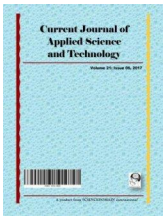

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Evaluation of Serum Mercury and Microalbuminuria in Sudanese Traditional Gold Miners in Northern State

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Authors' contributions

This work was carried out in collaboration between all authors. Author KKK was the principal investigator of the research project, responsible for designing of the entire work. Author MAI was responsible for the collection of literature, data collection and write up. Authors MAF and TK were responsible for write up, corrections before submission and statistical application. Author SQ was responsible for revision, response to the queries of the referees and correspondence with the journal.

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ABSTRACT

Traditional (Artisanal) gold mining is of global health concern; there is little available information about the health problems in gold traditional mining in Sudan. This study aimed to evaluate of serum mercury and microalbuminuria in Sudanese traditional gold miners. A total of 60 male miners (30 workers used or exposed to mercury and 30 workers used cyanide and exposed briefly

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to the mercury mixture with soil) as well as 30 male controls, in northern state of Sudan during March to May 2016. Mercury was analyzed by using standard technique atomic absorption spectrophotometer, and microalbuminuria was analyzed by semi-quantitative chromatographic immunoassay. The result we found significant increase in mercury levels in traditional gold miners, when compared with their control group but no significant difference when compared age between traditional miners and control group P Value=0.90, we also found significant increase in mercury levels in traditional gold miners compared with company gold miners but no significant difference when compared age between traditional miners and company gold miners P Value=0.070, there was significant increase in mercury levels in company gold miners, when compared with their control group, also no significant difference when compared age between company gold miners and control group P Value =0.131), there were significant increase in mercury levels in inhalation route traditional miners, when compared with skin contact route traditional miners, there is significant increase in mercury levels in abnormal renal function of traditional gold miners compared with mercury levels in normal renal function of traditional gold miners. This study concludes that, serum mercury levels are significantly increased in traditional gold miners, working in Kodorma area in comparison to non-exposed subjects and mining company workers used cyanide.

Keywords: Evaluation serum mercury; microalbuminuria; Kodorma; Northern State.

1. INTRODUCTION

Mercury is a toxic metal that can cause a variety of adverse health effects depending on the form of mercury (elemental, inorganic, or organic) and the pathway, quantity, and duration of exposure. Chronic exposure to small amounts of elemental or inorganic mercury occurs primarily through inhalation of mercury vapors and can cause tremors, kidney dysfunction, and various neurocognitive and behavioral disturbances [1]. Acute exposure to elemental or inorganic mercury can occur in specific occupational settings or during acute poisoning events and can result in severe lung injury or death. Chronic exposure to methylmercury, a common type of organic mercury, occurs primarily through eating contaminated fish. It can damage the central nervous system, causing impaired vision and hearing [1]. Methylmercury exposure is of particular concern to the developing fetus that is more susceptible to adverse neurological effects [2].

It is estimated that one tenth of all anthropogenic mercury emissions world-wide is from artisanal gold mining [3]. World-wide, estimated 10–20 million people mine gold in "artisanal" conditions and an estimated 80–100 million individuals are economically dependent on this way of life [4]. Although artisanal mining operations vary in size, production, and legality, all rely on elemental mercury to extract gold from ore deposits [4,5]. To mine gold, large amounts of elemental mercury are mixed with gold ore to form a gold–mercury alloy, called an amalgam. These amalgams contain a mix of mercury and gold; to remove the mercury, they are typically heated in an amalgam furnace. The mercury vaporizes, while the gold stays behind. During this process, mercury is often discarded into the environment. When it enters the water, it can transform into organic mercury compounds, such as methylmercury, and bioaccumulate in fish. This process presents three major potential routes of mercury exposure: [1] miners can have dermal exposure when they mix elemental mercury with gold ore; [2] elemental and inorganic mercury vapors can be inhaled when amalgams are heated; and [3] methylmercury can be consumed from contaminated fish.

Residents of artisanal gold mining communities are at risk for mercury exposure [5]. Previous research found elevated mercury exposure among residents of artisanal mining communities throughout Asia [6,7], Africa [8,9], and South America [10,11]. The Peruvian Amazon is a growing hotbed for artisanal mining, and there is growing concern over the extensive environmental mercury contamination that is occurring here [12,13]. One region in particular—Madre de Dios—is estimated to house approximately 30,000 artisanal miners [12]. However, many studies from this region have important laboratory limitations, with many not calculating creatinine-corrected urine mercury concentrations, and most not assessing blood methylmercury. Mercury levels measured in urine best represents exposure to elemental mercury, while mercury levels measured in blood best represents exposure to methylmercury; thus, without both, it is difficult to create a complete picture of mercury exposure.

2. MATERIALS AND METHODS

2.1 Study Design

This case control study was conducted to evaluate serum mercury level and microalbuminuria in traditional gold miners working during the period from March to May 2016.

2.2 Study Area

The research was conducted mining region near Dongola city named Kodorma and Alhsoor Company in the same area in north state and control subject in Khartoum State.

2.3 Study Population

The target population of this study includes 60 workers in traditional gold mining as a test group (30 workers used or exposed to mercury and 30 workers used cyanide and exposed briefly to the mercury mixture with soil) in addition to 30 age matched health Individual not being in the mining area as control group.

2.4 Inclusion Criteria

The study population includes all Sudanese male subjects being working in traditional gold mining in northern state, for period not less than six month, they are not less than 18 years.

2.5 Data Collection

Data will be collected by using a structural Interviewing questionnaire written in English language.

2.6 Statistical Analysis

Data was analyzed using SPSS computer program, data from all patient were presented as percentage and (mean±SD),differences between means of patients and control group were considered statistically significant with p-value threshold <0.05 using independent T-test. Significant correlation (r) was calculated using linear correlation test.

2.7 Ethical Consideration

Approval of this study was obtained Al-Neelain university ethical committee; verbal consent from individuals under study was also taken.

2.8 Specimen Collection

Approximately 5 ml of blood was drown from each subject by Sterile disposable venous blood collection syringes with the holder in Sterile vacutainers Plain containers, and the sample preparation will be done by the method of centrifugation at 3000 rpm for 10 minutes and serum will be stored at -20c still the time of mercury analysis.

Urine specimens were collected in sterile clean dry containers without preservatives, NO centrifugation or filtration and specimens collected any time may be used (random sample), if not used within 3 days of collection, should be stored refrigerated at 2-8c.

2.9 Measurement of Mercury (Hg)

The DMA-80 combines the techniques of thermal decomposition, catalytic conversion, Amalgamation and atomic absorption spectrophotometer controlled heating stages were implemented to first dry and then thermally decomposed a sample introduced into a quartz tube. A continuous flow of oxygen carries the decomposition products through a catalyst bed where interferences were trapped.

All mercury species were reduced to elemental Hg and were where carried along to a gold amalgamator where the mercury was selectively trapped. The system was purged and the amalgamator was subsequently heated which releases all mercury vapors to the single beam, fixed wavelength atomic absorption spectrophotometer here, absorbance measured at 253.7 nm was proportional to mercury content in the sample.

2.10 Measurement of Microalbuminuria (µAlb)

The diagnostic kit (DBC-diagnostic bio-chem micro-albumin devic-canada) is used for human urine micro albumin (colloidal gold). It is semi-quantitative chromatographic immunoassay using colloidal gold for detection of micro albumin in human urine as screening test for kidney damage in the early stage, basing competitive inhibition, after being dropped into the sample well on the membranes, urine specimen can dissolve the precoated micro albumin-specific mono-antibody labeled colloidal gold. If there is microalbumin in the urine specimen, it will react with the mono-antibody labeled colloidal gold on

the nitrocellulose filter, and there will be no or only an undertint band on the test region (T). Then the compounds labeled colloidal diffuse to the reference region (R) and control region (C) and react with the precoated goat anti-mouse IgG, and a purple colored band will be develop in both region on the membrane. If there is no microalbumin in the urine specimen, the microalbumin-specific mono-antibody labeled colloidal gold will react with the microalbumin in the test region (R), and a purple colored band will develop.

The result should be observed in 5 -10 minutes, and microalbumin is less than 20 mg/L, within normal limits.

3. RESULTS

The study comprised of 60 gold miners, 30 workers with traditional mining of means age (32.73±6.67) years and ranged from 19-50 years, and means of duration (3.1±1.81) years and ranged from 1-7 years. Other 30 workers with company mining used cyanide in gold extraction from the west soil of traditional process used mercury of means age (36.63±9.44) years and ranged from (23-54) years, with means of duration (12.8±5.43) years and ranged from .5-2 years. In addition to 30 (volunteers) with means, age (32.73±10.24) years ranged from 18-59 years.

The study revealed that the mean±SD of mercury in the traditional gold miners was (124.2±136.7µg/l) versus (1.029± 0.57µg/l) in the control group with P. Value (<0.000). As illustrated in (Table 1) normal value of serum Hg <10 µg/l there is the significant increase in mercury levels in traditional gold miners, when compared with their control group but no significant difference when compared age between traditional miners and control group P Value=0.90 (Table 1) (Fig. 1).

The results showed that the mean of mercury levels among traditional gold miners was (124.2±136.7 µg/l) versus (1.82±1.14) in company gold miners with p.value<0.000. As illustrated in (Table 2), also there is significant increase in mercury levels in traditional gold miners compared with company gold miners but no significant difference when compared age between traditional miners and company gold miners P. Value=0.070 (Table 2).

The results showed that the mean of serum mercury levels in company gold miners was (1.82± 1.14) versus (1.029± 0.57 µg/l) in the control group with P value<0.001. As illustrated in (Table 3), there is significant increase in mercury levels in company gold miners, when compared with their control group, also no significant difference when compared age between company gold miners and control group p. Value =0.131 (Table 3) (Fig. 2).

Table 1. Comparison of means of age, serum mercury (Hg) levels in traditional gold miners and their controls

Variable	Group 1 (Control) N=30	Group 2 (Traditional gold Miners) N=30	P value
Age/years	32.74 ± 10.24 (18 - 59)	32.73± 6.67 (19 - 50)	= 0.90
Serum Mercury (µg /L)	1.029± 0.57 (.04 – 3.07)	124.2± 136.7 (2.32 – 462.5)	< 0.000

P value ≤ 0.05 was considered significant

Table 2. Comparison of means of age, serum mercury (Hg) levels in traditional gold miners and company gold miners

Variable	Group (Company gold miners) N=30	Group (Traditional gold miners) N=30	P value
Age/years	36.63 ± 9.44 (23 - 54)	32.73± 6.67 (19 - 50)	= 0.070
Serum Mercury (µg / L)	1.82± 1.14 (.70 – 6.07)	124.2± 136.7 (2.32 – 462.5)	< 0.000

P value ≤ 0.05 was considered significant

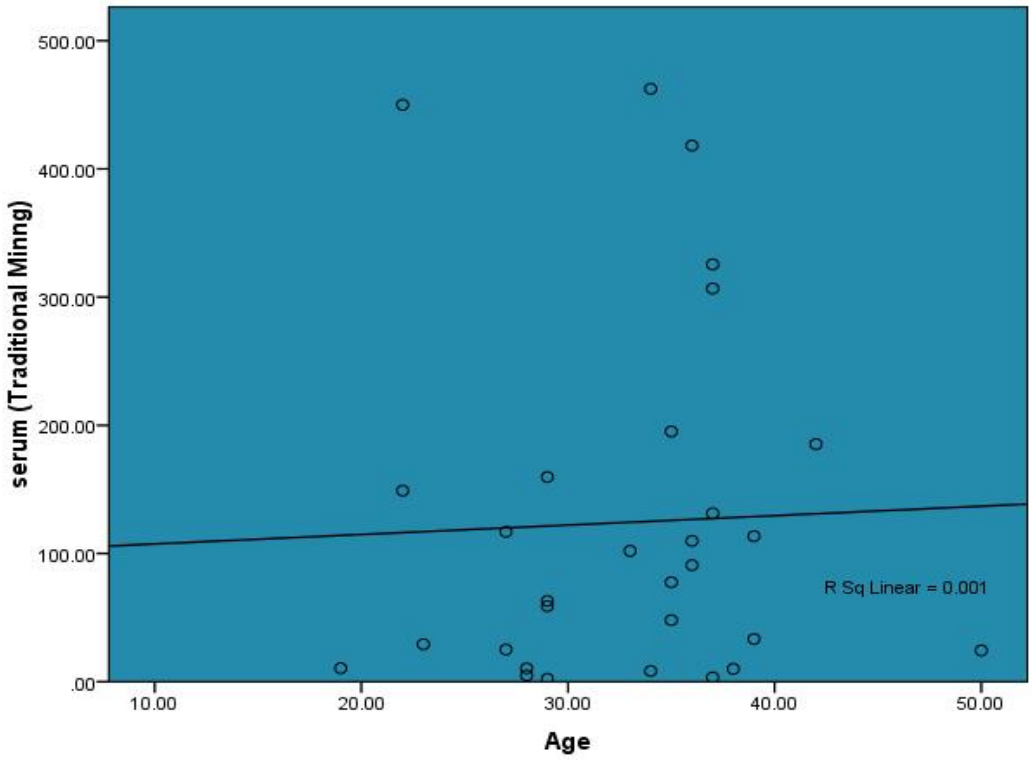

Fig. 1. Scatter plot shows the relationship between the Age & (Serum Traditional Mining) of the test group (r=-0.036, P= 0.891)

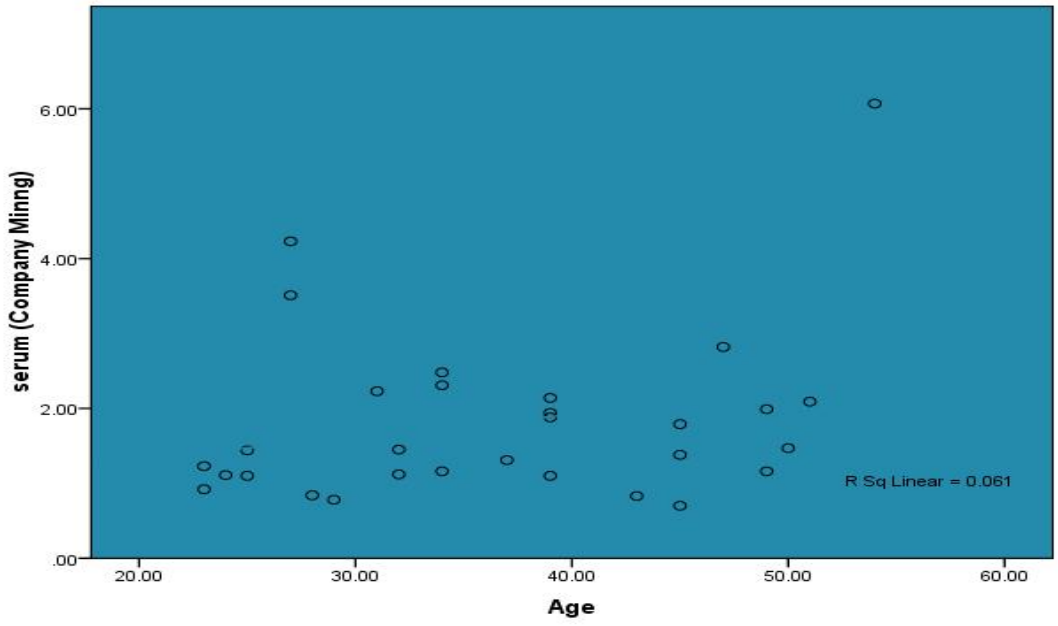

Fig. 2. Scatter plot shows the relationship between the Age & Serum (company gold mining) of the test group (r=-0.25, P= 0.189)

Table 3. Comparison of means of age, serum mercury (Hg) levels in company gold miners and their controls

Variable	Group 1 (Control) N=30	Group 2 (Company gold miners) N=30	P value
Age/years	32.73 ± 10.24 (18 - 59)	36.63± 9.44 (23 - 54)	= 0.131
Serum Mercury (µg / L)	1.029± 0.57 (.04 – 3.07)	1.82± 1.14 (.70 – 6.07)	< 0.001

P value ≤ 0.05 was considered significant

Table 4. Comparison of means of serum mercury in traditional gold miners according to routes of exposure (skin contact and inhalation)

Variable	Skin contact N=6	Inhalation N=24	P value
Serum mercury(µg/L)	38.57 ± 27.3 (2.32 – 185.3)	145 ± 141.6 (4.89 – 462.5)	<0.020

P value ≤ 0.05 was considered significant

Concern the routes of exposure within traditional gold miners, the results showed that the mean of inhalation route in traditional miners was (145 ± 141.6) versus (38.57 ± 27.3) in skin contact route with p.value<0.020. As illustrated in (Tables 4,5) (Fig. 3), there is significant increase in mercury levels in inhalation route traditional miners, when compared with skin contact route traditional miners.

Table 5. Distribution of exposure routes

Variable	Frequency	Percent
Inhalation	24	%80
Skin Contact	6	%20
Total	30	%100.0

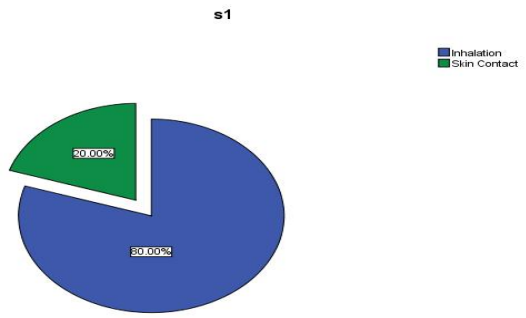

Fig. 3. Routes of exposure

Concerning the renal function the results of early detection microalbuminuria showed that the means of serum mercury in traditional gold miners with abnormal renal function was (57.36±26.536 µg/l) versus (131.61±70.141 µg/l) of serum mercury in traditional gold miners with normal renal function with P Value (<0.046). As illustrated in Tables 6, 7, there is the significant increase in mercury levels in abnormal renal function of traditional gold miners compared with mercury levels in normal renal function of traditional gold miners.

4. DISCUSSION

This case control study which carried out during March to May 2016 in north state of Sudan to determine serum levels of mercury, microalbuminuria in 90 Sudanese subjects (60 gold miners compared to 30 non exposed healthy subjects).the current study observed significant increase in serum mercury levels in traditional gold miners with p value <0.000, refering the accepted reference values for the blood mercury are 0 - 9 mg/l [14]. This finding from the present study is in agreement with Bishop et al. [14] and Watts et al. [15] who found significant increase of mercury (Hg) levels in the gold miners, it also agree with Gardner et al. [16], who stated that the study observed significant increase in serum mercury levels in the gold miners, when compared with control group (24,9±32.24 mg/l) versus (1.40±0.94 mg/l) respectively, (p=0.000).

Our findings suggest that mercury exposure may be widespread in north state. All residents had mercury detected in their blood sample, suggesting recent exposure. Thus, our findings support the need for preventive interventions to reduce mercury exposure in north state and other artisanal gold mining state and for continued assessments to measure baseline exposures and evaluate the adoptability and effectiveness of future interventions.

Table 6. Comparison of means of serum mercury in traditional gold miners according to results of microalbuminuria

Variable	Ab Normal N=3	Normal N=27	P value
Microalbuminuria (µg/L)	57.36± 26.536 (2.32 – 109.8)	131.61± 70.141 (3.38 – 462.5)	0.046

P value ≤ 0.05 was considered significant; T-test was used for comparison

Table 7. Distribution of microalbumin among traditional miners

Variable	Frequency	Percent
Normal µAL	27	%90
Ab Normal µAL	3	%10
Total	30	%100

This is one of the first investigations to measure mercury concentrations in an artisanal gold mining community using blood and microalbuminuria as biomarkers, and one of the first comparison in serum mercury level between traditional and company gold mining.

The result of study provide experimental evidence that, there was significant increase between mean serum mercury levels of traditional miners in comparison with company miners used cyanide with (p-value >0.000) which agree with the global direction which forced to use cyanide in gold extraction process as safety method in mining.

Concern the routes of exposure within traditional gold miners, the results showed that the mean of inhalation route in traditional miners was significant increase when compared with skin contact route with (P value<0.020).

When amalgams are heated, anyone in the vicinity can be exposed to mercury vapors. When amalgams are heated, anyone in the vicinity can be exposed to mercury vapors In Amazonian gold mining communities, amalgam furnaces are often dispersed throughout the town and can be located adjacent to community shops and residences. Thus, anyone who happens to be nearby can be exposed to mercury vapors when amalgams are heated. Given their potential to disperse mercury vapors throughout a wide area [4,9], it is likely that mercury inhalation via amalgam heating is the primary mercury exposure pathway in most Amazonian artisanal mining communities. Because mercury may reach water sources, people with high seafood consumption may have urine level of mercury up to 50g/l without clinical signs of toxicity [17].

5. CONCLUSION

The study concluded that, serum mercury levels are significantly increased in traditional gold miners, working in Kodorma area in comparison to non-exposed subjects and mining company workers used cyanide.

Urine microalbumin levels show significant increase in traditional gold miners in comparison to control group and mining company group.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Centers for Disease Control and Prevention. Fourth National Report on Human Exposure to Environmental Chemicals; 2009. Available:http://www.cdc.gov/exposurereport/
2. Gilbert SG, Grant-Webster KS. Neurobehavioral effects of developmental methylmercury exposure. Environ Health Perspect. 1995;103(Suppl6):135–142. [PMC free article] [PubMed] [Cross Ref] DOI: 10.1289/ehp.95103s6135
3. Telmer K, Veiga M. World emissions of mercury from small scale and artisanal gold mining, in mercury fate and transport in the global atmosphere. In: Pirrone N, Mason R, editors. Emissions, measurements and models. New York: Springer. 2009;131–172.
4. International Labour Organization. Social and labour issues in small-scale mines. Geneva; 1999. Available:http://www.ilo.org/public/english/dialogue/sector/techmeet/tmssm99/tmssmr.htm
5. Veiga M. Mercury in Artisanal gold mining in Latin America: Facts, fantasies, and solutions, UNIDO, Expert Group Meeting, Vienna, Austria; 1997.

6. Bose-O'Reilly S. Health assessment of artisanal gold miners in Indonesia. Sci Total Environ. 2010;408(4):713–725. [PubMed] [Cross Ref]
DOI: 10.1016/j.scitotenv.2009.10.070
7. Drasch G, et al. The Mt. Diwata study on the Philippines 1999—assessing mercury intoxication of the population by small scale gold mining. Sci Total Environ. 2001;267(1–3):151–168. [PubMed] [Cross Ref]
DOI: 10.1016/S0048-9697(00)00806-8
8. Bose-O'Reilly S, et al. Health assessment of artisanal gold miners in Tanzania. Sci Total Environ. 2010;408(4):796–805. [PubMed] [Cross Ref]
DOI: 10.1016/j.scitotenv.2009.10.051
9. Odumo OB, et al. Multielemental analysis of Migori (Southwest, Kenya) artisanal gold mine ores and sediments by EDX-ray fluorescence technique: Implications of occupational exposure and environmental impact. Bull Environ Contam Toxicol. 2011;86(5):484–489. [PubMed] [Cross Ref]
DOI: 10.1007/s00128-011-0242-y
10. Ashe K. Elevated mercury concentrations in humans of Madre de Dios, Peru. PLoS One. 2012;7(3):e33305. [PubMed] [Cross Ref] [PMC free article]
DOI: 10.1371/journal.pone.0033305
11. Drake PL, et al. Occupational exposure to airborne mercury during gold mining operations near El Callao, Venezuela. Int Arch Occup Environ Health. 2001;74(3):206–212. [PubMed] [Cross Ref]
DOI: 10.1007/s004200000206
12. Fraser B. Peruvian gold rush threatens health and the environment. Environ Sci Technol. 2009;43(19):7162–7164. [PubMed] [Cross Ref]
DOI: 10.1021/es902347z
13. Swenson JJ, et al. Gold mining in the Peruvian Amazon: Global prices, deforestation, and mercury imports. PLoS One. 2011;6(4):e18875. [PMC free article] [PubMed] [Cross Ref]
DOI: 10.1371/journal.pone.0018875
14. Bishop BE, Savitzky BA, Abdel-Fattah T. Lead bioaccumulation in emydid turtles of an urban lake and its relationship to shell disease. Ecotoxicology and Environmental safety. 2010;73:565-571.
15. Watts GT, Baddeley MR, Crawford N, Wellings R. Wound healing, biochemical methods for observation of cellular and intercellular phases. Br J Clin Pract. 1962;16:733-5.
16. Gardner RM, Nyland JF, Silva IA, et al. Mercury exposure, serum antinuclear/ antinucleolar antibodies, and serum cytokine levels in mining populations in Amazonian Brazil: A cross-sectional study. 2010;110:345-54.
17. Michael LP, Edward PF, Larry ES. Clinical chemistry principles, procedures and correlations, 5th ed. Lippincott Williams and Wilkins, London; 2010.

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