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Novel Insight on Organoleptic Water Quality and Menstrual Hygiene at Secondary Schools: A Cross-Sectional Study in Batanghari Regency, Sumatera, Indonesia

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ABSTRACT

Introduction: Menstrual hygiene management (MHM) practices among female students in Indonesia remain low (35.9%), increasing the risk of urinary tract and reproductive infections. While access to water is commonly studied in relation to MHM, few studies in Southeast Asia have examined how the sensory quality of water (organoleptic properties) influences hygiene behaviors. This study addresses that gap by analyzing the relationship between organoleptic water quality and MHM in schools among female students in Batanghari Regency.

Methods: A cross-sectional study was conducted with 342 female students from 93 secondary schools in Batanghari Regency. Data were analyzed using chi-square test and binary logistic regression.

Results: Although 60.5% of female students attended schools with good organoleptic water quality, only 36.5% practiced good MHM at school. MHM at schools were associated with organoleptic water quality; water availability; soap availability; availability of safe toilets; availability of closed waste bins, parental support; teacher support; friend support; maternal education, paternal education, and knowledge. Furthermore, a significant relationship was found between organoleptic water quality interacting with availability of safe toilets for MHM after controlling for confounding variables (AOR: 3.987-26.710).

Conclusion: Good MHM practices among female students are low. Schools and authorities should improve WASH facilities, protect water sources, and ensure toilets safety. Communication channels should allow students to report issues promptly. Teacher training on menstrual health should be prioritized, and menstrual health education should be integrated into the curriculum to improve knowledge, reduce stigma, and empower female students.

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INTRODUCTION

Menstruation is a natural process that all women experience, yet misconceptions and limited access to information often lead to lack understanding of menstrual hygiene management (MHM) (1). MHM practices include using clean menstrual hygiene materials, changing them as needed, and maintaining hand and genital hygiene with soap and water (2-5). Improved hygiene services in schools make a positive impact on student health, well-being, and enabling equal learning opportunities. As a result, MHM is directly linked to United Nations Sustainable Development Goals such as SDGs 6 and contributes to good health and well-being (SDGs 3), quality education (SDGs 4), and gender equality (SDGs 5) (3).

Poor MHM practices can cause health problems, such as urinary tract infections and skin irritation. Unclean sanitary napkins promote bacterial and fungal growth, as blood provides nutrients for microorganisms. Infrequent pad changes create moist conditions that favor harmful bacteria like *Gardnerella vaginalis* and *Staphylococcus aureus*. Soiled pads reduce protective Lactobacillus that maintain the pH balance of the vagina, increasing the risk of infection. Excess moisture also weakens the local immune system, increasing its susceptibility to infection (4, 6).

Differences in MHM practices among female students in various countries demonstrate that developed nations have better practices. In Japan, 95% of female students practice good MHM, followed by Germany (93%), the United Kingdom (85%), and the United States (82%). However, the proportion of female students that practices good MHM remains low in developing countries, such as Ethiopia (39.7%), Ghana (50.8%), India (37%), Papua New Guinea (27%), and Afghanistan (42%) (7-9).

In Indonesia, only 35.9% of female students (13 to 18 years old) practice good MHM, indicating challenges in achieving proper MHM practices (10). Although most female students use clean menstrual materials (99.1%) and wash their genitals at least once a day (98.3%), the proportion for other indicators remains low. Only 56.6% of students change their sanitary pads every four to eight hours, 59.3% wash their hands before and after changing pads, and 54.4% dispose of used pads properly (10, 11).

MHM practices among female students in Indonesia vary across regions. Poor practices have been reported in East Java (44.7%) while West Java showed better practices (63.4%) (10, 12). In Nusa Tenggara Islands, East Nusa Tenggara had very low MHM practices (16.6%), whereas Bali reached 62.86% (10, 13). Sulawesi Island consistently demonstrated low MHM practices, particularly South Sulawesi (24.9%) and West Sulawesi (39.2%) (10, 14). Similarly, on Sumatra Island, South Sumatra registered 56.6%, while East Kalimantan on Kalimantan Island recorded 39.1%, and Papua Province recorded 39% (10, 15, 16).

Batanghari Regency, a rural area in Jambi Province, may have unique social, cultural, and infrastructure characteristics compared with previously examined regions. MHM issues in Batanghari often are overlooked, with inadequate WASH amenities in secondary schools.

Secondary school education generally comprises adolescents ages 13–18, most of whom have passed the initial menstruation phase (menarche) (17). Female students spend more than eight hours at school daily, making schools essential in supporting good MHM practices.

MHM practices influenced by internal and external factors. Internal factors comprise personal and biological ones. Personal factors comprise socio-demographics, knowledge, and attitudes. Older female students with parents at higher education levels tend to have better access to information, enabling them to adopt good MHM practices (9, 18, 19). Female students with more knowledge about menstrual hygiene also practice MHM more consistently and positive attitude towards menstruation encourage better MHM practices (12, 20). Furthermore, biological factors such as age during menarche, menstrual intensity, and cycle also affects a student's readiness and knowledge in managing menstruation (6, 9).

External factors comprise social, environmental, and interpersonal elements. Social factors include policies, norms, and cultural values. Inadequate education and health policies can limit female students' access to information and amenities for MHM practices (21). Moreover, Cultural taboos around menstruation can limit open communication and support (22). Environmental factors like access to menstrual material and adequate WASH amenities are crucial for supporting MHM practices. If materials are difficult to access or the WASH amenities at school are not adequate, female students may resort to using unhygienic alternatives (2, 3, 23, 24). Interpersonal factors involve social interactions between female students and people around them—such as parents, teachers, peers,

and schools, which can serve as sources of information and support can help reduce the stigma surrounding menstruation (20, 23, 25).

While water quality is widely recognized as a critical component of school WASH infrastructure, most existing studies on MHM focused primarily on water availability and access, with limited attention to the sensory organoleptic qualities of water, which directly affect its acceptability and use. Organoleptic characteristics, though subjective, are essential to students' perceptions of cleanliness and influence whether water is used for menstrual hygiene purposes. However, a review of regional literature reveals a notable gap in research linking organoleptic water quality to MHM behaviours, particularly within the Southeast Asian context.

Overall, good MHM practices in Indonesia remain low. Therefore, this study addresses that gap by analyzing the relationship between organoleptic water quality and MHM in schools among female students in Batanghari Regency, Jambi Province, in 2024.

METHOD

This study used a cross-sectional design. The study location was secondary schools in Batanghari Regency, Jambi Province and was conducted in October 2024. Data was collected through self-administered questionnaires and researcher observations (Table 1). To ensure the reliability and validity of the questionnaires and observation sheet, a pilot test was conducted in five secondary schools and 30 female students who were not included in the main study sample. The instrument was adapted from national drinking water guidelines and WASH in Schools (WinS) indicators. Feedback from public health experts was incorporated to refine the definitions and ensure contextual relevance. This process helped improve clarity, standardize assessment procedures, and minimize observer bias in the main study. Observations were conducted by the researcher on the condition that they did not experience anosmia or hyposmia, had a normal sense of vision, and were not experiencing a medical condition that affected their senses.

Table 1. Questionnaire and Observation Sheet

No	Section	Information	Variables
1	First Section	Students' age and parental education level	Age (9): • < 15 years old • ≥ 15 years old Parents education level (26): • low education (no formal education, elementary school, and junior high school) • higher education (senior high school and university)
2	Second Section	MHM practices in School	MHM practices (3): the use of materials, changing materials, washing hands before and after changing materials, washing external genitalia, and disposing of used materials • good practices • poor practices
3	Third Section	Female student's knowledge of menstruation and MHM	Knowledge (27): • good knowledge • poor knowledge
4	Fourth Section	Female student's attitudes towards MHM	Attitudes (28): • debilitating and disturbing events • natural events
5	Fifth Section	Supporting infrastructure	Accessibility to menstrual hygiene materials (3): there was a place to get or buy menstrual hygiene materials at an affordable price). Availability of water and soap at school (20): there was water and soap available every day at school that could be used by female students freely.

	Section	Information	Variables
6	Sixth Section	Social support	Parents, teachers, friends, and school support: female students had discussed menstruation and hygiene with parents, teachers, or friends, and received education from the school about menstruation and/or menstrual hygiene (20, 25).
7	Observation Sheet	Supporting infrastructure and organoleptic water quality	Safe toilets availability (2, 3): at least one female-only, lockable, have and adequate lighting, and freely accessible toilets at school. Availability of closed waste bins in toilet (3): at least one toilet that has a closed waste bin and can be used freely by female students. Organoleptic water quality (29): assessed water based on color and odor.

The population of female students in Batanghari Regency totalled 10,099 students across 93 schools. The minimum sample size was calculated using the hypothesis test formula for two proportions with a 95% confidence interval (1.96) and 80% test power (0.84) (30). The minimum sample size was selected from the proportion of previous research, namely the proportion of social peer support of 0.574 (P1) and 0.423 (P2) (20), resulting in a minimum required sample size of 342 students. Sampling was conducted using stratified random sampling, taking into account the number of female students at each school and the schools' locations (Figure 1). The data were analysed with chi-square test and binary logistic regression with a risk factor model using SPSS version 26. The results from the analysis are presented in the tables below.

Figure 1. Samples Frame

Ethical Approval

Ethical approval was obtained from Research and Community Service Ethics Committee of the Faculty of Public Health, Universitas Indonesia, as stated in the Certificate Number of Ket-583/UN2.F10.D11/PPM.00.02/2024. All respondents provided written informed consent prior to enrolment in the study and the publication of the data obtained.

RESULTS

Descriptive Overview of Menstrual Hygiene Management Practices

Most female students in Batanghari Regency exhibited poor MHM practices (Table 2); where good MHM practices were more prevalent among female students attending schools near the regency capital (Figure 2).

Table 2. Descriptive Overview of Menstrual Hygiene Management Practices Among Female students in Batanghari Regency

Variables	Categories	Total (N = 342)	Percentage (%)
Dependent			
Menstrual hygiene management practices	Poor	217	63.5
	Good	125	36.5

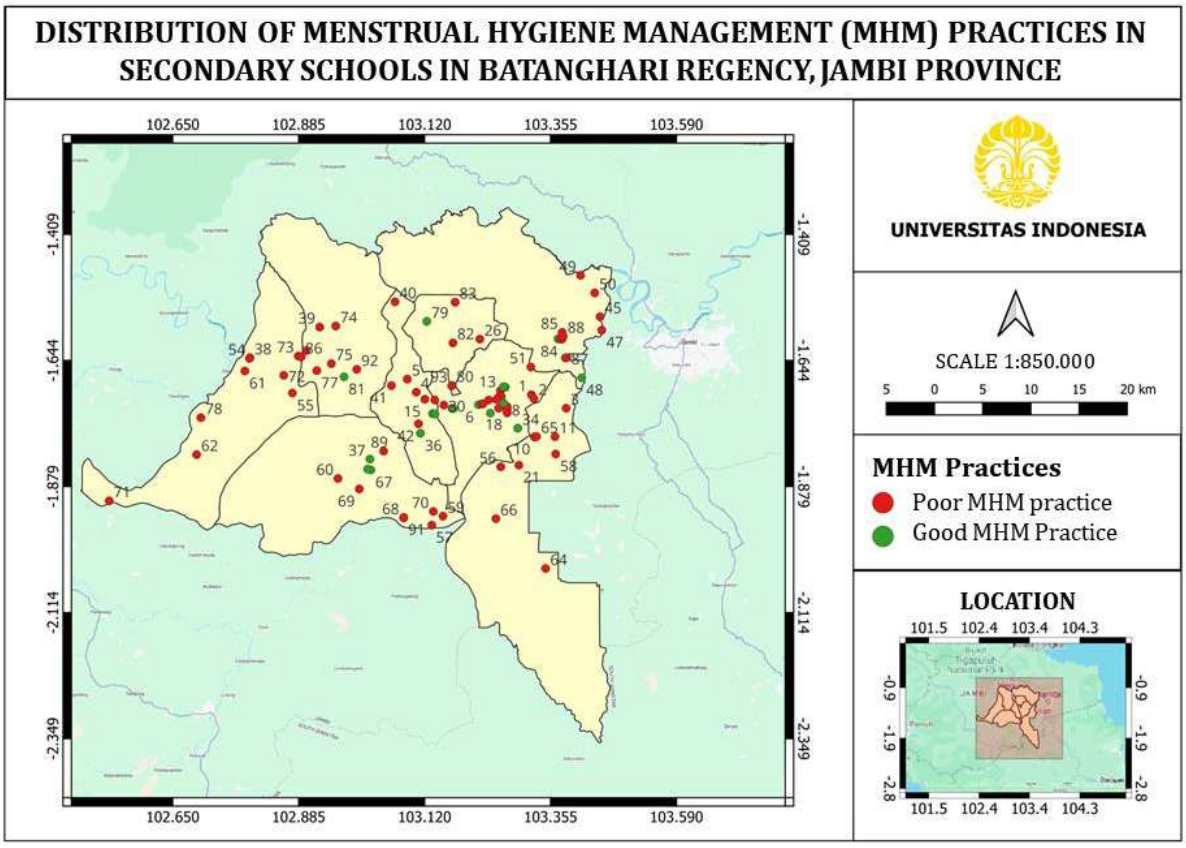

Figure 2. Map of the Distribution of Menstrual Hygiene Management Practices in Secondary Schools in Batanghari Regency, Jambi Province

Descriptive Overview of Organoleptic Water Quality and Covariate Factors

Most female students in Batanghari Regency experienced good organoleptic water quality, interpersonal factors, and personal factors, but poor environmental factors (Table 3).

Table 3. Descriptive Overview of Organoleptic Water Quality and Covariate Factors Among Female students in Batanghari Regency

Variables	Categories	Total (n, N = 342)	Percentage (%)
Main independent			
Organoleptic water quality	Poor	135	39.5
	Good	207	60.5
Covariates			
Environmental factors			
Access to Menstrual Hygiene Materials	Difficult access	11	3.2
	Easy access	331	96.8
Water availability in School	Rarely available or Not available	77	22.5
	Always available	265	77.5
Soap availability in School	Rarely available or Not available	277	81
	Always available	65	19
Availability of Safe Toilets	Not available	247	72.2
	Available	95	27.8
Availability of Covered Trash Bins in Toilets	Not available	238	69.6
	Available	104	30.4
Interpersonal Factors			
Parental Support	Never	49	14.3
	Sometimes	293	85.7
Teacher Support	Never	223	65.2
	Sometimes	119	34.8
Peer Support	Never	81	23.7
	Sometimes	261	76.3
School Support	Never	131	38.3
	Sometimes	211	61.7
Personal Factors			
Age	< 15 years old	154	45
	≥ 15 years old	188	55
Mother's Education	Low	171	50
	High	171	50
Father's Education	Low	173	50.6
	High	169	49.4
Knowledge	Poor	198	57.9
	Good	144	42.1
Attitude	Disruptive and Weakening	144	42.1
	Natural	198	57.9

Relationship between Organoleptic Water Quality and Covariate Factors in Menstrual Hygiene Management

The bivariate analysis indicate a significant relationship between organoleptic water quality, water availability in schools, soap availability in schools, availability of safe toilets, availability of covered trash bins in toilets, parental support, teacher support, peer support, mother's education, father's education, and knowledge of MHM. However, no significant relationship was found between MHM and access to menstrual hygiene materials, school support, age, and attitude (Table 4).

Table 4. Relationship between Organoleptic Water Quality and Covariate Factors with Menstrual Hygiene Management in Female students in Batanghari Regency

Variables	Categories	MKM (N = 342)		Total (N = 342)	*p-value*	OR (95% CI)
		Poor (n, %)	Good (n, %)			
Main Independent						
Organoleptic water quality	Poor	97 (71.9%)	38 (28.1%)	135 (100%)	0.013*	1.851 (1.162–2.948)
	Good	120 (58%)	87 (42%)	207 (100%)		
Covariates						
Environmental factors						
Access to Menstrual Hygiene Materials	Difficult access	7 (63.6%)	4 (36.4%)	11 (100%)	1.000	1.008 (0.289–3.515)
	Easy access	210 (63.4%)	121 (36.6%)	331 (100%)		
Water availability in School	Rarely available or Not available	58 (75.3%)	19 (24.7%)	77 (100%)	0.020*	2.035 (1.147–3.611)
	Always available	159 (60%)	106 (40%)	265 (100%)		
Soap availability in School	Rarely available or Not available	187 (67.5%)	90 (32.5%)	277 (100%)	0.002*	2.424 (1.400–4.196)
	Always available	30 (46.2%)	35 (53.8%)	65 (100%)		
Availability of Safe Toilets	Not available	166 (67.2%)	81 (32.8%)	247 (100%)	0.028*	1.768 (1.091–2.866)
	Available	51 (53.7%)	44 (46.3%)	95 (100%)		
Availability of Covered Trash Bins in Toilets	Not available	161 (67.6%)	77 (32.4%)	238 (100%)	0.021*	1.792 (1.118–2.872)
	Available	56 (53.8%)	48 (46.2%)	104 (100%)		
Interpersonal Factors						
Parental Support	Never	40 (81.6%)	9 (18.4%)	49 (100%)	0.007*	2.913 (1.362–6.229)
	Sometimes	177 (60.4%)	116 (39.6%)	293 (100%)		
Teacher Support	Never	153 (68.6%)	70 (31.4%)	223 (100%)	0.009*	1.878 (1.188–2.970)
	Sometimes	64 (53.8%)	55 (46.2%)	119 (100%)		
Peer Support	Never	64 (79%)	17 (21%)	81 (100%)	0.001*	2.657 (1.475–4.788)
	Sometimes	153 (58.6%)	108 (41.4%)	261 (100%)		
.	Never	87 (66.4%)	44 (33.6%)	131 (100%)	0.435	1.232 (0.780–1.945)
	Sometimes	130 (61.6%)	81 (38.4%)	211 (100%)		
Personal Factors						
Age	< 15 years old	99 (64.3%)	55 (35.7%)	154 (100%)	0.859	1.068 (0.686–1.663)
	≥ 15 years old	118 (62.8%)	70 (37.2%)	188 (100%)		
Mother's Education	Low	121 (70.8%)	50 (29.2%)	171 (100%)	0.007*	1.891 (1.209–2.956)
	High	96 (56.1%)	75 (43.9%)	171 (100%)		
Father's Education	Low	119 (70.4%)	50 (29.6%)	169 (100%)	0.011*	1.821 (1.165–2.847)
	High	98 (56.6%)	75 (43.4%)	173 (100%)		
Knowledge	Poor	150 (75.8%)	48 (24.2%)	198 (100%)	0.000*	3.591 (2.264–5.697)
	Good	67 (46.5%)	77 (53.5%)	144 (100%)		
Attitude	Disruptive and Weakening	97 (67.4%)	47 (32.6%)	144 (100%)	0.243	1.341 (0.855–2.104)
	Natural	120 (60.6%)	78 (39.4%)	198 (100%)		

* = statistically significant (p-value < 0,05)

Relationship between Organoleptic Water Quality and Menstrual Hygiene Management After Controlling for Confounding Variables

The multivariate analysis indicate a significant relationship between organoleptic water quality and MHM after controlling for confounding variables, namely water and soap availability in schools, parental and teacher support, mother's education, and knowledge. Confounding was assessed by sequentially removing covariate factors

with a p-value > 0.05 from the model, starting with the highest p-value. A variable was considered a confounder if its removal resulted in a change of more than 10% in the odds ratio (OR) of the main independent variable. The modelling identified interaction variables, i.e., in this study, organoleptic water quality's effect on MHM practices varies at depending on the availability of safe toilets (Tables 5 and 6).

Table 5. Initial Multivariate Modelling of the Relationship between Organoleptic Water Quality and Menstrual Hygiene Management

Variables	*Coef* (β)	*p-value*	COR (95% CI)
Organoleptic Water Quality	0.543	0.054	1.772 (0.991–2.990)
Access to Menstrual Hygiene Materials	0.835	0.241	0.434 (0.107–1.754)
Water availability in School	0.569	0.086	1.766 (0.923–3.377)
Soap availability in School	0.598	0.081	1.819 (0.928–3.565)
Availability of Safe Toilets	0.642	0.087	1.901 (0.912–3.962)
Availability of Covered Trash Bin in Toilets	0.156	0.654	1.169 (0.590–2.316)
Parental Support	1.095	0.013	2.989 (1.254–7.121)
Teacher Support	0.587	0.045	1.798 (1.012–3.193)
Peer Support	0.605	0.086	1.832 (0.917–3.658)
School Support	0.214	0.461	0.807 (0.457–1.426)
Age	0.556	0.066	1.744 (0.964–3.154)
Mother's Education	0.485	0.124	1.624 (0.875–3.015)
Father's Education	0.350	0.258	1.420 (0.773–2.605)
Knowledge	1.307	0.000	3.694 (2.213–6.168)
Attitude	0.477	0.078	1.612 (0.949–2.738)

Table 6. Final Multivariate Modelling of the Relationship between Organoleptic Water Quality and Menstrual Hygiene Management

Variables	*Coef* (β)	*p-value*	AOR (95% CI)
Organoleptic Water Quality	1.383	0.032	0.251 (0.071–0.888)
Water Availability in School	0.554	0.096	1.740 (0.907–3.338)
Soap Availability in School	0.780	0.024	2.181 (1.106–4.301)
Availability of Safe Toilets	0.255	0.548	0.775 (0.338–1.780)
Parental Support	1.160	0.006	3.191 (1.393–7.310)
Teacher Support	0.636	0.024	1.889 (1.089–3.276)
Age	0.068	0.855	0.935 (0.451–1.937)
Mother's Education	0.649	0.016	1.914 (1.126–3.253)
Knowledge	1.143	0.000	4.149 (2.462–6.994)
Organoleptic Water Quality × Age	1.231	0.038	Age ≥ 15 years old: 3.987 Age < 15 years old: 13.653
Organoleptic Water Quality × Availability of Safe Toilets	1.902	0.003	Available: 3.987 Not available: 26.710

DISCUSSION

Most female students in Batanghari Regency practice poor MHM even though they attend schools with good organoleptic water quality. This may happen because water in Batanghari Regency secondary schools generally comes from wells, which result in good organoleptic quality. Maintaining this quality is important as poor water quality can raise health risks and signal issues with the water source, treatment, or distribution (29). The persistence of poor MHM despite adequate water quality underscores that infrastructure quality is only one component; behavioral, cultural, and systemic barriers also play a critical role.

The lack of adequate WASH (Water, Sanitation, and Hygiene) facilities appears to be a central challenge. Even when water is available, the absence of clean, private, and well-equipped facilities significantly limits female students' ability to manage menstruation hygienically. This situation mirrors findings from West Sulawesi and

Ethiopia (14, 20, 24), suggesting that infrastructural limitations are a common constraint across low- and middle-income settings. Water availability allows students to wash their hands and genitalia and clean menstrual hygiene materials, improving MHM practices, reducing infection risks, and ensuring comfort. Female students are more likely to engage in hygiene practices, such as hand and genital washing, if the school provides clean and odorless water (29, 31-34).

Availability of soap and access to menstrual material are important to MHM. The absence of soap and supportive hygiene materials further restricts students' ability to manage menstruation during school hours. Although menstrual products are generally affordable in Indonesia, students often report not changing them at school due to a lack of soap and appropriate facilities (35). This suggests that material access, while important, must be supported by an enabling environment. When hygiene products do not align with students' comfort or preferences or when they cannot be used and disposed of discreetly, their presence becomes insufficient (20, 36).

Availability of safe toilets and covered trash bin were also important for MHM. Lockable toilets provide privacy when changing pads, which helping reduce shame and anxiety. Separate toilets for girls also create a safe space and avoid cultural stigma. Furthermore, well-lit toilets make it easier for female students to change their pad (4). Covered trash bins provide privacy when disposing of menstrual materials, reduce shame, maintain toilet cleanliness, and minimize bacterial spread and environmental contamination (20, 31).

Social support networks further influence MHM outcomes. While parents and friends play supportive roles, teachers are often constrained by limited training, stigma, and lack of resources. Parental discussions help reduce stigma and improve access to menstrual hygiene materials and friends contribute to emotional support and shared knowledge, helping students feel less isolated in managing menstruation (37-40). Teachers, though crucial sources of information, are often underprepared to deliver practical guidance, as reproductive education in Indonesian schools tends to focus on biological facts rather than actionable advice (20). The cumulative effect of these infrastructural features demonstrates that MHM is not a matter of single components, but rather of how multiple physical and social factors intersect to shape students' daily experiences. Improving teacher training and equipping schools to facilitate open discussions could better integrate these social supports into a cohesive, school-wide approach to menstrual health.

Sociodemographic factors, particularly age and parental education, shape students' knowledge and practices. Older students tend to have more opportunities and information about menstrual hygiene. Mothers and fathers with higher education are more likely to discuss menstrual hygiene with their daughters and provide the necessary supplies (20, 22, 38, 40).

Knowledge and attitude are important in good MHM practice. Good knowledge and positive attitude enables individuals to recognize hygienic methods for managing menstruation and increases awareness of MHM practices' positive impacts. However, having good knowledge and positive attitudes is not enough, female students may face barriers such as inadequate facilities or cultural norms that hinder the application of such knowledge and attitudes (19, 22, 39, 41).

The study found a significant relationship between organoleptic water quality and MHM, which interacts with the availability of safe toilets after controlling for confounding variables. Female students attending schools with safe toilets but poor organoleptic water quality are four times more likely to engage in poor MHM practices. Meanwhile, female students attending schools without safe toilets and with poor organoleptic water quality are 27 times more likely to practice poor MHM (10, 35).

This interaction suggest that interventions should be holistically structured, ensuring that improvements in one area are not undermined by deficiencies in another. It also highlights the need to include subjective water acceptability such as odor and clarity as part of water quality assessments, as these directly affect student behavior and use. This finding supports the development of multi-component WASH standards that account for both infrastructure and user perception. It also suggests that funding and implementation strategies should prioritize comprehensive upgrades, rather than single-focus projects, to maximize impact on menstrual hygiene and overall student well-being.

The wide confidence interval observed for the interaction between organoleptic water quality and the availability of safe toilets (AOR: 3.987–26.710) indicates a high level of uncertainty in the effect estimate, despite statistical significance. This may be attributed to small sample sizes within certain subgroups formed by the

interaction of the two variables, which can lead to unstable estimates. Additionally, the relatively low prevalence of poor MHM in some exposure groups may have further reduced statistical precision. Residual confounding is also possible, as unmeasured factors such as school maintenance, menstrual product availability, or cultural attitudes toward menstruation may influence the observed association. Measurement variability in assessing water quality especially given the subjective nature of organoleptic evaluation could also contribute to the wide interval. These factors suggest that while the interaction effect is compelling, it should be interpreted with caution, and future studies with larger, more balanced samples and refined measurement tools are recommended to validate these findings.

To improve menstrual hygiene management in schools, it is essential to ensure that water sources are protected and regularly maintained. Wells and storage tanks should be properly covered and sealed to prevent contamination from environmental pollutants and waste. In areas where water quality is compromised, schools should install basic treatment systems, such as filters or chlorination units, to enhance water safety. Additionally, using secure, covered water storage containers can help maintain cleanliness and prevent recontamination, ensuring that water remains suitable for personal hygiene use. Schools can also provide communication channels for female students to report issues related to water quality and toilet cleanliness or damage either directly or through suggestion boxes or school apps.

An example from the Philippines illustrates the development of school-based WASH facilities through the implementation of the Three-Star Approach. This approach emphasizes the establishment of operational standards, a monitoring and evaluation system, and a recognition mechanism. It supports improvements in the installation of toilets and handwashing facilities, the provision of an adequate water supply and hygiene items for schools, as well as the implementation of school-based solid waste management programs to support students hygiene as well as menstrual hygiene management at school (42, 43).

The limitation of this study is that there are several factors that were not analysed, such as the implementation of MHM at home, reproductive diseases caused by poor MHM practices and poor organoleptic water quality, the proportion of female students and the number of toilets, as well as the cleanliness of toilets.

CONCLUSION

Menstrual Hygiene Management (MHM) practices among female students in Batanghari Regency remain poor, despite access to good water quality. Many schools still lack basic WASH facilities such as soap, safe toilets, and covered trash bins. While students receive support from parents and peers, teacher involvement is lacking. Most students are aged ≥15 years, with mothers more educated than fathers. Although their attitudes toward menstruation are generally neutral, their knowledge remains limited. This study highlights that MHM is influenced not only by water quality but also by key factors such as soap and water availability, safe sanitation facilities, waste management, social support systems, and parental education. A significant interaction effect between water quality and safe toilet access suggests that infrastructure improvements need to be comprehensive to be effective. Education and health authorities must invest in upgrading school WASH facilities, ensuring reliable access to clean water, soap, private toilets, and menstrual waste disposal. Water sources must be protected and maintained, and schools should provide communication channels for students to report issues. Teacher training on menstrual health should be institutionalized to create supportive environments. Additionally, menstrual health education should be integrated into the curriculum to improve knowledge, reduce stigma, and empower female students.

AUTHOR'S CONTRIBUTION STATEMENT

J.P.H. conceived of the presented idea. J.P.H. and Z contributed to the design and implementation of the research. Z., L.F., E.H., and S.F. verified the analytical methods. M.R. and S.Y.A. verified and supply the data. J.P.H. and Z took the lead in writing the manuscript. Z., L.F., E.H., and S.F. supervised the findings of this work. All authors discussed the results and contributed to the final manuscript.

CONFLICTS OF INTEREST

The author(s) declared no potential conflicts of interest with the respect to the research, authorship, and/or publication of this article.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

I also would like to declare that no Generative AI or AI-assisted technologies were used in the process of this work.

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