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Determinants and spatial patterns of hygienic menstrual practices among tribal Women in India

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Abstract

Background Menstrual hygiene management (MHM) is a critical yet neglected component of women's reproductive health in India, particularly among tribal populations who face compounded socio-economic, cultural, and geographic disadvantages. Despite improvements in hygienic menstrual practices at the national level, tribal women continue to lag behind, and evidence on spatial and socio-economic heterogeneity within this group remains limited.

Methods This study uses data from the National Family Health Survey-5 (NFHS-5, 2019–21) to examine the prevalence, spatial distribution, and determinants of exclusive hygienic menstrual practices among 44,392 tribal women aged 15–24 years in India. Exclusive hygienic practice was defined as the use of sanitary napkins, locally prepared napkins, tampons, or menstrual cups without concurrent use of unhygienic methods. Descriptive statistics, district-level spatial mapping, and multivariable logistic regression analyses were used to examine the determinants and spatial distribution of exclusive hygienic menstrual practices.

Results Only 65.4% of young tribal women exclusively used hygienic menstrual methods, with substantial variation across states and districts. Higher education and household wealth were strongly associated with greater odds of hygienic practice, while rural residence and increasing age reduced the likelihood. The availability of improved toilet facilities was positively associated with hygienic menstrual use. Significant regional disparities were observed, with lower odds in central India and higher odds in southern and western regions. District-level maps suggested substantial intra-state variation in exclusive hygienic menstrual practices.

Conclusions Persistent socio-economic and spatial inequalities continue to shape menstrual hygiene practices among tribal women in India. Interventions must move beyond uniform national strategies and adopt region- and district-specific approaches that integrate education, poverty alleviation, reproductive health awareness, and improved access to affordable menstrual products to advance menstrual equity among tribal populations.

1 Introduction

Menstruation is a fundamental component of women's reproductive health. Menstrual hygiene management encompasses the practices and resources necessary to promote health during menstruation [1]. Women of reproductive age, 15–49 years, constitute nearly 380 million, or 26.5% of India's population, highlighting the necessity

for supporting menstrual health management [2]. While menstruating, adolescent girls and women adopt various methods to manage menstrual blood and bloodstains. Historically, social and cultural factors have presented barriers to menstrual hygiene for women in India [3]. This includes restrictions imposed on daily activity and life for individuals while they are menstruating [4,5]. While social norms can vary widely across different tribal groups, girls and women can be subject to stringent restrictions when menstruating. For instance, a study among adolescent girls in a tribal area of Nagpur district found that 98% were not allowed to attend religious functions, and 65.9% were not allowed to attend classes during menstruation [6]. Furthermore, socioeconomic factors, such as wealth and education, impact women's knowledge and ability to practice hygienic menstrual practices [7,8]. Poor menstrual hygiene management has implications for one's physical and mental health [9,10]. Additionally, menstrual hygiene management has effects on education and livelihood opportunities for girls and women [11,12]. These factors are exacerbated in the experiences of tribal girls and women in India. This population merits focus due to the lower prevalence of hygienic menstrual practices, lower levels of reproductive health knowledge, and cultural practices and taboos that view menstruation as unclean [13]. This paper examines the prevalence, spatial distribution, and socio-economic determinants of exclusive hygienic menstrual practices among young tribal women aged 15–24 years in India, using data from the National Family Health Survey 5. While prior studies largely analyze the general population and rural-urban gaps, this paper isolates tribal women to identify determinants within this marginalized population rather than between tribal and non-tribal groups. This analysis is specific to the tribal population and provides evidence for targeted tribal health programming, rather than documenting general patterns of inequality.

The tribal population in India accounts for about 104 million people, encompassing 8.6% of the population and constituting over 730 Scheduled Tribes notified under Article 342 of the Constitution of India [14]. Tribal populations face unique challenges to better health, exacerbated by tribal populations' geographical isolation, poverty, and lack of access to healthcare [15]. Prior studies on menstrual health in India have demonstrated a lack of knowledge of the ovulatory cycle [16] and a lower prevalence of hygienic menstrual practices among tribal women and girls compared to general caste women [17] in India. Research on women's health in India has highlighted the relationship between the use of menstrual hygiene practices and factors including higher education, wealth index, and urban residence [18,19]. Determinants of hygienic menstrual practices among tribal women and adolescents have received less attention. Studies have noted hygienic menstrual practices among tribal populations are significantly associated with higher education and wealth status, and positively associated with measures of higher autonomy and mass media exposure [17,20,21]. Additionally, one study found higher odds of knowledge of the ovulatory cycle among tribal women with higher-educated partners, knowledge and use of contraceptive methods, and urban residence [16].

Existing literature on the determinants of tribal health using national-level data has subsumed the entire population of tribal girls and women in one group. However, within India's tribal population, there is a large amount of diversity. For instance, while the average literacy rate among India's tribal population was 59% at the time of the 2011 Census [22], certain groups have been identified as "Particularly Vulnerable Tribal Groups" (PVTGs) on account of having literacy rates far below this average [23]. In Odisha, the state with the highest number of PVTGs, literacy rates are as low as 3.52% among females in some PVTGs [23]. Additionally, the status of women in tribal communities also varies. Women in some tribal communities are afforded higher status and rights, such as ownership over ancestral property, while in other tribal communities, this is not the case [24]. Furthermore, exposure to religion has led to the introduction of both greater freedoms—including access to education—and restrictions—including segregation between genders and discouragement of divorce [24].

Given this diversity of India's tribal population, spatial analysis has the potential to clarify our understanding of the determinants of hygienic menstrual practices among tribal girls and women. Existing spatial analysis of menstrual health in India has provided support to previous analysis finding the association between hygienic menstrual practice and urban/rural residence, education, wealth, and toilet facility availability [25,26]. Studies have observed a north-south regional gap, with lower use of hygienic methods in northern and central regions

[27,28]. While these regional trends have been illustrated spatially [18], there remains a need to understand the factors associated with the use of hygienic menstrual practices within these areas and groups with historically low prevalence of hygienic practices. Despite growing evidence on menstrual hygiene practices in India, nationally representative analyses focusing exclusively on tribal populations remain limited. Existing studies often aggregate tribal women as a homogeneous group, overlooking substantial regional, cultural, and socio-economic heterogeneity. Moreover, spatial variation in menstrual hygiene practices among tribal women has received little empirical attention. Addressing this gap, the present study examines the prevalence, spatial distribution, and socio-economic determinants of exclusive hygienic menstrual practices among young tribal women aged 15–24 years in India using NFHS-5 data.

2 Data and methods

2.1 Data source

This analysis uses survey data collected in the National Family Health Survey 5, conducted in 2019–2021. The National Family Health Survey (NFHS) is conducted to collect state and national-level data on key population health indicators. The NFHS-5 includes information from 724,115 individual women of reproductive age, aged 15–49 years. The following analysis focuses on individual and household characteristics related to demographics, reproductive health, and behaviour.

NFHS-5 used a stratified two-stage sampling design based on the 2011 Census to produce representative estimates at the national, state/union territory, and district levels [29]. Villages in rural areas and Census Enumeration Blocks in urban areas were selected as primary sampling units (PSUs) using probability proportional to size, after stratification and sorting by factors such as Scheduled Caste/Scheduled Tribe (SC/ST) population. Then, 22 households per cluster were randomly selected. The NFHS-5 survey was administered through household interviews in sampled households, with a longer questionnaire implemented in a 15% subsample to collect more detailed state-level information on selected topics.

2.2 Variable description

The dependent variable in this study was exclusive hygienic menstrual practice. In the National Family Health Survey-5 (NFHS-5, 2019–21), women were asked what they used as "protection to prevent bloodstains" during menstruation, with response options including cloth, locally prepared napkins, sanitary napkins, tampons, menstrual cups, nothing, and other materials Sanitary napkins, locally prepared napkins, tampons, and menstrual cups were classified as hygienic menstrual methods, while cloth, nothing, and other materials were categorized as unhygienic methods because of their association with adverse reproductive health outcomes, including reproductive tract infections and abnormal vaginal discharge [31,32]. The question was administered only to women aged 15–24 years. The effective sample size for the present analysis was 44,392 tribal women aged 15–24 years.

The independent variables included respondents' age, place of residence (urban/rural), religion, educational attainment, wealth index, employment status, toilet facility, water source, exposure to mass media, and region/state. Age was categorized into two groups: 15–19 years and 20–24 years. Educational attainment was categorized as no education, primary, secondary, and higher education. Employment status was categorized as currently working and not currently working. Toilet facilities and water sources were categorized as improved or unimproved according to NFHS standards. The wealth index was based on the NFHS-5 household wealth quintile variable and categorized into the poorest, poorer, middle, richer, and richest quintiles. Exposure to mass media was used as an indicator of women's empowerment and was derived from respondents' exposure to newspapers, radio, or television. Respondents reporting exposure to at least one media source were coded as "exposed," while those reporting no exposure to all three sources were coded as "not exposed."

The selection of explanatory variables was guided by the social determinants of health framework for menstrual health. Accordingly, the analysis incorporated individual-level factors (age and education), household socioeconomic factors (wealth index, employment status, and WASH availability), empowerment-related factors (mass media exposure), and contextual factors (residence, religion, and region/state). Previous studies have shown that menstrual hygiene practices are strongly shaped by both material access and social environments, supporting the inclusion of these variables in the analysis.

2.3 Statistical analysis

Descriptive statistics were used to examine the socio-demographic characteristics of tribal women and the prevalence of exclusive hygienic menstrual practices across different population groups and regions. District-level spatial maps were prepared to illustrate the geographic distribution of exclusive hygienic menstrual practices among tribal women in India.

Binary logistic regression models were employed to examine the association between socio-demographic characteristics and exclusive hygienic menstrual practices among tribal women aged 15–24 years. The outcome variable was coded as 1 if respondents reported exclusive use of hygienic menstrual methods (sanitary napkins, locally prepared napkins, tampons, or menstrual cups) without concurrent use of unhygienic methods, and coded as 0 otherwise.

Two regression models were estimated. Model 1 included age, place of residence, religion, educational attainment, and region. Model 2 additionally adjusted for wealth index, employment status, exposure to mass media, toilet facility, and water source. Results are presented as odds ratios (ORs) with 95% confidence intervals (CIs). Multicollinearity among explanatory variables was assessed using the Variance Inflation Factor (VIF), and no evidence of problematic multicollinearity was observed, as all VIF values were below the acceptable threshold. All analyses accounted for the complex survey design of NFHS-5 using sampling weights to ensure nationally representative estimates.

3 Results

Table 1 presents the socio-demographic and economic characteristics of tribal women aged 15–24 years included in the NFHS-5 survey. A large majority of tribal women resided in rural areas (86.7%). With respect to economic status, most respondents belonged to the poorer wealth quintiles, with 44.4% in the poorest quintile and 26.3% in the poorer quintile. In terms of educational attainment, the majority of tribal women had completed secondary education (68.9%), while only a small proportion had higher education (10.4%). Approximately three-fourths of respondents were exposed to mass media (71.5%).

Regarding sanitation and water access, 55.7% of tribal women belonged to households with improved toilet facilities, while 84.6% had access to improved water sources. The majority of respondents identified as Hindu (86.4%), followed by Christian (7.7%). Regionally, the highest proportion of tribal women was concentrated in the eastern (25.2%) and central (24.6%) regions of India, followed by the western region (19.7%). At the state level, the largest unweighted samples of tribal women were reported from Arunachal Pradesh, Meghalaya, and Chhattisgarh.

4 Menstrual hygienic practices among tribal populations

Table 2 presents the distribution of exclusive hygienic menstrual practices among tribal women across states in India. Substantial interstate variation in exclusive hygienic menstrual practices was observed among tribal women. Maharashtra accounted for the highest proportion of tribal women reporting exclusive hygienic menstrual

Table 1 Demographic and socio-economic characteristics of tribal women population in India, NFHS-5 (2019-21)

Background characteristics	%(weighted)	*N*	%(weighted)	*N*
Menstrual hygienic				
No hygienic method	34.6	13,903		
Uses hygienic method	65.4	30,489		
Age (years)				
15–19	50.2	22,563	51.7	15,870
20–24	49.8	21,829	48.3	14,619
Residence				
Urban	13.3	5,794	17.3	5,068
Rural	86.7	38,598	82.7	25,421
Religion				
Hindu	86.4	26,005	85.1	16,303
Muslim	2.3	1,503	2.2	1,021
Christian	7.7	13,089	8.7	10,120
Other	3.7	3,795	4.0	3,045
Education				
No education	11.8	4,182	6.5	2,732
Primary	9.0	3,644	6.4	1,933
Secondary	68.9	31,936	72.9	8,750
Higher	10.4	4,630	14.3	488
Wealth index				
Poorest	44.4	17,908	34.9	9,362
Poorer	26.3	12,643	27.8	9,156
Middle	15.9	7,709	18.8	6,380
Richer	8.5	4,300	11.4	3,873
Richest	4.9	1,832	7.1	1,718
Currently Working				
Not	76.5	5,247	78.4	3,699
Yes	23.5	1,433	21.6	876
Mass media exposure				
Not exposed	28.5	12,184	19.5	6,180
Exposed	71.5	32,208	80.5	7,723
Toilet facility				
Unimproved	44.3	14,806	37.8	8,113
Improved	55.7	29,586	62.2	22,376
Water source				
Unimproved	15.4	7,697	14.9	5,003
Improved	84.6	36,695	85.1	25,486
Region				
North	11.6	4,251	13.0	3,007
Central	24.6	8,884	18.7	4,315
East	25.2	6,772	26.2	2,173
North-East	9.1	17,633	10.4	3,832
West	19.7	4,246	18.8	1,657
South	10.3	2,606	13.0	428

practices, followed by Rajasthan and Odisha. Considerable variation was also evident across northeastern and central Indian states, highlighting the spatial heterogeneity in menstrual hygiene practices among tribal populations in India.

Additionally, hygienic menstrual practice details by practice type and region are provided in Table 3. The use of cloth, recorded as an unhygienic menstrual hygiene practice, is the most prevalent practice recorded in all regions except for the Northeast and the South, where the use of sanitary napkins is the most prevalent reported practice.

Table 2 Exclusive menstrual hygienic practice among tribal populations by state, NFHS-5 (2019-21)

States	Percent	*N* (total women, unweighted)
Jammu & Kashmir	0.2	221
Himachal Pradesh	0.2	96
Punjab	0.1	8
Uttarakhand	0.5	135
Haryana	0.6	60
Nct of Delhi	0.1	7
Rajasthan	9.2	1822
Uttar Pradesh	1.0	195
Bihar	3.4	323
Sikkim	0.3	203
Arunachal Pradesh	1.7	4601
Nagaland	1.6	2705
Manipur	0.6	1083
Mizoram	2.3	1833
Tripura	1.2	596
Meghalaya	3.5	4335
Assam	3.1	1359
West Bengal	6.5	338
Jharkhand	5.3	1559
Odisha	7.4	1453
Chhattisgarh	6.1	3081
Madhya Pradesh	7.1	2971
Gujarat	5.7	929
Dadra & Nagar Haveli and Daman & Diu	0.5	255
Maharashtra	18.8	1211
Andhra Pradesh	2.0	74
Karnataka	6.1	560
Goa	0.2	41
Lakshadweep	0.1	164
Kerala	0.3	27
Tamil Nadu	1.5	44
Puducherry	0.0	2
Andaman & Nicobar Islands	0.0	87
Telangana	3.2	399
Ladakh	0.1	322
Total	**100.0**	**44,392**

Exclusive hygienic use is recorded when respondents report the use of hygienic menstrual practices (sanitary napkins, locally prepared napkins, tampons, and menstrual cups) and no unhygienic menstrual practices (cloth, nothing, other).

4.1 Geographic distribution of exclusive menstrual hygienic practices among tribal women

Recognizing geographical disparities in the use of menstrual hygienic methods is a vital step toward effectively addressing this critical public health concern [33]. The map in Fig. 1 shows the rates of exclusive hygienic menstrual practices among tribal populations at the district level. The analysis appears to show higher levels of hygienic menstrual practices among tribal women populations in Southern India, with the addition of some regions of Northern and North-eastern India. Furthermore, this map provides insight into the variable rates of menstrual practices among tribal populations within states. For instance, Karnataka has not only districts with rates of menstrual hygiene practices higher than 72% but also districts with rates below 32%. This information provides spatial insight into the prevalence of menstrual hygiene practices among tribal women, highlighting areas within states with relatively higher and lower rates.

Table 3 Usage of menstrual hygienic practices among tribal women populations by region, NFHS- 5 (2019-21)

Menstrual health practice	Region						
	North	Central	East	North-east	West	South	India
% (weighted)	12.2	25.6	21.9	12.7	19.1	8.5	100.0
Hygienic							
Locally prepared napkins							
Yes	13.9	8.8	17.5	8.5	19.1	25.1	14.7
Sanitary napkins							
Yes	61.8	42.3	53.3	68.1	51.3	57.3	53.4
Tampon/Menstrual cup							
yes	0.9	1.2	2.8	1.5	2.3	3.1	1.9
Unhygienic							
Cloth							
Yes	64.6	78.2	59.6	55.4	47.8	39.4	60.5
Nothing							
Yes	0.1	0.1	0.1	0.7	0.2	0.2	0.2
Other							
Yes	0.0	0.1	0.0	1.1	0.2	0.0	0.2

Exclusive hygienic use is recorded when respondents report the use of hygienic menstrual practices (sanitary napkins, locally prepared napkins, tampons, and menstrual cups) and no unhygienic menstrual practices (cloth, nothing, other).

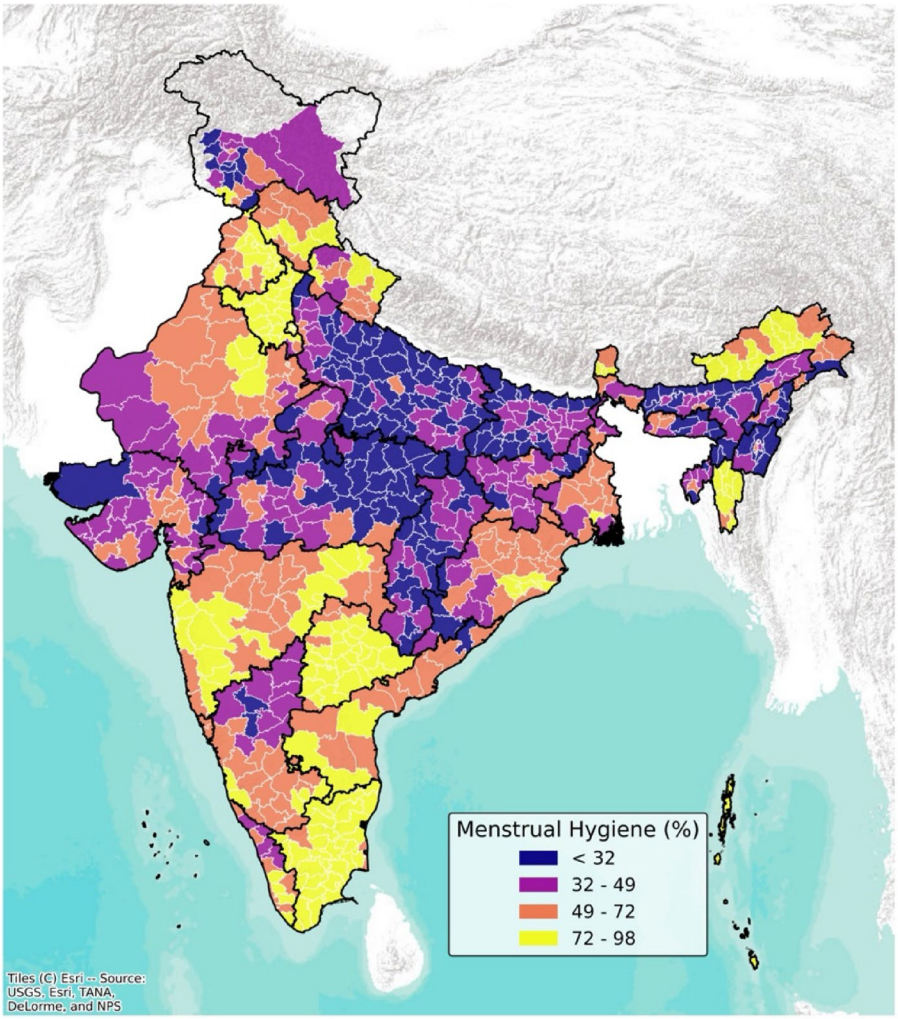

Fig. 1 Geographic distribution of exclusive menstrual hygiene use among tribal women aged 15–24 in India, NFHS-5 (2019-2021). *Note*: Exclusive hygienic use refers to respondents reporting the use of hygienic menstrual materials (sanitary napkins, locally prepared napkins, tampons, or menstrual cups) without concurrent use of cloth, nothing, or other materials. District-level estimates should be interpreted with caution, as the sample size of tribal women was small in some districts, which may affect the estimates.

Table 4 Multivariable logistic regression estimates of determinants of exclusive hygienic menstrual practices among tribal women aged 15–24 years in India, NFHS-5 (2019-21)

Variables	Model 1 uOR (95% CI)	Model 2 aOR (95% CI)
Age (years)		
15–19®		
20–24	0.87***(0.85–0.91)	0.80*** (0.72–0.90)
Residence		
Urban ®		
Rural	0.54*** (0.524–0.57)	0.70*** (0.59–0.83)
Religion		
Hindu®		
Muslim	1.29***(1.16–1.44)	0.58*** (0.42–0.81)
Christian	1.70***(1.62–1.77)	0.94**(0.79–1.12)
Other	2.31***(2.15–2.47)	1.38* (1.06–1.78)
Education		
No education®		
Primary	2.36***(2.12–2.62)	0.94 (0.70–1.26)
Secondary	13.03***(12.07–14.07)	2.05*** (1.64–2.56)
Higher	16.37***(15.03–17.83)	3.12*** (2.36–4.11)
Wealth index		
Poorest (Ref.)		
Poorer		1.57*** (1.36–1.81)
Middle		2.26*** (1.90–2.69)
Richer		2.87*** (2.29–3.59)
Richest		5.43*** (3.80–7.74)
Currently Working		
Not®		
Yes		0.80** (0.70–0.92)
Mass media exposure		
Not exposed®		
Exposed		1.04 (0.91–1.19)
Toilet facility		
Unimproved®		
Improved		1.33*** (1.16–1.53)
Water source		
Unimproved®		
Improved		1.11 (0.96–1.28)
Region		
North®		
Central	0.51***(049-0.52)	0.48*** (0.34–0.67)
East	0.72***(0.71–0.73)	1.62** (1.13–2.32)
North-East	0.62***(0.60–0.63)	0.92 (0.63–1.35)
West	0.84***(0.82–0.86)	1.54* (1.05–2.25)
South	0.97**(0.95–0.99)	1.94* (1.13–3.32)

® Reference category, uOR Unadjusted Odds Ratio, aOR Adjusted Odds Ratio *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

4.2 Variation in hygienic menstrual health practices: results of regression model

To understand the adjusted effect of each variable on menstrual hygiene practices, regression models were used. The regression models included in this analysis provide results on the associations between exclusive use of hygienic menstrual management and the demographic and socio-economic characteristics of the tribal women's population in India. The following two models are evaluated and shown in the table below: Model 1 includes explanatory variables of age, urban or rural residence, religion, education, and region; and Model 2 adds wealth quintile, employment, mass media exposure, toilet facility, and water source. Both models show that tribal women in the 20–24 age group are less likely to use hygienic menstrual practices than their younger counterparts in the 15–19 age group. Furthermore, residing in rural areas reduces the likelihood that tribal women use hygienic

menstrual practices compared to those residing in urban areas. Relative to tribal women with no education, tribal women with education are more likely to use hygienic menstrual management practices on average, and this association is stronger for tribal women with secondary education and even stronger for tribal women with higher education.

The relationship between wealth and hygienic menstrual practices was substantiated in the model – tribal women in the poorest quintile are the least likely to exclusively use hygienic menstrual practices, and the likelihood of using hygienic menstrual practices increases for each subsequent wealth group. Employment appears to be associated with hygienic menstrual practices. There appears to be a trend of tribal women who are currently working having a lower likelihood of using hygienic menstrual practices compared to those who are not employed. Mass media exposure is not associated with hygienic menstrual practices in the model. The analysis finds a statistically significant relationship between toilet facility availability and hygienic menstrual practices, with improved facility availability associated with higher odds of hygienic menstrual practices. The analysis did not find a statistically significant association between improved water source and menstrual hygiene practices.

5 Discussion

Tribal communities in India face unique constraints in improving hygienic menstrual practices. This analysis of a subpopulation of tribal girls and women aged 15–24 across India, surveyed in the NFHS-5, identifies several statistically significant independent explanatory variables. This analysis helps explain the factors contributing to lower rates of hygienic menstrual practices among tribal women in India. This study provides support to previous studies that have demonstrated lower rates of hygienic menstrual practices, in addition to other health concerns, among female tribal populations in India [34,35,36].

This analysis demonstrates an association between rural residence and a lower likelihood of using hygienic menstrual practices, as have previous studies looking at determinants of hygienic menstrual practice [19]. Tribal communities are often geographically isolated, with limited access to healthcare facilities [15]. Their isolation may also limit the ability of government schemes to reach the individuals who most need the resources. Furthermore, poor connectivity can be a barrier to accessing needed resources.

Wealth was also a major contributor to the use of menstrual hygiene practices in this analysis. Hygienic menstrual practices were increasingly likely among tribal women of increasing economic status compared to those of the poorest quintile in this study, similar to findings from previous studies on menstrual hygiene practices within tribal populations and broader populations in India [28,37]. Tribal communities have higher rates of poverty, which may constitute a barrier to accessing menstrual hygiene products [15]. Relatedly, the regression models showed a statistically insignificant relationship between employment status and the use of hygienic menstrual practices among tribal women and girls. Prior studies have shown mixed results on this relationship. One study focused on women in rural India found that lower exclusive usage of hygienic menstrual methods among rural women who were employed compared to rural women who were not working [38] Another study including the broader population of women in India, found that unhygienic menstrual practices were higher among women who were unemployed [39]. Additionally, unhygienic menstrual practices were also higher among those who did not have mass media exposure, a finding that is shared in this study. Age was also a statistically significant factor in this analysis of hygienic menstrual practices, with younger respondents more likely to use them. Younger tribal women may have had greater exposure to menstrual health campaigns or school-based messaging than older young women. This finding may also reflect a temporal shift toward increased menstrual hygiene practices in India [40].

In addition, India's tribal communities have lower literacy rates compared to the rest of the country's population and lower levels of education [41]. Lower levels of education are particularly salient for menstrual hygiene. The present analysis provides evidence for the relationship between women's education and menstrual health by demonstrating a significant relationship between levels of education and menstrual hygiene practices. Previous

studies support this link between women's education and maternal and child health in both India's general and tribal populations [42,43,44,45].

Infrastructure deficits, such as limited access to toilets and water supply, are also an impediment to managing menstrual hygiene [46,47]. While water, sanitation, and hygiene metrics have generally improved in India's tribal districts in the last decade, concerns remain, including a lack of access to a piped water supply for 70% of households [48]. One study of tribal girls and women in a remote area outside Udaipur cited the difficulty of disposal of hygiene menstrual management products in their contexts, as compared to urban contexts [49]. These situations may also play a role in the lower prevalence of hygienic menstrual practices among tribal girls and women. This analysis upholds this trend, with a statistically significant association between toilet facility availability and the use of hygienic menstrual practices.

This study provides a quantitative analysis of menstrual hygiene among tribal populations. A significant strength of this analysis arises from its reliance on a nationally representative sample survey. A limitation, however, is that this quantitative analysis may neglect the nuances of menstrual hygiene across different tribal communities. For instance, the survey does not ask respondents to report the stigmas and other socio-cultural taboos that may impact their ability to maintain menstrual hygiene. Qualitative studies—from Rajasthan to Jharkhand to Maharashtra to Kerala—have provided insight into the knowledge and practices related to menstruation among tribal populations [50,51,52,53]. Across various regions of India, menstruation and its related hygienic practices remain a challenge to the health of girls and women, particularly among the country's tribal populations [54,55]. Future work should continue to focus on this subpopulation, including through quantitative and spatial analyses of nationally representative datasets and qualitative data. Furthermore, work is required to explore potential solutions to improving the menstrual health of tribal girls and women through increased awareness and access to menstrual hygiene management products [56,57]. While this study focuses on the use of hygienic menstrual products, which is one aspect of menstrual health, other factors, such as knowledge, self-efficacy, and access to WASH facilities, impact women's menstrual health. An additional limitation is the potential for reporting bias, as menstrual hygiene is a sensitive topic, and stigma may have influenced responses. An additional limitation is that estimates for tribal women in some areas may be based on relatively small sample sizes, which should be considered when interpreting subgroup and spatial patterns. The spatial heterogeneity observed in this study underscores the limitations of one-size-fits-all interventions for improving menstrual hygiene among tribal populations. Even within states with relatively higher overall prevalence, substantial district-level disparities persist, suggesting the need for geographically targeted policies. Spatial analysis, such as the district map in this study, can help identify priority districts for tailored, intensified intervention in the local and tribal context. Potential policies include subsidizing the distribution of menstrual products, conducting educational campaigns led by community leaders, and improving WASH infrastructure. Integrating menstrual hygiene interventions with education, poverty alleviation, and reproductive health programs may yield more sustainable improvements.

6 Conclusions

While menstrual health in India has gained increased attention in recent years and successive rounds of the National Family Health Survey (NFHS) have reported improvements in hygienic menstrual practices, these gains have not translated into comparable progress among tribal women, whose rates continue to lag behind the national average. Tribal women living in rural areas, of lower economic standing, and of lower educational backgrounds are using hygienic menstrual practices at lower rates compared to their tribal women counterparts and the broader population of women in India. These patterns exist between states and vary widely within states, as demonstrated by the spatial analysis of rates among tribal populations at the district level. This study highlights persistent inequalities in menstrual hygiene practices among young tribal women in India. Lower education, poverty, and rural residence remain significant barriers, while substantial spatial variation exists both between and within states. Policy interventions must therefore move beyond uniform national approaches and adopt region- and

district-specific strategies that address structural disadvantages faced by tribal communities. Strengthening education, improving access to affordable menstrual products, and integrating menstrual health with broader reproductive health initiatives are critical to advancing menstrual equity among tribal women in India.

Author contributions SK supervised the study. SND and RRS developed the concept for this study and wrote the methods section. SND performed data analysis, SND and SK wrote the background, interpretation text, and discussion. RRS performed editorial checks and reviewed the manuscript for intellectual content. RRS performed in corresponding with the journal. All authors read and approved the final version of the manuscript.

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Data availability The datasets generated and/or analyzed during this study are available on the DHS website at [DHS Program Datasets]([https://dhsprogram.com/data/available-datasets.cfm](https:/dhsprogram.com/data/available-datasets.cfm)) and the IIPS website at [IIPS NFHS-5 District Factsheet]([http://rchiips.org/nfhs/districtfactsheet_ NFHS-5.shtml](http:/rchiips.org/nfhs/districtfactsheet_%20NFHS-5.shtml)). The shapefile utilized in this study to prepare maps can be easily accessed through the Spatial Data Repository, The Demographic and Health Surveys Program website ([https://spatialdata.dhsprogram.com/boundaries/#view=map&countryId=IA&surveyId=541&level=1%2 C%202](https:/spatialdata.dhsprogram.com/boundaries)).

Declarations

Ethical approval The study is based on nationwide secondary data sets from the NFHS-4 (2015-16) and NFHS-5 (2019-21) survey. As part of the original surveys, consent was obtained from participants, and data is publicly available with no identifiable information on the survey participants. This dataset is available in the public domain; therefore, no ethical approval was required for the present study.

Consent to participate Not applicable.

Consent to publish Not applicable.

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