

Relation of Urinary Mercury Level to Chronic Fatigue Syndrome among Workers of Artisanal and Small-scale Gold Mining: A Study of 3 Districts in West Nusa Tenggara Province and Lebak District of Banten Province, Indonesia

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ABSTRACT

Introduction. Chronic Fatigue Syndrome (CFS) is a collection of symptoms from a substantial reduction in the ability to engage in preillness levels of occupational, educational, social, or personal activities that persists for more than six months and is accompanied by fatigue, post-exertional malaise, and unrefreshing sleep. One of the effects of heavy metal exposure is the occurrence of CFS among workers. Artisanal and Small-scale Gold Mining (ASGM) workers used mercury in their work, and this leads to a higher risk of chronic mercury poisoning. One of the health problems due to mercury exposure is the occurrence of CFS and this has not been studied among ASGM workers.

Objective. This study intended to discover the prevalence of CFS among ASGM workers and the factors associated with it.

Method. This study used a cross-sectional design to find the relationship between independent variables such as age, sex, working period as a miner, type of work activities in ASGM, and cumulative urinary mercury levels with CFS in ASGM workers in West Nusa Tenggara and Banten province. CFS was measured using standardized questionnaire on effect on mercury released by WHO-UNEP, and creatinine-corrected urinary mercury levels.

Results. The prevalence of CFS in ASGM workers in West Nusa Tenggara and Banten provinces was 17.9%. Based on the results, the factors of age, sex, work period, type of work, province of origin and cumulative urinary mercury levels did not have a statistically significant relationship with CFS ($p > 0.05$).

Conclusion. There was no significant relationship between age, sex, work period, type of work, urinary mercury level and cumulative urinary mercury levels with CFS in ASGM workers.

Keywords: chronic fatigue syndrome, ASGM workers, mercury

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INTRODUCTION

Chronic fatigue syndrome (CFS) is a clinically defined condition, characterized by severe disabling fatigue and a combination of symptoms that prominently features self-reported impairments in concentration and short-term memory, sleep disturbances, and musculoskeletal pain. According to Keiji Fukuda, in a study published in 1994 by the International Chronic Fatigue Syndrome Study Group *Ann Intern Med*, there are no pathognomonic signs or diagnostic tests for this condition that has been validated in scientific studies.¹

CFS is serious, debilitating conditions that impose a burden of illness on millions of people in the United States and around the world. Somewhere between 836,000 and 2.5 million Americans are estimated to have these disorders. The cause of CFS remains unknown, although in many cases, symptoms may have been triggered by an infection or other prodromal event, such as immunization, anesthetics, physical trauma, exposure to environmental pollutants, chemicals and heavy metals, and rarely blood transfusions.^{2,3}

The incidence and prevalence of CFS remains unknown in most countries. The largest and most numerous epidemiological studies come from the United States. The first widely publicized study of CFS epidemiology was initiated by the Centers for Disease Control (CDC) in the late 1980's. The prevalence rates of CFS were found to range from 4.0 to 8.7 individuals per 100,000 cases.^{4,5}

Chronic fatigue is characterized by a significant new onset of fatigue for a period of six months or longer usually after infection, injury or a period of high stress. The exact etiology of chronic fatigue is unknown and diagnostic tests are not available. Therefore, a diagnosis is made by setting aside other explanations for the patient's symptoms and by meeting the research case definition of the CDC.⁶

Humans can be exposed to heavy metals such as mercury through two sources, namely sources produced from nature and sources produced from human industrial activities. Mercury is toxic at high exposure rates and at lower cumulative exposures. In a Chinese study of mercury and symptom exposure in mercury community smelting workers in Wuchuan-Guizhou, results showed that age, drinking alcohol, and smoking were not important factors that affect mercury levels in urine and hair.^{7,8}

Many gold mining activities are carried out in the traditional way, without good planning techniques and makeshift equipment, namely with an underground mining system by making tunnels and wells following the direction of quartz veins which are estimated to have high gold content. The processing system uses a mixture of mercury which has the potential to cause environmental pollution and health problems for workers and society. Research in Talawaan, North Sulawesi on gold mine workers contaminated with mercury, workers showed neurological health problems.⁹

Piikivi and Hanninen studied subjective symptoms and psychological performances on a computer-administered test battery among a group of 60 chlorine-alkali workers and their matched referents. The exposure time of the group exposed to inorganic mercury vapor had been about 14 years, and the estimated long-term average exposure had been about 25 $\mu\text{g}/\text{m}^3$ of air. The exposed workers had an actual mercury concentration of 84.1 (SD 56.6, range 15-260) nmol/l in urine. Neither perceptual motor nor memory nor learning abilities of the mercury-exposed workers showed any disturbances in comparison with the referents. However, the exposed group reported statistically significant more memory disturbances than the referents. Strain caused by three-shift work was a possible cofactor for other increased subjective symptoms, namely, sleep disorders, fatigue, and confusion.¹⁰

One of the effects of heavy metal exposure is the occurrence of CFS in workers. Association of mercury exposure with CFS was confirmed by Kern et al.¹¹ In the study, the author explained that mercury exposure from dental amalgam (containing elemental mercury, and hence the mercury vapor) caused CFS. This is understandable because one of mercury's target organ is the central nervous system. There are plenty of evidences that some form of fatigue can be caused or exacerbated by work. The working relationship and CFS can be questioned, but the elements in the workplace can worsen the symptoms of CFS. A study by Bar Sela et al. in 1992 on 38 workers at the battery rock factory found that 26 of them had fatigue problems. Those who have worked for more than 10 years have more symptoms, especially neurological diseases.^{12,13}

The aim of this study is to determine the relationship of mercury levels in urine, and other factors, with CFS in ASGM, in order that prevention efforts can be carried out.

METHODS

Cross sectional design was used. Data was obtained after getting permission from the Ethical Research Committee of Faculty of Medicine Universitas Indonesia (No. 0061/UN2.F1/ETIK/2019). Data was collected at West Nusa Tenggara Province in two provinces involving three sub-districts in area of traditional gold miners' activity. The variables analyzed were sex, age, duration of work, job type, urinary mercury level, and CFS. CFS was measured using standardized questionnaire on effect on mercury released by WHO-UNEP.¹⁴ The association between mercury exposure and fatigue has also been stated by WHO in the same publication.¹⁴ According to the questionnaire, CFS is defined by subjects who experienced Fatigue AND Post Exertional Malaise AND Sleep Disorder AND Cognitive Disorder OR Orthostatic Intolerance. Fatigue is defined as answering "Worse than usual" or "Much worse than usual" in the questionnaire. Post exertional Malaise is defined as answering "worse" or "much worse than usual" in question "Do you feel weak", or "Can you start things without

difficulties, but get weak as you go on?”. Sleep Disorder is defined as answering “bad” to the question “How do you feel after a usual night of sleep?”. Cognitive Disorder is defined as scoring 1 – 2 in the matchbox test. Orthostatic Intolerance is when there is rigidity of gait. Data was collected using guided questionnaire, and urine sample was collected by a trained doctor, and was sent to a local branch of a nationwide laboratory accredited with ISO 17025. Informed consent was secured before questionnaire and sample urine collection. Urine sample was sent to the head office with cold chain mechanism to make sure that urine was stored at 4-degree Celsius. Urine mercury level was measured using Inductively Coupled Plasma-Mass Spectrometry (ICP-MS). Data was entered and analyzed using Statistical Program for Social Sciences (SPSS) version 20 licensed to Universitas Indonesia. Analysis of relationship was performed to obtain Odd Ratios, 95% Confident Intervals and p-values.

RESULTS

Out of 316 subjects, 257 were included in the analysis based on inclusion and exclusion criteria. Fifty nine subjects had to be dropped because they were non-workers and/or did not fill in some of the demographic data. The proportion of CFS among workers was 17.9% (46 subjects). The distribution of CFS was presented in Table 1. The median of corrected urinary mercury level was 9.79 µg/g creatinine, with minimum and maximum (in µg/g creatinine) value of 0.12 and 348.71, respectively

The most prevalent symptoms were fatigue and cognitive disorder. The characteristics of workers based on demographic and occupational factors are presented in Table 2.

Table 1. Distribution of Workers according to Symptom of CFS

Variable	Frequency (n)	Percentage (%)
Fatigue		
Yes	140	54.5
No	117	45.5
Post exertional malaise		
Yes	127	49.4
No	130	50.6
Sleep disorder		
Yes	132	51.4
No	125	48.6
Cognitive disorder		
Yes	143	55.6
No	114	44.4
Orthostatic intolerance		
Yes	11	4.3
No	246	95.7
Chronic fatigue syndrome		
Yes	46	17.9
No	211	82.1

The relationship between various independent variables with CFS was determined. The complete analysis between independent variables and the presence of CFS is shown in Table 3. Cumulative mercury levels were calculated by multiplying current mercury level by work period in months, to get a rough estimate of chronic exposure.

Based on the results in Table 3, there was no significant relationship between cumulative urinary mercury levels and CFS (p > 0.05). The same results were obtained for urinary mercury level according to the ACGIH Biological Exposure Indices, age, gender, type of work, length of employment, and province of origin. There were 191 workers (74.3%) with cumulative urinary mercury levels ≥ 20. Of these, 36 workers (18.8%) experienced CFS. Ten workers (5.2%) with cumulative urine mercury levels <20 also experienced CFS.

The proportion of workers with high cumulative urinary mercury levels experienced CFS more than the proportion of workers with normal cumulative urinary mercury levels, although there is no statistically difference in this proportion.

There were 32 workers (12.4%) with amalgamation as the type of work and 14 workers (5.4%) whose type of work was not amalgamation who experienced CFS.

DISCUSSION

There is no long-standing data on mercury vapor exposure to small-scale gold miners which is important in assessing the health risk from the said exposure. The length of work of the subject is calculated during the period of work, not from the beginning of working as an ASGM because workers can change jobs. While not working as an ASGM, the workers usually work as farmers.

Table 2. Distribution of Subject for Risk Factors of CFS

Variable	Frequency (n)	Percentage (%)
Age		
≥40 years	86	33.5
<40 years	171	66.5
Sex		
Male	237	92.2
Female	20	7.8
Type of work		
Smelting	186	72.4
Not smelting	71	27.6
Urinary mercury level (BEI ACGIH)		
High (≥20 µg/g)	89	34.6
Normal (<20 µg/g)	168	65.4
Working duration		
≥1 year	24	9.3
<1 year	233	90.7
Cumulative urinary mercury level		
≥20 months µg/g creatinine	191	74.3
<20 months µg/g creatinine	66	25.7
Province		
West Nusa Tenggara	201	78.2
Banten	56	21.8

Table 3. Relationship of Risk Factors with CFS

Variable	Chronic Fatigue Syndrome				OR	95% CI	p
	Yes		No				
	n	%	n	%			
Urinary mercury level (BEI ACGIH)							
High (≥ 20 $\mu\text{g/g}$)	14	30.4	75	35.5	0.79	0.40 – 1.58	0.509 ^{cs}
Normal (< 20 $\mu\text{g/g}$)	32	69.6	136	64.5			
Cumulative urinary mercury level							
≥ 20 months $\mu\text{g/g}$	36	18.8	155	81.2	1.30	0.61 – 2.79	0.499 ^{cs}
< 20 months $\mu\text{g/g}$	10	15.2	56	84.8			
Age							
≥ 40 years	14	16.3	72	83.7	0.85	0.42 – 1.68	0.631 ^{cs}
< 40 years	32	18.7	139	81.3			
Sex							
Male	44	95.6	193	91.5	2.05	0.46 – 9.17	0.543 ^{fe}
Female	2	4.4	18	8.5			
Type of work							
Smelting	32	69.5	154	73.0	0.85	0.42 – 1.70	0.638 ^{cs}
Not smelting	14	30.5	57	27.0			
Working duration							
≥ 1 year	1	4.2	23	95.8	0.18	0.02 – 1.38	0.090 ^{fe}
< 1 year	45	19.3	188	80.7			
Province							
West Nusa Tenggara	36	17.9	165	82.1	1.00	0.46 – 2.17	0.993 ^{cs}
Banten	10	17.9	46	82.1			

This study examines cases of CFS according to IOM criteria in small-scale gold miners using a cross sectional study. The studied population can reflect ASGM workers in Indonesia because it represented the mining sites of Java and outside Java. These ASGM workers performed their mining activities without personal protective equipment and under inadequate ventilation. The level of exposure of the workers was also worsened by poor control from local officials since their activities took place illegally.

The results of the study showed that the clinical consequences of ASGM workers are not due to mercury vapor from ASGM activities. However, the risk of CFS is present and control measures are needed.

This study found a prevalence of CFS of 17.9%. When compared with Wessely's study which found prevalence of 2.6%,¹⁵ the prevalence of the results of this study was greater. This can be caused by other factors that have not been studied. Chronic fatigue can be caused by psychological factors. This study did not examine mental causes such as responsibility, worries and conflicts. The cut-off reference used are urine mercury levels of 20 $\mu\text{g/g}$ creatinine, 1 year working period and 40 years of age.

In this study, it was found that 16.3% of workers aged ≥ 40 years and 92.2% of workers were male. More workers have smelting as type of job which is equal to 72.4%.

There is no significant relationship between cumulative urinary mercury levels and CFS, with a value of $p > 0.05$. Cumulative urinary mercury level is the result of urinary mercury levels examination per gram of creatinine multiplied by the working period. Fourteen (15.7%) workers have high

cumulative urinary mercury levels and experienced CFS while 32 (19.0%) workers have normal cumulative urinary mercury levels and experienced CFS. The researchers did not find another study that linked urinary mercury levels with CFS in small-scale gold miners. According to the United States Food and Drug Administration, the range of urine mercury concentrations for people without occupational exposure is up to 20 mg / l. A retrospective cohort study by Bates in 2004 of 20,000 New Zealand military personnel found no association between cumulative amalgam exposure and CFS.¹⁶

CONCLUSION

There is no significant relationship between cumulative urinary mercury levels and CFS, with a value of $p > 0.05$. The same results were also obtained for gender, age, province of origin, and type of work.

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Statement of Authorship

NPA contributed in the idea and conceptualization, Person in Charge (PIC) for funding, creation of proposal for funding, creation of network in field, approval of statistical

analysis and final draft; AWH contributed in the revision of final draft and statistical analysis; AK contributed in the conceptualization, revision of final draft, conduct of data cleaning, and statistical analysis; AW contributed in the revision of final draft and statistical analysis; MI contributed in the data collection, site arrangement, revision of final draft, and statistical analysis; MM contributed in the data collection, sample collection, preparation of draft, preparation of data (data entry), and creation of first draft; MI is the Field Supervisor, and contributed in the data collection, sample collection, supervision of laboratory analysis, preparation of draft, preparation of data (data entry) and writing of first draft.

Author Disclosure

All authors declared no conflicts of interest.

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