ORIGINAL PAPER

International Journal of Occupational Medicine and Environmental Health 2016;29(2):219–228
http://dx.doi.org/10.13075/ijomeh.1896.00358

BLOOD LEAD DETERMINANTS AND THE PREVALENCE OF NEUROPSYCHIATRIC SYMPTOMS IN FIREARM USERS IN MEXICO

GUADALUPE AGUILAR MADRID[1], LILIANA TÉLLEZ-CÁRDENAS[1], CUAUHTÉMOC ARTURO JUÁREZ-PÉREZ[1], LUIS CUAUHTÉMOC HARO-GARCÍA[2], ADRIANA MERCADO-GARCÍA[3,4], RODRIGO GOPAR-NIETO[1], and ALEJANDRO CABELLO-LÓPEZ[1]

[1] Mexican Institute of Social Security, 21st Century National Medical Center, Mexico City, Mexico
Occupational Health Research Unit
[2] National Autonomus University of Mexico, Mexico City, Mexico
Public Health Department, Faculty of Medicine
[3] National Public Health Institute, Mexico City, Mexico
[4] American British Cowdray Hospital, Mexico City, Mexico
Research and Education Center for Environmental Health

Abstract
Objectives: To identify blood lead predictors and the prevalence of neuropsychiatric symptoms in firearm users of public security in Mexico. **Material and Methods:** A cross-sectional study was performed on 65 males. We obtained socio-occupational data and determined venous blood lead (blood (B), lead (Pb) – BPb), as well as neuropsychiatric symptoms using the Q-16 questionnaire. A multiple linear regression model was constructed to assess determinants of BPb. **Results:** The mean age in the study group was 34.8 years (standard deviation (SD) = 6.9, range: 21–60); the mean number of years spent in the company amounted to 14 years (SD = 8.5, range: 1–48). Twenty percent of the respondents (N = 13) used leaded glazed clay pottery (lead (Pb), glazed (G), and clay pottery (C) – PbGC) in the kitchen. During practice they fired a mean of 72 shots (SD = 60, range: 20–250), and during their whole duration of employment 5483 shots (SD = 8322.5, range: 200–50 000). The mean BPb was 7.6 μg/dl (SD = 6.8, range: 2.7–51.7). Two caretakers from the firing range had 29.6 μg/dl and 51.7 μg/dl BPb. The subjects who had shooting practice sessions ≥ 12 times a year reported a greater percentage of miscarriages in their partners (24% vs. 0%). Twelve percent of the respondents showed an increase in neuropsychiatric symptoms. The BPb multiple linear regression model explained $R^2 = 44.15\%$, as follows: those who had ≥ 12 practice sessions per year – $\beta = 0.5339$ and those who used PbGC – $\beta = 0.3651$. **Conclusions:** Using firearms and PbGC contributes to the increased BPb in the studied personnel. The determinants of BPb were: shooting practices >12 times a year and using PbGC. Blood lead concentrations reported in the study, despite being low, are a health risk, as evidenced by the prevalence of neuropsychiatric symptoms.

Key words:
Neuropsychiatric symptoms, Occupational exposure, Lead exposure, Blood lead, Firearms, Heavy metal toxicity

The article is financed by FIS 2006-785-040, National Research Commission, Mexican Institute of Social Security, Mexico City, Mexico. Grant manager: Cuauhtémoc Arturo Juárez Pérez, M.Sc.
Received: June 18, 2014. Accepted: April 13, 2015.
Corresponding author: C.A. Juárez-Pérez, Mexican Institute of Social Security, 21st Century National Medical Center, Occupational Health Research Unit, Av. Cuauhtémoc 330, Edificio C, 1er Piso, Colonia Doctores, Delegación Cuauhtémoc, CP 06720 Mexico City, Mexico (e-mail: carturojp@gmail.com).

INTRODUCTION

Blood lead levels (blood (B), lead (Pb) – BPb) in North American workers have been gradually decreasing. However, exposure to this metal still constitutes an occupational health problem [1]. BPb levels are also decreasing among the general adult population [2] and they are expected to reach level 0, considering health risks associated with lead [3,4]. In Mexico, in contrast, extremely high exposure to this metal persists, especially, among industrial processes and in small workshops workers [5–7]. Mexico is the 5th country of the top 10 in lead production worldwide, contributing to 4.1% of the worldwide lead production volume annually and production of 127 139 tons of lead per year during the 2001–2008 period [8,9].

Lead is used in diverse production processes, including ammunition production. Thus, workers employed in ammunition production as well as firearm users are exposed to lead particles. One of those exposed groups is public and private security personnel, as they use firearms during performance of their watch duties and during their shooting practice. Studies on the personnel in question have revealed high blood lead levels [10].

Health effects associated with lead exposure include: kidney, cardiovascular, hematologic, reproductive and neurological damage. Those effects are observed even at low levels of exposure [11]. In terms of neurological level, presence of neuropsychiatric symptoms, such as: anxiety, depression, and phobic anxiety, has been reported [12].

The purpose of the present study was to determine the main predictors of blood lead (BPb) levels and the prevalence of neuropsychiatric symptoms in a group of firearm users employed in public security in Mexico.

MATERIAL AND METHODS

A cross-sectional study was performed on 65 firearm users in Mexico City, between May and August 2009. The sample was selected at random and the participation of each patient was voluntary. Each subject received a formal invitation and, depending on a decision, had to sign an informed consent letter. The protocol was submitted to, and approved by the local ethics and research committee at the Hospital General No. 32 of the Mexican Institute of Social Security. The participants signed a letter of informed consent prior to the study commencement.

A questionnaire was filled in by each worker in order to obtain information on the risk factors for occupational and extra-occupational exposure to lead. Factors, which were collected using Q-16, adapted by Amador (1995) [13] from Hogstedt (1984) [14], included the use of leaded-glazed clay pottery (lead (Pb), glazed (G), clay pottery (C) – PbGC) for cooking, the presence of chronic symptoms related to lead poisoning and neuropsychiatric symptoms.

A venous blood sample (5 ml) was taken from each worker after aseptic and antiseptic techniques prior to venipuncture. Sterile disposable material was used for each individual and was kept in a lead-free Vacutainer®. Needles were discarded according to the Mexican Official Norm (NOM-087) [15]. The samples were then sent for an analysis to the Heavy Metals Laboratory of the American British Cowdray Hospital in Mexico City, using an atomic absorption spectro-photometer (Perkin-Elmer 3000, Chelmsford, MA). This laboratory participates in a special external quality program of the leading laboratories at Blood Lead Proficiency Testing, through the Hygiene Laboratory of Winconsin State University (WSLH) [16,17]. Blood lead levels were expressed as μg/dl.

Data analysis was performed using the Stata version 12 statistical software [18]. A univariate analysis was performed to observe the behavior of quantitative and qualitative variables. A bivariate analysis (the Student's t-test and Chi^2) was performed to calculate differences in the means and proportions among the groups. To identify predictors of blood lead levels, this variable was logarithmically transformed to normalize distribution, and the multiple linear regression model was constructed. The model underwent diagnosis to verify if the assumptions of the generalized linear models were fulfilled. A $p < 0.05$ was considered as statistically significant.

RESULTS

All 65 participants were male employees of public security sector and had shooting practices with firearms of different calibers. Mean ± standard deviation (M±SD) and range of socio-demographic variables were, as follows: age 34.8±6.9 (21–60) years; time living in Mexico City – 14.5±11.9 (0.3–50) years; years in the workplace 14±8.5 (1–48) years. Blood lead levels were 7.6±6.8 (2.7–51.7) μg/dl (Table 1). The reported percentages of the respondents for smoking were 34.43% (N = 21), and for alcohol intake – 52.4% (N = 32).

Twenty percent of the respondents (N = 12) reported use of PbGC to prepare food. The frequency with which the participants had shooting practices depended on their job position. It was either several times a week, once a month, or once a year. The mean number of shots fired during each practice session was 72 (SD = 60, range: 20–250), and the mean number of shots fired during their entire occupational life was 5483 (SD = 8322.5, range: 200–50 000) (Table 1). The types of guns used during their practice sessions were: 59% handguns, 17% long guns and 24% both.

The caretakers (N = 2) from the shooting range had the highest BPb levels – 29.6 μg/dl and 51.77 μg/dl, followed by bodyguards and instructors (Table 2). In the global analysis, we excluded 2 caretakers from the shooting range as they did not fulfill the only firearm-users criterion.

We estimated the differences in BPb according to age, time living in Mexico City, time working with firearms, smoking, alcohol intake, as well as a cutoff point of 3000 shots fired during their entire occupational lifetime. Statistically significant differences were found only among the personnel who had > 12 shooting practice sessions per year, those who used PbGC for cooking, and the categories considered under greater exposure (shooting instructors, bodyguards, and elite group) – excluding the caretakers from the shooting range (Table 3 and Figures 1–3).

Table 1. Socio-occupational characteristics in the study group – public security employees in Mexico, 2009

Variable	Respondents (N = 65)	
	M±SD	min.–max
Age [years]	34.80±6.90	21.0–60.0
Living in Mexico City [years]	14.50±11.90	0.3–50.0
Working in the institution [years]	14.00±8.50	1.0–48.0
Cigarettes per day [n]	2.70±3.50	0.0–15.0
Age at which the subject started alcohol consumption [years]	18.60±4.30	15.0–34.0
Use of leaded glazed clay for cooking [years]	8.25±16.30	0.0–60.0
Persons living at the subject's household [n]	3.95±1.90	0.0–11.0
Children [n]	2.02±1.14	0.0–7.0
Age at which the subject first used a firearm [years]	18.70±4.11	7.0–28.0
Shooting practice [years]	14.00±7.50	1.0–34.0
Shots per practice [n]	72.00±60.00	20.0–250.0
Shots fired during whole occupational life [n]	5 483.00±8 322.50	200.0–50 000.0
Blood Pb [μg/dl]	7.60±6.80	2.7–51.7

Pb – lead; M – mean; SD – standard deviation; min. – minimal value; max – maximal value.

Table 2. Blood lead level per occupational category in the study group – public security personnel in Mexico, 2009

Occupational category	Respondents (N = 64) [n]	Blood lead level [µg/dl]	
		M±SD	min.–max
Bodyguards	26	8.10±2.70	3.0–14.4
Instructors	2	7.60±1.40	6.6–8.6
Shooting range caretakers	2	40.65±15.63	29.6–51.7
Administrative	9	4.20±1.20	2.7–6.5
Security	9	4.90±1.20	3.0–7.3
Services	10	6.50±3.60	3.1–14.2
Elite group	6	6.40±2.60	4.2–11.4
All categories	64	7.60±6.80	2.7–51.7

Abbreviations as in Table 1.

Table 3. Blood lead concentrations by diverse socio-occupational characteristics in the study group – public security personnel in Mexico, 2009

Variable	Respondents (N = 65) [n]	Blood lead level [µg/dl]	
		M±SD	p**
Age [years]			0.400
≤ 34.5	32	6.90±2.90	
> 34.5	32	8.40±9.30	
Time living in Mexico City [years]			0.590
≤ 12	33	7.30±4.99	
> 12	29	8.20±8.80	
Time working in the institution [years]			0.150
≤ 13	33	6.50±2.74	
> 13	31	8.96±9.40	
Smoking			0.280
no	40	8.40±8.40	
yes	21	6.40±2.80	
Alcohol intake			0.760
no	29	7.30±5.10	
yes	32	7.90±8.50	
Shots fired [n]			0.260
≤ 3 000	36	6.20±2.90	
> 3 000	23	7.10±2.90	
Shooting practice sessions [n/year]			< 0.001
< 12	33	5.24±2.50	
≥ 12	28	8.26±2.40	

Table 3. Blood lead concentrations by diverse socio-occupational characteristics in the study group – public security personnel in Mexico, 2009 – cont.

Variable	Respondents (N = 65) [n]	Blood lead level [μg/dl] M±SD	Blood lead level [μg/dl] p**
Uses leaded glazed clay to cook			0.049
no	50	6.30±2.70	
yes	12	8.10±3.20	
Occupational categories and blood lead [μg/dl]			< 0.001
group 1 (administrative, services and security)*	28	5.24±2.50	
group 2 (bodyguards, elite group, instructors)	34	7.77±2.70	

Abbreviations as in Table 1.
* Shooting range caretakers were excluded.
** Student's t-test.

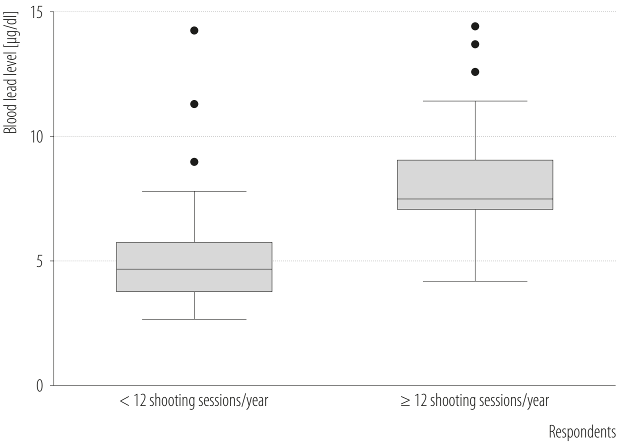

Fig. 1. Blood lead levels according to the practice sessions at the shooting range per year in the study group – Mexican firearm users, 2009

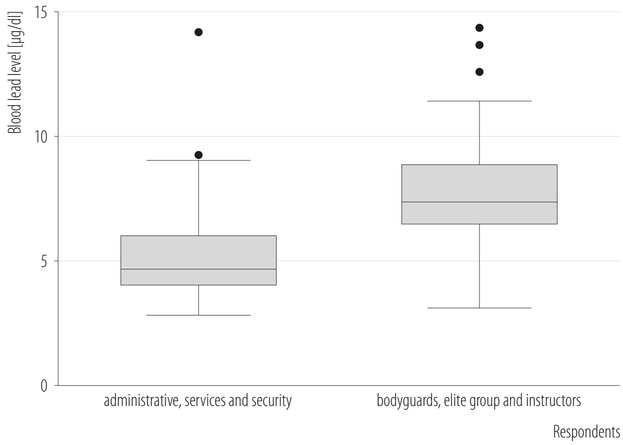

Fig. 2. Blood lead levels by work category in the study group – Mexican firearm users, 2009

Regarding the presence of neuropsychiatric symptoms explored by the use of Q-16, it was revealed that, on average, the participants had at least 1 symptom (range 0–11). The cut-off point was ≥ 5 symptoms and the prevalence was determined, observing a 12% (N = 8) increase. No differences were found in the prevalence among categories, number of shots fired, and practice sessions per year. Moreover, 1 of 5 general symptoms related to chronic lead poisoning (cephalalgia, stomach pain, nausea, general physical malaise, etc.) and it was present in 52% of the respondents (N = 34).

The frequency of miscarriages in the participants' wives was found to be greater among those who reported attending ≥ 12 shooting practice sessions per year, compared with those who had < 12 sessions per year (24% vs. 0%) (p = 0.006).

Blood lead was transformed by log-normal, as its distribution was not normal. The multiple linear regression model was constructed with the BPb variable. This way the variables that account for 44% of the log-BPb variability were: frequency ≥ 12 times per year shooting practice and

Table 4. Multiple linear regression model with determining factors for blood lead levels in the study group – public security employees, July–August 2009

Variable	β coefficient	SE	95% CI	p
Frequency of firearm use (≥ 12 times/year vs. < 12 times/year)	0.533	0.082	0.368–0.698	< 0.001
Using leaded glazed clay to cook food	0.365	0.103	0.158–0.572	0.001
Constant	1.485	0.060	1.363–1.606	< 0.001

SE – standard error; CI – confidence interval.
Adjusted $R^2 = 0.44$; N = 61.

Fig. 3. Blood lead levels according to using glazed clay utensils in the study group – Mexican firearm users, 2009

using PbGC for cooking (Table 4). The model diagnosed and fulfilled all the assumptions for the generalized linear models.

DISCUSSION

Since the 1st data from 1970's and 1980's of lead poisoning in shooting instructors, security agents, and caretakers at shooting ranges, a decrease in BPb has been observed in the United States [19–21]. This study is the 1st study in Mexico regarding this type of workers and we found that only 1 shooting range caretaker had BPb levels (51.7 μg/dl) similar to those reported by Novotny et al. in 1987 [21].

The mean BPb levels in the present study were lower (7.6 μg/dl) than those found by George et al. (> 50 μg/dl) in small-caliber firearm users [22]. In more recent studies BPb levels are similar to ours, such as the study by Gulson et al. [23] that have shown concentrations of 3.2–6.7 μg/dl. Instructors in our study had BPb levels 5 times lower compared with those observed in an instructor in Alaska [24] (Table 2). However, students at different shooting ranges in the same State of Alaska also had higher levels than those observed in our public security personnel, ranging 1–37 μg/dl [24,25] (Table 1 and 2). The BPb levels observed in our population, despite those found in other studies, are likely due to shooting practices, which mostly take place in outdoor rather than indoor shooting ranges, a lower frequency of shots fired, and a lower frequency in shooting practice.

The mean BPb levels in the respondents of the present study were 3% (N = 2) greater than the limit established by the Mexican Official Norm (30 μg/dl) for workers [26] and 14% of the respondents (N = 9) had BPb levels ≥ 10 μg/dl. The relationship with adverse health effects has been demonstrated, even at the lowest levels of the metal. Given that lead had no role in human physiologic processes, Centers for Disease Control and Prevention (CDC) aimed at lowering BPb to 0 by 2010 [3,4,11]. Although the objective has not been achieved, the levels reported among adult individuals are as low as 1–2 μg/dl [2–4]. These levels are 3–6 times lower than those that we observed in the population of public security personnel in our study, 7.6 μg/dl (standard deviation (SD) = 6.8 μg/dl, range: 2.7–51.7 μg/dl).

The other source of lead exposure in our population was the use of PbGC for cooking, which contributes to the increase in blood lead levels. This determining factor has been already related to in other studies in Mexico [27,28]. Our results indicate that it is still an important predictor of the increased BPb levels, as shown by the coefficient in our model (Table 4).

Shooting range caretakers, compared to the user population, are at higher health risks as they are highly exposed to this metal by staying in the shooting zone for longer periods of time. Even at low BPb concentrations there are several reports outlining the presence of adverse health effects in adult population. These include: high arterial blood pressure, high cardiovascular risk, and cerebrovascular mortality at mean BPb levels of 6.3–20 μg/dl [11]. Furthermore, low BPb levels have been associated with: increased serum creatinine, poor memory performance, verbal ability and mental processing speed. In addition, a 13% increase in miscarriages has been reported for every 1 μg/dl BPb increase [11].

Comparing the < 5 μg/dl BPb found in the United States adult population [4] with our results, 69.2% (N = 45) of our population would be above such levels. Taking into account BPb levels ≥ 10 μg/dl – with which health effects can be observed – 14% of the population we studied was above this cutoff point. Health effects observed in the case of BPb ≥ 10 μg/dl include: miscarriages, high blood pressure levels and kidney function alterations. Only 1 caretaker from the shooting range had BPb levels ≥ 20–39 μg/dl, which could be associated with the presence of non-specific symptoms of probable lead poisoning such as: cephalalgia, fatigue, sleep alterations, anorexia, constipation, diarrhea, arthralgia, myalgia, decreased libido, personality changes, and effects on memory and attention. The other caretaker had BPb levels ≥ 40–79 μg/dl, which increases the possibility of further symptoms and health damage such as: alterations in sperm count and morphology, peripheral neuropathy, probable hypertension, anemia, kidney damage and gout [29]. However, we did not evaluate these effects in our study population.

For the presence of neuropsychiatric symptoms, although we did not use the same evaluation instrument as other studies, we found a prevalence of 12% (N = 8) (≥ 5 symptoms) using Q-16, with a mean BPb level of 7.6 μg/dl (range: 2.7–51.7 μg/dl). This is greater than the level found by Bouchard et al. [28]. In their study a questionnaire from the World Health Organization was used (CIDI – Composite International Diagnostic Interview). They have found that 6.7% of their study subjects had major depression disorder, 2.2% panic attacks, and 2.4% generalized anxiety. This difference may be due to the lower BPb concentrations and a younger age of the population studied. Nevertheless, they have managed to notice that the increase of the above mentioned psychiatric alterations was proportional to the increase in BPb concentrations [30]. Results similar to ours have been also found by Rhodes et al. [12] using the brief symptom inventory (BSI), with a range of prevalence 4–16%, in the different dimensions evaluated, with a mean BPb level of 6.3 μg/dl (range: < 5–20 μg/dl).

A relevant finding is that there was a greater proportion of miscarriages in the wives of firearm users who reported attending shooting practice > 12 times a year. This is in accordance with some studies [31,32]; however those populations had higher BPb levels in males (> 30 μg/dl), compared with ours. Besides, we must consider that there are other factors, both in males and females, associated with the occurrence of a miscarriage. Additionally, the workers' wives were not queried about, among others: alcohol intake, exposure to other environmental risks, and age during pregnancy, because it was not the objective of the study. We found an association between BPb level and a miscarriage, but we have insufficient elements to confirm it.

Environmental lead levels in Mexico have decreased [33]. However, there is enough epidemiologic evidence that this metal is still an important public health problem in this country. On occupational basis, blood lead concentrations have been reported within a range of 8.4–99.6 μg/dl in industrial workers, potters who make leaded glazed clay pottery, and automobile radiator repair workers [5–7,34–37]. Besides, lead along with other heavy metals, such as cadmium, have been studied with regard to their association with depression and other neuropsychiatric symptoms, as indicated by the national surveys and other cross-sectional studies. Nevertheless, the research has been performed in open population with low exposure levels, leaving the workers behind. Therefore, it is important to monitor exposure and perform close follow-up studies among exposed populations [38,39].

It is necessary to develop a national epidemiologic surveillance program in Mexico for the public security population, since, in the last few years firearm use has increased, as well as the number of workers in the production processes that involve lead exposure. This will contribute to expanding knowledge on the magnitude of the problem, to taking action in adoption of industrial hygiene measures (substituting the metal, processes' isolation, extraction systems, washing work clothes in the workplace), as well as personal hygiene measures (showering after practice, not wearing work clothes and shoes at home) in order to reduce workers and their families' exposure.

CONCLUSIONS

The present study showed that using firearms contributes to increasing BPb concentrations in public security personnel. Although the levels found are relatively low, they still pose a risk to the health of the studied individuals. The levels of BPb were associated with the presence of more than 5 neuropsychiatric symptoms. Finally, we found, by the use of the multiple linear regression model, that having shooting practices > 12 times a year and using PbGC were the major determinants of BPb.

REFERENCES

1. Schwartz BS, Hu H. Adult lead exposure: Time for change. Environ Health Perspect. 2007;115:451–4, http://dx.doi.org/10.1289/ehp.9782.
2. Muntner P, Menke A, DeSalvo KB, Rabito FA, Batuman V. Continued decline in blood lead levels among adults in the United States. Arch Intern Med. 2005;165:2155–61, http://dx.doi.org/10.1001/archinte.165.18.2155.
3. Roscoe RJ, Ball W, Curran JJ, DeLaurier C, Falken MC, Fitchett R, et al. Adult blood lead epidemiology and surveillance. United States, 1998–2001. MMWR Surveill Summ. 2002 December 13;51(11):1–10.
4. Centers for Disease Control and Prevention. Adult blood lead epidemiology and surveillance. United States, 2003–2004. MMWR Morb Mortal Wkly Rep. 2006 Aug 18;55(32):876–9.
5. Torres-Alanís O, Garza-Ocañas L, Piñeyro-López A. [Environmental pollution and health. Part II. Lead: Exposure in adults, clinical experience with the use of DMSA]. Ciencia UANL. 2001;4:415–9. Spanish.
6. Dykeman R, Aguilar-Madrid G, Smith T, Juárez-Pérez CA, Piacitelli GM, Hu H, et al. Lead exposure in Mexican radiator repair workers. Am J Ind Med. 2002;41:179–87, http://dx.doi.org/10.1002/ajim.10044.
7. Hernández-Serrato MI, Mendoza-Alvarado LR, Rojas-Martínez R, González-Garza C, Hulme JM, Olaíz-Fernández G. Factors associated with lead exposure in Oaxaca, Mexico. J Expo Anal Environ Epidemiol. 2003;13:341–7, http://dx.doi.org/10.1038/sj.jea.7500282.
8. National Statistics, Geography and Informatics Institute. [Mining industry in Mexico. 2007 Edition. Sectorial Statistic Data Series] [Internet]. Mexico: The Institute; 2007 [cited 2015 Jan 25]. Available from: http://www.inegi.org.mx/prod_serv/contenidos/espanol/bvinegi/productos/integracion/sociodemografico/Mineria/2007/mine-2007.pdf. Spanish.
9. National Statistics, Geography and Informatics Institute. [Mining industry in Mexico. 2009 Edition. Sectorial Statistic Data Series] [Internet]. Mexico: The Institute; 2009 [cited 2015 Jan 25]. Available from: http://www.inegi.org.mx/prod_serv/contenidos/espanol/bvinegi/productos/integracion/sociodemografico/Mineria/2009/Mine-2009.pdf. Spanish.

10. Valway SE, Martyny JW, Miller JR, Cook M, Mangione EJ. Lead absorption in indoor firing range users. Am J Public Health. 1989;79:1029–32, http://dx.doi.org/10.2105/AJPH.79.8.1029.
11. Kosnett MJ, Wedeen RP, Rothenberg SJ, Hipkins KL, Materna BL, Schwartz BS, et al. Recommendations for medical management of adult lead exposure. Environ Health Perspect. 2007;115:463–71, http://dx.doi.org/10.1289/ehp.9784.
12. Rhodes D, Spiro A, Aro A, Hu H. Relationship of bone and blood lead levels to psychiatric symptoms: The normative aging study. J Occup Environ Med. 2003;45:1144–51, http://dx.doi.org/10.1097/01.jom.0000094995.23808.7b.
13. Amador R, Lundberg I, Escalona E. Development of a questionnaire in Spanish on neurotoxic symptoms. Am J Ind Med. 1995;28:505–20, http://dx.doi.org/10.1002/ajim.4700280407.
14. Van Wendel B, Mergler D, Wesseling C, Henao S, Amador R, Castillo L. [Manual on neuro-behaviour tests] [Internet]. San José, Costa Rica: Panamerican Health Organization; 2000 [cited 2015 Jan 25]. Available from: http://www.bvsde.paho.org/foro_hispano/3_neuroconductuales.pdf. Spanish.
15. NOM-087-ECOL-SSA1-2002. [Environmental protection – Environmental Health – Infectious biological hazardous waste – Disposal and management specifications and classification]. Mex Fed Off Gaz. 2003 [updated 2003 Feb 17; cited 2015 Jan 25]. Available from: http://www.salud.gob.mx/unidades/cdi/nom/087ecolssa.html. Spanish.
16. Meneses-González F, Lino M, Rivero A, Domínguez J, Palazuelos E, Moreno LC, et al. [Blood lead levels: Quality control in the metals laboratory from the ABC Medical Center]. A Méd. 2001;46;165–8. Spanish.
17. Aguilar-Madrid G, Piacitelli GM, Juárez-Pérez CA, Vázquez-Grameix JH, Hu H, Hernández-Avila M. [Occupational exposure to inorganic lead in press workers from Mexico City]. Salud Publica Mex. 1999;41:42–54, http://dx.doi.org/10.1590/S0036-36341999000100006. Spanish.
18. Stata Statistical Software: Release 12 [computer program]. College Station (TX): StataCorp LP; 2011.
19. Landrigan PJ, Mckinney AS, Hopkins LC, Rhodes WW, Price WA, Cox DH. Chronic lead absorption. Result of poor ventilation in an indoor pistol range. JAMA. 1975;234:394–7, http://dx.doi.org/10.1001/jama.1975.03260170030020.
20. Fischbein A, Rice C, Sarkozi L, Kon SH, Petrocci M, Selikoff IJ. Exposure to lead in firing ranges. JAMA. 1979;241:1141–4, http://dx.doi.org/10.1001/jama.1979.03290370045027.
21. Novotny T, Cook M, Hughes J, Lee SA. Lead exposure in a firing range. Am J Public Health. 1987;77:1225–6, http://dx.doi.org/10.2105/AJPH.77.9.1225.
22. George PM, Walmsley TA, Currie D, Wells JE. Lead exposure during recreational use of small bore rifle ranges. N Z Med J. 1993;106:422–4.
23. Gulson BL, Palmer JM, Bryce A. Changes in blood lead of a recreational shooter. Sci Total Environ. 2002;293:143–50, http://dx.doi.org/10.1016/S0048-9697(02)00003-7.
24. Middaugh J, editor. School rifle teams exposed to lead at indoor firing ranges. State Alaska Epidemiol Bull [Internet]. 2003 [cited 2015 Jan 25];1:1. Available from: http://www.cdc.gov/nceh/lead/ACCLPP/SupplementalOct04/Alaska%20-%20School%20Rifle%20Teams%20Exposed%20to%20Lead%20at%20Indoor%20Firing%20Ranges%20Bulletin.pdf/.
25. Centers for Disease Control and Prevention. Lead exposure from indoor firing ranges among students on shooting teams – Alaska, 2002–2004. MMWR Morb Mortal Wkly Rep. 2005;54:577–9.
26. NOM-047-SSA1-2011. [Environmental health-biological exposure indexes for workers occupationally-exposed to chemicals]. Mex Fed Off Gaz. 2012 [updated 2012 Jun 6; cited 2015 Jan 25]. Available from: http://dof.gob.mx/nota_detalle.php?codigo=5249877&fecha=06/06/2012. Spanish.
27. Lara-Flores E, Alagón-Cano J, Bobadilla JL, Hernández-Prado B, Ciscomani-Begoña A. [Associated factors to blood lead levels in residents from Mexico City]. Salud Publica Mex. 1989;31:625–33. Spanish.
28. Rojas-López M, Santos-Burgoa C, Ríos C, Hernández-Avila M, Romieu I. Use of lead-glazed ceramics is the main

factor associated to high lead in blood levels in two Mexican rural communities. J Toxicol Environ Health. 1994;42(1): 45–52, http://dx.doi.org/10.1080/15287399409531862.
29. Lauwerys RR. [Industrial toxicology and professional poisoning]. Barcelona: Elsevier Masson; 1994. p. 175–201. Spanish.
30. Bouchard MF, Bellinger DC, Weuve J, Matthew-Bellinger J, Gilman SE, Wright RO, et al. Blood lead levels and major depressive disorder, panic disorder, and generalized anxiety disorder in US young adults. Arch Gen Psychiatry. 2009;66:1313–9, http://dx.doi.org/10.1001/archgenpsychiatry.2009.164.
31. Lindbohm ML, Sallmén M, Anttila A, Taskinen H, Hemminki K. Paternal occupational lead exposure and spontaneous abortion. Scand J Work Environ Health. 1991;17:95–103, http://dx.doi.org/10.5271/sjweh.1721.
32. Anttila A, Sallmén M. Effects of parental occupational exposure to lead and other metals on spontaneous abortion. J Occup Environ Med. 1995;37:915–21, http://dx.doi.org/10.1097/00043764-199508000-00005.
33. Cortés-Lugo M, Téllez-Rojo MM, Gómez-Dantés H, Hernández-Avila M. [Trends in atmospheric lead levels in Mexico City: 1988–1998]. Salud Publica Mex. 2003;45 Suppl 2:S196–202. Spanish.
34. Olaiz G, Rojas R, Fortoul TI, Palazuelos E. High blood levels in ceramic folk art workers in Michoacan, Mexico. Arch Environ Health. 1997;52:51–5, http://dx.doi.org/10.1080/00039899709603800.
35. Manzanares-Acuña E, Vega-Carrillo HR, Salas-Luevano MA, Hernández-Dávila VM, Letechipia-de León C, Bañuelos-Valenzuela R. [Blood lead levels in a high-risk population in San Ignacio, Fresnillo, Zacatecas, Mexico]. Salud Publica Mex. 2006;48:212–9. Spanish.
36. Ornelas-Hicks M, Sanín-Aguirre LH, Díaz-Barriga F, Reza-López SA, Romieu I. [Risk assessment in an old lead smelter complex in Chihuahua, Mexico]. Tecnociencia Chihuahua. 2007;1(1):26–35. Spanish.
37. González-Valdez E, González-Reyes E, Bedolla-Cedeño C, Arrollo-Ordaz EL, Manzanares-Acuña E. [Blood lead levels and risk factors for lead poisoning in Mexican children]. Rev Fac Ing Univ Ant. 2008;43:114–9. Spanish.
38. Golub NI, Winters PC, van Wijngaarden E. A population-based study of blood lead levels in relation to depression in the United States. Int Arch Occup Environ Health. 2010;83:771–7, http://dx.doi.org/10.1007/s00420-009-0497-3.
39. Berk M, Williams LJ, Andreazza AC, Pasco JA, Dodd S, Jacka FN, et al. Pop, heavy metal and the blues: Secondary analysis of persistent organic pollutants (POP), heavy metals and depressive symptoms in the NHANES National Epidemiological Survey. BMJ Open. 2014;4:e005142, http://dx.doi.org/10.1136/bmjopen-2014-005142.