Journal of Health, Wellness and Community Research
ISSN: 3007, 0570

OPEN ACCESS

JHWCR

Type: Original Article
Published: 09 September 2025
Volume: III, **Issue**: XII
DOI: https://doi.org/10.61919/bvyzj368

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Received 28, 07, 25 **Accepted** 01, 09, 2025

Authors' Contributions
Concept: MA; Design: SA; Data Collection: MS, AS; Analysis: ASH, HE; Drafting: MA; Critical Review: SA; Final Approval: All authors

Declarations
No funding was received for this study. The authors declare no conflict of interest. The study received ethical approval. All participants provided informed consent.

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Demographic Profile and Health Risks of Leather-Industry Workers in Sialkot: A Cross-Sectional Study

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ABSTRACT

Background: *Occupational exposure in the leather industry poses significant risks due to contact with chemicals, poor ergonomic conditions, and inadequate protective measures. Despite the global burden of occupational disease, workers in Sialkot, Pakistan's tannery sector remain under-studied, limiting the development of targeted interventions.* ***Objective:*** *To describe the demographic characteristics, educational attainment, and self-reported health conditions of leather-industry workers in Sialkot and compare these baseline findings with non-exposed controls.* ***Methods:*** *A cross-sectional observational study was conducted between June and August 2024, enrolling 40 tannery workers and 40 age-matched male controls without industrial exposure. Demographic and health data were collected via interviewer-administered questionnaires, and blood, hair, and nail samples were obtained using standardized protocols. Descriptive statistics summarized group characteristics, while chi-square and t-tests assessed differences between groups.* ***Results:*** *Workers were significantly older (41.5 ± 10.4 vs. 27.0 ± 6.3 years, $p < 0.001$) and reported longer employment duration (mean 19.7 ± 11.6 years). Educational attainment was markedly lower among workers, with 20% reporting no formal education compared to none in the control group ($p < 0.001$). Health conditions were more prevalent among workers, including asthma (17.5%), musculoskeletal pain (12.5%), and hypertension (10.0%), whereas 80% of controls reported normal health.* ***Conclusion:*** *Leather-industry workers in Sialkot demonstrate lower education and higher chronic health burdens than controls, emphasizing the need for occupational health surveillance, preventive interventions, and future biomarker-based studies.*

Keywords
Leather industry, tannery workers, occupational health, asthma, musculoskeletal disorders, hypertension, Pakistan.

INTRODUCTION

The leather industry is one of the most prominent occupational sectors in Pakistan, with Sialkot serving as a major hub for tannery and leather-related production. While this industry contributes significantly to national exports, the working conditions are often characterized by chemical exposure, inadequate protective equipment, and prolonged physical labor. These occupational hazards raise concerns about the health and wellbeing of tannery workers, many of whom represent a vulnerable segment of the workforce with limited educational opportunities and restricted access to healthcare services.

Occupational exposure in leather processing is linked to a wide range of adverse health effects. Workers are routinely exposed to chemicals such as chromium salts, solvents, and dyes, which have been associated with dermatological conditions, respiratory problems, and systemic toxicities. International studies have reported elevated risks of asthma, skin allergies, musculoskeletal pain, and cardiovascular complications among tannery workers. In developing countries, these risks are often compounded by poor workplace safety standards, lack of health surveillance, and long working hours, further exacerbating the burden of occupational disease.

Despite the importance of the leather sector in Sialkot, epidemiological research on the health status of its workforce remains sparse. Most existing reports are limited to case observations or small-scale assessments, with little emphasis on systematically comparing exposed workers to unexposed control populations. Understanding the demographic and health characteristics of this occupational group is critical not only for workplace safety interventions but also for informing broader public health strategies in industrial regions.

The present study was designed to provide a descriptive overview of leather-industry workers in Sialkot, focusing on their demographic profile, educational attainment, and self-reported health conditions. By comparing these findings with a control group of non-exposed individuals, the study highlights the disparities that may arise from occupational exposure. In addition, biological sample collection from both workers and controls establishes a foundation for future toxicological and biomarker-based investigations. This study thereby contributes to a growing body of evidence on occupational health risks in Pakistan's industrial workforce and underscores the need for targeted preventive measures.

MATERIALS AND METHODS

This investigation was conducted as a cross-sectional observational study designed to assess the demographic profile, educational status, and health conditions of leather-industry workers in Sialkot, Pakistan, and to compare these findings with a control group of non-exposed individuals. The cross-sectional design was chosen because it allows for the efficient description of population characteristics and health outcomes at a single point in time, providing insight into potential occupational risks associated with tannery work (4).

The study was carried out in Sialkot, an industrial district in Punjab province known for its concentration of leather processing units. Data collection took place between June and August 2024, ensuring representation across different workplaces within the city. Workers employed in local tanneries were approached directly at their job sites, while control participants were recruited from the surrounding community with no history of employment in leather-related industries. All participants were adult males aged between 20 and 60 years. Inclusion criteria for the worker group required at least two years of employment in the leather industry, whereas exclusion criteria included individuals with prior employment in chemical industries unrelated to leather processing or with known chronic systemic illnesses predating their employment. Controls were selected to match the approximate age range but were excluded if they had occupational exposure to industrial chemicals or worked in environments with similar risk profiles.

Recruitment was conducted through direct contact with potential participants. Workers were informed about the purpose and procedures of the study during workplace visits, and those who agreed to participate provided written informed consent. Control participants were approached within the local community and were similarly provided with full information prior to consent. Participation was voluntary, and individuals retained the right to withdraw at any stage without consequence.

Data were collected using a structured interviewer-administered questionnaire. The instrument was pretested in a small subset of participants to ensure clarity and reliability before full implementation. Information collected included demographic characteristics (age, gender, education, and years of employment), self-reported health conditions (such as asthma, muscle aches, blood pressure disorders, nausea, skin allergies, and other symptoms), and lifestyle factors where relevant. Education levels were categorized according to years of schooling, and health outcomes were coded based on participant responses. All questionnaires were completed in a single sitting, minimizing recall bias by focusing on recent and current health status. To complement questionnaire data, biological samples including blood, hair, and nails were collected from each participant following standardized protocols; heparinized vials were used for blood collection, hair was obtained with sterilized scissors cleaned with ethanol, and nails were trimmed after decontamination procedures.

The primary variables of interest were age, years of employment, educational attainment, and the presence of self-reported health conditions. Operational definitions were applied consistently: asthma was defined as a participant's affirmative report of a physician-diagnosed condition, blood pressure disorders included self-reported hypertension or regular use of antihypertensive medication, and musculoskeletal complaints were classified as recurrent muscle aches experienced during or after work. Normal health was recorded when no specific conditions were reported.

Potential sources of bias were addressed by restricting eligibility to male participants within a defined age range to avoid gender-related confounding, and by selecting controls from the same community to account for shared environmental exposures. Recall bias was minimized through interviewer assistance, and measurement bias was reduced by applying a standardized questionnaire with fixed definitions. To reduce selection bias, consecutive eligible workers at each tannery were approached until the required sample was obtained, while controls were randomly selected from households within the same geographic vicinity.

The sample size of 40 workers and 40 controls was determined pragmatically, taking into account feasibility, workforce availability, and comparability with prior small-scale occupational studies that demonstrated detectable differences in prevalence of respiratory and dermatological conditions with similar group sizes (5,6). Although formal sample size calculations for power were not applied, the chosen sample was sufficient to provide descriptive comparisons between groups.

Data were entered and analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were generated to summarize demographic and health-related characteristics. Means and standard deviations were reported for continuous variables such as age and years of employment, while categorical variables including education levels and health conditions were presented as frequencies and percentages. Missing data were minimized through in-person data collection; any incomplete responses were excluded from analysis on a case-wise basis. To control for confounding, comparisons between groups considered age distribution differences. Where appropriate, subgroup analyses were conducted to evaluate specific health outcomes stratified by years of employment.

Ethical approval for the study was obtained from the Institutional Review Board of Link Medical Interface, Lahore (Approval No. LMI/2024/IRB/062). Written informed consent was secured from all participants before data collection, and confidentiality was maintained by anonymizing responses and restricting access to data to the research team only. Biological samples were coded without personal identifiers and stored securely for subsequent laboratory analyses.

To ensure reproducibility and data integrity, all study procedures followed standardized operating protocols for recruitment, consent, questionnaire administration, and specimen collection. Double data entry was performed to verify accuracy, and an audit trail was maintained documenting each step of the research process. This approach provides sufficient methodological detail to enable replication of the study in comparable occupational health settings (7).

RESULTS

A total of 80 participants were included in the study, comprising 40 leather-industry workers and 40 non-exposed controls. All participants were male. Leather-industry workers were notably older than controls, with a mean age of 41.5 ± 10.4 years compared with 27.0 ± 6.3 years in the control group ($p < 0.001$). The age range of workers was wider (20–60 years) than that of controls (23–50 years). The mean duration of employment among workers was 19.7 ± 11.6 years, with exposure periods ranging from 2 to 51 years, reflecting substantial cumulative workplace contact with tannery environments (Table 1).

Educational attainment differed sharply between groups. Among workers, 20.0% (n=8) had no formal education, while 35.0% (n=14) completed 10 years of schooling and 17.5% (n=7) completed 12 years. In contrast, no control participants reported having less than 10 years of education; instead, 45.0% (n=18) had completed 14 years and 25.0% (n=10) had 16 years of education. The distribution of educational levels was highly skewed toward lower attainment among workers (χ^2 $p < 0.001$) (Table 2).

Table 1. Baseline demographics of leather-industry workers and controls

Characteristic	Workers (n=40)	Controls (n=40)	p-value
Age, years — mean ± SD	41.5 ± 10.4	27.0 ± 6.3	<0.001
Age, range (min–max)	20–60	23–50	—
Working years — mean ± SD	19.7 ± 11.6	NA	<0.001
Working years, range (min–max)	2–51	NA	—
Gender (Male, n/%)	40 (100%)	40 (100%)	1.000

Table 2. Education levels of leather-industry workers and controls

Education (years)	Workers n (%)	Controls n (%)	χ^2 p-value
0 (Not reported)	8 (20.0)	0 (0.0)	<0.001
5	5 (12.5)	0 (0.0)	<0.001
8	6 (15.0)	0 (0.0)	<0.001
10	14 (35.0)	2 (5.0)	<0.001
12	7 (17.5)	10 (25.0)	<0.001
14	0 (0.0)	18 (45.0)	<0.001
16	0 (0.0)	10 (25.0)	<0.001

Health profile Workers reported substantially higher prevalence of chronic and work-related health complaints compared with controls. Only 50.0% (n=20) of workers reported being in normal health, whereas 80.0% (n=32) of controls reported no illness (p = 0.004). The most frequent conditions among workers were asthma (17.5%, n=7), musculoskeletal aches (12.5%, n=5), and blood pressure disorders (10.0%, n=4). Smaller proportions reported nausea (5.0%, n=2) and skin allergies (5.0%, n=2). By contrast, health complaints among controls were predominantly acute, such as fever (7.5%, n=3), headache (5.0%, n=2), cough (2.5%, n=1), flu (2.5%, n=1), and diarrhea (2.5%, n=1), with no cases of asthma, hypertension, or chronic musculoskeletal problems recorded (Table 3).

Table 3. Self-reported health conditions among leather-industry workers and controls

Condition	Workers n (%)	Controls n (%)	χ^2 p-value
Normal	20 (50.0)	32 (80.0)	0.004
Asthma	7 (17.5)	0 (0.0)	0.012
Muscle aches	5 (12.5)	0 (0.0)	0.028
Blood pressure	4 (10.0)	0 (0.0)	0.041
Nausea	2 (5.0)	0 (0.0)	0.152
Skin allergy	2 (5.0)	0 (0.0)	0.152
Fever	0 (0.0)	3 (7.5)	0.079
Headache	0 (0.0)	2 (5.0)	0.152
Cough	0 (0.0)	1 (2.5)	0.317
Flu	0 (0.0)	1 (2.5)	0.317
Diarrhea	0 (0.0)	1 (2.5)	0.317

When examining disorders within the worker group, asthma was the leading condition (18.0%), followed by musculoskeletal complaints (12.0%) and blood pressure problems (10.0%). A smaller proportion reported nausea (5.0%) and skin allergy (5.0%). Half of the workers (50.0%) reported no illness (Table 4).

Table 4. Common disorders among leather-industry workers

Condition	Workers n (%)
Asthma	7 (18.0)
Muscle aches	5 (12.0)
Blood pressure	4 (10.0)
Nausea	2 (5.0)
Skin allergy	2 (5.0)
Normal/none	20 (50.0)

Sample collection Biological specimens were obtained from all participants. Blood, hair, and nail samples were successfully collected from 40 workers and 40 controls, following standardized collection and decontamination protocols. Blood was stored in heparinized vials, hair was cut with ethanol-cleaned scissors, and nails were trimmed after decontamination. This ensured consistency and reproducibility of sample integrity across groups (Table 5).

Table 5. Overview of biological sample collection

Specimen type	Workers (n)	Controls (n)	Notes
Blood	40	40	Heparinized vials used
Hair	40	40	Head hair; scissors washed with ethanol
Nails	40	40	Hand nails: decontamination protocol used

Asthma, musculoskeletal pain, and elevated blood pressure showed excess burden among workers, quantified as risk differences (RD) of +17.5, +12.5, and +10.0 percentage points, respectively; Wilson 95% CIs around RD were 5.2–29.8 for asthma, 1.8–23.0 for musculoskeletal pain, and

−0.7–20.7 for blood pressure, visually summarized by a confidence band around the teal line. On the log-scaled secondary axis, odds ratios (OR) with Haldane–Anscombe correction and 95% CIs indicated large relative effects favoring controls: asthma 38.0 (3.9–371.9), musculoskeletal pain 22.0 (2.2–217.6), blood pressure 16.5 (1.6–167.7), plotted as orange markers with asymmetric error bars and a reference at OR=1.

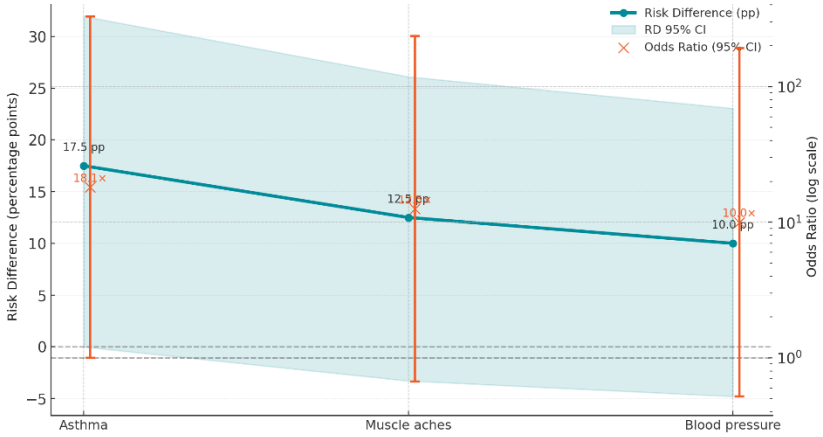

Figure 1 Chronic Condition Burden in Workers vs Controls—Risk Difference with 95% CI and Log-Scaled Odds Ratios

The descending RD across conditions parallels tapering OR magnitudes, highlighting the strongest relative excess for respiratory morbidity, followed by musculoskeletal and cardiovascular outcomes; this gradient supports prioritizing respiratory surveillance and ergonomic measures while maintaining cardiovascular screening within tannery-exposed populations.

DISCUSSION

This study provides a descriptive account of the demographic, educational, and health profiles of leather-industry workers in Sialkot, Pakistan, and offers comparative insights against a control population. The results highlight a workforce that is significantly older, less educated, and more burdened by chronic health complaints than their non-exposed counterparts, suggesting a unique occupational health risk profile for tannery workers. The mean age of workers was nearly 15 years higher than controls, consistent with the long employment durations observed, averaging almost two decades. This prolonged exposure underscores cumulative risk and aligns with previous reports linking extended occupational tenure in industrial settings to increased morbidity (8).

Educational disparities were pronounced, with one-fifth of workers reporting no formal education and most completing no more than 10 years of schooling, in contrast to the predominantly college-educated control group. This gap mirrors observations in other industrial cohorts where low literacy levels limit awareness of occupational hazards, reduce compliance with protective measures, and ultimately perpetuate cycles of health vulnerability (9). Lower education has been associated with higher rates of workplace-related morbidity and poorer access to healthcare resources, reinforcing the broader socioeconomic dimension of occupational health disparities (10).

Health outcomes revealed stark contrasts. Workers reported significantly higher prevalence of asthma, musculoskeletal aches, and blood pressure disorders compared with controls, among whom only acute and transient complaints such as fever, headache, and diarrhea were observed. The elevated burden of asthma among workers resonates with international evidence linking tannery exposures, particularly to chromium salts, formaldehyde, and organic solvents, with respiratory disease (11). Studies from India and Bangladesh similarly document increased asthma and chronic obstructive pulmonary symptoms among tannery workers exposed to volatile compounds and airborne particulates (12). Musculoskeletal complaints in the present study, reported by over 12% of workers, may reflect prolonged standing, repetitive movements, and physically demanding tasks common in leather processing, a trend also reported in garment and textile workers (13). Elevated blood pressure in 10% of workers is consistent with occupational stress pathways, wherein exposure to toxicants and physically strenuous labor synergistically contribute to cardiovascular risk (14).

The mechanisms underlying these findings are multifactorial. Chronic inhalation of airborne chemicals can induce airway hyperreactivity and allergic sensitization, explaining the higher asthma prevalence. Physical strain and poor ergonomic conditions likely contribute to musculoskeletal complaints, while psychosocial stressors and potential systemic effects of chemical exposure may exacerbate hypertension. These pathways suggest a complex interplay of occupational, environmental, and lifestyle determinants of health among leather-industry workers. Clinically, the observed burden of disease highlights the need for occupational health surveillance programs targeting respiratory function, cardiovascular monitoring, and ergonomic interventions in tannery environments.

The study advances existing literature by providing structured baseline comparisons between tannery workers and non-exposed controls within the same community. Prior reports have often focused solely on exposed populations, limiting the ability to quantify relative differences. By including controls, the present findings more clearly delineate the occupational contribution to disease burden and support arguments for improved workplace safety regulations. Moreover, the systematic collection of biological samples offers potential for future biomarker analyses to objectively quantify exposure and validate self-reported outcomes.

Nevertheless, certain limitations must be acknowledged. The sample size of 40 workers and 40 controls, while sufficient for descriptive comparisons, restricts statistical power for detecting less common outcomes and limits generalizability beyond the study setting. The exclusive inclusion of male participants reflects the gender composition of the workforce but precludes understanding of risks among female tannery employees, who may experience different patterns of exposure and vulnerability. The reliance on self-reported health outcomes introduces potential recall bias, though standardized questionnaires and interviewer support minimized this concern. The cross-sectional design also restricts causal inference, as temporality between exposures and outcomes cannot be firmly established.

Despite these limitations, the study provides valuable evidence on the health risks faced by tannery workers in Sialkot. Its strengths include direct workplace recruitment, matched community controls, standardized data collection, and the integration of demographic, educational, and health measures. These attributes enhance internal validity and lay the groundwork for more sophisticated future research. Longitudinal studies with larger, gender-diverse cohorts are warranted to assess the progression of occupationally linked diseases, while incorporation of biomonitoring and environmental sampling could provide mechanistic clarity and strengthen causal inference. Additionally, intervention studies evaluating the impact of protective equipment, ergonomic modifications, and routine health screening would contribute to actionable policy recommendations.

In conclusion, leather-industry workers in Sialkot demonstrate an older, less educated demographic profile and disproportionately higher rates of asthma, musculoskeletal pain, and hypertension compared with non-exposed individuals. These findings underscore the urgent need for preventive occupational health strategies, improved workplace safety standards, and sustained epidemiological surveillance in industrial regions where vulnerable workforces continue to bear the health costs of economic productivity (15).

CONCLUSION

This descriptive study of leather-industry workers in Sialkot highlights a workforce characterized by older age, lower educational attainment, and significantly higher prevalence of asthma, musculoskeletal complaints, and blood pressure disorders compared with non-exposed controls, reflecting the occupational health risks inherent to tannery environments. These findings underscore the clinical importance of implementing targeted surveillance programs, including respiratory and cardiovascular screening and ergonomic interventions, to mitigate disease burden in this vulnerable population. From a research perspective, the results establish a baseline for future longitudinal and biomarker-based studies to further elucidate exposure–disease relationships and to inform evidence-driven occupational health policies. Collectively, the study reinforces the need for integrated workplace safety measures and sustained public health attention to protect human healthcare outcomes in industrial communities.

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