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Factors associated with anemia among early adolescents in a rural junior high school: A cross-sectional study

Marian Magdalena Ina Dapa Melda[1], Rifzul Maulina[1]

[1]Bachelor of Midwifery Study Program, Faculty of Health Sciences, ITSK RS. dr. Soepraoen, Malang, Indonesia

Corresponding Author:
Marian Magdalena Ina Dapa Melda, meldadapa1110@gmail.com

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Abstract:
Anemia remains a major public health problem among adolescents and can impair growth, cognition, and school performance. This study aimed to analyze factors associated with anemia among junior high school adolescents in Southwest Sumba, Indonesia. An analytical cross-sectional study was conducted among 80 students in grades VII–IX recruited through total sampling. Knowledge of anemia, dietary patterns, breakfast habits, menstrual characteristics, and adherence to iron tablet supplementation were assessed using structured instruments. Hemoglobin was measured with a portable digital hemoglobinometer, and anemia was defined as hemoglobin <12 g/dL. Associations were tested using the chi-square test. Anemia was found in 52.5% of respondents. Anemia was significantly associated with adherence to iron tablet supplementation ($p < 0.001$), dietary patterns ($p = 0.001$), breakfast habits ($p = 0.008$), knowledge ($p = 0.012$), and menstrual characteristics ($p = 0.020$). Irregular iron tablet intake (81.3%) and irregular breakfast (65.0%) were the most common risk exposures. Anemia among early adolescents is multifactorial and involves behavioral, nutritional, and physiological factors. School health programs should integrate supervised iron supplementation, nutrition and breakfast promotion, menstrual health education, and routine hemoglobin screening.

Keywords:
adolescent; anemia; breakfast; dietary pattern; iron supplementation

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INTRODUCTION

Anemia is one of the most persistent nutritional problems in the world. The Global Burden of Disease Study 2021 estimated that nearly one in four people worldwide were living with anemia, with dietary iron deficiency remaining its leading cause (Gardner et al., 2023). The burden is concentrated in low- and middle-income countries, where women and adolescent girls are disproportionately affected and where progress toward global nutrition targets has been slow (Safiri et al., 2021; Stevens et al., 2022). Anemia prevalence also varies widely between and within districts of the same country, so national averages can hide local areas with very high risk (Kinyoki et al., 2021).

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Adolescence is a critical window for the development of anemia. Rapid growth, expansion of blood volume and muscle mass, and the onset of menstruation sharply increase iron requirements at a time when diets are often low in bioavailable iron (Christian & Smith, 2018). When iron intake or absorption cannot meet these needs, iron stores become depleted, hemoglobin synthesis declines, and anemia develops (Camaschella, 2015). Iron deficiency anemia in adolescents is linked to fatigue, reduced physical capacity, poor concentration, lower school performance, and impaired immunity. For girls, entering adulthood with low iron stores also increases the risk of adverse pregnancy outcomes (Pasricha et al., 2021). Preventing anemia during adolescence is therefore an investment in both present wellbeing and the health of the next generation.

In Indonesia, anemia among adolescents remains a national health priority. Surveys continue to show a high burden among adolescent girls and young women, and a review of Indonesian studies concluded that important knowledge gaps persist about the specific causes of anemia in this age group, including the roles of dietary intake, infection, and menstrual disorders (van Zutphen et al., 2021). The government has responded with a school-based weekly iron–folic acid (IFA) supplementation program combined with nutrition education (Roche et al., 2018). However, adherence remains low. Adolescent girls report fear of side effects, unpleasant taste, forgetfulness, and limited support from family and teachers as barriers to regular tablet consumption (Hidayanty et al., 2025).

Evidence from Indonesia and other developing countries shows that adolescent anemia is multifactorial. Reviews have identified inadequate dietary iron intake, low dietary diversity, limited knowledge, heavy or prolonged menstruation, infection, and socioeconomic disadvantage as key risk factors (Lubis et al., 2026; Wiafe et al., 2023). Indonesian studies have linked anemia to eating patterns and menstrual cycle characteristics (Wulandari et al., 2024). In East Nusa Tenggara Province, breakfast habits and IFA adherence were the strongest correlates of anemia among female adolescents (Bani et al., 2025). Dietary transitions toward energy-dense snacks and low fruit and vegetable intake have also been documented among Indonesian adolescents (Purnomo et al., 2024). At the same time, nutrition education has been shown to improve knowledge about anemia and, in some studies, hemoglobin levels (Febrianti et al., 2023).

These factors may interact rather than contribute independently to the risk of anemia. Inadequate dietary iron intake and poor dietary diversity may reduce iron availability, while irregular breakfast habits can further limit daily nutrient intake. At the same time, menstrual blood loss increases iron requirements among adolescent girls, particularly when bleeding is prolonged or heavy (Christian & Smith, 2018; Camaschella, 2015; Mansour et al., 2021). Low adherence to iron supplementation may further increase the risk of iron store depletion when dietary intake is insufficient to meet physiological demands (Pasricha et al., 2021; Hidayanty et al., 2025). Understanding these factors together is therefore important for identifying the combination of nutritional and behavioral conditions associated with anemia during early adolescence.

Despite this growing evidence, three gaps remain. First, many studies examine one or two determinants in isolation, such as IFA adherence or diet, rather than assessing behavioral and physiological factors together in the same population. Second, most studies have focused on senior high school students or older adolescent girls. Early adolescents aged 12–14 years in junior high school receive less attention, even though this is the period when menarche usually occurs and

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long-term eating habits are formed. Third, evidence from rural areas of eastern Indonesia, where access to food, health services, and school health programs may differ from that in urban Java, is still limited. Context-specific data are needed because effective interventions must fit local food cultures, school routines, and health system capacity.

Schools provide an important setting for identifying and addressing anemia because they offer regular opportunities to reach adolescents during a critical period of growth and development. School-based interventions can combine iron supplementation with nutrition education, promotion of healthy breakfast habits, and menstrual health awareness. However, the effectiveness of these strategies depends on consistent implementation, student adherence, and collaboration among teachers, parents, and healthcare providers. Evidence from Indonesia suggests that multisectoral school-based programs can support the implementation of adolescent nutrition interventions, although barriers related to adherence and family support remain important considerations (Roche et al., 2018; Hidayanty et al., 2025). Integrating these activities into routine school health services may provide a practical approach to improving anemia prevention among adolescents in rural communities.

Early identification of anemia during early adolescence is particularly important because this period provides an opportunity to prevent nutritional deficiencies before they affect subsequent stages of growth and development. Adolescents with inadequate iron intake may experience progressive depletion of iron stores, while menstrual blood loss can further increase iron requirements among girls (Christian & Smith, 2018; Camaschella, 2015). Without timely identification, iron deficiency may go unnoticed until symptoms or functional consequences become apparent (Pasricha et al., 2021). Routine hemoglobin screening, combined with assessment of dietary practices, menstrual characteristics, and adherence to iron supplementation, may help identify adolescents who require further evaluation and appropriate intervention. This preventive approach is particularly relevant in rural school settings, where access to regular nutritional assessment and health services may be limited (Kinyoki et al., 2021; Roche et al., 2018).

This study addresses these gaps by examining five potentially relevant determinants (knowledge of anemia, dietary patterns, breakfast habits, menstrual characteristics, and adherence to iron tablet supplementation) within a single analytical framework among early adolescents in a rural junior high school in eastern Indonesia. Identifying the factors associated with anemia may help school nurses, teachers, and primary healthcare staff develop integrated prevention strategies that address nutritional, behavioral, and physiological aspects of adolescent health. Therefore, this study aimed to examine the factors associated with anemia among adolescents at SMP K. Santo Gerardus Mayella Kalembuweri, Indonesia.

METHODS

This study used an analytical cross-sectional design to examine the associations between selected behavioral and physiological factors and anemia status among adolescents. A cross-sectional design was chosen because it allows exposures and outcomes to be measured simultaneously and is suitable for estimating prevalence and identifying associated factors. The

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study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (von Elm et al., 2007).

The study was conducted at SMP K. Santo Gerardus Mayella Kalembuweri, a junior high school in Southwest Sumba Regency, East Nusa Tenggara Province, Indonesia, in 2025. The population comprised all students enrolled in grades VII to IX during the data collection period. Because the population was small, a total sampling approach was used, and all eligible students were invited to participate. Inclusion criteria were being an active student in grades VII–IX, being present on the day of data collection, and being able to complete the questionnaire independently. Students who declined hemoglobin testing or had incomplete data were excluded. A total of 80 adolescents were included in the final analysis.

The dependent variable was anemia status. Hemoglobin concentration was measured from a fingertip capillary blood sample using a portable digital hemoglobinometer operated by trained health personnel according to the manufacturer's instructions. Anemia was defined as a hemoglobin level below 12.0 g/dL, in line with the World Health Organization cut-off for adolescents aged 12–14 years and non-pregnant females aged 15 years and older.

The independent variables were knowledge of anemia, dietary patterns, breakfast habits, menstrual characteristics, and adherence to iron tablet supplementation. Knowledge was assessed using a structured questionnaire with items covering the causes, signs and symptoms, consequences, and prevention of anemia, as well as the dietary sources of iron. Each correct answer scored 1, and each incorrect answer scored 0; total scores were converted to percentages and categorized as good (76–100%), moderate (56–75%), or poor (<56%). Dietary patterns were assessed using a structured food consumption checklist that recorded how often respondents consumed iron-rich foods, vegetables, and fruits, and were categorized as good, moderate, or poor. Breakfast habits were classified as regular when respondents ate breakfast before school on most school days in a typical week and irregular otherwise. Menstrual characteristics were classified by menstrual duration as normal (<7 days) or abnormal (≥7 days). Adherence to iron tablet supplementation was classified as regular when respondents consumed the weekly iron–folic acid tablet distributed through the school health program as scheduled during the previous month, and irregular otherwise. The questionnaires were developed from the literature on adolescent nutrition and anemia prevention and were reviewed for content validity and pilot-tested before use.

Data were collected after permission was obtained from the school administration and informed consent was obtained. Respondents first completed the questionnaire in the classroom under the supervision of the researchers, who were available to clarify unclear items without guiding the answers. The food consumption and breakfast checklists were then completed using standardized forms. Finally, hemoglobin was measured individually in a private room. All forms were checked for completeness on the same day, and incomplete items were clarified with the respondent before data entry.

Data were coded, cleaned, and analyzed using a computer program. Categorical variables were summarized as frequencies and percentages. The association between each independent variable and anemia status was tested using Pearson's chi-square test. Fisher's exact test was planned for 2 × 2 tables in which more than 20% of cells had expected counts below 5. A two-tailed p-value of less than 0.05 was considered statistically significant. Permission was also obtained

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from the school principal. Because the participants were minors, written informed consent was obtained from parents or guardians, and verbal assent was obtained from each student. Participation was voluntary; respondents could withdraw at any time without consequences, and all data were anonymized using codes and used only for research purposes. Students identified as anemic were informed of their results and referred to the local primary health center (Puskesmas) for follow-up.

RESULTS

A total of 80 adolescents in grades VII–IX participated in this study. Most respondents were aged 12–14 years, and the majority were female. Hemoglobin measurements identified anemia in 42 respondents (52.5%). The distribution of the study variables is presented in Table 1.

Table 1. Distribution of study variables among adolescents (n = 80)

Variable	Category	n	%
Knowledge of anemia	Good	25	31.3
	Moderate	30	37.5
	Poor	25	31.3
Dietary patterns	Good	20	25.0
	Moderate	35	43.8
	Poor	25	31.3
Menstrual characteristics	Normal (<7 days)	40	50.0
	Abnormal (≥7 days)	40	50.0
Breakfast habits	Regular	28	35.0
	Irregular	52	65.0
Iron tablet supplementation	Regular	15	18.8
	Irregular	65	81.3
Anemia status	Anemia (Hb <12 g/dL)	42	52.5
	Non-anemia (Hb ≥12 g/dL)	38	47.5

Note: Hb = hemoglobin.

Table 1 shows that more than one-third of respondents (37.5%) had moderate knowledge of anemia, while good and poor knowledge were each found in 31.3%. Only one-quarter of respondents (25.0%) had good dietary patterns, whereas 43.8% had moderate and 31.3% had poor dietary patterns. Half of the respondents (50.0%) reported that their menstruation lasted seven days or longer. Most respondents ate breakfast irregularly (65.0%), and adherence to iron tablet supplementation was low, with only 18.8% taking the tablets regularly.

Table 2. Association between independent variables and anemia status among adolescents (n = 80)

Variable	p-value	Interpretation
Knowledge of anemia	0.012	Significant
Dietary patterns	0.001	Significant
Menstrual characteristics	0.020	Significant
Breakfast habits	0.008	Significant
Iron tablet supplementation adherence	<0.001	Significant

Note: p-values were obtained from Pearson's chi-square test; significance level $p < 0.05$.

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As presented in Table 2, all five independent variables were significantly associated with anemia status. Adherence to iron tablet supplementation showed the smallest p-value ($p < 0.001$), followed by dietary patterns ($p = 0.001$), breakfast habits ($p = 0.008$), knowledge of anemia ($p = 0.012$), and menstrual characteristics ($p = 0.020$). Anemia was more frequently observed among respondents with irregular iron tablet consumption, less favorable dietary patterns, irregular breakfast habits, lower anemia knowledge, and menstrual duration of seven days or longer.

Table 3. Prevalence of at-risk exposures and ranking of their associations with anemia (n = 80)

Factor	At-risk category	n (%)	p-value	Rank
Iron tablet supplementation	Irregular	65 (81.3)	<0.001	1
Dietary patterns	Poor	25 (31.3)	0.001	2
Breakfast habits	Irregular	52 (65.0)	0.008	3
Knowledge of anemia	Poor	25 (31.3)	0.012	4
Menstrual characteristics	Abnormal (≥7 days)	40 (50.0)	0.020	5

Note: Rank is based on the p-value of the bivariate chi-square test (1 = strongest association). It reflects statistical significance, not an adjusted effect size.

Table 3 summarizes the distribution of selected at-risk exposures and their corresponding bivariate p-values. Irregular iron tablet supplementation was the most prevalent exposure (81.3%), followed by irregular breakfast habits (65.0%) and menstrual duration of seven days or longer (50.0%). Poor dietary patterns and poor knowledge of anemia each affected 31.3% of respondents. Based on the statistical significance of the bivariate analyses, iron tablet supplementation had the smallest p-value, followed by dietary patterns, breakfast habits, knowledge of anemia, and menstrual characteristics. Overall, the findings indicate that several potentially modifiable factors were present among the respondents.

DISCUSSION

This study found that more than half (52.5%) of early adolescents in a rural junior high school in Southwest Sumba were anemic. This proportion exceeds the 40% threshold that is commonly used to classify anemia as a severe public health problem (Stevens et al., 2022). Anemia was significantly associated with all five factors examined: adherence to iron tablet supplementation, dietary patterns, breakfast habits, knowledge of anemia, and menstrual characteristics. The strongest associations were found for iron tablet adherence and dietary patterns. Together, these findings suggest that anemia in this population is not caused by a single factor but by several behavioral, nutritional, and physiological factors acting simultaneously.

The high prevalence observed in this study is consistent with the uneven distribution of anemia in low- and middle-income countries, where rural and remote districts often carry a much higher burden than national averages suggest (Kinyoki et al., 2021). It is also in line with findings from East Nusa Tenggara, where anemia among female adolescents was closely linked to breakfast habits and IFA adherence (Bani et al., 2025), and with studies of school-aged adolescent girls in other low-income settings (Gebreyesus et al., 2019). Several local conditions may explain the high prevalence, including limited household access to animal-source foods, a diet based mainly on

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staple carbohydrates, and long distances to health services. Infections, which were not measured in this study, may also contribute to eastern Indonesia (van Zutphen et al., 2021).

Adherence to iron tablet supplementation showed the strongest association with anemia, and only 18.8% of respondents took the tablets regularly. This finding is biologically plausible. When dietary iron is insufficient to meet the high demands of adolescence, supplementation is the most direct way to replenish iron stores and support hemoglobin synthesis. A Cochrane review showed that daily iron supplementation in menstruating women reduces anemia and improves hemoglobin and iron status (Low et al., 2016). A school-based weekly IFA program in Ghana also significantly reduced anemia among adolescent girls (Gosdin et al., 2021), and systematic reviews support micronutrient supplementation as an effective adolescent nutrition intervention (Lassi et al., 2017). The low adherence found here mirrors national evidence that Indonesian girls often avoid tablets because of side effects, taste, forgetfulness, and limited support (Hidayanty et al., 2025). Gastrointestinal side effects are a known cause of poor adherence to oral iron therapy (Pasricha et al., 2021). Practical solutions include taking tablets together at school on a fixed day, taking them after a meal to reduce discomfort, involving teachers and peers in monitoring, and engaging parents, as shown in Indonesia's multisectoral school program (Roche et al., 2018).

Dietary patterns were also strongly associated with anemia. Only one-quarter of respondents had good dietary patterns. This is important because the body absorbs heme iron from meat, fish, and poultry much more efficiently than non-heme iron from plant foods, and vitamin C-rich fruits enhance non-heme iron absorption (Camaschella, 2015). Adolescents whose diets rely mostly on rice, maize, or cassava, with few animal foods, fruits, and vegetables, are therefore at high risk of iron deficiency. Reviews of adolescents in developing countries consistently identify low intake of iron-rich foods and poor dietary diversity as major risk factors (Wiafe et al., 2023), and similar patterns have been reported among Indonesian adolescents (Wulandari et al., 2024). Indonesian adolescents are also shifting toward energy-dense, low-nutrient snacks (Purnomo et al., 2024), which can displace iron-rich foods. Interventions should therefore promote affordable local sources of iron, such as fish, eggs, legumes, and dark green leafy vegetables. Community programs that use local agricultural products and empower health cadres offer a feasible model for this approach (Ardiana et al., 2020).

Breakfast habits were significantly associated with anemia, and almost two-thirds of respondents ate breakfast irregularly. Breakfast contributes a meaningful share of daily energy and micronutrient intake, and children and adolescents who eat breakfast generally have better diet quality (Lundqvist et al., 2019). Skipping breakfast is also linked to a broader unhealthy lifestyle, including irregular meals and increased snack consumption (Monzani et al., 2019). For adolescents with limited food access, missing one meal a day may substantially reduce total iron intake. The strong link between breakfast and anemia reported in East Nusa Tenggara (Bani et al., 2025) supports this explanation. Schools can encourage breakfast through health education for students and parents and, where possible, through simple school breakfast or healthy canteen initiatives.

Knowledge of anemia was significantly associated with anemia status. Knowledge is a basic condition for health behavior; adolescents who understand the causes and consequences of anemia are more likely to choose iron-rich foods and take iron tablets. A meta-analysis found that nutrition education improves knowledge of anemia and hemoglobin levels in female adolescents (Febrianti

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et al., 2023), and a school-based program in Jordan improved knowledge, attitudes, and practices related to iron-deficiency anemia (Abu-Baker et al., 2021). Health education delivered by nurses in schools has also been shown to be a feasible approach for adolescents in Indonesia (Afandi et al., 2023). However, knowledge alone is rarely enough to change behavior. Education should be combined with practical skills, such as planning low-cost iron-rich meals, and with a supportive school environment that makes healthy choices easier.

Menstrual characteristics were also associated with anemia. Half of the respondents reported menstruating for seven days or longer. Prolonged or heavy menstrual bleeding increases monthly iron loss and is a major cause of iron deficiency and iron deficiency anemia in women (Mansour et al., 2021). In early adolescence, menstrual cycles are often irregular, and girls may not recognize that their bleeding is abnormal. Because iron needs already rise sharply during the growth spurt (Christian & Smith, 2018), additional menstrual losses can quickly deplete iron stores. Menstrual health is rarely discussed openly in schools, which may delay recognition and care. Simple questions about menstrual duration and bleeding can be added to school health screening so that girls with prolonged or heavy bleeding can be referred for evaluation.

An important implication of these findings is that anemia prevention among early adolescent girls requires attention to the interaction between nutritional intake, health behaviors, and physiological changes during puberty. Inadequate dietary iron intake may reduce the body's capacity to compensate for increased iron requirements during rapid growth, while prolonged menstrual bleeding can further increase iron loss. Irregular breakfast habits and poor dietary diversity may also limit the intake of essential micronutrients needed to maintain adequate hemoglobin levels (Christian & Smith, 2018; Camaschella, 2015; Wiafe et al., 2023). These overlapping factors suggest that interventions addressing only one behavioral aspect may have limited benefits. An integrated approach that combines adequate dietary intake, regular iron supplementation, and menstrual health monitoring is therefore important for reducing the risk of anemia during early adolescence.

The findings have clear implications for nursing and school health practice. Because the risk factors overlap, single-component programs are unlikely to be sufficient. The school health unit (Usaha Kesehatan Sekolah), primary health center nurses, teachers, and parents should work together on an integrated package that includes supervised weekly iron supplementation, nutrition and breakfast education, menstrual health counseling, and routine hemoglobin screening, ideally starting when students enter grade VII. School and community nurses are well placed to coordinate this package, monitor adherence, and follow up with students who are anemic. Such integrated approaches are consistent with recommendations for adolescent nutrition programs in Indonesia and other low- and middle-income countries (Lubis et al., 2026; Roche et al., 2018).

The sustainability of school-based anemia prevention also depends on consistent monitoring and collaboration among healthcare providers, schools, and families. School nurses and primary healthcare nurses can facilitate regular assessment of hemoglobin status, monitor weekly iron tablet consumption, identify students experiencing side effects, and provide individualized counseling for those with anemia. Teachers can support implementation through scheduled supplementation activities and attendance monitoring, while parents can reinforce healthy dietary practices and adherence at home. Health education should also be adapted to adolescents' developmental needs by combining information with practical activities, such as identifying affordable, locally available

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iron-rich foods and recognizing abnormal menstrual bleeding. The feasibility of school-based health education and multisectoral nutrition programs provide a foundation for strengthening these collaborative approaches (Afandi et al., 2023; Roche et al., 2018; Lubis et al., 2026).

This study has several strengths, including the objective measurement of hemoglobin, the simultaneous assessment of several modifiable factors, and its focus on early adolescents in an under-researched rural area of eastern Indonesia. Several limitations should also be noted. First, the cross-sectional design does not allow causal conclusions. Second, only bivariate analyses were performed, so the associations were not adjusted for potential confounders such as socioeconomic status, nutritional status, and infections; the ranking of factors therefore reflects statistical significance rather than independent effect sizes. Third, dietary patterns, breakfast habits, menstrual characteristics, and tablet consumption were self-reported and may be affected by recall and social desirability bias. Fourth, hemoglobin was measured with a portable device using capillary blood, which may differ slightly from laboratory measurement of venous blood. Finally, the study was conducted at a single school with a relatively small sample size, which limits generalizability. Future studies should use larger multi-school samples, multivariable logistic regression, objective dietary assessment, and longitudinal or intervention designs to test integrated school-based anemia prevention programs.

CONCLUSION

More than half of the adolescents at SMP K. Santo Gerardus Mayella Kalembuweri were anemic, which shows that anemia is a serious health problem in this setting. Anemia was significantly associated with knowledge of anemia, dietary patterns, breakfast habits, menstrual characteristics, and adherence to iron tablet supplementation, with the strongest associations observed for adherence to iron tablet supplementation and dietary patterns. These findings indicate that anemia in early adolescence results from several interacting behavioral and physiological factors. Therefore, prevention should be integrated within school health programs through supervised weekly iron supplementation, nutrition and breakfast promotion, menstrual health education, and routine hemoglobin screening.

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CONFLICT OF INTEREST

The authors declare no conflict of interest related to the conduct, analysis, or publication of this study.

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