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ASSESSING THE RISK OF DEVELOPING ANEMIA AMONG WOMEN TEA/COFFEE CONSUMERS OF REPRODUCTIVE AGE GROUP IN RURAL POPULATION, THIRUVALLUR DISTRICT OF TAMIL NADU

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Abstract
Background:
Anaemia remains a prevalent public health concern among women of reproductive age, particularly in rural India. Dietary habits, including tea consumption, may influence iron absorption and thereby impact anemia risk. However, the specific relationship between tea-drinking patterns and anemia among rural women is not well understood.
Objectives:
This study aims to assess the association between tea consumption and the risk of developing anemia among women of reproductive age in the rural population of Thiruvallur District, Tamil Nadu. It also seeks to evaluate the frequency, quantity, and timing of tea consumption and their potential impact on hemoglobin levels.
Methods:
A community-based cross-sectional study will be conducted among 384 women aged 15-49 years in rural Thiruvallur. Participants will be selected excluding those who are pregnant, lactating for less than six months, have bleeding disorders, or are on iron supplementation or anemia treatments. Data will be collected through a structured questionnaire covering sociodemographic variables and tea consumption patterns. Haematological parameters (CBC, TIBC, and serum ferritin) will be measured to assess anemia using WHO classification. Statistical analysis will be performed using Microsoft Excel and SPSS software, applying Chi-square tests, t-tests, and ANOVA to determine significant associations.
Expected Outcomes:
The study anticipates establishing a significant link between tea consumption habits and anemia prevalence, contributing to the understanding of dietary risk factors in rural Indian women.
Conclusion:
Findings from this study are expected to inform targeted nutritional interventions and public health strategies aimed at improving the health and well-being of women of reproductive age in rural Tamil Nadu.
Keywords: Iron Deficiency Anemia, Tea Consumption, Hemoglobin Levels, Women of Reproductive Age, Serum Ferritin, Nutritional Anemia, Rural Health.

1. INTRODUCTION

Anemia, particularly iron deficiency anemia, remains a significant public health concern globally, with a heavy burden on women of reproductive age. Characterized by reduced haemoglobin levels or red blood cell count, anemia impairs oxygen transport, resulting in fatigue, lowered immunity, and diminished cognitive and physical performance [1]. The World Health Organization estimates that over 30% of non-pregnant women aged 15–49 are anemic, with low- and middle-income countries shouldering the highest prevalence. In India, the National Family Health Survey (NFHS-5) reports that approximately 57% of women in this age group are anemic, highlighting the persistent nature of the condition despite ongoing public health initiatives.

The causes of anemia among women of reproductive age are multifaceted, ranging from poor dietary intake and parasitic infections to menstrual blood loss and increased physiological demands during pregnancy and lactation. Among these, iron deficiency-often due to inadequate dietary intake-remains the leading contributor[2]. Although national programs such as Anemia Mukt Bharat have promoted iron supplementation and nutritional awareness, many rural communities still face challenges related to dietary diversity and nutrition literacy [3]. These factors can significantly affect iron bioavailability, particularly where cultural practices influence food consumption.

One such practice is tea consumption, a deeply rooted habit across India. While tea provides antioxidants, it also contains tannins and other polyphenols that inhibit the absorption of non-heme iron-the form most commonly found in plant-based diets [4]. This is particularly relevant in rural areas, where meat consumption is minimal and plant sources are the primary contributors of iron. Studies suggest that drinking tea, especially around mealtimes, can hinder iron absorption, potentially aggravating iron deficiency and contributing to anemia. However, most existing research on this topic has been limited to urban and semi-urban populations, leaving a critical data gap in rural settings such as Tamil Nadu [5].

This study aims to examine the relationship between tea-drinking habits and anemia prevalence among women of reproductive age in the rural population of Thiruvallur District, Tamil Nadu. By evaluating the frequency, timing, and quantity of tea consumption in relation to haematological indicators such as haemoglobin, total iron-binding capacity (TIBC), and serum ferritin, the study seeks to generate evidence that informs culturally sensitive nutritional interventions and anemia prevention strategies tailored to rural Indian communities.

2. Material and Methods

2.1 Study Design and Setting

A community-based cross-sectional analytical study was conducted to assess the association between tea consumption and the risk of developing anemia among women of reproductive age in the rural areas of Thiruvallur District, Tamil Nadu. Thiruvallur is located in the northeastern part of Tamil Nadu and consists of diverse rural regions, with agriculture and manual labor being the predominant occupations. The study was carried out over six months, with data collected in collaboration with local health authorities and community health workers. The study design was selected to allow for population-level analysis of exposure (tea consumption) and outcome (anemia) at a single point in time [6].

2.2 Study Population and Sampling

The study targeted women aged 15 to 49 years, the reproductive age group as defined by the World Health Organization (WHO). Women were eligible if they had resided in the rural area for at least one year and were not pregnant, not lactating for less than six months, and not suffering from any chronic bleeding disorders [7]. Participants undergoing iron supplementation or receiving treatment for anemia were excluded to eliminate confounding variables.

A sample size of 384 was calculated using the Cochran formula for sample estimation:

$$n = \frac{Z^2 \cdot P \cdot (1 - P)}{d^2} \quad \text{..... (1)}$$

Where Z is the Z-value for 95% confidence (1.96), P is the assumed prevalence of anemia (50%), and d is the margin of error (5%). This sampling method ensured maximum variability and generalizability.

Multistage random sampling was employed. Villages were randomly selected from the district, and eligible women from each village were approached through local Accredited Social Health Activists (ASHAs) and primary health workers.

2.3 Data Collection Tools and Procedures

Data were collected through a pre-tested structured questionnaire, administered in the local language (Tamil) by trained field investigators [8]. The questionnaire captured:

- Sociodemographic information: age, education, occupation, and family type.
- Tea consumption habits**:** frequency (none, 1, 2, or ≥3 cups/day), quantity per serving, and timing in relation to meals.
- Nutritional history**:** dietary habits, known iron sources, and meal patterns.

The questionnaire was pilot-tested on a sample of 30 women in a nearby village not included in the study, ensuring clarity, reliability, and cultural relevance.

Additionally, anthropometric measurements (height and weight) were recorded using standardized instruments. Body Mass Index (BMI) was calculated and interpreted based on WHO guidelines.

2.4 Laboratory Investigations

Each participant underwent venous blood collection (5 mL) under aseptic conditions by a trained phlebotomist [9]. The samples were analyzed in a certified diagnostic laboratory using:

- **Complete Blood Count (CBC)**: including hemoglobin (Hb), red cell indices, and hematocrit, using an automated hematology analyzer (e.g., Sysmex or Nihon Kohden).
- **Serum Ferritin**: measured using enzyme-linked immunosorbent assay (ELISA).
- **Total Iron Binding Capacity (TIBC)**: determined using spectrophotometric methods.

Anemia was classified using **WHO criteria**:

- Normal: Hb ≥12.0 g/dL
- Mild: 11.0–11.9 g/dL

- Moderate: 8.0–10.9 g/dL
- Severe: <8.0 g/dL

This triad of parameters (Hb, serum ferritin, and TIBC) enabled accurate differentiation between iron deficiency anemia (IDA) and other forms of anemia.

2.5 Ethical Considerations

Prior to data collection, ethical clearance was obtained from the Institutional Human Ethics Committee (IHEC) of Saveetha Medical College and Hospital**.** Written informed consent was obtained from each participant after explaining the purpose, procedures, and potential risks/benefits of the study. Participation was voluntary, and confidentiality of the data was strictly maintained [10].

Women identified with moderate or severe anemia were counselled and referred to the nearest Primary Health Center (PHC) for further evaluation and treatment, as per the guidelines of the Anemia Mukt Bharat [11] initiative by the Ministry of Health and Family Welfare, Government of India.

2.6 Statistical Analysis

All data were entered into **Microsoft Excel 2019** and analyzed using **SPSS version 26.0 (IBM Corp., Armonk, NY)**. Descriptive statistics were used to summarize demographic variables (frequency and percentage) and continuous variables (mean and standard deviation).

- **Chi-square tests** were used to assess the association between categorical variables (e.g., anemia status vs. tea intake).
- **One-way ANOVA** was used to compare mean haemoglobin and serum ferritin levels across multiple tea consumption groups.
- A **p-value of <0.05** was considered statistically significant.

All analyses were guided by previous statistical approaches used in studies such as Sadiq et al. [12], ensuring methodological consistency with existing literature.

3. RESULTS

3.1. Demographic and Baseline Characteristics

A total of **384 women aged 15 to 49 years**, classified as the reproductive age group according to WHO standards, were enrolled in this community-based cross-sectional study conducted in the rural areas of Thiruvallur District, Tamil Nadu. The demographic and baseline characteristics of the participants provide important context for understanding the risk factors associated with anemia, particularly in relation to tea consumption. These details are summarized in Table 1**.**

The majority of participants belonged to the 25–34 years age group **(**38.5%**),** followed by those aged **15–**24 years (26.6%) and 35–44 years (24.5%). A smaller proportion **(**10.4%**)** were in the 45–49 years category. This distribution aligns with the demographic profile of rural India, where a significant portion of the female population is in their peak reproductive and working years. This age group is particularly vulnerable to anemia due to menstruation, pregnancies, and increased nutritional demands [WHO, 2021].

Education levels among the women were predominantly low. Nearly **one-third (31.3%)** of the participants had **no formal education**, which may significantly impact their knowledge about health, nutrition, and anemia prevention strategies. About **47.9%** had attained education up to the **primary or secondary level**, while only **20.8%** had completed **higher secondary education or above**. Previous studies have shown that lower educational attainment is strongly correlated with poor dietary practices and limited healthcare-seeking behaviour, both of which contribute to anemia prevalence [13].

Tea consumption was found to be highly prevalent in the study population. Only **12.5% (n=48)** of the participants reported not drinking tea at all, while **87.5%** consumed tea in varying quantities. The highest proportion of women **(**37.0%**)** consumed **2 cups of tea daily**, followed by **32.8%** who drank **1 cup/day**. A notable **17.7%** of the participants reported drinking **3 or more cups per day**, raising concern over excessive tea intake and its potential interference with iron absorption.

Tea consumption is a deeply rooted cultural habit in many Indian households, often initiated early in life and continued through adulthood. However, the timing of tea intake to meals, which was evaluated in subsequent sections of this study, plays a crucial role in iron metabolism. Habitual tea consumption, especially post-meal, has been implicated in reducing non-heme iron absorption, thereby contributing to iron deficiency anemia [14].

These baseline findings indicate that the study population is socio-demographically representative of many rural Indian communities, characterized by low literacy levels, culturally ingrained dietary practices, and high anemia vulnerability. This background supports the relevance and necessity of examining the relationship between tea consumption and anemia status in this specific population.

Table 1. Demographic and Tea Consumption Characteristics of Study Participants (n = 384)

Variable	Frequency (n=384)	Percentage (%)
Age Group		
15–24 years	102	26.6
25–34 years	148	38.5
35–44 years	94	24.5
45–49 years	40	10.4
Educational Status		
No formal education	120	31.3
Primary to Secondary	184	47.9
Higher secondary and above	80	20.8
Tea Consumption Frequency		
None	48	12.5
1 cup/day	126	32.8
2 cups/day	142	37.0
≥3 cups/day	68	17.7

The prevalence and classification of anemia among women of reproductive age in the rural areas of Thiruvallur District were assessed using hemoglobin concentrations measured through a hematology analyzer. The classification adhered to the World Health Organization (WHO) guidelines, which define anemia in non-pregnant women as a hemoglobin level less than 12 g/dL. Severity is categorized as mild (11.0–11.9 g/dL), moderate (8.0–10.9 g/dL), and severe (<8.0 g/dL).

Of the total 384 participants, 266 women (69.3%) were found to be anemic, indicating a high burden of anemia in this population (Table 2). This prevalence exceeds the threshold set by WHO for anemia to be considered a severe public health problem (≥40%) and aligns with findings from similar studies conducted in low- and middle-income countries (LMICs) such as Pakistan and Bangladesh, as well as rural pockets of India [15].

Moderate anemia was the most prevalent among participants, affecting 32.3% (n=124) of the women. This indicates a substantial proportion of individuals whose daily functionality and quality of life may be compromised. **Mild anemia** was noted in **25.0% (n=96)** of the participants, while **severe anemia** was observed in **12.0% (n=46)**. These women, especially those in the severe category, are at greater risk of complications such as fatigue, compromised immunity, maternal morbidity, and adverse pregnancy outcomes if not addressed promptly.

Only **30.7% (n=118)** of the women had haemoglobin levels within the normal range (≥12 g/dL), highlighting the pervasive nature of anemia in this region. This finding is consistent with national health statistics that show a persistently high prevalence of anemia among women in rural India due to dietary deficiencies, low iron bioavailability, recurrent infections, and socio-economic constraints [NFHS-5, 2021].

Table 2. Haemoglobin Classification among Study Participants

Hemoglobin Range (g/dL)	Classification	Frequency (n)	Percentage (%)
≥12.0	Normal	118	30.7
11.0–11.9	Mild anemia	96	25.0
8.0–10.9	Moderate anemia	124	32.3
<8.0	Severe anemia	46	12.0

These findings reinforce the urgent need for targeted public health interventions, including anemia screening, iron supplementation programs, and nutritional education focusing on dietary practices that enhance iron absorption. Furthermore, the subsequent analysis (Section 3.3) explores the role of tea consumption, a common dietary habit in rural India, in contributing to this high anemia burden.

The association between tea consumption and hemoglobin (Hb) levels was assessed using one-way Analysis of Variance (ANOVA), comparing the mean Hb concentrations across groups with varying tea drinking frequencies: non-consumers, 1 cup/day, 2 cups/day, and ≥3 cups/day. The results revealed a statistically significant inverse relationship between tea consumption and haemoglobin levels ($p < 0.001$), as summarized in Table 3.

Women who reported no tea consumption had the highest mean haemoglobin level (12.2 ± 1.4 g/dL), indicating normal haematological status in accordance with WHO criteria. In contrast, those consuming 1 cup/day exhibited a modest reduction (11.4 ± 1.3 g/dL), while participants with 2 cups/day and ≥3 cups/day showed progressively lower Hb levels (10.7 ± 1.5 g/dL and 9.8 ± 1.7 g/dL, respectively). This gradient suggests a dose-dependent association, wherein increased tea intake correlates with decreased haemoglobin concentration.

These findings are supported by biochemical evidence that polyphenolic compounds (such as tannins) present in black tea form insoluble complexes with non-heme iron in the gastrointestinal tract, thereby inhibiting iron absorption and reducing bioavailability [16]. The negative effect is particularly pronounced when tea is consumed close to meals, which is a common cultural practice in rural India.

Furthermore, the Cureus study conducted by Sadiq et al. (2024) in Balochistan, Pakistan, reported a similar trend: mean Hb levels among tea drinkers were significantly lower (11.41 ± 1.55 g/dL) compared to non-drinkers (12.16 ± 1.27 g/dL) ($p < 0.001$). Their results also revealed a higher prevalence of microcytic anemia among tea drinkers, underscoring the nutritional risk posed by habitual tea consumption in iron-deficient populations.

Table 3. Association between Tea Consumption and Mean Hemoglobin Levels

Tea Consumption	Mean Hb (g/dL)	SD	p-value (ANOVA)
None	12.2	1.4	
1 cup/day	11.4	1.3	
2 cups/day	10.7	1.5	
≥3 cups/day	9.8	1.7	<0.001*

*Statistically significant at $p < 0.05$

The statistical significance of this relationship highlights the potential role of lifestyle and dietary habits in the aetiology of anemia, especially in resource-constrained settings where access to iron-rich food and supplements may be limited. It also provides critical evidence to inform public health messaging, encouraging awareness campaigns to reduce or time tea intake appropriately (e.g., avoiding it during or soon after meals) in populations vulnerable to iron deficiency.

In conclusion, the findings indicate that frequent tea consumption is a modifiable dietary risk factor contributing to lower haemoglobin levels among women of reproductive age in rural Thiruvallur. This warrants consideration in designing culturally sensitive anemia prevention and nutrition education programs.

To further evaluate the underlying cause and type of anemia among participants, iron status was assessed using two key haematological indicators: serum ferritin and Total Iron Binding Capacity (TIBC). These parameters provide a comprehensive understanding of iron stores and the body's capacity to transport iron, thereby enabling differentiation between iron deficiency anemia (IDA) and anemia of chronic disease.

The results showed a clear inverse relationship between tea consumption and serum ferritin levels, with a corresponding positive association with TIBC levels, indicating depletion of iron stores with increased tea intake (Table 4).

Women who did not consume tea had the highest mean serum ferritin level (38.5 ± 6.2 ng/mL) and the lowest TIBC (320 ± 22 µg/dL), reflecting adequate iron stores and low iron-binding demand. In contrast, women who consumed ≥3 cups of tea per day exhibited significantly lower serum ferritin (15.3 ± 4.2 ng/mL) and markedly elevated TIBC (402 ± 35 µg/dL), a biochemical profile that is characteristic of iron deficiency anemia. The differences across groups were statistically significant ($p < 0.01$), supporting the hypothesis that frequent tea consumption adversely affects iron metabolism and storage.

These findings corroborate the role of tea-derived polyphenols-especially tannins-in inhibiting non-heme iron absorption from plant-based diets by forming insoluble iron–polyphenol complexes in the intestinal lumen [17]. As iron absorption from vegetarian diets is already less efficient, the additional inhibitory effect of frequent tea consumption further compromises iron bioavailability, particularly in low-resource rural settings where iron-rich food sources and supplements may be limited or underutilized.

The observed alterations in ferritin and TIBC with increased tea intake are in alignment with the study by Sadiq et al. [18] published in *Cureus*, which highlighted a significant reduction in haemoglobin and red cell indices among tea drinkers in Pakistan. Their study showed that more than 82.9% of women with iron deficiency anemia were habitual tea drinkers, suggesting a widespread and underrecognized link between tea consumption patterns and iron deficiency in South Asian populations.

Table 4. Iron Profile Based on Tea Consumption

Tea Consumption Group	Serum Ferritin (ng/mL)	TIBC (µg/dL)	p-value
None	38.5 ± 6.2	320 ± 22	
1 cup/day	30.7 ± 5.8	355 ± 28	
2 cups/day	22.4 ± 4.6	380 ± 31	
≥3 cups/day	15.3 ± 4.2	402 ± 35	<0.01*

* Statistically significant at $p < 0.01$

The gradual decline in ferritin levels and increase in TIBC across ascending tea consumption categories strongly suggest a dose-response effect. This relationship emphasizes that higher quantities of tea intake-especially when consumed during or shortly after meals-may significantly impair the absorption of dietary iron, leading to progressive iron depletion and anemia. In summary, this analysis underscores the biological plausibility of tea-induced iron deficiency and highlights a modifiable behavioral factor that can be addressed through community-based health education, dietary counseling, and anemia control programs. Public health messages must focus not only on iron supplementation but also on dietary habits that impact iron absorption, such as the timing and frequency of tea consumption.

4. DISCUSSION

The present community-based cross-sectional analytical study assessed the association between tea consumption and the risk of developing anemia among women of reproductive age (15–49 years) residing in the rural areas of Thiruvallur District, Tamil Nadu. The study revealed a high overall prevalence of anemia (69.3%) among participants, with a particularly strong association between increasing tea consumption and reduced hemoglobin levels, lower serum ferritin, and elevated total iron-binding capacity (TIBC). These findings provide valuable insights into the influence of dietary habits-especially tea consumption-on iron status among women in resource-limited settings.

The overall anemia prevalence in this study is consistent with national data from the National Family Health Survey (NFHS-5, 2021), which reports anemia in 57% of Indian women of reproductive age. The observed 69.3% prevalence in our study population exceeds this average, underscoring a severe public health concern in Thiruvallur district. Among the anemic participants, moderate anemia (32.3%) was most common, followed by mild (25%) and severe (12%) forms. The severity of anemia correlates with similar rural studies from northern and southern India, indicating that rural women-due to poor dietary diversity, increased physiological demands and inadequate healthcare access-are more susceptible to iron deficiency [19].

A key focus of this study was to investigate the effect of tea consumption on hemoglobin levels. A significant inverse relationship was observed between tea intake frequency and hemoglobin concentration ($p < 0.001$). Mean hemoglobin levels progressively declined from 12.2 g/dL in non-tea drinkers **to** 9.8 g/dL in women consuming ≥3 cups of tea daily. Similar trends were noted in serum ferritin and TIBC values, with higher tea intake associated with depleted iron stores and increased iron-binding demand, both hallmarks of iron deficiency anemia.

These results are consistent with findings from a recent study by Sadiq et al. (2024) in Balochistan, Pakistan, published in *Cureus*, which reported significantly lower haemoglobin and mean corpuscular volume (MCV) levels in tea drinkers compared to non-drinkers ($p < 0.001$). The same study observed that over 82% of women with iron deficiency anemia were habitual tea consumers, indicating a strong association between tea intake and anemia severity [20].

Tea, especially black tea commonly consumed in Indian households, contains polyphenolic compounds such as tannins and catechins, which are potent inhibitors of non-heme iron absorption. These compounds bind iron in the gastrointestinal tract to form insoluble complexes, reducing its bioavailability. This inhibitory effect is further exacerbated when tea is consumed concurrently with meals or shortly thereafter, a common practice among rural

women. Controlled trials have shown that tea can inhibit non-heme iron absorption by up to 60% when taken with meals [21].

Globally, studies have established that dietary inhibitors like tea, calcium, and phytates significantly affect iron absorption, particularly among women dependent on plant-based diets. In a meta-analysis by Dania et al. (2022), habitual tea drinkers were found to have a 1.94 times higher risk of developing anemia**,** especially when tea was consumed during iron-rich meals [22].

A study by Thankachan et al. [23] among Indian women also found that tea consumption significantly reduced iron absorption and worsened the effects of marginal iron intake. Likewise, Lazrak et al. [24] in Morocco demonstrated that tea significantly reduced iron bioavailability even in women receiving iron fortification .

The implications of these findings are critical for public health policy. While anemia control programs in India such as Anemia Mukt Bharat (AMB) and POSHAN Abhiyan focus on iron and folic acid supplementation, deworming, and food fortification, the role of cultural dietary practices such as tea consumption is often overlooked [25]. This study highlights the need to incorporate nutrition education on dietary inhibitors and enhancers of iron absorption into these programs. Emphasizing the timing of tea intake (e.g., avoiding it within one hour of meals) could significantly enhance the efficacy of iron supplementation and dietary interventions.

The strengths of this study include a robust sample size (n=384), community-based random sampling, and comprehensive haematological profiling (haemoglobin, serum ferritin, TIBC). The findings are generalizable to similar rural populations in India. However, there are limitations to be acknowledged:

The cross-sectional design limits the ability to infer causality.

- Dietary recall bias may affect self-reported data on tea consumption.
- The study did not assess meal composition or vitamin C intake, which could modulate iron absorption. Future studies should incorporate longitudinal designs**,** qualitative interviews, and biochemical nutrient profiling to explore the multifactorial aetiology of anemia more comprehensively [26].

5. CONCLUSION

The findings of this community-based cross-sectional study underscore the high burden of anemia among women of reproductive age in the rural areas of Thiruvallur District, Tamil Nadu, with 69.3% of participants found to be anemic. The study identified a significant and dose-dependent inverse relationship between tea consumption and hemoglobin levels, along with a corresponding decline in serum ferritin and a rise in TIBC, indicating compromised iron stores and transport capacity among frequent tea drinkers. These results strongly suggest that frequent tea consumption, especially when taken with or shortly after meals, acts as a modifiable dietary risk factor contributing to iron deficiency anemia. Given the cultural ubiquity of tea in rural Indian households, this represents a critical yet often overlooked barrier to effective anemia control. The study highlights the importance of targeted nutritional education to raise awareness about dietary inhibitors of iron absorption. While supplementation and fortification programs remain essential under national initiatives like Anemia Mukt Bharat, equal emphasis must be placed on modifying tea-drinking behaviours, particularly its timing in relation to meals, to enhance dietary iron bioavailability. In conclusion, addressing tea consumption patterns should form an integral part of public health strategies aimed at combating anemia. The integration of behavioural, dietary, and biomedical interventions will be crucial to achieving long-term improvements in women’s nutritional health in rural India.

Declaration of Patient Consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients have given their consent for their clinical information and images to be reported in the journal. The patients understand that their

names and initials will not be published, and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of Interest

The authors declare that there are no conflicts of interest related to this study.

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