Canine Lead Exposure in Automotive Repair Workshops: A Pilot Study Conducted in Cajamarca City, Peru.

Exposición a plomo en caninos de talleres mecánicos: estudio piloto en la ciudad de Cajamarca, Perú

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Highlights

- Environmental lead exposure was detected in dogs inhabiting automotive repair workshops in the city of Cajamarca (Peru).
- A proportion of the evaluated dogs (18.75%) presented blood lead levels exceeding the critical threshold of 3.5 μg/dL established by the CDC, indicating potential health risks.
- Dogs inhabiting automotive repair workshops may serve as a valuable sentinel model for environmental lead contamination.

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ABSTRACT

Introduction. Lead is a heavy metal widely used in the automotive industry and is considered one of the most harmful toxic agents for living organisms. Dogs inhabiting automotive repair workshops may experience chronic exposure to this metal, making them potential sentinels of environmental contamination. **Objective.** This study aimed to determine blood lead levels in dogs residing in automotive repair workshops in the city of Cajamarca (Peru). **Materials and Methods**. Blood lead levels were quantified in 16 dogs using graphite furnace atomic absorption spectrometry. **Results and Discussion.** Blood lead levels ranged from 0.427 μg/dL (0.0043 ppm) to 4.348 μg/dL (0.0435 ppm), with a mean ± standard deviation of 2.264 ± 1.243 μg/dL and a coefficient of variation of 54.907%. A proportion of the evaluated dogs (18.75%; 3/16) presented blood lead levels exceeding 3.5 μg/dL, the reference value established by the Centers for Disease Control and Prevention (CDC) for children in the United States, indicating environmental exposure within these settings. **Conclusions**. Although most dogs exhibited blood lead levels below the critical threshold for human health, the presence of elevated levels in certain individuals suggests potential long-term risks for both the animals and workshop personnel. These findings highlight the need for further research to identify sources of exposure and assess their implications within a One Health framework.

RESUMEN

Introducción. El plomo es un metal pesado ampliamente utilizado en la industria automotriz y constituye uno de los agentes tóxicos más perjudiciales para los seres vivos. Los perros que habitan talleres de mecánica automotriz pueden estar expuestos de forma crónica a este metal, lo que los convierte en potenciales centinelas de la contaminación ambiental. **Objetivo.** Determinar los niveles de plomo en perros que pernoctan en talleres de mecánica automotriz en Cajamarca (Perú). **Materiales y Métodos**. Se cuantificaron los niveles de plomo en sangre de 16 perros mediante espectrofotometría de absorción atómica con horno de grafito. **Resultados y discusión.** Los niveles de plomo oscilaron entre 0,427 μg/dL (0,0043 ppm) y 4,348 μg/dL (0,0435 ppm), con una media ± desviación estándar de 2,264 ± 1,243 μg/dL y un coeficiente de variación del 54,907 %. El 18,75 % (3/16) de los perros presentó niveles de plomo en sangre superiores a 3,5 μg/dL, valor de referencia establecido por los CDC para niños en EE. UU., indicando la presencia de exposición ambiental en estos entornos. **Conclusiones.** Aunque la mayoría de los perros presentó niveles por debajo del umbral crítico para la salud humana, la detección de valores elevados en algunos caninos sugiere posibles riesgos a largo plazo tanto para los animales como para el personal que trabaja en estos talleres. Estos hallazgos resaltan la necesidad de estudios adicionales para caracterizar las fuentes de exposición y sus implicancias en un enfoque de salud integral.

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INTRODUCTION

The excessive use of heavy metals to meet various human needs has led to significant environmental contamination [(1)]. These metals tend to accumulate in living organisms when their absorption and storage exceed the body's capacity for metabolism and excretion [(2)]. Among them, lead stands out due to its high toxicity, even at concentrations as low as parts per billion [(3)]. Its toxic effects impact multiple organ systems, including the nervous, reproductive, hematopoietic, and renal systems, among others [(1)]. Although lead occurs naturally in the environment, anthropogenic activities have greatly increased its concentration. It is released through processes such as mineral extraction and processing, the manufacture of lead-containing products, vehicle emissions, and the combustion of fossil fuels [(4,5)]. Inadequate disposal of lead-containing waste, including paints and damaged batteries, further contributes to its accumulation in landfills, where it strongly binds to soil particles and concentrates in surface layers [(6,7)].

Lead has numerous industrial applications, including shipbuilding, bearings, construction materials, paints, batteries, automobiles, pipes, ceramics, plastics, smelting, mining, and the arms industry [(1)]. However, one of the most common and widespread sources of exposure is the automotive repair sector. Improper handling of waste and vehicle components in these workshops can represent a significant source of environmental contamination.

In dogs, lead poisoning occurs primarily through the ingestion of contaminated water or food. The toxic effects observed in this species are similar to those documented in humans, including neurological, gastrointestinal, hematological, and reproductive alterations [(8)]. Monitoring lead levels in dogs is particularly relevant, as their exposure may reflect the presence of environmental risk sources also shared by humans, thereby assisting in the identification of common areas of exposure [(9,10)].

Automotive repair workshops are widespread in urban environments, and it is common practice for workshop owners to keep dogs permanently on the premises for security purposes. However, the potential exposure of these animals to heavy metals in such work environments is rarely considered. This situation may pose health risks not only to the dogs but also to the workshop personnel. In this context, the present study aimed to determine blood lead levels in dogs inhabiting automotive repair workshops in the city of Cajamarca, Peru.

MATERIALS AND METHODS

This study was conducted in the urban area of Cajamarca, Perú in August 2019. A non-probabilistic convenience sampling approach was employed, systematically surveying the city to identify automotive repair workshops. In workshops where dogs were present, owner consent was obtained prior to participation. If no dogs were present, the survey continued to the next location. The sampling covered the entire urban area, with efforts made to distribute sampling points as evenly as possible. A total of 16 dogs of varying sexes, breeds, and ages were included in the study.

The dogs resided permanently within the workshops, serving as guard animals, and were housed in improvised shelters or areas enclosed with wire mesh and wood. In some instances, the dogs were kept in designated sections of the workshop, equipped only with bedding (**Figure 1**).

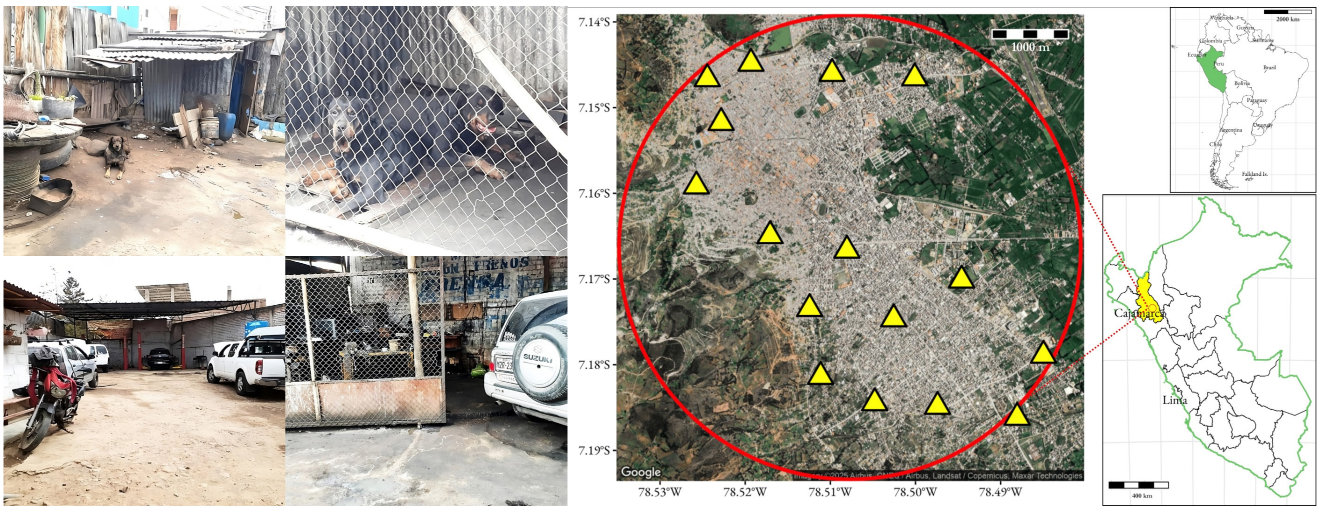

Figure 1. Living conditions of dogs sampled in automotive repair workshops in Cajamarca, Peru, with the geographic location of the workshops.

Prior to blood collection, the puncture site was disinfected with 70% alcohol. Blood samples (5 mL) were obtained via cephalic venipuncture using vacuum tubes containing EDTA-K2 and 21 G × 1 ½" needles. The samples were subsequently transported to the Laboratory of the Information, Toxicological Control, and Environmental Management Support Center, Faculty of Pharmacy and Biochemistry, Universidad Nacional Mayor de San Marcos, Lima, Peru.

Blood lead concentrations were quantified using graphite furnace atomic absorption spectrometry, following method MTA/MB-011/R92 of the Spanish National Institute for Occupational Safety and Health [11], as well as protocols established in previous studies [12]. A double-beam spectrophotometer (Thermo Scientific, model iCE 3500) equipped with a graphite furnace (model GFS 35), lead hollow cathode lamp, and a deuterium background correction system was used to minimize non-specific interferences. Several reagents were employed for sample and standard preparation. Triton X-100 (0.1%), a non-ionic surfactant, was used to facilitate hemolysis. A matrix modifier consisting of 10% ammonium phosphate ($NH_4H_2PO_4$) was used to improve reading precision. Lead standards were prepared from a 1000 µg/mL stock solution and diluted to 50, 100, 200, and 300 ppb to construct the calibration curve.

The graphite furnace analysis consisted of three primary stages: drying at 105 °C to eliminate solvents, ashing at 1200 °C to decompose organic material and volatilize inorganic compounds, and atomization at 1800–2600 °C to vaporize lead for detection by the spectrophotometer. Twenty microliters of each sample were injected into the spectrophotometer autosampler, and absorbance readings were obtained at a wavelength of 217 nm. Each sample was analyzed in duplicate. The results were compared to the calibration curve. To ensure accuracy, reagent blanks were included and subtracted from the sample and standard readings. Final lead concentrations were expressed in µg/dL, the standard unit for blood lead measurement, and were also converted to parts per million (ppm) to facilitate comparison with certain previous studies.

Since no internationally established reference values for blood lead levels in dogs currently exist, the results were compared to the reference value for blood lead levels in children established by the U.S. Centers for Disease Control and Prevention (CDC), which is set at 3.5 µg/dL [13]. This comparison is based on shared mammalian physiology and the similar adverse effects of lead in both species [8].
Data were organized using Microsoft Excel (version 2021), and descriptive statistics were calculated, including mean, standard error, median, standard deviation, variance, range (minimum and maximum), interquartile range, and coefficient of variation.

RESULTS

Blood lead levels in the 16 dogs sampled in this study ranged from 0.427 µg/dL to 4.348 µg/dL, with a mean ± standard deviation of 2.264 ± 1.243 µg/dL and a coefficient of variation of 54.907% (**Table 1**). Furthermore, a proportion of the samples (18.75%; 3/16) presented blood lead levels exceeding the CDC reference value of 3.5 µg/dL (**Figure 2**).

Table 1. Blood lead levels in dogs (n = 16) from automotive repair workshops in the city of Cajamarca, Peru. (ppm= parts per million).

Statistic	µg/dL	ppm
Mean	2.264	0.0226
Standard error	0.311	0.0031
Median	2.112	0.0211
Standard deviation	1.243	0.0124
Sample variance	1.545	0.0002
Range	3.921	0.0392
Minimum	0.427	0.0043
Interquartile range - Q1	1.237	0.0124
Maximum	4.348	0.0435
Interquartile range - Q3	3.282	0.0328
Coefficient of variation (%)	54.907	54.907

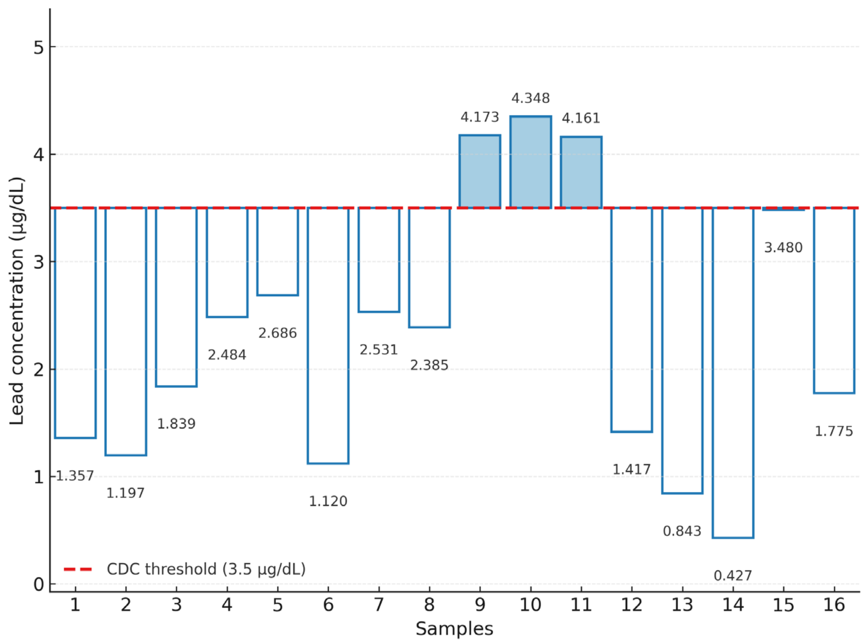

Figure 2. Distribution of individual blood lead levels in the dogs evaluated, relative to the 3.5 µg/dL reference value.

DISCUSSION

Lead exposure in dogs can result in poisoning and various adverse effects, similar to those described in humans [8]. This metal exerts toxicity across multiple organ systems, including the nervous, hematopoietic, reproductive, and excretory systems [1]. However, the effects of chronic low-dose lead exposure in dogs, as well as its clinical manifestations, remain poorly defined.

The blood lead levels observed in this study may be considered relatively low (maximum value: 4.348 µg/dL) and are unlikely to pose a significant clinical risk to the dogs evaluated, especially when compared to levels reported in other studies. For example, a study conducted in Zambia reported an overall mean blood lead concentration of 27.16 µg/dL in dogs, with even higher levels (35.29 ± 20.51 µg/dL) in dogs residing near a mining site, despite the absence of evident clinical signs of lead poisoning in those animals [9].

Environmental factors are key determinants of lead exposure. Previous research has shown that urban dogs tend to have higher blood lead concentrations compared to rural dogs [14,15]. Additionally, specific canine activities also influence exposure risk. For example, dogs regularly exposed to shooting ranges exhibit higher blood lead concentrations than military dogs with limited or no such exposure [16]. The ingestion of game meat containing lead pellets further increases the risk of poisoning [17].

Several studies have highlighted the value of dogs as sentinels for environmental and human lead contamination [9]. In this context, the present findings suggest the presence of environmental lead contamination in the city of Cajamarca. These results should be considered when developing strategies to mitigate environmental exposure. According to the World Health Organization, a blood lead level of 3.5 µg/dL in children is considered elevated and potentially harmful, due to its well-documented adverse effects [13]. The presence of dogs with blood lead levels exceeding this threshold may reflect environmental sources of exposure that could also pose risks to human populations.

Automotive repair workshops use various components that may contain lead. One of the most common sources is automotive paint; in unregulated settings, such paints can represent significant sources of environmental contamination and exposure [18]. Consequently, improving waste management practices and enhancing biosecurity measures for both workers and animals in these facilities is essential. It is also important to note that the conditions observed in many workshops are inadequate to ensure proper animal welfare.

Furthermore, individual factors may influence blood lead levels in dogs. Age is a well-recognized factor, as lead concentrations tend to increase over time [15]. Breed and living conditions may also play a role. For example, a study conducted in rural and urban dogs in India reported higher lead levels in mixed-breed and stray dogs compared to purebred dogs [14]. In Cajamarca, it is common practice to use breeds such as Rottweilers, Dobermans, Pit Bulls, and their mixes, as well as mixed-breed dogs, for facility security. The latter are often preferred due to their lower cost and maintenance requirements. These factors may have influenced the blood lead levels observed in this study and should be considered in future research.

As a pilot study, the present findings provide a foundation for future, larger-scale investigations. It is recommended that subsequent studies include a greater number of animals and appropriate comparison groups (such as dogs not exposed to workshop environments) to strengthen the analysis. Additionally, assessing lead concentrations in environmental matrices (soil, dust, water) would facilitate the correlation of environmental exposure with blood lead levels. Finally, evaluating clinical parameters and conducting comparative analyses between exposed animals and human populations could offer valuable insights into shared health risks within a One Health framework.

CONCLUSIONS

This study identified blood lead levels exceeding 3.5 µg/dL in 18.75% of the dogs evaluated in automotive repair workshops in the city of Cajamarca (Peru), indicating potential environmental exposure. These findings underscore the need for further research to characterize sources of exposure, assess clinical effects in dogs, and evaluate potential implications for human health considering the interconnection between human, animal, and environmental health.

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ETHICAL CONSIDERATIONS

The study was conducted in accordance with national ethical standards and was approved by the Faculty of Veterinary Sciences of the National University of Cajamarca, under Resolution No. 090-2019-FCV-UNC. Informed consent was obtained from the responsible owners of the dogs residing in the workshops included in the study.

DECLARATION OF COMPETING INTEREST

The authors have declared no conflict of interest.

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