

“Prevalence of Urinary and Cytological Abnormalities in Apparently Healthy Hostel-Residing University Students: A Cross-Sectional Study Using Routine Urinalysis and Rapid Papanicolaou Staining”

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Background: Routine urinalysis is a low-cost, non-invasive screening tool capable of detecting silent renal and urinary tract disease in apparently healthy individuals. Asymptomatic urinary abnormalities are rarely systematically documented among university hostellers, particularly in North-East India.

Objective: To describe the physical, chemical, microscopic and cytological (Rapid Papanicolaou-stained) urinalysis findings among apparently healthy hostel-residing students, to determine the prevalence of accidental urinary and cytological findings, and to test whether these findings differ significantly by sex.

Methods: This cross-sectional study was conducted in the Department of Medical Laboratory Technology, RIPANS, Aizawl, Mizoram, from February to April 2023. A total of 250 apparently healthy hostel-residing students (172 females, 78 males; age range 18–29 years) were enrolled by consecutive sampling. Random-voided urine specimens were analysed within two hours of collection for physical, chemical (reagent-strip) and microscopic parameters, together with Rapid Papanicolaou-stained urinary cytology. Descriptive statistics (frequencies, percentages, 95% Wilson confidence intervals) summarised findings; Pearson's chi-square test or Fisher's exact test (where any expected cell count was <5) compared findings by sex, with odds ratios (OR) and 95% confidence intervals (Wald method, Haldane–Anscombe corrected for zero cells); two-sided $p < 0.05$ was considered statistically significant.

Results: Of 250 participants, 145 (58.0%, 95% CI 51.8–63.9%) showed at least one abnormal urinalysis finding. Microscopy revealed pyuria in 23 (9.2%) participants, of whom 3 were suspected of urinary tract infection; bacteriuria in 6 (2.4%); yeasts in 2 (0.8%); and parasites (*Trichomonas vaginalis*) in 1 (0.4%). Crystalluria was the most frequent abnormality — calcium oxalate crystals in 60 (24.0%) and uric acid crystals in 50 (20.0%) — with triple phosphate crystals in 3 (1.2%). No haematuria or glycosuria was detected. Sex-stratified comparison showed that pyuria (12.2% vs 2.6%, OR 5.28, 95% CI 1.21–23.13, $p = 0.027$) and the presence of epithelial cells (75.6% vs 7.7%, OR 37.14, 95% CI 15.06–91.59, $p < 0.001$) were significantly more frequent among females than males, while triple phosphate crystals were significantly more frequent among males (3.8% vs 0.0%, $p = 0.030$); crystalluria (calcium oxalate, uric acid) and bacteriuria did not differ significantly by sex. On Rapid Pap-stained cytology, the majority of smears showed scanty cellularity (<5 cells/high-power field) with benign intermediate squamous cells, negative for intraepithelial lesion or malignancy; a minority showed inflammatory cellular change, and fungal hyphae morphologically consistent with *Candida* were noted in a small number of smears.

Conclusion: Urinary abnormalities, predominantly crystalluria and pyuria, were common among apparently healthy hostel-residing students, with a sex-specific pattern favouring higher pyuria and epithelial-cell shedding among females. Findings support the value of routine urinalysis as an inexpensive first-line screening tool in this population. Provision of clean filtered drinking water, counselling against tobacco use, and periodic health check-ups are recommended for hostel-based student populations.

Keywords: *urinalysis; urinary cytology; Rapid Papanicolaou stain; crystalluria; pyuria; asymptomatic screening; hostel students; North-East India*

1. Introduction

1.1 Background

The urinary system — comprising the kidneys, ureters, bladder and urethra — filters approximately 1,000 litres of blood daily to yield around one litre of urine, with 99% of the filtered fluid reabsorbed and the remainder excreted as a reflection of systemic metabolic and renal status.⁽¹⁾ Because urine composition mirrors renal, hepatic, endocrine and urological function, urinalysis has long been regarded as a “window” into internal physiology, evolving from ancient uroscopic practice into the modern, standardised physical, chemical and microscopic examination used today.^(1,2)

Urinalysis remains one of the most practical and cost-effective screening investigations available in clinical and public-health settings. It requires minimal technical infrastructure, can be performed within minutes, and yields information relevant to the detection of renal disease, diabetes mellitus, hepatobiliary disease, urinary tract infection (UTI) and hydration status.⁽²⁾ Microscopic examination of urinary sediment — including erythrocytes, leukocytes, epithelial cells, casts, crystals, bacteria, yeasts and parasites — adds diagnostic value beyond dipstick chemistry alone and remains indispensable wherever automated urinalysis platforms are unavailable.⁽²⁾

Urinary cytology complements routine urinalysis by enabling direct visualisation of exfoliated urothelial and squamous cells. Although neoplastic urothelial cells were first identified in urine as early as 1864, it was Papanicolaou and Marshall's landmark 1945 description that established the diagnostic utility of urinary cytology in urothelial malignancy.⁽³⁾ The Rapid Papanicolaou (Rapid Pap) stain — a hybrid of Romanowsky and conventional Papanicolaou techniques — preserves the diagnostic strengths of standard Pap staining while substantially reducing processing time, making it well suited to high-throughput screening settings such as institutional health surveillance programmes.⁽⁴⁾

1.2 Global and Regional Burden

Asymptomatic urinary abnormalities are increasingly recognised as a public-health concern because they may represent the earliest detectable signal of otherwise silent renal disease. Mass urinary screening programmes are well established in parts of East Asia (Japan, Korea, Taiwan) but remain inconsistently implemented in North America, Europe and much of the developing world, owing to unresolved questions about cost-effectiveness and the absence of regional consensus guidelines.⁽⁵⁾ Screening studies among university candidates, school children and community

cohorts across the Middle East, Africa and South Asia report a wide range of abnormality prevalence — from under 2% in some school-based dipstick programmes to more than 15% in university entrant cohorts — reflecting substantial heterogeneity in population characteristics, screening methodology and case definitions.⁽⁶⁻⁹⁾

Within India, and particularly in the North-Eastern states including Mizoram, hostel-residing student populations constitute a demographically distinct group: young adults living communally, often with shared water sources, variable dietary patterns, and limited access to routine preventive health check-ups outside acute illness presentation. Region-specific urinary screening data in this population are lacking, despite the recognised value of such data in informing institutional health policy.

1.3 Current Knowledge and Research Gap

Prior urinalysis screening studies have predominantly focused on hospitalised patients or school-aged children, with comparatively few studies examining apparently healthy university-aged hostellers using a combined urinalysis-plus-cytology approach.⁽⁶⁻⁹⁾ Furthermore, most published screening studies rely on chemical reagent-strip (dipstick) testing alone, without accompanying cytological evaluation of exfoliated urinary cells — an omission that limits the ability to characterise benign inflammatory, infective or reactive cytological change, and to exclude cytological atypia as an incidental finding. To our knowledge, no prior study has combined routine urinalysis with Rapid Pap-stained urinary cytology, together with formal inferential statistical comparison by sex, specifically among asymptomatic hostel-residing university students in North-East India.

1.4 Rationale

Given the low cost, minimal invasiveness and rapid turnaround of combined urinalysis and Rapid Pap cytology, this approach is well suited to institutional screening in resource-constrained settings such as regional paramedical training institutes. Characterising the baseline prevalence and pattern of urinary and cytological findings — and testing whether these differ by sex — can inform hostel-level preventive health measures (e.g., drinking-water quality and tobacco-use counselling) and provides a foundation for future longitudinal or comparative studies.

1.5 Study Aim, Objectives and Hypothesis

The aim of this study was to describe the pattern and prevalence of routine urinalysis and urinary cytological (Rapid Pap stain) findings among apparently healthy hostel-residing students at Regional Institute of Paramedical and Nursing

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Sciences(RIPANS) in Mizoram, North-East India, and to determine whether these findings differ significantly by sex.

The specific objectives were: (i) to describe urine examination findings — physical, chemical and microscopic — in apparently healthy individuals residing in RIPANS hostels; (ii) to determine the value of routine urinalysis as a screening test for clinically relevant urinary and renal abnormalities in this population; (iii) to assess the prevalence, with 95% confidence intervals, of accidental (incidental) urinary and cytological findings among the hostellers; and (iv) to compare the frequency of each urinalysis/cytology parameter between female and male participants using appropriate inferential statistical tests.

We hypothesised that a clinically meaningful proportion of apparently healthy, asymptomatic hostel residents would harbour detectable urinary abnormalities on routine screening, and that the pattern of these abnormalities would differ by sex, underscoring the value of periodic, sex-aware urinalysis-based surveillance even in the absence of overt symptoms.

2. Materials and Methods

2.1 Study Design

This was a prospective, cross-sectional prevalence study.

2.2 Study Setting

The study was conducted in the Cytology and Histopathology Laboratory of the Department of Medical Laboratory Technology (MLT), Regional Institute of Paramedical and Nursing Sciences (RIPANS), Aizawl, Mizoram. RIPANS was established in 1995–96 by the Ministry of Home Affairs, Government of India, under the North Eastern Council, and is situated on a 13.2-acre campus on the outskirts of Aizawl city.

2.3 Study Duration

Data collection was carried out over a three-month period, from February 2023 to April 2023.

2.4 Study Population

The study population comprised apparently healthy male and female students residing in the RIPANS boys' and girls' hostels. “Apparently healthy” was operationally defined as the absence of self-reported urinary symptoms (dysuria, frequency, urgency, flank pain, visible haematuria) at the time of enrolment.

2.5 Sample Size and Sampling Method

A total of 250 hostel-residing students were enrolled by consecutive (non-probability) sampling over the study period. No formal a priori sample-size calculation was performed; the sample size was determined pragmatically by the number of eligible, consenting hostellers available during the three-month study window. A post-hoc sensitivity check indicates that a sample of this size estimates a prevalence in the region of 58% with a 95% confidence interval of approximately ± 6 percentage points (Wilson method),

which is reported as a limitation in Section 4.6 rather than a substitute for prospective power calculation.

2.6 Inclusion Criteria

- Students residing in the RIPANS boys' or girls' hostels who provided a urine specimen and consented to participate.

2.7 Exclusion Criteria

- Students unwilling to provide a urine sample.
- Students who were acutely unwell or currently receiving medical treatment/medication.
- Female students who were menstruating at the time of collection.

2.8 Ethical Approval

This study involved human urine specimens collected for educational and screening purposes under institutional dissertation research at RIPANS, Mizoram University. Participants completed a structured questionnaire capturing demographic details and relevant clinical/dietary history, with an explicit assurance of confidentiality. Consents were taken from all the participants.

2.9 Data Collection Procedure

Eligible students were briefed on the purpose of the study and the correct technique for urine collection, and were provided with a sterile wide-mouth container (Uri-Col). A structured questionnaire captured demographic data (age, sex, state of residence) together with self-reported clinical history (prior UTI diagnosis, family history of UTI, diabetes, family history of diabetes, family history of bladder cancer, history of renal/ureteric calculi), dietary pattern (vegetarian/non-vegetarian), daily water intake, and tobacco use. Random-voided urine specimens were collected and transported to the laboratory for testing within two hours of collection to minimise pre-analytical degradation of formed elements and analytes.

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The overall study workflow, from participant enrolment through to descriptive and inferential statistical analysis, is summarised below.

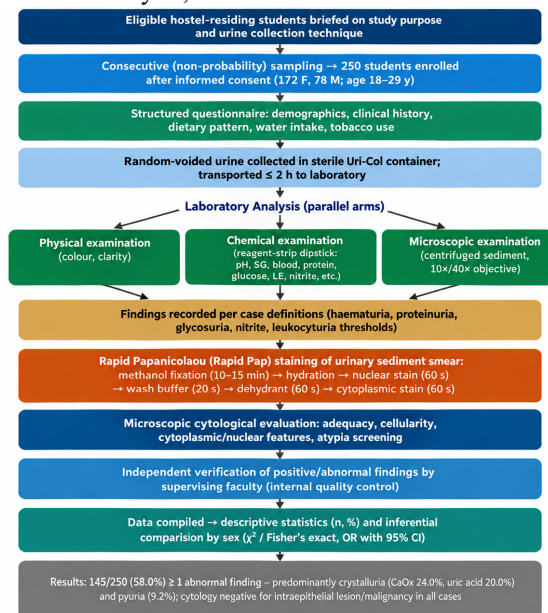


Figure 1. Study workflow: enrolment, specimen collection, parallel physical/chemical/microscopic examination, Rapid Pap staining, quality control and statistical analysis.

2.10 Laboratory Methods

2.10.1 Physical Examination

Colour and clarity were assessed by direct visual inspection of the mixed specimen against a light source, in accordance with standard urinalysis technique.(10)

2.10.2 Chemical Examination

Reagent (dipstick) strips were used to assess pH, specific gravity, blood, bilirubin, urobilinogen, nitrite, ketones, protein and leucocyte esterase. Strips were briefly immersed in well-mixed, uncentrifuged urine at room temperature, excess urine removed by blotting against the container edge, and colour reactions read against the manufacturer's reference chart after the specified reaction time, under adequate lighting.(10)

2.10.3 Microscopic Examination

Approximately 12 mL of urine was centrifuged at 2,500–3,000 rpm for 5 minutes; the supernatant was discarded, and the sediment was resuspended, mounted on a clean glass slide under a coverslip, and examined under 10× and 40× objective magnification for erythrocytes, leukocytes, epithelial cells, crystals, bacteria, yeasts and parasites.

2.10.4 Rapid Papanicolaou (Rapid Pap) Staining Procedure

Smears were prepared and immediately fixed in methanol for 10–15 minutes, then hydrated in tap water for 3–5 minutes and blotted. Nuclear stain was applied for 60 seconds and rinsed under running tap water; wash buffer was applied for 20 seconds and blotted; slides were dehydrated using Rapid-Pap dehydrant for 60 seconds; cytoplasmic stain was applied for 60 seconds; and slides were rinsed, blotted and examined microscopically (Figure 1 illustrates the full workflow).

2.10.5 Case Definitions

Urinalysis was considered abnormal if any of the following was present: haematuria (>5 – 10 RBC/ μ L); proteinuria of 1+ or greater; glycosuria of 1+ or greater; positive nitrite; or leukocyturia (>25 WBC/ μ L).(11) Cytological adequacy and findings were reported descriptively (adequate/satisfactory, unsatisfactory, or rejected specimen) with cellularity, cytoplasmic and nuclear features recorded per smear.

2.11 Quality Control

Reagent strips were used within their validity period and read against manufacturer colour charts under standard lighting. Microscopic and cytological findings were independently verified by supervising faculty in the MLT department (second-reader confirmation of all positive/abnormal findings) to minimise inter-observer variability.

2.12 Statistical Analysis

Data were entered in a structured spreadsheet and cross-checked for entry errors prior to analysis. Categorical variables (sex, individual urinalysis and cytology findings) are summarised as frequencies and percentages, with 95% confidence intervals for prevalence estimates calculated by the Wilson score

method, which performs better than the normal approximation at proportions close to 0% or 100%.

Sex-stratified inferential comparison: For each urinalysis/cytology parameter, a 2×2 contingency table (present/absent $\times$ female/male) was constructed. Pearson's chi-square test with Yates' continuity correction was applied when all expected cell counts were ≥ 5 ; Fisher's exact test was used instead whenever any expected cell count was < 5 , which was the case for several low-frequency findings (e.g., triple phosphate crystals, parasites). Effect size is expressed as the odds ratio (OR) for females relative to males, with 95% confidence intervals calculated by the Wald method on the log-odds scale; a Haldane–Anscombe correction (addition of 0.5 to each cell) was applied when any cell contained a zero count. A two-sided p-value < 0.05 was considered statistically significant. No correction for multiple comparisons was applied given the exploratory, hypothesis-generating nature of this secondary analysis.

Statistical analyses were performed using Python 3 (SciPy v1.11, statsmodels v0.14). Two-sided $p < 0.05$ was considered statistically significant throughout.

3. Results

3.1 Participant Characteristics

A total of 250 apparently healthy hostel-residing students were enrolled, comprising 172 females (68.8%) and 78 males (31.2%), aged 18–29 years (Table 1). All 250 specimens were assessable for both routine urinalysis and Rapid Pap-stained urinary cytology.

Table 1. Demographic and overall urinalysis characteristics of study participants (N = 250)

Characteristic	n	%
Total participants	250	100.0
Sex — Female	172	68.8
Sex — Male	78	31.2
Age range (years)	18–29	—
Overall urinalysis result — Abnormal (≥ 1 finding)	145	58.0
Overall urinalysis result — Normal	105	42.0

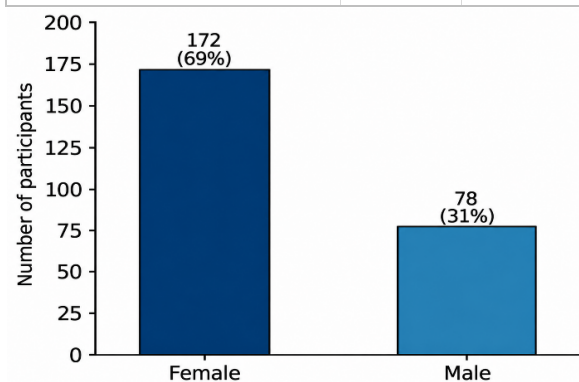


Figure 2. Sex distribution of study participants (n = 250).

3.2 Overall Urinalysis Findings

Of the 250 participants screened, 145 (58.0%, 95% CI 51.8–63.9%) demonstrated at least one abnormal finding on routine urinalysis and/or cytology, while 105 (42.0%) showed entirely normal findings (Figure 3).

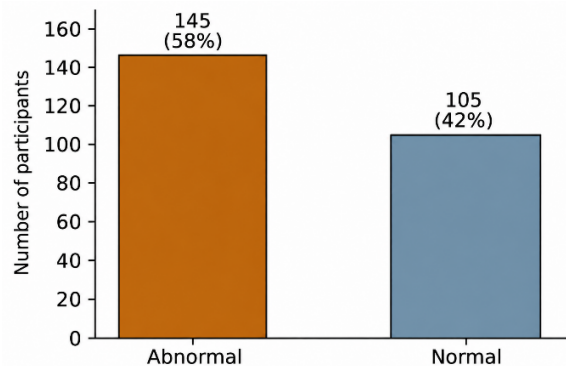


Figure 3. Overall distribution of normal versus abnormal urinalysis findings (n = 250).

3.3 Urinary pH Distribution

Urinary pH values ranged from 6.0 to 8.0, with the majority of participants (215/250, 86.0%) showing pH values of 6.0 or 6.5, consistent with a predominantly acidic to mildly acidic urine profile in this cohort (Table 2, Figure 4).

Table 2. Distribution of urinary pH values among study participants (N = 250)

Urinary pH	n	%
6.0	124	49.6
6.5	91	36.4
7.0	29	11.6
7.5	5	2.0
8.0	1	0.4

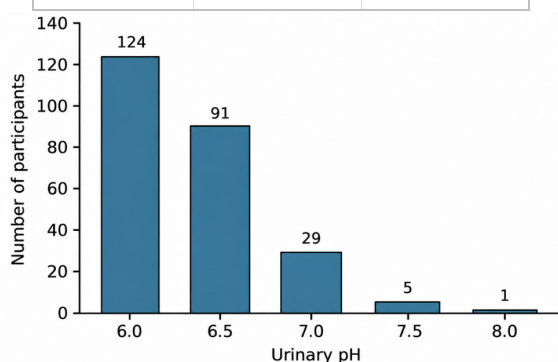


Figure 4. Distribution of urinary pH values (n = 250).

3.4 Microscopic and Cytological Findings by Sex

Microscopic and Rapid Pap-cytology findings by sex are summarised in Table 3. Epithelial cells were the most frequently observed sediment component overall (136/250, 54.4%), followed by calcium oxalate

crystals (60/250, 24.0%) and uric acid crystals (50/250, 20.0%). Pyuria was present in 23 participants (9.2%), of whom 3 were suspected of urinary tract infection. Bacteriuria was detected in 6 participants (2.4%); Gram-stained smears confirmed Gram-positive bacilli in all bacteriuric specimens, a morphology consistent with normal periurethral flora rather than a uropathogenic organism. Yeasts were identified in 2 participants (0.8%) and parasites (morphologically consistent with *Trichomonas vaginalis*) in 1 participant (0.4%). No haematuria (by microscopy case definition) or glycosuria was detected in any participant; dipstick blood-positivity, discussed separately in Table 5, did not meet the >5–10 RBC/μL microscopy threshold used to define confirmed haematuria in this study.

Table 3. Result distribution of routine urinalysis and cytological parameters by sex (N = 250), with row-wise percentages

Sex	Blood	Bilirubin	Urobilinogen	Leucocytes	Pyuria	Epithelial cells	Uric acid crystals	Calcium oxalate crystals	Triple phosphate	Bacteria	Parasites
Female (n = 172), n	13	5	3	4	21	130	30	46	0	5	0
Female, % of	7.6	2.9	1.7	2.3	12.2	75.6	17.4	26.7	0.0	2.9	0.0

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S e x	B l o o d	B i l i r u b i n	U r o b i l i n o g e n	L e u c o c y t e s	P y u r i a	E p i t h e l i a l c e l l s	U r i c a c i d c r y s t a l s	C a - o x a l a t e c r y s t a l s	T r i p l e p h o s p h a t e	B a c t e r i a	P a r a s i t e s
s u b g r o u p											
M a l e (n = 7 8) , n	2	3	1	0	2	6	2 0	1 4	3	1	1
M a l e, % o f s u b g r o u p	2 · 6	3. 8	1. 3	0. 0	2 · 6	7. 7	2 5 · 6	1 7 · 9	3. 8	1. 3	1. 3
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S e x	B l o o d	B i l i r u b i n	U r o b i l i n o g e n	L e u c o c y t e s	P y u r i a	E p i t h e l i a l c e l l s	U r i c a c i d c r y s t a l s	C a - o x a l a t e c r y s t a l s	T r i p l e p h o s p h a t e	B a c t e r i a	P a r a s i t e s
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% o f t o t a l c o h o r t	6 · 0	3. 2	1. 6	1. 6	9 · 2	5 4. 4	2 0 · 0	2 4 · 0	1. 2	2. 4	0. 4

3.5 Crystalluria and Abnormal Findings — Comparative Frequency

Among the abnormal findings, crystalluria predominated: calcium oxalate crystals were the single most common abnormality (60/250, 24.0%), followed by uric acid crystals (50/250, 20.0%) and pyuria (23/250, 9.2%). Triple phosphate crystals, bacteriuria, yeasts and parasites were each detected in fewer than 10% of participants (Table 4, Figures 5 and 6).

Table 4. Summary of abnormal urinalysis findings (N = 250)

Finding	n	% (of 250)	Notes
Pyuria	23	9.2	3 participants suspected of urinary tract infection
Bacteriuria	6	2.4	Gram-positive bacilli — consistent with normal flora
Yeasts	2	0.8	—

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Finding	n	% (of 250)	Notes
Parasites (<i>T. vaginalis</i>)	1	0.4	—
Calcium oxalate crystals	60	24.0	Most frequent abnormality overall
Uric acid crystals	50	20.0	—
Triple phosphate crystals	3	1.2	—
Haematuria	0	0.0	Not detected (microscopy case definition)
Glycosuria	0	0.0	Not detected

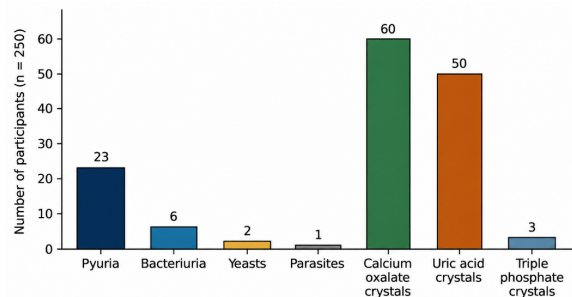


Figure 5. Frequency of individual abnormal urinalysis findings among study participants (n = 250).

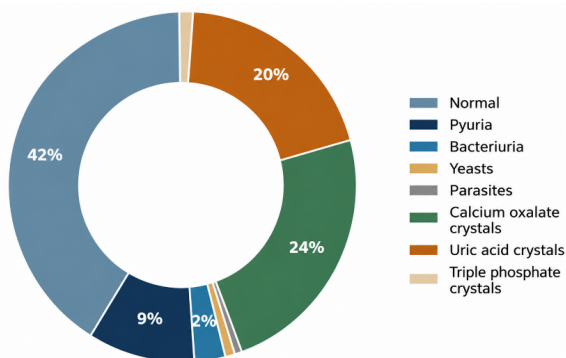


Figure 6. Composite distribution of all urinalysis findings, including normal specimens, expressed as a percentage of the total cohort (n = 250).

3.6 Sex-Stratified Statistical Comparison

Each urinalysis/cytology parameter was compared between female and male participants using chi-square or Fisher's exact tests as appropriate (Section 2.12). Three findings reached statistical significance (Table 5, Figures 7 and 8): pyuria and the presence of epithelial cells were significantly more common among females, whereas triple phosphate crystals were significantly more common among males. No

significant sex difference was found for dipstick blood-positivity, bilirubinuria, urobilinogenuria, calcium oxalate crystals, uric acid crystals or bacteriuria.

Table 5. Chi-square / Fisher's exact comparison of urinalysis and cytological findings by sex, with odds ratios (N = 250)

Parameter	Female n/172 (%)	Male n/78 (%)	Test used	Test statistic	p-value	OR (95 % CI), F vs M
Blood (dipstick)	13 (7.6)	2 (2.6)	Fisher's exact	—	0.157	3.11 (0.68–14.12)
Bilirubinuria	5 (2.9)	3 (3.8)	Fisher's exact	—	0.707	0.75 (0.17–3.21)
Urobilinogenuria	3 (1.7)	1 (1.3)	Fisher's exact	—	1.000	1.37 (0.14–13.35)
Leucocyturia (dipstick)	4 (2.3)	0 (0.0)	Fisher's exact	—	0.313	4.19 (0.22–78.84)
Pyuria (microscopy)	21 (12.2)	2 (2.6)	Chi-square	4.88	0.027*	5.28 (1.21–23.13)
Epithelial cells present	130 (75.6)	6 (7.7)	Chi-square	96.99	<0.001*	37.14 (15.06–91.59)
Uric acid crystals	30 (17.4)	20 (25.6)	Chi-square	1.77	0.183	0.61 (0.32–1.17)
Calcium oxalate crystals	46 (26.7)	14 (17.9)	Chi-square	1.82	0.177	1.67 (0.85–3.26)

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Parameter	Female n/172 (%)	Male n/78 (%)	Test used	Test statistic	p-value	OR (95% CI), F vs M
Triple phosphate crystals	0 (0.0)	3 (3.8)	Fisher's exact	—	0.030*	0.06 (0.0–1.23)
Bacteriuria	5 (2.9)	1 (1.3)	Fisher's exact	—	0.669	2.31 (0.26–20.07)
Parasites (<i>T. vaginalis</i>)	0 (0.0)	1 (1.3)	Fisher's exact	—	0.312	0.15 (0.01–3.72)

* $p < 0.05$, statistically significant. OR = odds ratio (female relative to male); a Haldane–Anscombe correction (+0.5 per cell) was applied to rows containing a zero cell.

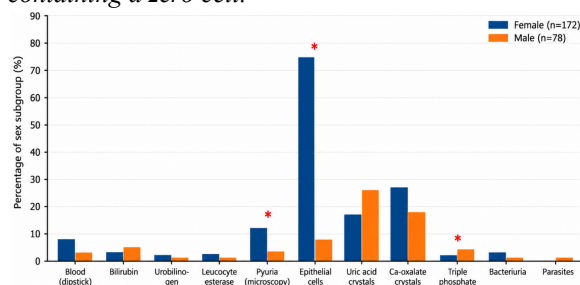


Figure 7. Urinalysis and cytological findings by sex (row percentages), with significant differences marked (* $p < 0.05$).

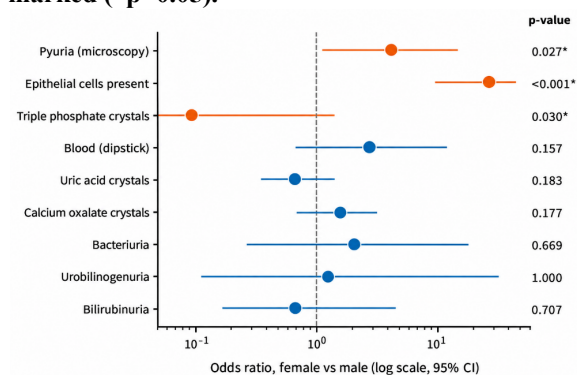


Figure 8. Forest plot of odds ratios (female vs male, log scale, 95% CI) for each urinalysis parameter.

3.7 Prevalence Estimates with 95% Confidence Intervals

To communicate the precision of the reported prevalence figures, 95% Wilson confidence intervals were calculated for the overall abnormality rate and for

each major individual finding (Figure 9). The overall abnormal-finding rate of 58.0% carries a 95% CI of 51.8–63.9%, indicating that the true population prevalence in comparable hostel cohorts most plausibly lies within this range. Confidence intervals for less frequent findings (bacteriuria, triple phosphate crystals, yeasts, parasites) are wide, reflecting the relatively small number of positive cases.

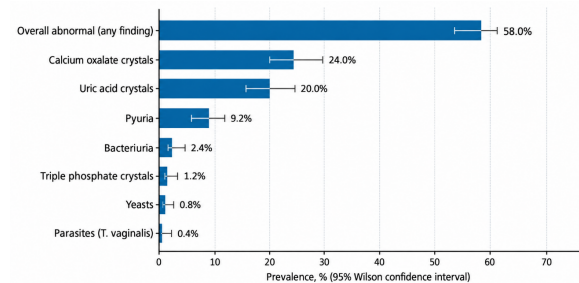


Figure 9. Prevalence of overall and individual abnormal findings with 95% Wilson confidence intervals (n = 250).

3.8 Ranked (Pareto) Distribution of Abnormal Findings

Ranking the individual abnormal findings by frequency shows that calcium oxalate and uric acid crystals together account for the large majority of all recorded abnormal-finding events, with pyuria contributing a further sizeable share; the remaining findings (bacteriuria, triple phosphate crystals, yeasts, parasites) are individually infrequent (Figure 10). This Pareto-type pattern reinforces that crystalluria, rather than infective or neoplastic pathology, is the dominant driver of the overall 58% abnormality rate in this cohort.

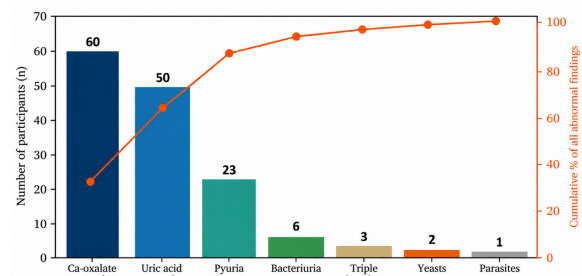


Figure 10. Pareto distribution of individual abnormal urinalysis findings, ranked by frequency, with cumulative percentage (n = 250).

3.9 Epithelial Cell Counts on Microscopy

Epithelial cell counts per high-power field (hpf) varied widely across specimens, ranging from nil to full-field coverage (Figure 11). The majority of specimens showed either no epithelial cells (113/250) or scanty counts in the 0–5/hpf range, consistent with adequately collected, minimally contaminated specimens; a smaller proportion showed higher counts (10–20/hpf) or full-field coverage. This distribution is consistent with the marked female excess in epithelial cell presence identified in Section 3.6 and most plausibly reflects a higher rate of vaginal-squamous-cell

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contamination in midstream specimens from female participants rather than a pathological process.

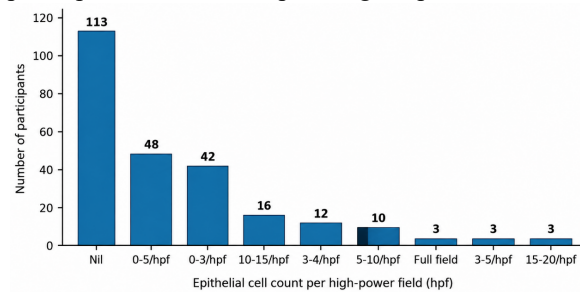


Figure 11. Distribution of epithelial cell counts per high-power field on microscopy (n = 250).

3.10 Rapid Papanicolaou-Stained Urinary Cytology and Photomicrographic Atlas

On Rapid Pap-stained cytology, the majority of specimens showed scanty cellularity (<5 cells/hpf) with a predominance of benign intermediate squamous cells, negative for squamous atypia, squamous metaplastic change, intraepithelial lesion or malignancy, and with no shift in flora observed. A minority of specimens showed cellular changes suggestive of inflammation, and fungal hyphae with morphology consistent with *Candida* species were identified in a small number of smears. Gram-positive bacilli, calcium oxalate, calcium carbonate, uric acid and triple phosphate crystals, red blood cells, pus cells and a parasite morphologically consistent with *Trichomonas vaginalis* were each identified on microscopy.

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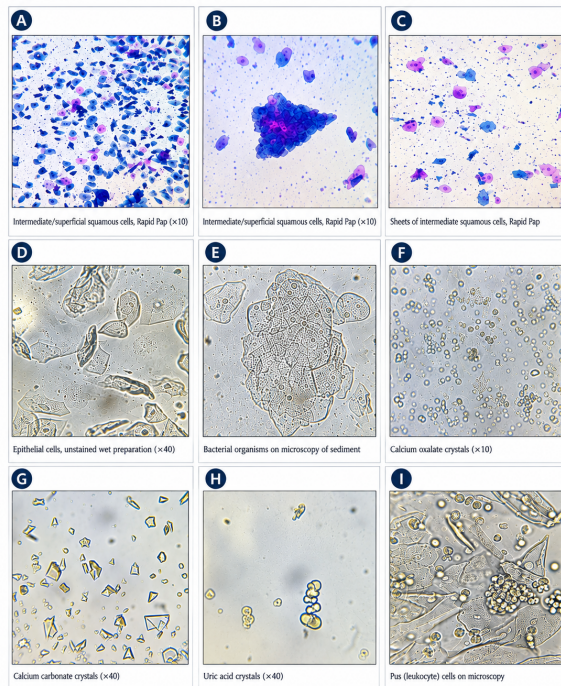


Plate I. Cytomorphological and microscopic findings — panels A–I: (A,B) intermediate/superficial squamous cells, Rapid Pap (×10); (C) sheets of intermediate squamous cells; (D) epithelial cells, unstained wet preparation (×40); (E) bacterial organisms; (F) calcium oxalate crystals (×10); (G) calcium carbonate crystals (×40); (H) uric acid crystals (×40); (I) pus (leukocyte) cells.

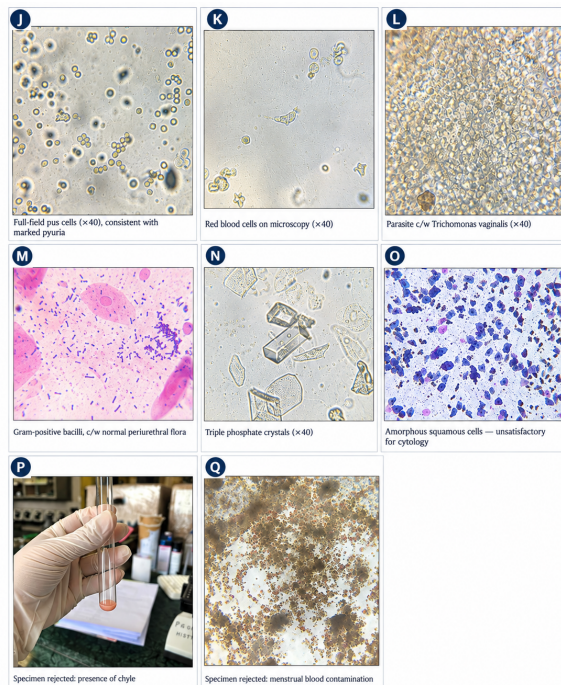


Plate II. Gram stain, parasite, crystal morphology and specimen adequacy — panels J–Q: (J) full-field pus cells (×40), marked pyuria; (K) red blood cells (×40); (L) parasite c/w *Trichomonas vaginalis*

(×40); (M) Gram-positive bacilli, c/w normal periurethral flora; (N) triple phosphate crystals (×40); (O) amorphous squamous cells, unsatisfactory for cytology; (P) specimen rejected — chyle; (Q) specimen rejected — menstrual blood contamination.

3.11 Specimen Adequacy

The majority of specimens were satisfactory for routine urinalysis and Rapid Pap-stained cytology. A small number of specimens were adequately processed but rendered unsatisfactory for cytological evaluation owing to obscuring blood or scanty squamous cellularity (Plate II, panel O), and a small number were rejected owing to the presence of chyle or contamination with menstrual blood (Plate II, panels P–Q).

3.12 Summary of Key Findings

- 58.0% (95% CI 51.8–63.9%) of apparently healthy hostel-residing students had at least one abnormal urinalysis finding.
- Crystalluria (calcium oxalate 24.0%, uric acid 20.0%) was the leading category of abnormal finding, together accounting for the majority of all abnormal-finding events (Pareto analysis, Figure 9).
- Pyuria (9.2%) and bacteriuria (2.4%, Gram-positive bacilli/normal flora) were present but comparatively infrequent.
- Pyuria ($p=0.027$) and epithelial-cell presence ($p<0.001$) were significantly more frequent in females; triple phosphate crystals were significantly more frequent in males ($p=0.030$). Crystalluria overall did not differ significantly by sex.
- No confirmed haematuria (microscopy case definition) or glycosuria was detected in this cohort.
- Rapid Pap-stained cytology was negative for intraepithelial lesion or malignancy in all specimens, with only minor inflammatory or fungal (*Candida*-morphology) changes noted incidentally.

4. Discussion

4.1 Principal Findings

In this cross-sectional screening of 250 apparently healthy hostel-residing university students in Aizawl, Mizoram, 58.0% demonstrated at least one abnormal urinalysis finding, most commonly crystalluria (calcium oxalate 24.0%, uric acid 20.0%) and pyuria (9.2%). No confirmed haematuria or glycosuria was detected, and Rapid Pap-stained urinary cytology was uniformly negative for intraepithelial lesion or malignancy, with only minor inflammatory or *Candida*-morphology fungal changes noted incidentally. Formal inferential testing showed that pyuria and epithelial-cell shedding were significantly more common among females, while triple phosphate crystals were significantly more common among

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males. These findings confirm that clinically silent urinary abnormalities are common even in an ostensibly healthy, young-adult, hostel-residing population, and that the pattern of abnormality is not uniform across sexes, supporting the feasibility and analytical value of combined urinalysis-cytology screening as an institutional health surveillance tool.

4.2 Comparison with Previous Studies

The overall abnormality prevalence observed here (58.0%) is markedly higher than that reported by Khalid and Haddad among 247 university candidates in Jordan, where 15% of students showed one or more urinary abnormality, with pyuria (8.1%), haematuria (6.1%) and albuminuria (4.8%) predominating.(6) It is likewise higher than the 1.3–1.9% abnormality rates reported in school-based dipstick screening programmes in Egypt and Malaysia.(7,8) This discrepancy most plausibly reflects methodological differences: unlike dipstick-only screening protocols, the present study incorporated detailed microscopic sediment examination, which is considerably more sensitive to crystalluria than chemical reagent-strip testing alone. Calcium oxalate and uric acid crystals — the leading abnormalities in our cohort — are frequently under-ascertained by dipstick-based protocols, which do not directly visualise urinary sediment.

The predominance of crystalluria over haematuria or proteinuria in our cohort also contrasts with several school-based screening studies from Nigeria, Egypt and Iran, in which haematuria and proteinuria were the leading reported abnormalities.(9,24,32) This may reflect differences in population age, dietary pattern (notably protein and oxalate intake), hydration status and environmental water-mineral content between our hostel-based young-adult cohort and the predominantly paediatric populations studied elsewhere.

Consistent with prior observations that urinary findings are more common in female than male participants in some cohorts, we found a significantly higher prevalence of pyuria among females (12.2% vs 2.6%, OR 5.28, $p=0.027$) — in keeping with the shorter female urethra and closer anatomical proximity to the perineal flora, both recognised contributors to a female excess in lower urinary tract colonisation. The markedly higher prevalence of epithelial cells among females (75.6% vs 7.7%, OR 37.14, $p<0.001$) most plausibly reflects a higher rate of vaginal-squamous-cell contamination of midstream specimens in female participants rather than a true sex difference in urothelial pathology, and should be interpreted as a specimen-collection phenomenon rather than a disease association. Conversely, triple phosphate crystals — which classically form in more alkaline urine, often associated with urease-producing organisms or a higher-protein/higher-purine dietary pattern — were seen exclusively among males in this cohort (3.8% vs 0.0%, $p=0.030$), although the small absolute number

of cases ($n=3$) warrants a cautious interpretation. Calcium oxalate and uric acid crystalluria, together with bacteriuria, did not differ significantly by sex (all $p>0.05$), suggesting that the principal driver of the overall abnormality rate — crystalluria — is not itself sex-dependent in this population, even though several secondary findings are. This pattern is broadly consistent with prior reports from Nigeria showing higher overall urinary abnormality rates in female participants, though it contrasts with an Egyptian study that found no significant effect of age or sex on screening outcomes; our formally tested, parameter-specific results help reconcile these apparently discrepant prior findings by showing that a sex effect is present for some parameters (pyuria, epithelial cells, triple phosphate) but not others (crystalluria overall, bacteriuria).(7,24)

The rate of pyuria and bacteriuria observed here (9.2% and 2.4% respectively) is broadly comparable to community and university-based screening prevalence reported elsewhere, and the confirmation of Gram-positive bacilli — rather than typical Gram-negative uropathogens such as *Escherichia coli* — in bacteriuric specimens supports an interpretation of normal periurethral flora rather than clinically significant infection in the majority of cases, consistent with prior cautions that urinalysis findings must be interpreted alongside clinical correlation and, where indicated, confirmatory urine culture.(9) The absence of confirmed haematuria and glycosuria in this cohort is reassuring and consistent with the generally low prevalence of these findings reported among asymptomatic young-adult populations in comparable screening studies.(23,40)

4.3 Diagnostic and Biological Considerations

Crystalluria of the type observed here — predominantly calcium oxalate and uric acid — is a common and frequently benign finding related to urinary concentration, dietary oxalate and purine intake, and hydration status, though persistent or heavy crystalluria may represent a risk factor for nephrolithiasis and warrants attention to fluid intake and dietary counselling. The finding that clean drinking-water access and adequate hydration were identified as relevant considerations in this hostel population aligns with the biological plausibility that concentrated, infrequently voided urine promotes crystal precipitation.(10) The Rapid Pap stain's utility in this study lay primarily in confirming the benign nature of exfoliated urothelial and squamous cells and excluding cytological atypia, consistent with its established diagnostic role in urothelial cytology since its original description by Papanicolaou and Marshall.(3,4)

4.4 Clinical and Public Health Relevance

These findings reinforce the value of urinalysis as an inexpensive, non-invasive, first-line screening tool capable of detecting silent urinary abnormalities in ostensibly healthy young adults — a population that

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infrequently accesses routine preventive health services outside acute illness presentation. The demonstration of a statistically significant sex difference in pyuria and epithelial-cell shedding suggests that hostel health surveillance protocols might reasonably apply sex-stratified reference expectations when interpreting screening urinalysis, to avoid over-calling epithelial contamination as pathological in female specimens while remaining appropriately alert to pyuria as a potential early UTI signal in this group. In resource-limited institutional settings such as RIPANS, periodic urinalysis screening, combined with basic counselling on hydration, diet and tobacco avoidance, represents a low-cost intervention with the potential to identify early, modifiable risk factors for renal and urinary tract disease.(5) Given the established value of mass urinary screening programmes in reducing progression to chronic kidney disease in some Asian health systems, similar institutional-level programmes may be a pragmatic model for resource-constrained regional settings such as Mizoram.(5)

4.5 Strengths

- Combined routine urinalysis and Rapid Pap-stained urinary cytology were performed in the same cohort, providing complementary chemical, microscopic and cytological data rarely reported together in prior screening studies.
- A relatively large, consecutively sampled cohort (n = 250) was screened over a defined three-month period at a single, well-characterised institutional setting.
- Formal inferential statistical testing (chi-square/Fisher's exact, with odds ratios and 95% confidence intervals) was applied to every urinalysis and cytology parameter by sex.
- Sex-stratified reporting of all microscopic and cytological parameters, including row-wise percentages, allows more granular interpretation than aggregate reporting alone.
- A consolidated two-plate photomicrographic atlas (Plates I–II) improves the visual accessibility and reviewer-friendliness of the image-heavy findings relative to dispersed single-panel figures.

4.6 Limitations

- The consecutive, single-centre sampling strategy and absence of a formal a priori sample-size calculation limit the generalisability of prevalence estimates to other hostel or university populations; the 95% confidence intervals reported in Section 3.7 should be consulted alongside all point estimates.

- Dietary intake, fluid intake and other lifestyle factors captured by questionnaire were not available at the participant level for multivariable analysis in this revision and so could not be formally tested for association with crystalluria or other findings, limiting causal inference.
- No confirmatory urine culture was performed for bacteriuric or pyuric specimens, limiting definitive diagnosis of urinary tract infection in the subset of participants flagged as suspected UTI cases.
- As a cross-sectional, single time-point study, the persistence, resolution or clinical significance of detected abnormalities over time could not be assessed.

4.7 Future Research Directions

Future studies should incorporate confirmatory urine culture for participants with pyuria or bacteriuria, participant-level multivariable analysis of associations between questionnaire-derived lifestyle variables (hydration, diet, tobacco use) and urinalysis findings, and longitudinal follow-up to determine the natural history and clinical significance of crystalluria detected on single-timepoint screening. Multi-centre studies across other North-East Indian hostel populations would help establish the generalisability of the high abnormality prevalence and the sex-specific pattern observed here, ideally with a priori sample-size calculation and pre-specified correction for multiple statistical comparisons.

5. Conclusion

5.1 Main Conclusion

Urinary abnormalities — predominantly crystalluria and pyuria — were common among apparently healthy, hostel-residing university students in this North-East Indian cohort, with 58.0% of participants showing at least one abnormal finding on routine urinalysis and/or cytology despite being asymptomatic. Formal statistical testing showed that this pattern is partly sex-dependent: pyuria and epithelial-cell shedding were significantly more frequent among females, while triple phosphate crystals were significantly more frequent among males. Rapid Pap-stained cytology confirmed the benign nature of these findings in all cases, with no evidence of intraepithelial lesion or malignancy.

5.2 Clinical Implications

Routine urinalysis should be considered a valuable, low-cost screening tool for institutional health surveillance in hostel-based student populations, capable of detecting clinically silent renal and urinary tract abnormalities that would otherwise go unrecognised in the absence of symptoms. Interpretation of individual parameters — particularly epithelial-cell counts and pyuria — may benefit from sex-aware reference expectations.

5.3 Recommendations

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- Institutions housing student hostellers should ensure access to clean, filtered drinking water to reduce the risk of concentrated urine and associated crystalluria.
- Students should be counselled against the use of tobacco and nicotine-containing products as part of routine hostel health education.
- Periodic urinalysis-based health check-ups are recommended for hostel-residing students, even in the absence of urinary symptoms.
- Participants with pyuria or bacteriuria suspicious for urinary tract infection should be referred for confirmatory urine culture and clinical evaluation, with particular attention to female hostellers given their significantly higher observed pyuria rate.

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Conflict of interest

The authors declare no conflict of interest.

Author contributions

SHT: Conceptualization, methodology, data collection, investigation, and manuscript preparation. Z: Data collection, investigation, and literature review. RVLTM: Data collection, investigation, and manuscript review. TRM: Data collection, investigation, and data curation. AMM: Data collection, investigation, and manuscript review. JNS: Methodology, data analysis, interpretation of results, and manuscript preparation. GG: Literature review, manuscript review, and editing. SM: Supervision, conceptualization, critical review, and final approval of the manuscript. All authors contributed to the interpretation of the findings, critically reviewed the manuscript, and approved the final version for publication.

All authors have read and agreed to the published version of the manuscript.

Ethical approval statement

The study was conducted in accordance with the Declaration of Helsinki and was reviewed and approved by the Institutional Ethics Committee of RIPANS. Written informed consent was obtained from all participants prior to enrolment.

Data availability statement

The datasets generated and/or analysed during the current study are available from the corresponding author upon reasonable request.

Consent statement

Written informed consent was obtained from all individual participants included in the study.

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