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Period Poverty and Menstrual Hygiene Management Among Adolescent Schoolgirls in the Northern Himalayas of India: A Cross-Sectional Study from Ladakh

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Abstract

Background

Period poverty is an important public health issue affecting the health, education and well-being of adolescent girls, particularly in remote settings. However, evidence from the high-altitude Northern Himalayas is limited. This study assessed period poverty and menstrual hygiene management (MHM) among adolescent schoolgirls in Ladakh, India.

Methods

A school-based cross-sectional study was conducted among 310 post-menarcheal adolescent girls from government schools in Leh and Kargil districts. Data on menstrual knowledge, hygiene practices, access to menstrual products, school WASH facilities, menstrual restrictions and absenteeism were collected using a structured questionnaire. Descriptive and logistic regression analyses were performed.

Results

Overall, 58.7% of participants experienced period poverty. Although 70.0% demonstrated good menstrual knowledge, only 66.1% reported good hygiene practices. While 94.2% used sanitary pads, 44.2% had used cloth due to unaffordability, 68.7% perceived pads as expensive and 27.1% lacked reliable access to menstrual products. Menstruation-related absenteeism affected 39.4% of girls, mainly because of menstrual pain. Poor hygiene practices were significantly associated with inadequate school menstrual waste disposal facilities.

Conclusions

Period poverty remains widespread among adolescent schoolgirls in the Northern Himalayas despite good menstrual knowledge. Improving affordable access to menstrual products and strengthening menstruation-friendly school WASH facilities are essential to support menstrual health and educational outcomes in remote Himalayan communities.

1. Introduction

1.1 Global context

Menstruation is a normal physiological process experienced by approximately 1.8 billion girls, women and gender-diverse people of reproductive age worldwide at any given time [1]. Yet for a substantial proportion of adolescent girls, menstruation is accompanied by inadequate knowledge, insufficient access to safe absorbent materials, poor water, sanitation and hygiene (WASH) provision and entrenched social stigma. The umbrella term “period poverty” describes the constellation of constraints-economic, material, infrastructural and informational-that prevent menstruators from managing their menstruation safely, hygienically and with dignity [2, 4]. Period poverty has gained increasing recognition

as a cross-cutting determinant of adolescent health, gender equality and education and is implicitly addressed within several of the United Nations Sustainable Development Goals (SDGs), notably SDG 3 (good health and well-being), SDG 4 (quality education), SDG 5 (gender equality) and SDG 6 (clean water and sanitation) [2, 3].

Globally, poor menstrual hygiene management (MHM) has been linked to reproductive and urinary tract infections, dermatological irritation, psychosocial distress, school absenteeism and reduced participation in daily activities [5, 8, 9]. In many low- and middle-income countries (LMICs), girls report using sub-optimal absorbent materials such as old cloth, tissue or other improvised items, change them infrequently and lack private spaces and disposal facilities [6, 10]. The cost of commercial menstrual products is a recurrent barrier; where products are unaffordable, girls fall back on reusable cloth that may be inadequately washed or dried, increasing infection risk [8, 26]. Menstrual stigma compounds these material constraints by limiting open communication, restricting movement and reinforcing harmful taboos [20, 29]. Adolescence is a particularly sensitive window: the establishment of menstrual practices at this stage shapes lifelong reproductive health behaviour, making the school setting a strategic platform for intervention [2, 49].

1.2 The Indian context

India is home to the world's largest adolescent population and menstrual health remains a significant public-health and equity challenge. National and sub-national surveys have documented wide disparities in the use of hygienic absorbent materials between urban and rural areas, across wealth quintiles and by maternal education [6, 38, 51]. Although government initiatives-including the Menstrual Hygiene Scheme, the distribution of subsidised sanitary napkins and the Swachh Bharat Mission's emphasis on school sanitation-have improved access in many districts, coverage remains uneven and the most remote and tribal communities are frequently underserved [25, 27, 50]. Rural and tribal adolescent girls face compounded disadvantages: limited purchasing power, weak supply chains for menstrual products, inadequate school WASH infrastructure and strong cultural restrictions surrounding menstruation [24, 28]. These barriers translate into measurable educational costs, including missed school days, reduced concentration and, in extreme cases, school dropout [40, 55]. Evidence from Indian states consistently shows that maternal education, household socioeconomic status and the availability of school sanitation are among the strongest correlates of safe menstrual practice [6, 37, 39].

1.3 The Himalayan and Ladakh context

The Union Territory of Ladakh occupies a unique position within this landscape. Situated in the trans-Himalayan cold desert at elevations frequently exceeding 3,000 metres, Ladakh is characterised by extreme aridity, prolonged sub-zero winters, sparse and widely dispersed settlements and formidable geographical isolation. Many villages are connected by roads that close for months during winter, constraining the supply of consumer goods-including menstrual products-and limiting access to health facilities. The cold-desert ecosystem imposes particular challenges for menstrual hygiene: water for washing is scarce and often frozen, sun-drying of reusable cloth is difficult during long winters and

indoor sanitation is limited in many traditional dwellings. Sociocultural norms rooted in local religious and community traditions can impose restrictions during menstruation, particularly on entry to religious spaces [17, 44]. Educational barriers intersect with these conditions; girls in remote blocks may travel long distances to school and menstruation-related discomfort or lack of facilities can disrupt attendance.

Despite these distinctive vulnerabilities, Ladakh's adolescent girls have been almost entirely absent from the menstrual-health evidence base. The region's small, dispersed population and logistical inaccessibility have meant that high-altitude cold-desert settings are rarely represented in MHM and period-poverty research, which has concentrated on plains, urban slums and flood-prone or humanitarian settings [11, 43, 48].

1.4 Research gap

To our knowledge, no peer-reviewed study has quantified period poverty and menstrual hygiene practices among adolescent schoolgirls in Ladakh and high-altitude regions more broadly remain conspicuously under-represented in the global literature [17, 55]. Existing Indian studies rarely disaggregate findings for remote mountain or tribal districts and the specific interplay between extreme climate, weak product supply chains, school WASH deficits and local cultural restrictions in shaping menstrual experience is poorly understood. This evidence gap hampers the design of context-appropriate policies for one of India's most geographically and climatically distinctive territories [41, 56].

1.5 Study objectives

General objective. The overarching objective of this study was to assess period poverty and menstrual hygiene practices among adolescent schoolgirls in the Union Territory of Ladakh, India and to identify the socio-demographic, infrastructural and cultural factors associated with menstrual hygiene practice.

Specific objectives were to: (i) describe the socio-demographic and menstrual characteristics of adolescent schoolgirls in Leh and Kargil districts; (ii) assess their menstrual knowledge and awareness; (iii) characterise menstrual hygiene practices, including absorbent use, frequency of change and disposal; (iv) estimate the prevalence of period-poverty indicators, including product affordability, access and menstruation-related school absenteeism; (v) document menstrual restrictions, taboos and school WASH conditions; and (vi) identify factors independently associated with good menstrual hygiene practice.

2. Methods

This study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cross-sectional studies [46].

2.1 Study area

The study was conducted in the Union Territory of Ladakh, the northernmost administrative territory of India, comprising the two districts of Leh and Kargil. Ladakh covers a vast, sparsely populated trans-Himalayan landscape with a total population of approximately 0.27 million (Census of India), giving one of the lowest population densities in the country. The territory is a high-altitude cold desert; most inhabited settlements lie between roughly 2,700 and 4,000 metres above sea level and the climate is marked by very low annual precipitation, intense solar radiation and winter temperatures that routinely fall well below freezing. Many blocks-including Nubra and the trans-Himalayan valleys-are accessible only seasonally. The economy is predominantly agropastoral and settlements are concentrated along river corridors, notably the Indus and its tributaries. The educational system is served largely by government schools, including recently upgraded PM-SHRI and government higher-secondary schools, which formed the sampling frame for this study. Surveyed respondents were drawn from 13 administrative blocks spanning both districts (Fig. 1).

2.2 Study design

A school-based, descriptive cross-sectional survey was carried out among adolescent schoolgirls during the 2026 academic field season. The cross-sectional design was selected to provide a representative snapshot of menstrual knowledge, practice and period poverty across the diverse blocks of Ladakh within the constraints of a single field campaign in a logistically challenging environment.

2.3 Study population

The study population comprised adolescent girls enrolled in government secondary and higher-secondary schools in Leh and Kargil districts who had attained menarche and were present on the day of the survey. Girls who had not yet begun menstruating and those who declined to participate, were excluded. The final analytic sample comprised 310 post-menarcheal adolescent girls.

2.4 Sampling strategy

A multistage purposive and convenience sampling approach was adopted, reflecting the dispersed settlement pattern and access constraints of the region. Within each district, administrative blocks were selected to capture geographical and altitudinal diversity and within each block, government schools with adolescent girl enrolment were approached. Within selected schools, all eligible post-menarcheal girls present and willing to participate were invited. The realised sample was distributed across 13 blocks, with the largest contributions from Nubra (n = 108), Khaltse (n = 42), Taisuru and Kargil (n = 33 each), Pashkum (n = 30) and Shargol (n = 21), among others (Fig. 1).

2.5 Sample size

With no prior estimate of period-poverty prevalence available for Ladakh, the proportion was conservatively assumed to be 50% to maximise the required sample. For a 50% expected prevalence, a 95% confidence level and a margin of error of approximately 5–6% yield a target in the order of 270–310 respondents. The achieved sample of 310 girls therefore provides adequate precision for descriptive prevalence estimates and supports multivariable modelling, while the cross-sectional, non-probability

design means findings remain best interpreted as hypothesis-generating for this hard-to-reach high-altitude setting. This limitation is considered explicitly in the Discussion.

2.6 Data collection

Data were collected using a structured, interviewer-administered questionnaire organised into nine thematic sections plus an attitude-and-perception (Likert) module. The questionnaire was developed by the authors specifically for this study following a review of the relevant literature on menstrual hygiene management and period poverty, and was designed to address the study objectives. The complete English version of the questionnaire is provided as Supplementary File 1. The domains comprised: (I) socio-demographic and household characteristics (district, block, school, age, class, family type and size, household income, household toilet, drinking-water source); (II) menstrual characteristics (menarche, cycle regularity, bleeding duration, dysmenorrhoea); (III) menstrual knowledge and information sources; (IV) menstrual hygiene practices (absorbent material, frequency of change, disposal, hand-washing); (V) period-poverty indicators (product access, source, menstruation-related absenteeism, use of cloth due to inability to afford pads, perceived cost); (VI) menstrual restrictions and taboos; (VII) school WASH facilities; (VIII) menstrual health experience and treatment-seeking; and (IX) self-reported principal problems and support needs. Items were pre-coded for direct entry. Trained female field investigators administered the questionnaire in the local language to ensure comprehension and comfort, and confidentiality was maintained throughout. Representative fieldwork settings are shown in Supplementary Figure S1.

2.7 Variables and operational definitions

Outcome variables. Two principal composite outcomes were derived. A menstrual-knowledge index summed four binary knowledge items (awareness of menstruation before menarche; understanding of menstruation as a natural process; knowledge of how to maintain cleanliness during menstruation; and awareness that poor menstrual hygiene can cause infection). A menstrual-practice index summed four binary practice items (use of sanitary pads, alone or in combination; changing the absorbent at least 2–3 times per day; disposal of used material in a bin; and hand-washing after changing). Following the approach used in comparable studies, each index was dichotomised at the sample mean, with scores above the mean classified as “good” and scores at or below the mean classified as “poor” [14, 34, 35]. A composite period-poverty indicator was defined as the presence of two or more of the following: no reliable access to pads when needed; use of cloth because pads could not be afforded; perception of pads as expensive or very expensive; and menstruation-related school absenteeism.

Predictor variables. Candidate predictors included district (Kargil/Leh), age group (12–13, 14–16, 17–21 years), school class, family type (nuclear/joint), household income category, presence of a household toilet, drinking-water source, availability of a school menstrual-waste disposal facility and menstrual restrictions. The coding scheme for all variables is summarised in Table 1 of the Results (Table V, variable dictionary, Supplementary).

2.8 Statistical analysis

Data were entered into a spreadsheet, cleaned and analysed using standard statistical software. Continuous variables were summarised as means and standard deviations (SD) and categorical variables as frequencies and percentages. Bivariate associations between predictor variables and the binary outcomes were assessed using the Pearson chi-square test (or Fisher's exact test where expected cell counts were small). Variables associated with good menstrual hygiene practice at a liberal screening threshold ($p < 0.20$) at the bivariate stage were entered into a binary logistic regression model to estimate crude and adjusted odds ratios (OR and AOR) with 95% confidence intervals (CI). A two-sided p-value < 0.05 was considered statistically significant. Analyses were performed using standard statistical software [37, 39].

2.9 Ethical considerations

The study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was obtained from the relevant Institutional Ethics Committee [approval number to be inserted] and administrative permission was granted by the school education authorities of Ladakh and by the head of each participating school. The objectives, voluntary nature and confidentiality safeguards of the study were explained to participants and school authorities. Written informed assent was obtained from participating adolescents and informed consent was obtained from a parent or guardian and/or the school authority acting in loco parentis for minors, in line with institutional requirements. Participation was entirely voluntary, no personal identifiers were retained and respondents could decline or withdraw at any point without consequence.

3. Results

3.1 Socio-demographic and menstrual characteristics

A total of 310 post-menarcheal adolescent girls were surveyed across 13 administrative blocks of Leh and Kargil districts. Just over half of the participants were from Kargil district (160; 51.6%) and the remainder from Leh (150; 48.4%). The mean age was 16.0 ± 1.8 years (range 12–21); 45.5% were aged 14–16 years and 44.8% were aged 17 years or older. The mean self-reported age at menarche was 12.9 ± 1.2 years (range 10–18) and the mean reported duration of menstrual bleeding was 6.1 ± 1.4 days. Nuclear and joint family structures were almost equally represented (45.5% and 46.8%) and the mean household size was 4.7 members. Almost all girls (94.5%) reported having a toilet at home; piped tap water (36.8%) and hand-pumps (22.3%) were the most common drinking-water sources, although 9.0% relied on river water. A large proportion of girls did not know their household income or did not report it (78.1%), reflecting limited awareness of household finances among adolescents. Socio-demographic characteristics are summarised in Table 1.

Table 1
Socio-demographic and menstrual characteristics of the respondents (N = 310).

Characteristic	Category	n (%)
District	Kargil	160 (51.6)
	Leh	150 (48.4)
Age group (years)	12–13	30 (9.7)
	14–16	141 (45.5)
	17–21	139 (44.8)
School class	Class 8	42 (13.5)
	Class 9	64 (20.6)
	Class 10	33 (10.6)
	Class 11	42 (13.5)
	Class 12	97 (31.3)
	Not stated	32 (10.3)
Family type	Nuclear	141 (45.5)
	Joint	145 (46.8)
	Not stated	24 (7.7)
Household income (₹/month)	< 10,000	22 (7.1)
	10,000–30,000	34 (11.0)
	> 30,000	12 (3.9)
	Do not know / not stated	242 (78.1)
Toilet at home	Yes	293 (94.5)
	No	17 (5.5)
Drinking-water source	Tap	114 (36.8)
	Hand-pump	69 (22.3)
	River	28 (9.0)
	Other / not stated	99 (31.9)
Age at menarche (years)	Mean ± SD	12.9 ± 1.2
Bleeding duration (days)	Mean ± SD	6.1 ± 1.4

Characteristic	Category	n (%)
Menstrual cycle	Regular	229 (73.9)
	Irregular	81 (26.1)
Dysmenorrhoea (period pain)	None	32 (10.3)
	Mild	176 (56.8)
	Moderate	88 (28.4)
	Severe	13 (4.2)
	Not stated	1 (0.3)

SD, standard deviation. Percentages are of the total sample (N = 310) unless otherwise indicated.

3.2 Menstrual knowledge and awareness

Overall menstrual knowledge was high. Most girls (97.7%) understood menstruation to be a natural physiological process, 96.5% knew how to maintain cleanliness during menstruation and 94.8% were aware that poor menstrual hygiene can cause infection. A large majority (78.1%) reported having known about menstruation before their first period. The dominant source of information was the mother (71.3%), followed by friends (16.8%); teachers, the internet and health workers each accounted for a small minority, underscoring the limited role of formal and digital information channels in this setting (Fig. 2). Applying the composite knowledge index (mean 3.7 of 4), 70.0% of girls were classified as having good knowledge. Knowledge indicators are presented in Table 2.

Table 2
Menstrual knowledge and awareness among adolescent schoolgirls (N = 310).

Knowledge indicator	n (%)
Understands menstruation as a natural process	303 (97.7)
Knows how to maintain cleanliness during menstruation	299 (96.5)
Aware that poor menstrual hygiene can cause infection	294 (94.8)
Knew about menstruation before menarche	242 (78.1)
Information source: mother	221 (71.3)
Information source: friends	52 (16.8)
Information source: teacher / internet / health worker / other	35 (11.3)
Composite index: good knowledge (above mean)	217 (70.0)
Composite index: poor knowledge (at or below mean)	93 (30.0)

3.3 Menstrual hygiene practices

Sanitary pads were the predominant absorbent material: 79.7% used pads exclusively and a further 14.5% used pads in combination with cloth, while only 5.8% relied on cloth alone-giving an overall pad-use prevalence of 94.2%. Most girls changed their absorbent 2–3 times per day (55.2%) or more than three times per day (24.8%), although one in five (20.0%) changed fewer than twice daily. Disposal practices were comparatively favourable, with 91.9% disposing of used materials in a bin; the remainder burned (8.1%) or placed them in the toilet (1.3%). All respondents (100%) reported washing their hands after changing. Applying the composite practice index (mean 3.7 of 4), 66.1% of girls were classified as having good practice. Practices are summarised in Table 3 and Fig. 3.

Table 3
Menstrual hygiene practices among adolescent schoolgirls (N = 310).

Practice	Category	n (%)
Absorbent material used	Pads only	247 (79.7)
	Pads and cloth	45 (14.5)
	Cloth only	18 (5.8)
Frequency of changing per day	< 2 times	62 (20.0)
	2–3 times	171 (55.2)
	> 3 times	77 (24.8)
Disposal of used material	Bin	285 (91.9)
	Burn	25 (8.1)
	Toilet	4 (1.3)
Hand-washing after changing	Yes	310 (100.0)
Composite index	Good practice	205 (66.1)
	Poor practice	105 (33.9)

3.4 Period-poverty indicators

Despite high pad use, period-poverty indicators were widespread. While 72.9% of girls reported reliable access to pads when needed, 27.1% did not. Notably, 44.2% of girls reported having used cloth specifically because they could not afford pads and the perceived affordability of pads was poor: 62.3% regarded pads as expensive and a further 6.5% as very expensive, with only 30.3% considering them affordable. Pads were sourced almost entirely from shops (93.9%), with negligible contributions from government supply (4.8%) or NGOs, indicating heavy reliance on out-of-pocket commercial purchase.

Applying the composite definition (≥ 2 of 4 indicators), 58.7% of girls were experiencing period poverty. Period-poverty indicators are presented in Table 4 and their geographical distribution in Fig. 4.

Table 4
Period-poverty indicators among adolescent schoolgirls (N = 310).

Indicator	n (%)
No reliable access to pads when needed	84 (27.1)
Used cloth because pads could not be afforded	137 (44.2)
Perceives pads as expensive	193 (62.3)
Perceives pads as very expensive	20 (6.5)
Obtains pads from shops (out-of-pocket)	291 (93.9)
Obtains pads from government supply	15 (4.8)
Menstruation-related school absenteeism	122 (39.4)
Composite period poverty (≥ 2 indicators)	182 (58.7)

3.5 School attendance and educational impact

Menstruation-related school absenteeism was reported by 39.4% of girls (122 of 310). Among those who specified a reason, menstrual pain/dysmenorrhoea was overwhelmingly the dominant driver (57.7% of all girls cited pain as a reason for missing school), while a smaller group attributed absence to a lack of pads (7.4%). The high contribution of pain is consistent with the dysmenorrhoea burden observed in Table 1, where 89.0% of girls reported some degree of period pain. Attendance outcomes are summarised in Table 5.

Table 5
Menstruation-related school attendance outcomes (N = 310).

Attendance outcome	n (%)
Ever missed school because of periods	122 (39.4)
Did not miss school because of periods	188 (60.6)
Reason for absence: pain	179 (57.7)
Reason for absence: no pads available	23 (7.4)
Reason for absence: no toilet / restrictions	0 (0.0)

Reasons are reported among all respondents. Categories are not mutually exclusive of the overall “ever missed” estimate.

3.6 Menstrual restrictions, taboos and school WASH conditions

Menstrual restrictions were reported by 52.3% of girls. Among those reporting restrictions, the overwhelming majority (98.1%) related to exclusion from religious spaces, with isolated reports of school- or other-type restrictions; restrictions on entering the kitchen-commonly reported in many Indian plains settings-were essentially absent in this sample. Just over half of girls (53.2%) felt shy or embarrassed discussing menstruation with others, indicating persistent communication taboos. School WASH provision was incomplete and emerged as a key vulnerability: although 90.6% of girls reported a separate girls' toilet and 89.0% reported a water facility at school, only 41.0% attended a school with a menstrual-waste disposal facility (59.0% had none) and only 55.5% reported that sanitary pads were reliably available at school when needed. School-level WASH conditions differed markedly by district (see Section 3.7). Restrictions, taboos and WASH conditions are summarised in Table 6.

Table 6
Menstrual restrictions, taboos and school water-sanitation-hygiene (WASH) conditions (N = 310).

Item	n (%)
Reports any menstrual restriction	162 (52.3)
- Restriction from religious places (among restricted, n = 162)	159 (98.1)
Feels shy discussing menstruation	165 (53.2)
School has general menstrual facility	229 (73.9)
School has separate girls' toilet	281 (90.6)
School has water facility	276 (89.0)
School has menstrual-waste disposal facility	127 (41.0)
Sanitary pads reliably available at school	172 (55.5)

3.7 Factors associated with menstrual hygiene practice

In bivariate analysis, good menstrual hygiene practice differed significantly by district: girls in Leh district were substantially more likely to demonstrate good practice (79.3%) than girls in Kargil district (53.8%; $\chi^2 = 21.49$, $p < 0.001$). Counter-intuitively, attending a school that reported having a disposal facility was associated with lower odds of good practice ($\chi^2 = 24.99$, $p < 0.001$); this paradox is examined in the Discussion and reflects the confounding of district-level differences, where Leh schools more often lacked formal disposal facilities yet girls there showed better individual practice. Age was also associated with practice ($\chi^2 = 11.37$, $p = 0.003$). Menstrual knowledge, period poverty, family type, household toilet and income were not significantly associated with practice at the bivariate level.

In the multivariable logistic regression model, the absence/presence of a school disposal facility remained independently associated with practice (AOR 0.35, 95% CI 0.21–0.59; $p < 0.001$ for having a reported disposal facility relative to not having one). With the larger sample, district also remained an independent predictor: girls in Leh district had roughly twice the odds of good practice compared with Kargil (AOR 2.03, 95% CI 1.12–3.69; $p = 0.020$), consistent with district-level differences in school-level WASH characteristics. Age group was no longer significantly associated with practice after adjustment (14–16 years: AOR 1.05, 95% CI 0.40–2.79; $p = 0.920$). Crude and adjusted estimates are presented in Table 7. For completeness, predictors of good knowledge were also examined; knowledge did not differ significantly across age groups ($\chi^2 = 2.47$, $p = 0.291$) and no socio-demographic factor was significantly associated with the composite period-poverty outcome (all $p > 0.05$), indicating that period poverty was pervasive across sub-groups rather than concentrated in any single stratum.

Table 7
Crude and adjusted predictors of good menstrual hygiene practice among adolescent schoolgirls (binary logistic regression).

Covariate	Good practice, n (%)	Crude OR (95% CI)	Adjusted OR (95% CI)	p (adj.)
District: Kargil (ref)	86 (53.8)	1.00	1.00	-
District: Leh	119 (79.3)	3.30 (2.00-5.46)	2.03 (1.12–3.69)	0.020*
Age 12–13 (ref)	23 (76.7)	1.00	1.00	-
Age 14–16	104 (73.8)	0.86 (0.34–2.16)	1.05 (0.40–2.79)	0.920
Age 17–21	78 (56.1)	0.39 (0.16–0.97)	0.65 (0.25–1.74)	0.394
School disposal facility: no (ref)	142 (77.6)	1.00	1.00	-
School disposal facility: yes	63 (49.6)	0.28 (0.17–0.46)	0.35 (0.21–0.59)	< 0.001*
Low household income: no (ref)	193 (67.0)	1.00	1.00	-
Low household income: yes	12 (54.5)	0.59 (0.25–1.42)	0.88 (0.34–2.28)	0.795
Good knowledge: no (ref)	62 (66.7)	1.00	1.00	-
Good knowledge: yes	143 (65.9)	0.97 (0.58–1.62)	0.94 (0.54–1.65)	0.840

*OR, odds ratio; CI, confidence interval; ref, reference category. *p < 0.05. The negative association of a reported school disposal facility with individual good practice reflects district-level confounding (see*

Discussion). Adjusted model controls for district, age group, school disposal facility, low income and knowledge.

3.8 Menstrual challenges reported by respondents

When the principal challenges experienced during menstruation were ranked, pain and cramps were by far the most common (89.4%), followed by the perception of pads as expensive (68.7%), the absence of a school disposal facility (59.0%), embarrassment in discussing menstruation (53.2%) and menstrual restrictions (52.3%). Nearly all girls (98.4%) identified menstrual cramps and mood disturbance as their biggest problem and 98.4% expressed a need for support-most frequently maternal support. The ranked profile of challenges is shown in Fig. 5.

4. Discussion

This study provides, to our knowledge, the first quantitative characterisation of period poverty and menstrual hygiene practices among adolescent schoolgirls in the high-altitude cold desert of Ladakh. The central finding is a striking dissociation between high menstrual knowledge (70.0% classified as good; 97.7% recognising menstruation as natural) and the persistence of substantial material deprivation: 58.7% of girls met a composite definition of period poverty, 44.2% had used cloth because they could not afford pads and 68.7% perceived pads as expensive or very expensive. This pattern indicates that, in Ladakh, the binding constraints on safe menstruation are economic and infrastructural rather than purely informational-a finding with direct implications for intervention design [4, 56].

4.1 Period poverty

The high prevalence of period poverty, despite near-universal pad use, is best understood as a problem of affordability and supply rather than absence of demand or awareness. Reliance on out-of-pocket commercial purchase was almost total (93.9% sourced pads from shops), with negligible government or NGO provision, leaving households exposed to the elevated retail prices that characterise remote, seasonally accessible markets. This contrasts with settings where subsidised or free distribution has expanded-such as parts of mainland India under the Menstrual Hygiene Scheme [25, 50]-and resonates with affordability barriers reported elsewhere in South Asia [12, 13, 57]. In rural and flood-affected Bangladesh, roughly one in ten girls cited the cost of pads as a barrier and a large majority were reported unable to afford better products; comparable affordability constraints have been described in Nepal, Pakistan and across sub-Saharan Africa [13, 16, 36, 52]. The Ladakh figure of 44.2% using cloth specifically due to cost is high relative to many of these comparators and likely reflects the compounding effect of remoteness on product prices and availability [18, 31].

4.2 Menstrual hygiene practices

Menstrual hygiene practices in this sample were, in several respects, more favourable than commonly reported in South Asian studies. Pad use (94.2% alone or combined) considerably exceeded the 55.4% reported among flood-affected Bangladeshi schoolgirls and the 37.7% national pad-use estimate cited

for Bangladeshi women and bin disposal (91.9%) was dramatically higher than the 1.6% reported in that Bangladeshi sample [11, 12]. Hand-washing after changing was universal. These relatively strong practices likely reflect the high knowledge levels, near-universal household toilets (94.5%) and the influence of school-based sanitation upgrades. Nonetheless, important gaps remained: one in five girls changed their absorbent fewer than twice daily and only 66.1% achieved the composite good-practice threshold. The persistence of cloth use among the poorest, combined with the cold-desert constraints on washing and sun-drying reusable materials, raises infection-risk concerns analogous to those documented in studies linking unhygienic management to reproductive and urinary tract infections [8, 9, 26].

4.3 School absenteeism

Menstruation-related absenteeism affected 39.4% of girls, a level comparable to or exceeding estimates from several Indian and African studies [15, 40, 45, 47]. Crucially, the dominant driver in Ladakh was menstrual pain (57.7%) rather than lack of products or facilities, mirroring the high dysmenorrhoea burden (89.0% reporting some pain) [39, 45]. This points to an under-recognised dimension of period poverty in this setting-the inadequate management of dysmenorrhoea-where only 13.9% of girls sought any treatment and most of those relied on home remedies, with minimal recourse to clinical care. Addressing absenteeism in Ladakh will therefore require not only product access and facilities but also pain-management education and school-based health support [41, 49].

4.4 Cultural restrictions

Just over half of girls reported menstrual restrictions and these were almost exclusively restrictions on entering religious spaces (98.1% of those restricted). This profile differs from many plains-Indian and Bangladeshi settings, where kitchen and food-related restrictions predominate; in Ladakh, dietary and kitchen taboos were essentially absent [22, 23, 24]. The concentration of restriction in the religious domain reflects the region’s distinctive cultural and spiritual landscape and suggests that culturally tailored engagement-working with community and religious institutions-will be more relevant than messaging focused on kitchen taboos [20, 44]. The finding that 53.2% of girls felt shy discussing menstruation indicates that communication taboos, while less severe than in some comparator settings, remain a barrier to help-seeking and open dialogue [22,50,68].

4.5 Public-health and educational implications

The independent association between school WASH characteristics and menstrual practice is the most actionable finding of this study. Although the bivariate direction of the disposal-facility association was paradoxical-an artefact of district-level confounding, since Leh girls showed better individual practice despite their schools more often lacking formal disposal facilities-the robust retention of school disposal status in the adjusted model underscores that the school environment is a key modifiable determinant. From a public-health perspective, menstruation-responsive school WASH (private toilets, water, soap, safe disposal and reliable product availability) represents a high-yield investment [2, 46, 49]. The educational implications are equally clear: with one-third of girls missing school during

menstruation, deficits in facilities and pain management translate directly into lost learning time and potential long-term disadvantage.

4.6 Policy relevance and SDG implications

The findings map directly onto multiple SDGs. Persistent period poverty undermines SDG 3 (health), SDG 4 (education), SDG 5 (gender equality) and SDG 6 (water and sanitation) [30, 32, 56]. For the Ladakh administration, the data make a strong case for integrating subsidised or free menstrual-product distribution into the school system, strengthening government and NGO supply chains to buffer households against high retail prices in remote markets and upgrading school disposal and product-availability infrastructure. Because awareness is already high, the marginal returns to information-only campaigns are likely to be modest relative to investments that relieve affordability and infrastructural constraints. Comparative experience from India, Nepal, Bhutan, Pakistan, Bangladesh and African contexts consistently shows that combined interventions-product access, facilities and education-outperform single-component approaches [33, 49, 53] and the Ladakh evidence reinforces the priority of the material and infrastructural components in this high-altitude cold-desert setting.

5. Strengths and Limitations

This study has several strengths. It is the first to generate quantitative period-poverty and MHM evidence for adolescent schoolgirls in Ladakh, a high-altitude cold-desert region almost entirely absent from the literature. The sample spans both districts and 13 administrative blocks, capturing substantial geographical and altitudinal diversity and data were collected by trained female investigators in the local language to enhance comfort and validity. The use of composite, mean-referenced knowledge and practice indices follows established methodology and facilitates comparison with prior studies [14, 34, 35].

Several limitations must be acknowledged. First, the cross-sectional design precludes causal inference; associations between school WASH conditions, age and practice should be interpreted as correlational. Second, although the sample of 310 girls is substantial for this hard-to-reach region and adequately powered for the descriptive and multivariable analyses presented, the dispersed multistage purposive/convenience sampling necessitated by the region’s inaccessibility means the sample is not strictly probability-based, so generalisability beyond the surveyed blocks should be made with caution. Third, the questionnaire was pre-coded and locally administered but was not formally psychometrically validated for Ladakh and self-reported behaviour is subject to social-desirability and recall bias-pad use and hand-washing may be over-reported. Fourth, household income was unknown or unreported for the majority of adolescents, weakening socioeconomic analyses. Fifth, the composite period-poverty and outcome definitions, while transparent, are study-specific and may not be directly comparable to other operationalisations. Finally, the study sampled only in-school girls, omitting out-of-school adolescents who may experience the most severe period poverty. Larger, probability-based and mixed-methods studies, ideally incorporating biomarker or clinical follow-up of infection outcomes, are warranted.

6. Conclusions

Among adolescent schoolgirls in the high-altitude cold desert of Ladakh, menstrual knowledge was high and basic hygiene practices were comparatively good, yet period poverty was pervasive: nearly six in ten girls met a composite period-poverty definition, four in ten had used cloth because they could not afford pads and three in ten lacked reliable product access. Menstruation-related absenteeism affected one-third of girls and was driven principally by inadequately managed pain. School WASH provision-particularly disposal facilities and reliable product availability-emerged as a key modifiable determinant of practice, while cultural restrictions, concentrated in the religious domain and communication taboos persisted. Because awareness is already high, the priorities for Ladakh are material and infrastructural: affordable or free products, robust supply chains, menstruation-responsive school facilities and dysmenorrhoea management, delivered with cultural sensitivity. These measures are essential to protect the health, dignity and education of adolescent girls in one of India's most remote and climatically extreme regions.

7. Policy Recommendations

Based on the evidence, the following actionable recommendations are proposed for key stakeholders.

For schools:

- Ensure every school has functional, private girls' toilets with water and soap and install safe menstrual-waste disposal facilities (incinerators or covered bins) in all blocks.
- Maintain a reliable in-school stock of free or subsidised sanitary pads, with discreet access points and designate a trained female focal teacher for menstrual health.
- Provide rest space and basic pain-relief support to reduce dysmenorrhoea-related absenteeism.

For the Department of Education:

- Integrate a standardised, culturally appropriate menstrual-health curriculum into school education, emphasising pain management and dispelling taboos and engaging boys and teachers.
- Monitor menstruation-related absenteeism as an education-quality indicator, with district-disaggregated reporting for Leh and Kargil.

For the Health Department:

- Strengthen adolescent-friendly health services to manage dysmenorrhoea and menstrual disorders, given that only 13.9% of girls currently seek any treatment.
- Expand government supply of sanitary products through health centres and frontline workers to reduce reliance on high-priced commercial retail.

For NGOs and development partners:

- Support last-mile product distribution and winter stockpiling to buffer seasonally inaccessible blocks such as Nubra.
- Pilot environmentally appropriate disposal and reusable-product solutions suited to cold-arid conditions, with attention to safe drying.

For policymakers and the Ladakh administration:

- Establish a territory-wide menstrual-health policy that prioritises product affordability, school WASH infrastructure and supply-chain resilience, explicitly aligned with SDGs 3, 4, 5 and 6.
- Allocate dedicated budget lines for free product distribution and school disposal infrastructure, with culturally sensitive community and religious-institution engagement.
- Commission a larger, probability-based survey including out-of-school adolescents to guide and evaluate these investments.

Abbreviations

AOR, adjusted odds ratio; CI, confidence interval; LMIC, low- and middle-income country; MHM, menstrual hygiene management; OR, odds ratio; SD, standard deviation; SDG, Sustainable Development Goal; STROBE, Strengthening the Reporting of Observational Studies in Epidemiology; WASH, water, sanitation and hygiene.

Declarations

Ethics approval and consent to participate. The study was approved by the Institutional Ethics Committee of University of Ladakh, Leh, India. Informed assent was obtained from participating adolescents and informed consent from a parent/guardian or the school authority acting in loco parentis. Participation was voluntary and anonymous.

Consent for publication. Not applicable; no individually identifiable data are presented. Field photographs (Supplementary Figure S1) do not identify individuals.

Availability of data and materials. The dataset analysed during the current study is 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. Conceptualisation, methodology and supervision: Mohd Rafee and Saket Kushwaha. Investigation and data collection: Mohd Rafee, Tsewang Dolma and Jigmet Tsomo. Formal analysis and visualisation: Mohd Rafee and Tsewang Dolma. Writing-original draft: Tsewang Dolma,

Stanzin Khenrab and Jamila Banoo. Writing-review and editing: all authors. All authors read and approved the final manuscript.

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Figures

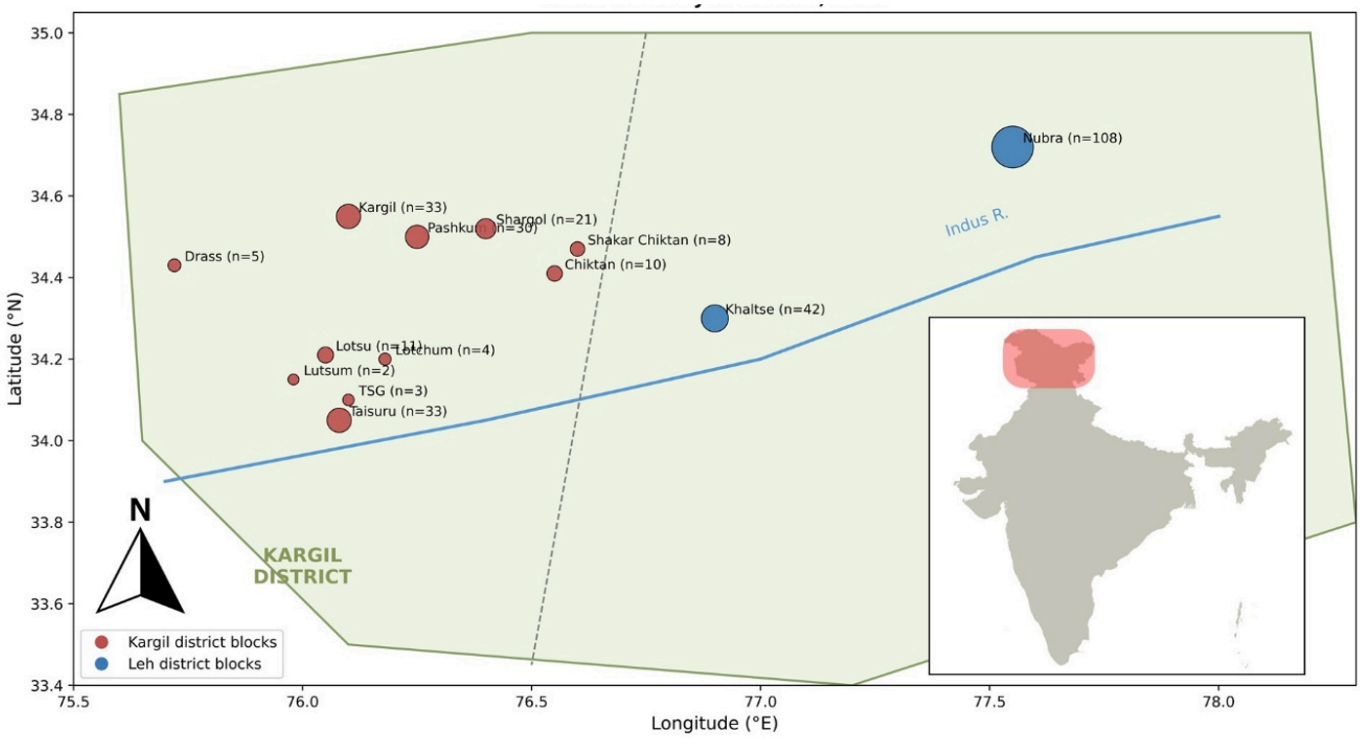


Figure 1

Study area map showing the Union Territory of Ladakh and the distribution of surveyed administrative blocks across Kargil district (red) and Leh district (blue). Marker size is proportional to the number of respondents per block.

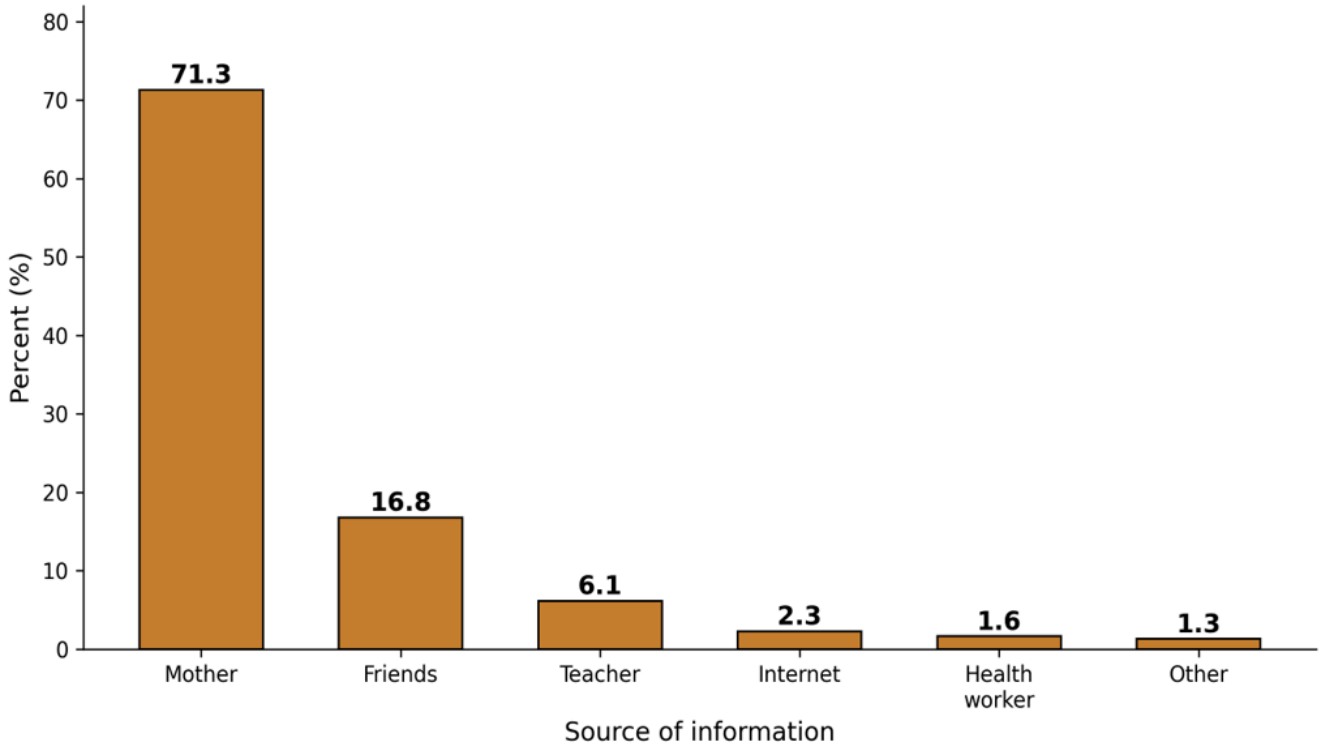


Figure 2

Sources of information on menstruation reported by adolescent schoolgirls in Ladakh. The mother was by far the most common source, with formal channels (teachers, health workers) and digital sources contributing minimally.

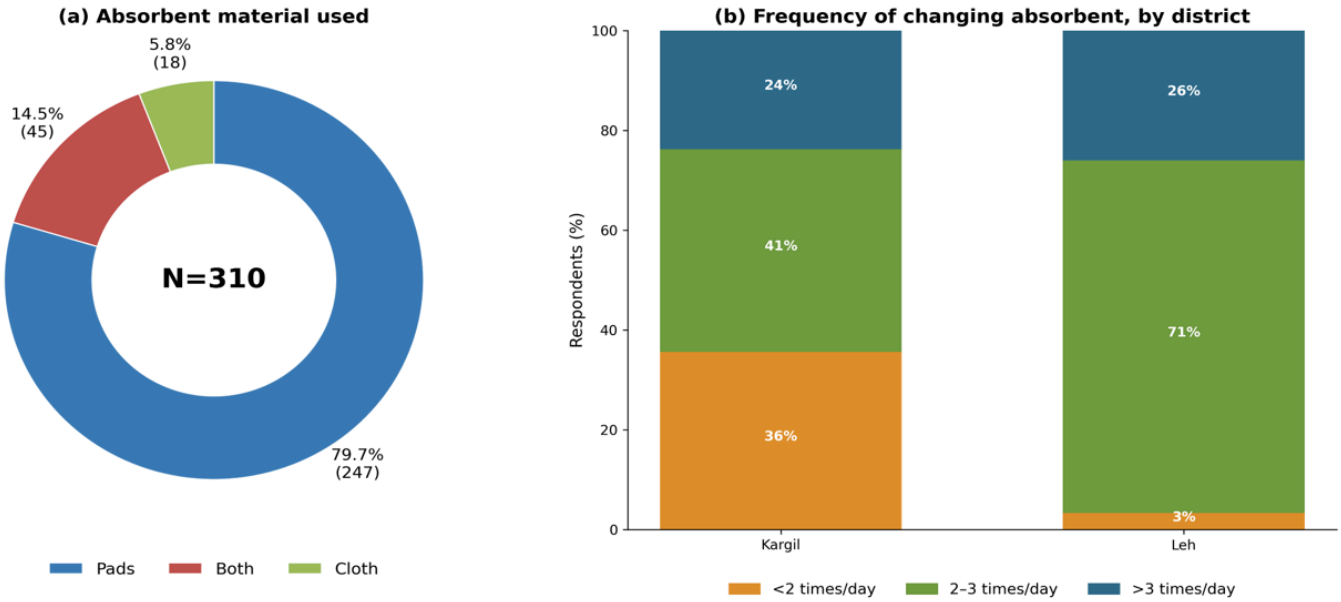


Figure 3

Menstrual product usage and hygiene behaviour. (a) Distribution of absorbent materials used during menstruation (donut chart). (b) Frequency of changing the absorbent per day, disaggregated by district (stacked bar chart).

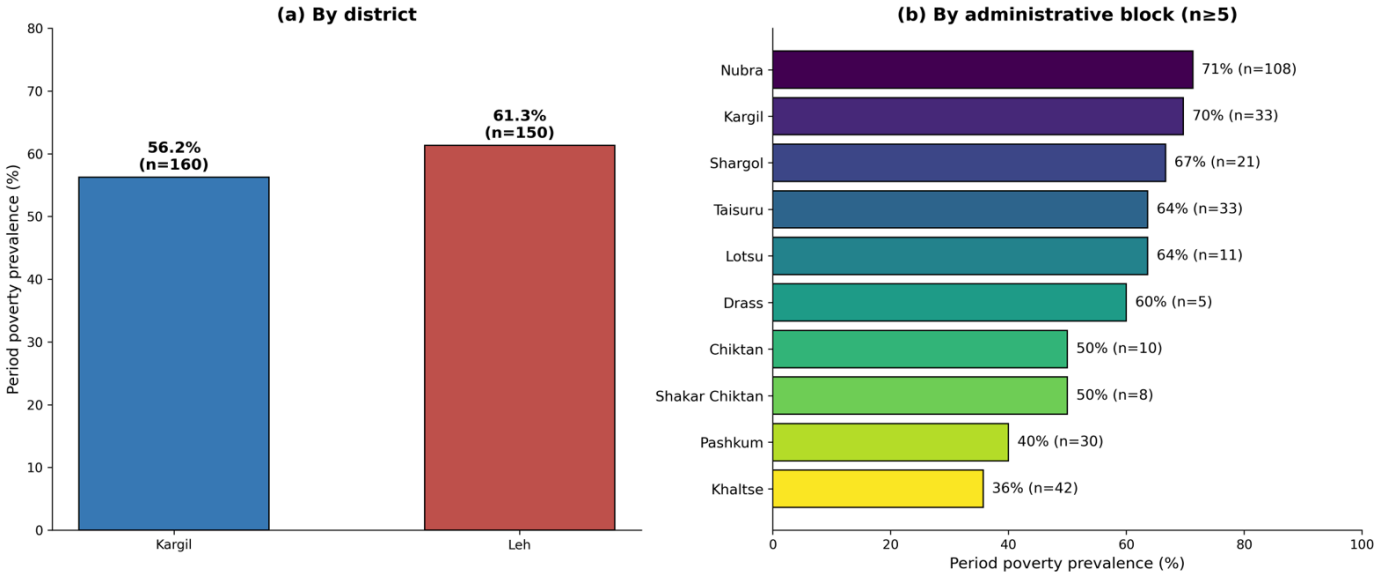


Figure 4

Prevalence of period poverty among adolescent schoolgirls. (a) Composite period-poverty prevalence by district. (b) Prevalence by administrative block, ordered from lowest to highest.

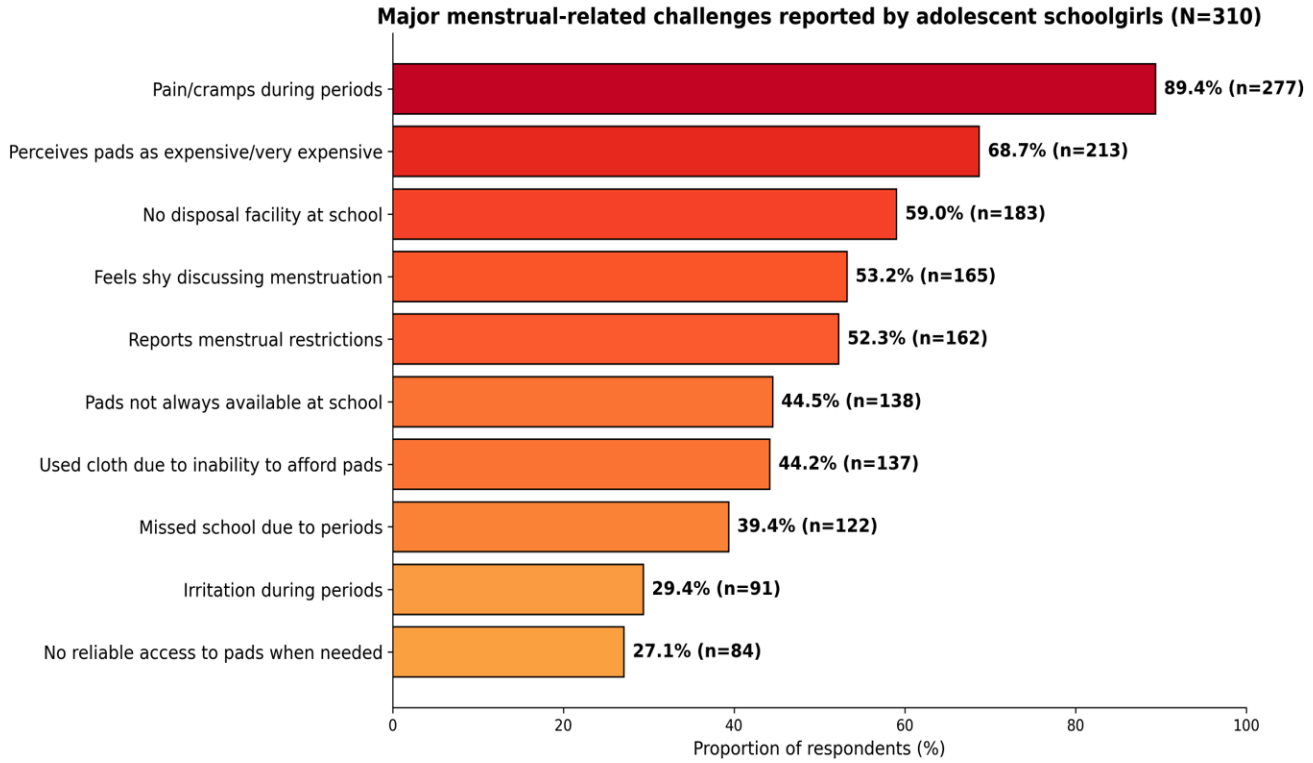


Figure 5

Major menstrual-related challenges reported by adolescent schoolgirls in Ladakh, ranked by the proportion of respondents affected (N = 310). Pain/cramps, product affordability and the absence of school disposal facilities dominate the burden.

Supplementary Files

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

- SupplementaryFile1.Englishversionofthestudyquestionnaire.pdf
- SupplementaryMaterial.docx