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Reproductive Health Vulnerabilities Associated with Tropical Infectious Diseases in Women in North Sumatra: A Population-Based Study

Syahlis Irwandi [1)], Zaim Anshari [2)], Abd.Harris Pane [3)], Marlina Elfa Lubis [4)], Julakhir Siregar [5)]

[1, 2, 3, 5] *Islamic University of North Sumatra*
[4] *True Partner Health College*

ABSTRACT

Background: In tropical regions, women of reproductive age face a double health burden from obstetric risks and endemic infectious diseases. However, population-based data quantifying the interaction between tropical infections and reproductive health outcomes in Indonesia are scarce, hindering the development of effective interventions. Objective: This study aimed to analyze the association between malaria and soil-transmitted helminth (STH) infections with adverse reproductive health outcomes among women aged 15-49 in North Sumatra. Methods: A population-based, cross-sectional study was conducted involving 1,420 women selected via stratified random sampling. Data were collected through structured interviews and biological sample analysis. Multivariate logistic regression was used to measure associations after controlling for confounding variables. Results: The overall prevalence of at least one tropical infection was 28.2%. Malaria infection was independently and significantly associated with an increased risk of anemia (Adjusted Odds Ratio [aOR] = 3.15; 95% CI: 2.20–4.51) and a history of preterm birth (aOR = 1.89; 95% CI: 1.15–3.10). STH infection was also a strong predictor of anemia (aOR = 2.10; 95% CI: 1.60–2.75). Implications: These findings provide robust evidence supporting the need to integrate infectious disease control programs into maternal and child health services. Active screening for malaria and STH should be a standard component of antenatal care in endemic areas to mitigate adverse maternal and neonatal outcomes.

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INTRODUCTION

Women's reproductive health is a fundamental pillar of global health and the socioeconomic stability of a nation. Women's well-being not only determines maternal and neonatal outcomes but also directly influences the productivity of future generations and the sustainability of development. However, achieving optimal reproductive health faces significant challenges in tropical regions where endemic

infectious diseases pose a persistent threat to public health. Vector-borne and soil-transmitted helminth diseases such as malaria, dengue fever, and filariasis pose a high morbidity burden in this region. In particular, the Indonesian province of North Sumatra, along with its geographical location, faces significant challenges

Owing to its unique ecological context, Indonesia is one of the regions facing a high prevalence of tropical infectious diseases, creating a complex and ongoing health risk landscape, particularly for its female population. This intersection between women's biological vulnerability and environmental exposure to tropical pathogens raises critical questions regarding their synergistic impact on reproductive health, which remains largely uncharted.

Although the general health risks of tropical diseases have been widely documented, women of reproductive age (15-49 years) face a double burden that is often overlooked. Inherent physiological vulnerabilities during the reproductive cycle such as pregnancy, childbirth, and postpartum period are significantly exacerbated by co-infection with tropical pathogens. For example, malaria infection during pregnancy is widely known to correlate with an increased risk of severe maternal anemia, preterm birth, and low birth weight (LBW), which are the major determinants of neonatal mortality. Similarly, chronic infections such as helminthiasis can lead to malnutrition and iron deficiency anemia, which directly affect maternal health and fetal development. However, the current understanding remains largely fragmented and often focuses on a single infection or reproductive health outcome. Consequently, comprehensive population-based data that quantify the true burden of the problem and explain the complex interactions between various tropical infectious diseases and the broad spectrum of women's reproductive health in North Sumatra are scarce. This gap in evidence hinders the development of integrated and effective public health strategies to protect vulnerable groups.

Addressing the identified evidence gaps, this study aimed to comprehensively analyze the association between exposure to tropical infectious diseases and reproductive health vulnerability and outcomes among women in North Sumatra through a population-based study. Specifically, this study has three main objectives. The first is the prevalence of clinically relevant tropical infectious diseases (e.g., malaria, filariasis, and helminthiasis) in women of childbearing age (15-49 years) in the study area. Second, we analyzed the statistical association between infection status (either single or multiple) and various reproductive health indicators, including but not limited to pregnancy complications, menstrual cycle disorders, and history of infertility. Third, we evaluated the role of socion demographic, behavioral, and environmental factors as potential modulators or moderators of the association between infection exposure and reproductive health outcomes. Achieving these objectives is expected to provide an in-depth epidemiological understanding of these complex interactions at a community level.

A systematic literature review showed that most previous research has explored the domains of reproductive health and tropical infectious diseases as separate entities. Studies on reproductive health often focus on obstetric or socioeconomic risk factors, whereas tropical disease research tends to concentrate on epidemiology, transmission, and clinical trials of treatments. Although several important studies have successfully linked specific infections such as malaria to pregnancy outcomes, they often have

significant limitations. Many of these are retrospective, hospital-based, or focused on a single pathogen. Consequently, their findings may not fully reflect the true burden of disease at the community level and fail to capture the complexity of co infections common in endemic areas. Thus, there is a clear gap in the literature: the absence of prospective, population-based studies that comprehensively assess the broad spectrum of tropical infectious diseases and their simultaneous impact on multiple aspects of women's reproductive health in a specific geographic context such as North Sumatra.

Therefore, the primary novelty of this study lies in its prospective, population-based design, which allows for comprehensive and simultaneous assessment of the interactions between multiple tropical infectious diseases and a broad spectrum of reproductive health outcomes. This approach surpasses previous fragmented studies by providing more representative and holistic epidemiological data on the true burden of the problem at a community level. The justification for this study is multi faceted and significant. First, from a public health perspective, the findings of this study will provide crucial scientific evidence for policymakers at the provincial and national levels to design intervention programs that integrate reproductive health services with tropical disease control programs. Second, at the clinical level, the results of this study have the potential to shift the practice paradigm by encouraging clinicians to implement tropical disease screening as a standard component of antenatal care and other women's health services in endemic areas. Finally, this study makes a substantial contribution to the global literature on women's health in the tropics, filling a critical knowledge gap and paving the way for future research.

METHOD

Research Design

This was a population-based cross-sectional study. This design was chosen to simultaneously estimate the prevalence of exposure to tropical infectious diseases and various reproductive health outcomes at a single point in time. This approach allows for the analysis of associations between exposure variables (infectious diseases) and outcome variables (reproductive health status) within the target population as well as for identifying other associated factors.

Research Population and Sample

The target population in this study was women of reproductive age, defined as women aged 1549 years, who resided in North Sumatra Province.

Stratified random sampling was used to ensure the representativeness of samples from various regions with potentially different epidemiological and demographic characteristics. North Sumatra Province is divided into several strata based on relevant geographic or administrative classifications (e.g., coastal areas, highlands, urban, and rural areas). From each stratum, severeal cluster units (e.g., villages or sub-districts) were randomly selected. Next, from each selected cluster, a number of individuals (women aged 15-49 years) will be randomly selected proportionally to become study respondents until a predetermined sample size is reached. Inclusion criteria included women aged 15-49 years who had lived in the study location for at least six months and

were willing to provide written informed consent. Exclusion criteria are Women who were unable to participate due to serious medical or cognitive reasons were excluded.

Research Procedures and Data Collection

Prior to field implementation, this research protocol was approved by the authorized Health Research Ethics Committee. Formal coordination and permits will be obtained from the North Sumatra Provincial Government, including the North Sumatra Level I Health Office.

Data collection will be conducted by a team of trained enumerators consisting of local health workers. The data collection procedure for each participant included three main components

1. Structured Interview:Participants will be interviewed using a standardized questionnaire to collect data on socio demographic characteristics (age, education, occupation), reproductive health history (menstrual cycle, pregnancy history and outcomes, contraceptive use, history of infertility), and behavioral and environmental risk factors.
2. Clinical Examination:A baseline examination will be performed, including anthropometric measurements (weight and height) to determine the body mass index (BMI).
3. Biological Sampling:

Venous blood samples and/or other relevant specimens will be collected by trained laboratory personnel according to standard operating procedures (SOPs) for the diagnosis of tropical infectious diseases under investigation (e.g., rapid diagnostic tests or thick blood smears for malaria and serology tests for filariasis). All samples were uniquely coded to maintain confidentiality and were analyzed at designated reference laboratories.

Secondary data regarding regional health profiles and epidemiological data on infectious diseases will be obtained from the annual reports and databases of the North Sumatra Level I Health Service to complement the primary data.

Data Analysis Techniques

All collected data were analyzed using statistical software (SPSS or Stata). The analysis was conducted in three stages:

1. Descriptive Analysis: Descriptive statistics (frequency, percentage, mean, and standard deviation) will be used to describe the baseline characteristics of participants, the prevalence of each tropical infectious disease, and the distribution of reproductive health indicators.

2. Bivariate Analysis:The Chi-square test or Fisher's exact test was used to analyze the association between categorical variables. For continuous variables, an independent t-test or ANOVA variance was applied. Prevalence ratios (PR) with 95% confidence intervals (95% CI) were calculated to measure the strength of the association between infection status and health outcomes.

3. Multivariate Analysis:Multiple logistic regression models were used to analyze the association between primary exposures and outcomes, controlling for potential confounders such as age, socioeconomic status, and parity. This analysis identified the

independent predictors of adverse reproductive health outcomes. The statistical significance level was set at a p-value <0.05.

RESULTS AND DISCUSSION

Characteristics of Research Participants

Of the 1,500 women invited to participate, 1,420 met the inclusion criteria and completed all the study procedures, resulting in a response rate of 94.7%. As summarized in Table 1, the mean age of participants was 29.8 ± 6.4 years. The majority of participants lived in rural areas (65.5%), were married (78.2%), and had high school education (45.8%). Approximately one-third of the participants (34.5%) worked in agriculture, which was the most common occupation of the study population.

Table 1. Socio-Demographic Characteristics of Participants (n=1,420).

Characteristics	n	%
Age Group (years)		
15-24	412	29.0
25-34	596	42.0
35-49	412	29.0
Domicile		
Urban	490	34.5
Rural areas	930	65.5
Marital status		
Not married yet	281	19.8
Marry	1110	78.2
Widow/Divorcee	29	2.0
Last education		
Not/Not Yet in School	128	9.0
Elementary School/Equivalent	355	25.0
Junior High School/Equivalent	284	20.0
High School/Equivalent	650	45.8
College	103	7.2
Main Job		
Not Working/Housewife	568	40.0
Agriculture/Plantation	490	34.5
Self-employed/Trader	185	13.0
Employees	113	8.0
Other	64	4.5

Prevalence of Tropical Infectious Diseases

Analysis of biological samples showed that the overall prevalence of at least one tropical infectious disease among the participants was 28.2% (95% CI: 25.9% - 30.5%). The highest prevalence of specific infections was associated with soil-transmitted helminth infections (18.5%), followed by malaria (8.2%) and filariasis (4.5%).

Coinfections (double or more infections) were detected in 3.0% of the total study population.

The Relationship between Tropical Infectious Diseases and Reproductive Health Outcomes

Bivariate analysis revealed significant associations between the infection status and reproductive health outcomes (Table 2). Women with malaria had a significantly higher prevalence of anemia (Hb < 11 g/dL) than uninfected women (45.3% vs. 18.9%; PR = 2.40, 95% CI: 1.95-2.95; p < 0.001). Similarly, a history of preterm birth was significantly more frequently reported in the malaria group. Worm infection showed the strongest association with anemia status (PR = 1.85, 95% CI: 1.52-2.25; p < 0.001), but not with other pregnancy outcomes.

Table 2. Bivariate Analysis of the Association between Infection Status and Reproductive Health Outcomes

Reproductive Health Outcomes	Infected with Malaria (n=116)	Worm Infection (n=263)	Uninfected (n=1020)	p-value
Prevalence of Anemia (%)	45.3	35.0	18.9	<0.001
History of Premature Birth (%)	22.4	14.1	12.5	0.015
History of LBW (%)	18.1	13.7	11.8	0.062
Menstrual Disorders (%)	25.0	22.1	20.5	

Note: p-values were calculated using the chi-square test. LBW: Lowbirthweight infant.
Multivariate Logistic Regression Analysis

After adjusting for age, education level, and domicile in a multivariate logistic regression model, malaria infection remained a significant independent predictor of anemia (Adjusted Odds Ratio [aOR] = 3.15, 95% CI: 2.20-4.51) and history of preterm birth (aOR = 1.89, 95% CI: 1.15-3.10). Worm infection also remained a strong predictor of anemia (aOR = 2.10, 95% CI: 1.60-2.75).

The main findings of this study confirm a significant double health burden among women of reproductive age in North Sumatra, with nearly one-third of the study population (28.2%) being diagnosed with at least one tropical infectious disease. This prevalence, particularly for helminthiasis (18.5%) and malaria (8.2%), indicates active and persistent community-level disease transmission, which may be higher than that officially reported by health facilities. Importantly, multivariate analysis strongly suggests that exposure to these infections is not an isolated clinical event but has direct consequences on reproductive health. The strong associations identified between malaria infection and an increased risk of anemia (aOR = 3.15) and preterm birth (aOR = 1.89) are consistent with known pathophysiological mechanisms, such as placental parasite sequestration and induction of a systemic inflammatory response. The strength of the associations found in this population-based study confirms that the impact of malaria on pregnancy is not limited to severe clinical cases but represents a substantial, widespread risk in the community. Similarly, the independent association between

helminth infection and anemia (aOR = 2.10) strengthens evidence regarding the detrimental impact of chronic blood loss and nutrient malabsorption due to intestinal parasitic infections, which directly worsen maternal nutritional status during the crucial reproductive period.

Discussion

This population-based study provides strong epidemiological evidence for the critical interconnection between tropical infectious diseases and women's reproductive health in North Sumatra. Key findings clearly demonstrate that nearly one-third of women of childbearing age in the region bear the burden of at least one tropical infectious disease, with malaria and helminth infections being the most prevalentones. Beyond simply mapping the prevalence, this study confirms that exposure to these infections is a strong independent predictor of adverse reproductive health outcomes. Specifically, malaria infection substantially increases the risk of maternal anemia and a history of preterm birth, whereas helminth infections demonstrate a strong association with anemia. These findings collectively challenge siloed approaches to public health and underscore the urgency of integrating infectious disease control into women's health service delivery platforms.

The 28.2% prevalence of tropical infectious diseases identified in this study reflects the substantial and potentially hidden public health burden in North Sumatra. This figure, obtained through active population-based screening, appears higher than the passive surveillance data reported by many health facilities, which often only captures symptomatic cases. Compared with other regional studies, the prevalence of helminth infections (18.5%) in the adult female population is consistent with findings in other regions in Southeast Asia with similar sanitation and environmental conditions However,the focus of deworming programs, which have largely targeted school-aged children, may need to be expanded. Meanwhile, the 8.2% malaria prevalence among women of childbearing age, while lower than some hyper-endemic areas in sub-Saharan Africa, remains alarming for a region targeting elimination. These high prevalences collectively reflect persistent environmental and socioeconomic risk factors in North Sumatra, such as agricultural practices, housing conditions, and access to clean water, which continuously facilitate pathogen transmission and place women at constant risk of exposure in their daily activities.

One of the most crucial findings of this study was the strong confirmation of the devastating impact of malaria infection on maternal health, even in the general population. The highly significant associations between malaria infection status and an increased risk of anemia (aOR = 3.15) and a history of preterm birth (aOR = 1.89) underscore that malaria during the reproductive period is not simply a febrile illness but a serious pathological condition with severe obstetric consequences. The strength of the associations, even after controlling for potential confounders, aligns with extensive pathophysiological evidence showing that sequestration of Plasmodium falciparum-infected erythrocytes in the placental intervillous space leads to tissue damage, local hypoxia, and placental insufficiency. This process not only directly triggers maternal anemia through hemolysis but also creates a suboptimal intrauterine environment that can precipitate preterm birth. Importantly, the findings from this population-based study extend our understanding beyond data from hospital-based clinical studies

suggesting that the risk is not a phenomenon limited to severe cases seeking treatment but rather a widespread and perhaps often undiagnosed public health threat at the community level.

CONCLUSION

This study demonstrates the interconnected double burden of tropical infectious diseases and reproductive health issues among women of childbearing age in North Sumatra. Malaria and helminth infections were independently shown to be significant predictors of adverse health outcomes, particularly maternal anemia and preterm birth. These findings underscore that reproductive health vulnerabilities in endemic areas are inextricably linked to the risk of exposure to persistent infectious diseases in their environments. Therefore, a vertical or "silo" approach to health services—where maternal and child health is addressed separately from infectious disease control programs—is no longer sufficient to effectively protect this vulnerable population.

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