jewellery ordered. Each goldsmith is an expert on different types of jewellery. Each type of gold jewellery, such as rings, necklaces, bracelets and earrings, is handled by different persons. The initial process of goldsmithing is receiving gold bars from traders or consumers.

These gold bars are then sorted according to the size required using a distiller. The gold bars are heated for easy shaping to jewellery and dipped into liquid hydrochloric acid (HCL). The liquid waste dumped into their gutter. Gold processing uses heat to melt the gold bar. The mercury contained in the gold refining and amalgam burning exposed the workers through inhalation.

Mercury that enters the body with the help of ROS binds to glutathione and cysteine enzymes to form conjugates. Mercury and enzymes binding inactivates enzymes and result in tissue damage, and interfere with various metabolic processes. One of the impacts is neurological

problems [11]. Some of the symptoms that arise as a result of mercury exposure are tremors, dysarthria, ataxia, weight loss, dizziness, and headaches and sleep disorders [12–14].

The impact of mercury exposure occurs for a long time. Occupational exposure to chemicals is closely related to the emergence of neurological problems. However, the causal correlation between this exposure and neurological symptoms is often difficult to establish. This caused by some factors such as age, alcohol intake, drug consumption, stress and smoking habits [25].

Study in Chicago showed that there was no relationship between the levels of mercury in urine with neurological problems [26]. In Ecuador, research also concluded there was no significant between the relationship of mercury exposure and neurological issues [22]. Decrease in conducive nerve velocity has been shown in workers exposed by mercury [27].

The dangerousness of mercury comes from their characteristics. The characteristics of mercury are persistent, ease of accumulation and amplification along the food chain and the route of exposure. Mercury is observed via three main exposure routes are inhalation, dermal and oral. In developed countries, such as Finland, the average age of workers at diagnosis of neurological problems was 52.8 years with a range of 35–73 years [28]. The result of this research showed that most of the goldsmiths were 25–44 years old, with a percentage of 63.6%. Based on bivariate analysis, it was found that there was no relationship between age and neurological problems with p-Value p = 0.155. Time of exposure to mercury pollution affects neurological problems. The goldsmiths worked for more than 8 h per day and were exposed to mercury every day.

The mechanism of the effect of mercury on neurological problems is complex. In general, mercury has entered into the human body through some route such us inhalation, dermal and oral route. The amount of mercury intake depends on the dose and time of exposure [12]. The exposure time of 10.50 h/day potentially has a chronic impact on the organs of the body, such as the neurological system. This current study is In line with the research in Aceh that found no significant relationship between working time and neurological problems [20].

Conclusion

This study has examined the relationship between the concentrations of mercury in urine with neurological problems. Several neurological symptoms were experienced by some goldsmiths in Makassar city. It is concluded that age, time of exposure, time of working, smoking behaviour and nutrition status had no significant relationship with neurological problems. It is recommended that goldsmiths use personal protective equipment during working such as masks, glasses and gloves.

Research funding: None declared.

Author contributions: All authors have accepted responsibility for the entire content of this manuscript and approved its submission.

Conflict of interest: Authors state no conflict of interest.

Informed consent: Informed consent was obtained from each participant included in the study.

Ethical approval: Ethical Clearance was approved by Ethics Committee of Medical Faculty of Hasanuddin University.

References

1. Ratcliffe HE, Swanson GM, Fischer LJ. Human exposure to mercury: a critical assessment of the evidence of adverse health effects. J Toxicol Environ Health 1996;49:221–70.
2. Bose-O'Reilly S, Drasch G, Beinhoff C, Rodrigues-Filho S, Roider G, Lettmeier B, et al. Health assessment of artisanal gold miners in Indonesia. Sci Total Environ 2010;408:713–25.
3. Gibb H, O'Leary KG. 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.
4. WHO. Chemicals of public health concern and their management in the African Region. Africa: Africa WHO; 2014.
5. Harari R, Harari F, Gerhardsson L, Lundh T, Skerfving S, Strömberg U, et al. Exposure and toxic effects of elemental mercury in gold-mining activities in Ecuador. Toxicol Lett 2012;213:75–82.
6. Bose-O'Reilly S, Drasch G, Beinhoff C, Rodrigues-Filho S, Roider G, Lettmeier B, et al. Health assessment of artisanal gold miners in Indonesia. Sci Total Environ 2010;408:713–25.
7. Abbas HH, Sakakibara M, Sera K, Arma LH. Mercury exposure and health problems in urban artisanal gold mining (UAGM) in Makassar, South Sulawesi, Indonesia. Geosciences 2017;7:44.
8. Sakakibara M, Sera K. Current mercury exposure from artisanal and small-scale gold mining in Bombana, southeast Sulawesi, Indonesia—future significant health risks. Toxics 2017;5:7.
9. Sumantri A, Laelasari E, Junita NR, Nasrudin N. Logam Merkuri pada Pekerja Penambangan Emas Tanpa Izin. Kesmas: National Public Health J 2014;8:398–403.
10. Ekawanti A, Krisnayanti BD. Effect of mercury exposure on renal function and hematological parameters among artisanal and small-scale gold miners at Sekotong, west Lombok, Indonesia. J Health Pollut 2015;5:25–32.
11. Langworth S, Almkvist O, Söderman E, Wikström BO. Effects of occupational exposure to mercury vapour on the central nervous system. Occup Environ Med 1992;49:545–55.
12. Fernandes Azevedo B, Barros Furieri L, Peçanha FM, Wiggers GA, Frizera Vassallo P, Ronacher Simões M, et al. Toxic effects of mercury on the cardiovascular and central nervous systems. BioMed Res Int 2012;2012. https://doi.org/10.1155/2012/949048.

13. Bose-O'Reilly S, McCarty KM, Steckling N. Mercury exposure and children's health. Curr prob pediatr Adolesc Health Care 2010;40: 186–215.
14. Zalups RK, Lash LH. Advances in understanding the renal transport and toxicity of mercury. J Toxicol Environ Health, Part A Current Issues 1994;42:1–44.
15. Paruchuri Y, Siuniak A, Johnson N, Levin E, Mitchell K, Goodrich JM, 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;408:6079–85.
16. Ngowi AV, Macha EW. 785 Occupational exposure to mercury in a small scale gold mining workers and families in handeni. Tanzania: BMJ Publishing Group Ltd; 2018.
17. Abbas HH, Sakakibara M, Sera K, Arma LH. Mercury exposure and health problems in urban artisanal gold mining (UAGM) in Makassar, South Sulawesi, Indonesia. Geosciences 2017;7:44.
18. Corral S, Sáez D, Lam G, Lillo P, Sandoval R, Lancellotti D, et al. Neurological and neuropsychological deterioration in artisanal gold miners from the town of Andacollo, Chile. Toxicol Environ Chem 2013;95:344–58.
19. Yard EE, Horton J, Schier JG, Caldwell K, Sanchez C, Lewis L, et al. Mercury exposure among artisanal gold miners in Madre de Dios, Peru: a cross-sectional study. J Med Toxicol 2012;8:441–8.
20. Risqa M. Analisis status neurologis akibat paparan merkuri dari kegiatan penambangan emas rakyat pada masyarakat di Kecamatan Krueng Sabee Kabupaten Aceh Jaya tahun 2013. ETD Unsyiah 2014. https://etd.unsyiah.ac.id/index.php?p=show_detail&id=5147. In press.
21. Veiga MM, Baker RF, Fried MB, Withers D. Protocols for environmental and health assessment of mercury released by artisanal and small-scale gold miners. United Nations: United Nations Publications; 2004.
22. Harari R, Harari F, Gerhardsson L, Lundh T, Skerfving S, Strömberg U, et al. Exposure and toxic effects of elemental mercury in gold-mining activities in Ecuador. Toxicol Lett 2012; 213:75–82.
23. Arifin YI, Sakakibara M, Sera K. Impacts of artisanal and small-scale gold mining (ASGM) on environment and human health of Gorontalo utara regency, Gorontalo province, Indonesia. Geosciences 2015;5:160–76.
24. Mallongi A. Bahan pencemar toxic di Udara dan upaya pengendaliannya. Yogyakarta: Penerbit WR; 2015.
25. Lotti M, Bleecker L. Principles and practice of occupational neurology: an overview. Handb Clin Neurol 2015:131. https://doi.org/10.1016/B978-0-444-62627-1.00001-9.
26. Anglen JN. Occupational mercury exposure and neurological disease prevalence in US dentists. Chicago: Rush University Medical Center; 2015.
27. Friberg L. Inorganic mercury. Sweden: World Health Organisation; 1991.
28. Sainio MA. Neurotoxicity of solvents. Handb Clin Neurol 2015;131. https://doi.org/10.1016/B978-0-444-62627-1.00007-X.

problems_in_artisanal_gold_in_Makassar_city__1__21910308_-_1.pdf

ORIGINALITY REPORT

%9	%7	%7	%1
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.mdpi.com Internet Source	%4
2	mafiadoc.com Internet Source	%1
3	G Drasch, S Böse-O'Reilly, C Beinhoff, G Roider, S Maydl. "The Mt. Diwata study on the Philippines 1999 — assessing mercury intoxication of the population by small scale gold mining", Science of The Total Environment, 2001 Publication	%1
4	"Proceedings of the Andalas International Public Health Conference 2017", BMC Public Health, 2017 Publication	%1
5	"Elements and Their Compounds in the Environment", Wiley, 2004 Publication	<%1
	www.tandfonline.com	

6	Internet Source	<%1
7	Deutsche Forschungsgemeinschaft, . "Mercury and inorganic mercury compounds [MAK Value Documentation, 2001]", The MAK-Collection for Occupational Health and Safety Annual Thresholds and Classifications for the Workplace, 2012. Publication	<%1
8	Ellingsen, D.G.. "Neuropsychological Effects of Low Mercury Vapor Exposure in Chloralkali Workers", Neurotoxicology, 200104 Publication	<%1
9	www.neliti.com Internet Source	<%1
10	Alejandra Manjarres-Suarez, Jesus Olivero-Verbel. "Hematological parameters and hair mercury levels in adolescents from the Colombian Caribbean", Environmental Science and Pollution Research, 2020 Publication	<%1
11	"Toxicological Profile for Mercury", ATSDR s Toxicological Profiles Web Version, 2002. Publication	<%1

EXCLUDE QUOTES	ON	EXCLUDE MATCHES	< 5 WORDS
EXCLUDE BIBLIOGRAPHY	ON		