

Prevalence of Burtonian Lines and its Correlation with Environmental and Occupational Factors Among Individuals Residing in Rural Areas of Haryana, India

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Abstract

Aim

Lead is one of the most heavy toxic metals with widespread environmental distribution and severe systemic as well as oral health consequences. The present study aimed to determine the prevalence, extent, and severity of Burtonian lines in rural areas of Haryana and to examine their correlation with demographic, occupational, environmental, and dietary risk factors.

Materials and Methodology:

A cross-sectional study was conducted among 725 participants representing WHO index age groups across two rural locations selected randomly from four geographical zones of Haryana each. Data regarding demographic details, occupational and environmental exposures, family history, dietary practices, and systemic symptoms were collected using self-prepared validated questionnaires. All participants underwent clinical examination for Burtonian lines. Soil and water samples from the study areas were analysed. Statistical analysis was performed using chi-square tests, correlation studies, and multivariate logistic regression.

Results

All participants presented with Burtonian lines, of which 70% showed moderate to severe pigmentation and more than half exhibited generalized involvement affecting over five teeth. Severity was significantly associated with older age, male gender, poor oral hygiene, and long duration of rural residency. Soil and water analysis revealed high lead levels, with significant positive correlations between environmental lead concentrations and severity of Burtonian lines.

Conclusion

Burtonian lines were found to be highly prevalent among the rural population of Haryana, serving as a reliable, non-invasive biomarker of systemic lead burden. The findings emphasize the importance of integrating oral screening for Burtonian lines into routine public health programs as a cost-effective surveillance tool in resource-limited rural settings.

Introduction

Lead has been recognized since antiquity as a widely used but highly toxic heavy metal due to its favorable physico-chemical properties such as malleability, ductility, corrosion resistance, and weak conductivity. Its continued industrial use despite proven health hazards has made lead one of the most persistent environmental toxins worldwide.¹ According to the Institute for Health Metrics and Evaluation,

lead exposure accounted for over half a million deaths and nearly 14 million disability-adjusted life years (DALYs) globally in 2016, with India bearing a disproportionately high burden.² Almost half of the world's children with elevated blood lead levels live in India, and lead exposure contributes to more than 230,000 deaths annually in the country.³ In Haryana, several district-level surveys have reported high soil and water lead concentrations, with Rohtak, Kurukshetra, and Panchkula showing particularly elevated values.⁴

While the systemic impact of lead exposure on the nervous, cardiovascular, renal, and reproductive systems is well-documented, oral manifestations, particularly Burtonian lines, provide a unique and visible biomarker of chronic lead toxicity.⁵ Burtonian lines appear as a blue-black pigmentation along the gingival margin, caused by the precipitation of lead sulfide through interactions between lead and hydrogen sulfide released by oral bacteria (Figs. 1 and 2). Their presence serves not only as a clinical indicator of systemic lead burden but also as an accessible screening tool, particularly in low-resource rural settings.⁶

Despite the alarming statistics on lead poisoning in India, very limited data exist on the prevalence of Burtonian lines in rural populations, where traditional agricultural practices, unsafe occupational exposures, contaminated drinking water, and inadequate health awareness increase susceptibility. This study was therefore undertaken to assess the prevalence, extent, and severity of Burtonian lines in rural Haryana and to analyze their association with demographic, occupational, environmental, and dietary determinants, thereby generating evidence for public health action.

Materials & Methodology

This cross-sectional observational study was carried out in eight randomly selected rural areas representing four geographical zones of Haryana. The sample comprised 725 participants, with 145 individuals drawn from each of the WHO index age groups (5, 12, 15, 35–44, and 65–74 years). Eligible participants were residents of the selected rural areas for at least five years. Ethical clearance was obtained from the institutional ethics committee (IEC-SGTDCHRI/FDS/RP/03), and informed consent was taken from all participants or guardians in case of minors.

Data were collected using self-prepared, validated, closed-ended questionnaire which was developed specifically for this study after an extensive literature review and was further pilot-tested for assessing demographic characteristics, family history, occupational exposure, environmental exposure, dietary habits, and systemic symptoms. (see Supplementary File 1) The content validity of the questionnaires used for data collection were ensured by submitting the forms to 9 experts in the field of Dentistry including both clinicians and academicians' personnel selected as per the experience and interest in the problem area. The changes suggested by the experts were incorporated in the study tools. Pilot research was carried out with 30 people from a rural region who were not part of the main study sample after expert validation. Any ambiguities, comprehension issues, or technological faults in the questionnaire and clinical examination protocol were found during this pretesting were amended. The questionnaire

was then circulated further among the study participants and data was collected for different parameters. Clinical intraoral examinations were performed by trained dental professionals to record the presence, extent, and severity of Burtonian lines using standard criteria. Soil and water samples were collected from each zone and analyzed for lead concentrations using atomic absorption spectrophotometry.

Statistical Analysis

Data were analyzed using SPSS version 22. Descriptive statistics were generated, and chi-square tests was applied to test the association between categorical variables. Pearson or Spearman correlation coefficients were used to assess the relationships between Burtonian lines and lead levels in water and soil. Logistic regression were done to evaluate the association of Burtonian lines with various factors (lead water content, blood lead levels, family/genetic history, occupational hazards) while controlling for potential confounders.

Results

The study population consisted of 412 males (56.8%) and 313 females (43.2%), evenly distributed across all age groups. More than one-fourth of participants resided near industrial areas, and groundwater was the most common source of drinking water. Educational attainment was generally low, with over 40% having only primary or secondary schooling (Table 1)

Table 1
Distribution of study participants across demographic variables

Variable	Categories	Frequency (n)	Percentage (%)
Age Group	5 years	145	20.0
	12 years	145	20.0
	15 years	145	20.0
	35–44 years	145	20.0
	65–74 years	145	20.0
Gender	Male	412	56.8
	Female	313	43.2
Residential Area	Industrial vicinity	214	29.5
	Non-industrial vicinity	511	70.5
Duration of Residency	> 5 years	178	24.6
	> 10 years	259	35.7
	> 15 years	288	39.7
Zone	Zone I	181	25.0
	Zone II	181	25.0
	Zone III	181	25.0
	Zone IV	182	25.0
Education	No formal education	96	13.2
	Primary school	188	25.9
	Secondary school	231	31.9
	Graduation	142	19.6
	Postgraduation	68	9.4
Drinking Water Source	Groundwater	365	50.3
	Municipal	106	14.6
	Tap/Pipe Surface	89	12.3
	Surface (direct)	130	17.9
	Other/Unknown	35	4.8
Primary Occupation	Agriculture	295	40.7

Variable	Categories	Frequency (n)	Percentage (%)
	Factory/Laborer	176	24.3
	Household work	112	15.4
	Student	109	15.0
	Others/Unemployed	33	4.6
Toothbrushing Habit	Twice daily	178	24.6
	Once daily	385	53.1
	Occasionally	122	16.8
	Never	40	5.5

All participants exhibited Burtonian lines. Among them, 55% showed generalized Burtonian lines, while 45% had localized involvement. Severity distribution revealed that 29.9% had mild, 51.3% had moderate, and 18.8% had severe pigmentation (Table 2). Logistic regression indicated that older age (65–74 years), male gender, low education, and poor oral hygiene were strongly associated with higher severity (Table 3). Occupational exposures such as current employment in lead-based industries, lack of PPE, and absence of administrative safety measures significantly increased the odds of severe Burtonian lines (Table 4). Environmental exposures, including absence of household water filtration and use of lead-based products, also showed significant associations. Nutritional deficiencies, particularly infrequent consumption of green leafy vegetables and dairy, were found to exacerbate severity (Table 5).

Table 2
Distribution of study participants across extent and severity of Burtonian lines

Clinical Parameter	Category	Frequency (n)	Percentage (%)
Extent of lines	Localized (≤ 5 teeth)	326	45.0
	Generalized (> 5 teeth)	399	55.0
Severity (Grade)	Mild ($< 33.3\%$)	217	29.9
	Moderate ($33.3\text{--}66.7\%$)	372	51.3
	Severe ($> 66.7\%$)	136	18.8

Table 3

Multiple Logistic Regression Analysis of Demographic details associated with Burtonian lines severity

Parameter	Adjusted Odds Ratio (AOR)	95% Confidence Interval (CI)	p-value
Gender (Male vs Female)	1.47	1.02–2.15	0.045
Age Group (65–74 vs 5–15 yrs)	1.89	1.02–3.52	0.042
Education (None vs Postgraduate)	1.62	0.95–2.76	0.075
Residence (Industrial vs Non)	1.58	1.04–2.39	0.031
Duration of Stay > 15 yrs	1.38	0.87–2.20	0.174
Zone I vs Zone IV	1.41	0.84–2.38	0.194
Toothbrushing (Never vs Twice)	2.21	1.08–4.51	0.029

Table 4

Multiple Logistic Regression Analysis of occupational exposure associated with Burtonian lines severity

Parameter	AOR	95% CI	p-value
Current Occupational Exposure (Yes)	1.76	1.03–3.01	0.038
Use of PPE (No vs Yes)	1.62	1.00–2.63	0.049
Engineering Controls (No vs Yes)	1.28	0.81–2.04	0.285
Administrative Controls (No vs Yes)	1.38	0.88–2.18	0.155
Health Symptoms Reported (Yes)	1.84	1.10–3.06	0.021
Diagnosed with Lead Poisoning (Yes)	2.02	1.12–3.65	0.019

Table 5

Multiple Logistic Regression Analysis of environmental and dietary exposure associated with Burtonian lines severity

Parameter	AOR	95% CI	p-value
Lead-Based Product Use (Yes)	1.43	0.96–2.14	0.077
No Water Filtration	1.58	1.01–2.49	0.045
Nearby Construction (Yes)	1.43	0.95–2.17	0.087
Green Leafy Veg Intake (Rare/Never)	1.86	1.10–3.13	0.019
Dairy Intake (Rare/Never)	1.51	0.96–2.38	0.073
Meat/Fish Intake (Rare/Never)	1.29	0.82–2.03	0.271

Soil and water analysis confirmed elevated lead levels across all zones, with Zone I showing the highest concentrations. There was a statistically significant correlation between environmental lead levels and the prevalence of moderate-to-severe Burtonian lines (Table 6). Systemic symptoms including fatigue, abdominal pain, appetite loss, learning difficulties, and behavioral disturbances were independently associated with generalized pigmentation, suggesting a link between clinical oral findings and systemic toxicity (Table 7).

Table 6
Correlation Between Environmental Lead Levels (Water and Soil) and Moderate–Severe Burtonian Lines Across Zones

Zone	Mean Water Lead (ppb)	Mean Soil Lead (ppm)	% Moderate–Severe Burtonian Lines	Correlation (r)
Zone I	18.2	33.5	76.8	Water: 0.51*** Soil: 0.47***
Zone II	13.5	26.8	58.3	
Zone III	16.7	30.1	66.4	
Zone IV	15.8	29.0	65.2	

Table 7
Multiple Logistic Regression Analysis of systemic signs and symptoms associated with Burtonian lines extent

Parameter	Adjusted Odds Ratio (AOR)	95% Confidence Interval (CI)	p-value
Fatigue	1.94	1.20–3.14	0.007
Loss of Appetite	1.59	1.03–2.45	0.035
Abdominal Pain	1.63	1.02–2.61	0.042
Constipation	1.38	0.87–2.18	0.172
Vomiting	1.18	0.73–1.92	0.491
Learning Difficulties	2.06	1.24–3.44	0.006
Behavioral Changes	1.76	1.10–2.91	0.019

Discussion

This study provides compelling evidence of the high prevalence of Burtonian lines in rural Haryana, underscoring the severity of chronic lead exposure in these communities. The findings highlight the multifactorial nature of lead poisoning, with demographic vulnerabilities, unsafe occupational practices, environmental contamination, and dietary inadequacies contributing synergistically to disease burden. The strong ecological correlation between soil and water lead levels and the severity of Burtonian lines

emphasizes the role of environmental contamination as a major determinant of oral and systemic toxicity.

One of the most significant demographic factors influencing the intensity and extent of the Burtonian line was age. The prevalence of both severe pigmentation and generalized distribution was statistically significant in participants aged 65–74 years than in those in younger age groups. Adjusted odds ratios (AORs) for severity in this age group was 1.89 according to multivariate logistic regression. Cumulative exposure over time might have been the cause of this. Since lead is known to bioaccumulate in soft tissues and bones, it may be mobilized as people age as a result of increased bone turnover, which is particularly common in older adults.⁷ The overall lead load was further increased by older persons' extended periods of exposure at work and their stay at particular locations and contaminated environments.⁸ Research from both developed and developing nations confirms that these chronic exposure dynamics are the reason why older age groups regularly exhibit higher blood and bone lead levels.^{9,10}

Data demonstrating elevated soil and water lead levels in these zones, particularly Zone I, which had the greatest mean environmental lead concentrations and the highest rates of moderate-to-severe pigmentation, environmentally support this conclusion. Indicating prolonged environmental exposure from contaminated groundwater or air deposition from industrial emissions, long-term residence (> 15 years) further raised the incidence of severe pigmentation.¹¹ The correlation between duration of stay and lead toxicity has been confirmed in studies from industrial belts in South Asia and Latin America.^{12,13}

Frequent complaints included vomiting and constipation, with severe Burtonian lines present in nearly one-third of the participants. Despite being in line with increased pigmentation, these patterns failed to reach statistical significance in either the multivariate or bivariate models.

Although constipation is a recognized sign of lead-induced dysmotility, it is not a very sensitive stand-alone diagnostic due to its low specificity and prevalence in general populations.¹⁴ Similar results were seen in a research by El-Farrash RA et al., wherein gastrointestinal symptoms were prevalent but only significant when combined with additional symptoms such as neurological abnormalities and pigmentation.¹⁵ Our findings confirm this conclusion; although these symptoms provide supportive value, these are not a reliable way to predict the degree or severity of Burtonian lines on their own.

The highest percentage of moderate-to-severe Burtonian lines was seen in Zone I, which had the highest mean soil (33.5 ppm) and water lead (18.2 ppb) concentrations. Lead concentration and pigmentation severity were shown to be significantly correlated ($r = 0.51$ for water, $r = 0.47$ for soil, $p < 0.001$) by correlation analysis. These findings are in accordance with international geospatial studies like those by Gonzalez M. and Bellinger D., who found that visual indicators of lead poisoning in adults and children were well predicted by soil and water lead levels.¹⁶ According to our research, Burtonian lines can

function as diagnostic markers at the community level that indicate environmental contamination at the local level, providing a useful surveillance tool in places without regular biomonitoring.

Overall, these findings support the notion that Burtonian lines are a clinically significant, non-invasive biomarker of lead toxicity that represents the interaction of systemic health, occupational hazard, environmental exposure, and nutritional condition. In environments with limited resources, the application of Burtonian lines as a field-level diagnostic tool shows great promise, highlighting the significance of including oral health evaluations into more comprehensive environmental and occupational health surveillance.

Conclusion

Burtonian lines were found to be highly prevalent among rural populations in Haryana, reflecting the cumulative impact of environmental contamination, occupational exposures, and dietary deficiencies. They serve as a simple yet powerful non-invasive diagnostic marker of systemic lead burden and should be incorporated into community health screening programs. Integrating oral health examinations with environmental monitoring and occupational safety measures could provide an effective strategy for early detection, prevention, and control of lead-related health risks in rural India.

Declarations

Ethics approval and consent to participate

An institutional ethics committee were formally presented with the proposal, and ethical approval were secured; the ethical clearance number provided was IEC-SGTDCHRI/FDS/RP/03.

Written informed consent was obtained by each research participant. They received assurances about the confidentiality of the information they provided for the study.

Consent for publication- Not applicable

Availability of data and materials- The datasets generated and/or analysed during the current study are not publicly available due to the inclusion of participant-level clinical and demographic information that could compromise individual privacy, but are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions-

The primary author Dr. Surbhi Priyadarshi was involved in conceptualization, framing and writing the manuscript while the second Author Dr. Shalini Kapoor helped with data collection and statistical analysis part of the manuscript.

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Figures



Figure 1

Patients with generalized bluish staining/pigmentation of gingiva



Figure 2

Patient with presence of generalized Burtonian lines

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Annexuresmerged.pdf](#)