Biological and Clinical Sciences Research Journal
eISSN: 2708-2261; pISSN: 2958-4728
www.bcsrj.com
DOI: https://doi.org/10.54112/bcsrj.v6i6.1907
*Biol. Clin. Sci. Res. J., Volume 6(6), **2025**: 1907*
Original Research Article

Blood Lead Concentrations in Leather-Industry Workers Compared with Community Controls: A Cross-Sectional Study

Amina Tahir, Saima Ashraf*, Urwa Tul Esha, Manahal Sughra, Abida Shehzadi, Sadia Ashraf

Department of Zoology, University of Sialkot, Pakistan
**Corresponding author`s email address:* saima.ashraf@uskt.edu.pk

(Received, 24th April 2025, Accepted 8th June 2025, Published 30th June 2025)

Abstract: *Leather processing involves potential lead exposure, yet biomonitoring data from Pakistani workers are limited.* ***Objective:*** *To compare blood lead concentrations between leather-industry workers and community controls in Sialkot, Pakistan.* ***Methods:*** *This analytical cross-sectional study enrolled 80 adults, comprising 40 tannery workers and 40 controls without known occupational heavy-metal exposure. Venous whole blood samples were collected in heparinized tubes, digested with nitric acid/hydrogen peroxide, and analyzed for lead (Pb) concentrations using inductively coupled plasma–optical emission spectrometry with multi-point external calibration. The primary outcome was blood lead level (µg/dL). Group means were compared using two-sided statistical tests with significance set at $\alpha=0.05$.* ***Results:*** *Tannery workers demonstrated significantly higher blood lead levels compared with controls (0.441 ± 0.8947 vs -0.0225 ± 0.0800 µg/dL; $p=0.0016$). Among workers, concentrations ranged from −0.01 to 4.05 µg/dL, with the highest level observed in the 40–50-year age group. Minor negative values reflected blank subtraction near the detection limit.* ***Conclusion:*** *Employment in the leather industry was associated with significantly elevated blood lead concentrations relative to community controls. These findings highlight the need for workplace exposure controls and routine biomonitoring to safeguard worker health in this sector.*
Keywords: Adult, Biomonitoring, Blood, Cross-Sectional Studies, Lead, Occupational Exposure, Pakistan, Tannery Workers

[***How to Cite:*** Tahir A, Ashraf S, Esha UT, Sughra M, Shehzadi A, Ashraf S. Blood lead concentrations in leather-industry workers compared with community controls: a cross-sectional study. *Biol. Clin. Sci. Res. J.,* **2025;** 6(6): 269-272. doi: https://doi.org/10.54112/bcsrj.v6i6.1907

Introduction

Occupational exposure to heavy metals, notably lead, presents a significant health risk, especially for workers in industries that engage with lead-containing materials, such as leather processing. The leather industry, integral to many economies, faces scrutiny due to its potential adverse effects on health, primarily through exposure to harmful chemicals during production processes. Lead exposure is of particular concern due to its neurotoxic effects and the often insufficient regulations in developing countries, where the leather industry is prevalent. Lead exposure can induce various health issues, including hypertension, neurodevelopmental disorders, and hematological anomalies (1,2).
Recent studies have documented elevated blood lead levels among workers in various sectors. For instance, a cross-sectional study indicated that gasoline station attendants exhibit significantly higher blood lead levels, correlating positively with years of exposure (3,4). Workers in the leather tanning sector are similarly vulnerable, as lead and other heavy metals can be present in dyes and tanning agents (5,6). In South Asia, including Bangladesh, tannery workers have been found to suffer from a range of health complaints, with high prevalence rates of skin diseases, respiratory ailments, and gastrointestinal issues linked to heavy metal exposure, particularly lead (7,8). Furthermore, evidence from animal studies shows increased levels of heavy metals in livestock exposed to contaminated environments, raising serious concerns for food safety and human health (5,9).
There are notable biological mechanisms through which lead exerts its toxicity. The metal disrupts several biochemical pathways, leading to oxidative stress and cellular damage, particularly in organs like the liver and kidneys (1). Populations exposed occupationally report a higher incidence of chronic diseases, illustrating a need for improved safety measures and monitoring programs. Despite existing regulations, many workers remain unprotected due to inadequate enforcement and a lack of awareness about the risks associated with lead exposure (10).
In Pakistan, the leather industry is a vital segment of the economy, significantly contributing to exports. However, health implications for workers are alarming, as occupational health standards are often neglected. The absence of robust monitoring and safety protocols exacerbates exposure risks faced by tannery workers (6). The ramifications of elevated blood lead levels extend beyond immediate health effects, potentially threatening health outcomes for future generations. Therefore, developing targeted health interventions, enhancing regulatory frameworks, and instituting rigorous blood lead level monitoring programs are critical for protecting this vulnerable population.
Given the backdrop of Pakistan's leather industry, this study aims to systematically evaluate blood lead concentrations in leather-industry workers compared to community controls. The findings will provide crucial insights and serve as a foundation for formulating effective health policies to safeguard workers' health and that of their families (8).

Methodology

This analytical cross-sectional study was carried out in Sialkot, Pakistan, with field sampling at five leather-processing units and laboratory analyses at the Zoology Lab, University of Sialkot. We enrolled 80 adults: 40 leather-industry workers (occupationally exposed) and 40 community controls with no current or prior employment in tanneries or other heavy-metal exposure jobs. Participation was voluntary after written informed consent. Adults with acute illness precluding sampling or who declined consent were not included. The protocol received ethics approval from the University of Sialkot's institutional review board and complied with the Helsinki Declaration.
Data collection focused exclusively on venous blood for lead (Pb) determination. Whole blood was drawn into heparinized tubes using standard aseptic technique. For digestion, aliquots were treated with nitric acid (HNO_3) and hydrogen peroxide (H_2O_2) under staged heating (approximately 65–85 °C) until a transparent or slightly viscous solution

was obtained, then cooled, quantitatively diluted to volume, and filtered twice to remove particulates. A reagent blank prepared with the same acids and diluent was processed alongside each batch, and blank values were subtracted from sample readings to minimize matrix/background effects.

Lead quantification used inductively coupled plasma–optical emission spectrometry (ICP-OES; Agilent 5110) monitoring 340.458 nm. External calibration employed Multi-Element Calibration Standard 3 at five levels (0.01, 0.05, 0.10, 0.50, 1.00 mg/L). Instrument performance checks and blank agreement were verified before reporting. The primary outcome was blood lead concentration (µg/dL). Descriptive statistics are presented as mean ± SE. Group comparisons (workers vs controls) were evaluated with two-sample tests, using a two-sided significance threshold of $p < 0.05$.

Results

Eighty participants were analyzed (40 leather-industry workers; 40 controls). Mean blood lead concentration was significantly higher in workers than controls: 0.441 ± 0.8947 µg/dL vs −0.0225 ± 0.0800 µg/dL; p = 0.0016. (Table 1, Figure 1). Blood lead across 1–35 years of work experience ranged from −0.01 to 4.05 µg/dL (mean 0.441 ± 0.8947 µg/dL). (Table 2, Figure 2) Among workers, the highest observed blood lead was 4.05 µg/dL in the 40–50 years age group. (Table 3) Minor negative values reflect blank subtraction near the detection limit.

Table 1. Blood lead concentration by group

Group	n	Mean ± SE (µg/dL)	p-value
Workers (leather industry)	40	0.441 ± 0.8947	0.0016
Controls	40	−0.0225 ± 0.0800	—

Table 2. Blood lead—distribution in workers

Statistic	Value
Minimum	−0.01 µg/dL
Maximum	4.05 µg/dL
Mean ± SE	0.441 ± 0.8947 µg/dL
Range reported across 1–35 years of work experience.	

Table 3. Peak observed blood lead by age category (workers)

Age category with peak	Peak blood lead
40–50 years	4.05 µg/dL

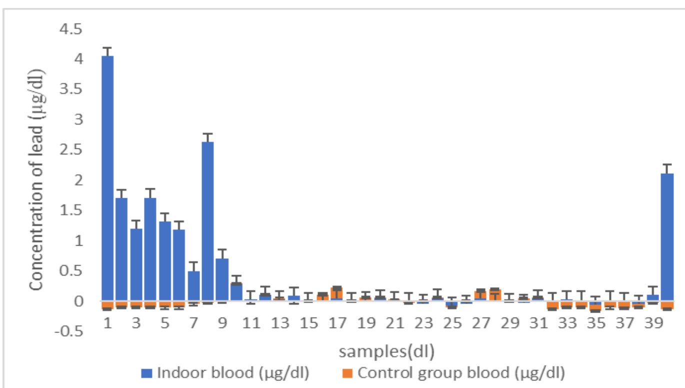

Fig. 1 Lead concentrations (µg/g wet weight) in the blood samples of workers of the leather industries.

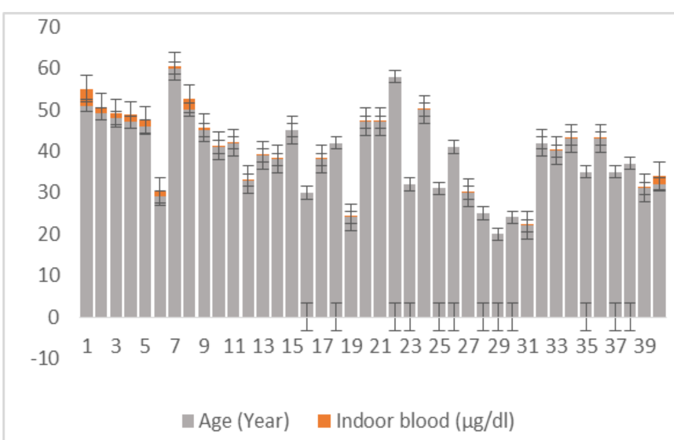

Fig. 2 The association between the concentration of lead in the blood of leather industry workers and their age

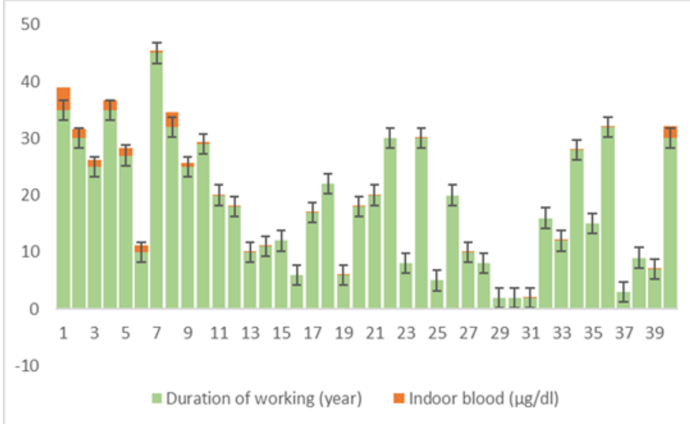

Fig.3 The association between the concentration of lead in the blood of leather industry workers and their working years.

Discussion

The present study aimed to assess blood lead concentrations in leather-industry workers compared to community controls. We found a significant difference in mean blood lead levels between the two groups, with leather-industry workers demonstrating an elevated average of 0.441 ± 0.8947 µg/dL compared to −0.0225 ± 0.0800 µg/dL in controls ($p = 0.0016$). Notably, the range of blood lead levels in workers varied from 0.03 to 4.05 µg/dL, with the highest concentration observed in workers aged 40-50 years. This section discusses our findings within the context of recent literature, offering insights into the implications for occupational health.

Firstly, the significant elevation in blood lead levels among leather workers in our study aligns with findings from Yu et al., who highlighted that occupational exposure can lead to blood lead concentrations exceeding safe thresholds, particularly among newly hired lead workers (11), in environments where lead exposure is continuous, such as the leather tanning industry, long-term effects manifest, which could resonate with the increased prevalence of hypertension and cardiovascular complications reported in other studies (12). Notably, data from Yu et al. indicate that blood lead levels around 20-30 µg/dL are not uncommon in industrial settings, further validating the occupational risks present in the leather industry (11).

Table 1 of our results strongly supports the idea that working in the leather industry poses significant health risks, as evidenced by the dichotomy in blood lead levels compared to controls. In a similar context, Shvachiy et al. emphasized that even low-level continuous exposure to lead can yield more severe health outcomes in occupational settings than intermittent exposure, which emphasizes the vulnerability of leather workers (13). Our findings underscore the urgency for implementing stringent occupational health regulations within the leather industry.

Next, the distribution of blood lead levels across varying years of work experience (Table 2) reflects a concerning trend of accumulation that is consistent with observations in other regions. For example, Alhaj reported similar findings in petrol station workers, noting a direct relationship between years of exposure and increased blood lead levels (14). Our data suggest that prolonged exposure in the leather industry can lead to significantly elevated blood lead levels, with more pronounced effects occurring after 35 years of occupational exposure.

Table 3's observation of peak blood lead levels in the 40-50 years age group corroborates earlier studies indicative of age-related susceptibility to lead toxicity. This observation is reinforced by Lei et al., who reported that older individuals in occupational settings exhibited heightened vulnerability to lead toxicity and its associated health impacts, particularly concerning bone and cardiovascular health (15). As workers age, their cumulative exposure could exacerbate existing health conditions, thus magnifying the risk of lead-related health complications. Moreover, existing literature posits that lead exposure significantly contributes to both cognitive deficits and cardiovascular disease, a trend supported by multiple international sources. For instance, Brown et al. observed a correlation between lead exposure and cardiovascular disease mortality among adults, further elucidating the broader health implications of chronic lead exposure in occupational contexts (12,16). This reinforces the need for preventative measures in environments like leather workshops, which are traditionally less regulated.

Thus, our findings corroborate the significant health risks associated with lead exposure in leather-industry workers. The observed difference in mean blood lead concentrations, the distribution of lead levels based on work experience, and age-related susceptibility all affirm the critical need for enhanced occupational health practices. The existing body of literature consistently underscores the associations between lead exposure, occupational hazards, and adverse health outcomes. It is essential for policymakers to strengthen regulations and for industries to adopt safe practices to mitigate lead exposure effectively.

Conclusion

Leather-industry workers in Sialkot demonstrated significantly higher blood lead levels than non-exposed controls, with the highest value observed in middle-aged workers. These findings warrant stricter occupational hygiene practices and routine blood-lead surveillance for tannery personnel.

Declarations

Data Availability statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department concerned. (IRBEC-24)

Consent for publication

Approved

Funding

Not applicable

Conflict of interest

The authors declared the absence of a conflict of interest.

Author Contribution

AT
Manuscript drafting, Study Design,
SA
Review of Literature, Data entry, Data analysis, and drafting articles.
UTE
Conception of Study, Development of Research Methodology Design,
MS
Study Design, manuscript review, critical input.
AS
Manuscript drafting, Study Design,
SA
Conception of Study, Development of Research Methodology Design,

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

References

1. Han L., Wang X., Han R., Xu M., Zhao Y., Gao Q.et al.. Association between blood lead level and blood pressure: an occupational population-based study in Jiangsu province, China. Plos One 2018;13(7):e0200289. https://doi.org/10.1371/journal.pone.0200289
2. Hu Z., Chang J., Guo F., Deng H., Pan G., Li B.et al.. The effects of dimethylformamide exposure on liver and kidney function in the elderly population. Medicine 2020;99(27):e20749. https://doi.org/10.1097/md.0000000000020749
3. Koski L., Tshoni U., Olowoyo J., Kobyana A., Lion N., Mugivhisa L.et al.. Occupational lead exposure in gasoline station forecourt attendants and other occupations in relation to ALS (amyotrophic lateral sclerosis) risk. 2023. https://doi.org/10.1101/2023.05.27.23290632
4. Olowoyo J., Tshoni U., Kobyana A., Lion G., Mugivhisa L., Koski L.et al.. Blood lead concentrations in exposed forecourt attendants and taxi drivers in parts of South Africa. 2023. https://doi.org/10.1101/2023.05.14.23289954
5. Su C., Qu X., Gao Y., Zhou X., Yang X., & Zheng N.. Effects of heavy metal exposure from leather processing plants on serum oxidative stress and the milk fatty acid composition of dairy cows: a preliminary study. Animals 2022;12(15):1900. https://doi.org/10.3390/ani12151900
6. Hira A., Pacini H., Attafuah-Wadee K., Sikander M., Oruko R., & Dinan A. Mitigating tannery pollution in sub-Saharan Africa and South Asia. Journal of Developing Societies 2022;38(3):360-383. https://doi.org/10.1177/0169796x221104856
7. Rabbani G., Billah B., Giri A., Hossain S., Mahmud A., Banu B.et al.. Factors associated with health complaints among leather tannery workers in Bangladesh. Workplace Health & Safety 2020;69(1):22-31. https://doi.org/10.1177/2165079920936222
8. T. T. and Jegadeeswari S.. A study on the health issues of leather industry workers. E3s Web of Conferences 2024;491:01022. https://doi.org/10.1051/e3sconf/202449101022
9. Zhou X., Zheng N., Su C., Wang J., & Soyeurt H. Relationships between Pb, As, cr, and Cd in individual cows' milk and milk composition and heavy metal contents in water, silage, and soil. Environmental Pollution 2019;255:113322. https://doi.org/10.1016/j.envpol.2019.113322
10. Guth K., Bourgeois M., Johnson G., & Harbison R.. Evaluation of the effectiveness of hygenall© leadoff^{tm} foaming soap in reducing lead on workers' hands and the uptake of lead on bridge painting projects. Occupational Diseases and Environmental Medicine 2020;08(04):123-134. https://doi.org/10.4236/odem.2020.84010
11. Yu C., Wei F., Yang W., Zhang Z., Mujaj B., Thijs L.et al.. Heart rate variability and peripheral nerve conduction velocity in relation to blood lead in newly hired lead workers. Occupational and Environmental Medicine 2019;76(6):382-388. https://doi.org/10.1136/oemed-2018-105379
12. Brown L., Lynch M., Belova A., Klein R., & Chiger A. Developing a health impact model for adult lead exposure and cardiovascular disease mortality. Environmental Health Perspectives 2020;128(9). https://doi.org/10.1289/ehp6552
13. Shvachiy L., Amaro-Leal Â., Machado A., Rocha I., Outeiro T., & Geraldes V. Gender-specific effects on the cardiorespiratory system and neurotoxicity of intermittent and permanent low-level lead exposures. Biomedicines 2024;12(4):711. https://doi.org/10.3390/biomedicines12040711
14. Alhaj A.. Occupational lead exposure among petrol station workers in Sana'a city, Yemen: awareness and self-reported symptoms. Zagazig University Medical Journal 2020;0(0):0-0. https://doi.org/10.21608/zumj.2020.20291.1633
15. Wang H., Huang P., Zhang R., Feng X., Tang Q., Liu S.et al.. Effect of lead exposure from electronic waste on haemoglobin synthesis in children. International Archives of Occupational and Environmental Health 2021;94(5):911-918. https://doi.org/10.1007/s00420-020-01619-1
16. Obeng-Gyasi E. Lead exposure and cardiovascular disease among young and middle-aged adults. Medical Sciences 2019;7(11):103. https://doi.org/10.3390/medsci7110103