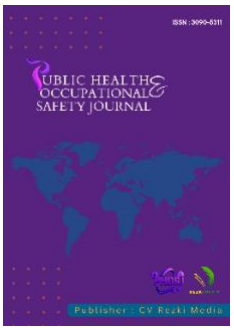

# Better BMI but higher anemia risk? Evidence from lacto-vegetarian women

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E – Critical revision of the article
F – Final approval of article



## ABSTRACT

**Background:** The increasing adoption of plant-based diets in the United States, particularly lacto-vegetarian patterns, has been driven by their perceived metabolic benefits. However, middle-aged women represent a nutritionally vulnerable group due to menopausal transitions and a high risk of anemia. In this context, the potential trade-off between improved body weight and micronutrient deficiencies remains insufficiently explored.

**Objectives:** This study examined the nutritional trade-offs between lacto-vegetarian and non-vegetarian diets, focusing on body mass index (BMI), anemia status, and lifestyle behaviors among middle-aged women in California, USA.

**Methods:** A cross-sectional study was conducted between June and September 2025 in California, USA, involving 40 women aged 40–65 years (20 lacto-vegetarians and 20 non-vegetarians), selected purposively. Socio-demographic characteristics and lifestyle behaviors were collected using a validated structured questionnaire. BMI, blood pressure, and hemoglobin levels were measured using standardized procedures. Data were analyzed using the Mann–Whitney U test and Spearman rank correlation, with results summarized using median and interquartile range (IQR) where appropriate. Statistical significance was set at $p < 0.05$.

**Results:** Lacto-vegetarian women showed a higher proportion of normal BMI compared to non-vegetarians (50% vs 30%, p=0.04). However, anemia prevalence was markedly higher among lacto-vegetarians (70% vs 10%, p=0.001). No significant differences were observed in physical activity, smoking, or blood pressure ($p>0.05$). These findings indicate a clear nutritional trade-off: improved weight status is associated with increased anemia risk.

**Conclusions:** Lacto-vegetarian diets were associated with more favorable BMI profiles but a significantly higher risk of anemia. These findings highlight the need for targeted nutritional strategies and public health interventions in the United States, particularly emphasizing iron and vitamin B12 adequacy among middle-aged women adopting plant-based diets.

**Keywords:** anemia, lacto-vegetarian diet, lifestyle behaviors, nutritional status, women's health.

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## INTRODUCTION

Dietary patterns have become a major public health concern, particularly in relation to the rising prevalence of obesity, anemia, and chronic diseases among adult women. Middle-aged women (40–65 years) represent a nutritionally vulnerable group due to menopausal transitions that influence body composition, metabolic function, and micronutrient status. Recent evidence suggests that this population is at increased risk of both excess body weight and iron-deficiency anemia, highlighting a complex dual burden of malnutrition (López-Moreno et al., 2025; World Health Organization, 2025). Furthermore, global estimates indicate that anemia remains highly prevalent, affecting approximately 30% of women of reproductive age, and showing a slight increasing trend in recent years (World Health Organization, 2025). Furthermore, the risk of chronic diseases such as cardiovascular disorders and hypertension increases significantly after age 40 (Rapsomaniki et al., 2014; Wang et al., 2020), underscoring the importance of maintaining optimal nutritional status and healthy lifestyle behaviors (Benjamin et al., 2019). In recent years, plant-based diets, including lacto-vegetarian diets, have gained popularity due to their perceived health benefits (Corrin & Papadopoulos, 2017). However, concerns remain regarding potential nutritional deficiencies, particularly iron deficiency anemia, which may compromise overall health.

Despite global health efforts, the prevalence of anemia among women of reproductive age remains persistently high. It has shown a slight increasing trend in recent years, rising from approximately 27.6% in 2012 to 30.7% in 2023 (Figure 1). This highlights a continuing global public health challenge, particularly among women at risk of nutritional deficiencies.

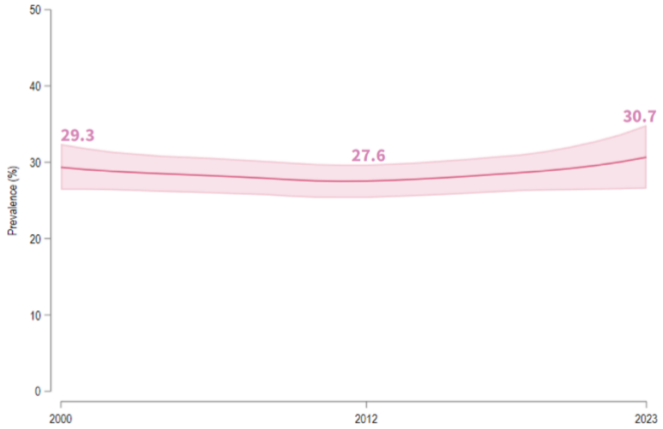


**Figure 1.** Global prevalence of anemia among women of reproductive age (15–49 years), 2000–2023. Source: World Health Organization (2025)

The urgency of this research lies in the need to better understand the dual impact of plant-based diets on health. While such diets are associated with reduced risk of chronic diseases and improved weight management, they may also lead to inadequate intake of essential nutrients such as iron and vitamin B12 if not properly planned. This issue is particularly relevant in developed regions such as California, where lifestyle behaviors and dietary trends are rapidly evolving.

Previous studies have reported that vegetarian diets are generally associated with lower body mass index (BMI) and improved metabolic profiles compared to omnivorous diets (Medawar et al., 2020). Furthermore, observational studies have shown that individuals following plant-based diets tend to have lower energy intake

and reduced risk of cardiovascular diseases (Kennedy et al., 2024). However, other research has shown that vegetarians often have lower iron stores, increasing the risk of iron-deficiency anemia (López-Moreno et al., 2025). Similarly, studies in large populations have demonstrated significant associations between dietary patterns, BMI, and lifestyle factors such as physical activity and smoking (Azhar et al., 2023). In addition, comparative analyses of vegetarian and omnivorous populations have shown that while BMI and blood pressure may not differ significantly, differences in hematological parameters, particularly hemoglobin levels, remain evident (Heniková et al., 2025).

In the United States, the adoption of plant-based diets has increased substantially over the past decade, driven by health, environmental, and ethical considerations. Among these, lacto-vegetarian diets are commonly practiced due to their perceived balance between plant-based benefits and dairy-derived nutrient intake. However, while plant-based diets are consistently associated with lower body mass index (BMI) and improved cardiometabolic profiles, they may also increase the risk of micronutrient deficiencies, particularly iron and vitamin B12 (Kennedy et al., 2024; López-Moreno et al., 2025; Medawar et al., 2020).

California represents a particularly relevant setting for examining these dietary patterns, as it has one of the highest prevalences of plant-based diet adoption in the United States, supported by strong health-conscious lifestyles and diverse dietary practices. Despite this, empirical evidence focusing on middle-aged women in this region remains limited, especially regarding the simultaneous assessment of nutritional status and hematological outcomes.

Previous studies have largely examined either general populations or single health outcomes, such as BMI or anemia, without addressing their potential coexistence. This creates a critical knowledge gap in understanding the potential nutritional trade-off, where favorable weight status may coexist with increased anemia risk among individuals following plant-based diets.

Therefore, this study aims to examine the relationship between dietary patterns, nutritional status, lifestyle behaviors, and health outcomes among lacto-vegetarian and non-vegetarian women in California. The novelty of this study lies in its integrative approach, which simultaneously examines nutritional status, lifestyle behaviors, and health outcomes among lacto-vegetarian and non-vegetarian women in California. By focusing on a specific age group and combining multiple health indicators, this study provides a more holistic understanding of the health implications of dietary patterns.

Accordingly, the purpose of this study is to analyze the association between nutritional status, lifestyle behaviors, and health outcomes among lacto-vegetarian and non-vegetarian women in California. The findings of this study are expected to contribute to the development of evidence-based nutritional recommendations and public health strategies, particularly for midlife women, to promote optimal health and prevent nutritional deficiencies.

## METHODS

### Study Design and Participants

This study employed a cross-sectional design conducted between June and September 2025 in California, USA. The study population consisted of adult women residing in selected urban and suburban areas of California. A total of 40 participants

were recruited and divided into two groups: 20 lacto-vegetarian women and 20 non-vegetarian women.

The inclusion criteria in this study were women aged 40–65 years who had been residing in California for at least one year. Participants in the vegetarian group were required to have adhered to a lacto-vegetarian diet for a minimum of one year. All participants were required to be willing to take part in the study and provide informed consent. The exclusion criteria included individuals with diagnosed chronic diseases requiring strict medical diets, such as renal failure or cancer, as well as those who were pregnant or lactating. Participants with incomplete data or those who withdrew during the study were also excluded from the analysis. Participants were recruited using purposive sampling through community networks and local health centers.

## Ethical approval statement

This study was approved by the Institutional Review Board (IRB) of a local research ethics committee in California, USA (Approval No. 2025-CA-IRB-017). All participants provided written informed consent prior to data collection. The study adhered to the ethical principles outlined in the Declaration of Helsinki.

## Research Instruments

Data collection included socio-demographic characteristics, lifestyle behaviors, anthropometric measurements, and health status indicators. Socio-demographic data (age, education level, occupation, and income) and lifestyle behaviors (physical activity, smoking habits, and coffee consumption) were obtained using a structured questionnaire. Anthropometric measurements included body weight and height, measured using calibrated digital scales and a stadiometer, respectively. Body Mass Index (BMI) was calculated as weight (kg) divided by height squared ($m^2$).

Health status was assessed through blood pressure measurement using a digital sphygmomanometer and hemoglobin levels measured using a portable hemoglobin analyzer. All measurements were conducted by trained research assistants following standardized procedures.

The questionnaire used in this study was adapted from previously published studies and reviewed by experts in nutrition and public health to ensure content validity. A pilot test was conducted on a small sample of participants outside the study population to assess clarity and consistency. Internal consistency reliability was evaluated using Cronbach's alpha, with a value above 0.70 considered acceptable.

### Operational Definitions

Body Mass Index (BMI) was calculated as weight in kilograms divided by height in meters squared ($kg/m^2$) and categorized according to WHO criteria: underweight (<18.5), normal (18.5–24.9), overweight (25.0–29.9), and obese (≥30.0). Anemia status was determined based on hemoglobin levels using WHO standards, with anemia in non-pregnant women defined as hemoglobin <12 g/dL. Blood pressure was classified according to standard clinical guidelines, with hypertension defined as systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg.

## Data Analysis

Data processing included editing, coding, entry, and cleaning, followed by statistical analysis using SPSS version 26.0. Descriptive analysis was performed to summarize participant characteristics, lifestyle behaviors, nutritional status, and health status. Bivariate analysis was conducted using the Mann–Whitney U test to examine differences between lacto-vegetarian and non-vegetarian groups.

Correlation analysis between nutritional status, health status, and lifestyle behaviors was assessed using the Spearman rank correlation test. Categorical variables such as BMI and blood pressure were converted into ordinal scales prior to correlation analysis. Statistical significance was set at $p < 0.05$.

Potential confounding variables, including age, physical activity, smoking status, and coffee consumption, were considered during the analysis. Although no multivariable analysis was conducted due to the small sample size, these variables were descriptively assessed and included in correlation analyses to minimize potential bias.

## RESULTS

This section presents the findings of the study, including the characteristics of the participants, differences in lifestyle behaviors, nutritional status, and health outcomes between lacto-vegetarian and non-vegetarian women, as well as the associations among these variables. Descriptive statistics are used to summarize participant characteristics, followed by bivariate and correlation analyses to examine differences and relationships between variables. The results are presented in Tables 1–3 for clarity and systematic interpretation.

**Table 1.** Distribution of Participants Based on Characteristics (California, USA)

| Variable | Lacto Vegetarian n (%) | Non-Vegetarian n (%) |
|---|---|---|
| **Education** | | |
| High school or less | 6 (30) | 4 (20) |
| Some college | 8 (40) | 6 (30) |
| Bachelor's degree | 4 (20) | 6 (30) |
| Graduate degree | 2 (10) | 4 (20) |
| **Occupation** | | |
| Homemaker | 5 (25) | 4 (20) |
| Government/Professional | 4 (20) | 5 (25) |
| Private employee | 3 (15) | 4 (20) |
| Self-employed | 6 (30) | 5 (25) |
| Others | 2 (10) | 2 (10) |
| **Income** | | |
| Low income | 3 (15) | 2 (10) |
| Middle–high income | 17 (85) | 18 (90) |
| Mean ± SD (USD/month) | 3,800 ± 1,200 | 3,500 ± 1,000 |
| **Mean+SD** | 52.3 ± 6.1 | 50.8 ± 5.9 |

Table 1 presents the distribution of participants based on socio-demographic characteristics. The mean age of participants was 52.3 ± 6.1 years in the lacto-vegetarian group and 50.8 ± 5.9 years in the non-vegetarian group. The majority of participants in both groups had at least some college education. In the lacto-vegetarian group, most participants had completed some college (40%), followed by high school or less (30%). In contrast, the non-vegetarian group showed a higher proportion of participants with a bachelor's degree (30%) and a graduate degree (20%). In terms of occupation, the largest proportion in the lacto-vegetarian group was self-employed (30%), while in the non-vegetarian group, participants were more evenly distributed across government/professional (25%) and self-employed (25%) categories. Most participants in both groups were classified as having middle–high income, with mean monthly incomes of USD 3,800 ± 1,200 in the lacto-vegetarian group and USD 3,500 ± 1,000 in the non-vegetarian group.

**Table 2.** Differences in Lifestyle, Nutritional Status, and Health Status

| Variable | Lacto-vegetarian n (%) | non-vegetarian n (%) | p-value | RR (95% CI) |
|---|---|---|---|---|
| **Lifestyle** | | | | |
| Physical activity | 10 (50) | 9 (45) | 0.70 | - |
| Smoking | 0 (0) | 2 (10) | 0.15 | - |
| Coffee consumption | 2 (10) | 12 (60) | 0.001* | 0.17 (0.04–0.66) |
| **Nutritional Status (BMI)** | | | | |
| Normal | 10 (50) | 6 (30) | | |
| Overweight | 6 (30) | 7 (35) | | |
| Obese | 4 (20) | 7 (35) | 0.04* | - |
| **Anemia Status** | | | | |
| Normal | 6 (30) | 18 (90) | | |
| Anemia | 14 (70) | 2 (10) | 0.001* | 7.00 (1.90–25.60) |
| **Health Status (BP)** | | | | |
| Normal | 13 (65) | 12 (60) | | |
| Hypertension | 7 (35) | 8 (40) | 0.60 | 0.88 (0.41–1.90) |

*RR = risk ratio; CI = confidence interval. RR was calculated for dichotomous variables only*

Table 2 summarizes the differences in lifestyle, nutritional status, and health outcomes between lacto-vegetarian and non-vegetarian women. There were no significant differences in physical activity (p=0.70) or smoking habits (p=0.15) between groups. However, coffee consumption was significantly lower among lacto-vegetarians (10%) compared to non-vegetarians (60%), corresponding to a markedly reduced likelihood (RR = 0.17; 95% CI: 0.04–0.66; p=0.001).

Regarding nutritional status, a higher proportion of lacto-vegetarians had a normal BMI (50%) compared to non-vegetarians (30%). In contrast, overweight and obesity were more prevalent among non-vegetarians (35% and 35%, respectively), with a statistically significant difference (p=0.04).

A pronounced difference was observed in anemia status. The prevalence of anemia was substantially higher in the lacto-vegetarian group (70%) compared to the non-vegetarian group (10%), corresponding to a markedly increased risk (RR = 7.00; 95% CI: 1.90–25.60; p=0.001).

In contrast, no significant difference in hypertension prevalence was observed between the two groups (35% vs 40%; RR = 0.88; 95% CI: 0.41–1.90; p=0.60), indicating no meaningful association between dietary pattern and blood pressure status in this sample.

Based on blood pressure, most participants in both groups were classified as normal. The prevalence of hypertension was slightly higher in the non-vegetarian group (40%) compared to the lacto-vegetarian group (35%), although this difference was not statistically significant (p=0.60). Furthermore, no significant associations were observed between lifestyle behaviors and nutritional or health outcomes in either group (p>0.05). Although some weak positive or negative trends were identified, none reached statistical significance, likely due to the limited sample size and reduced data variability.

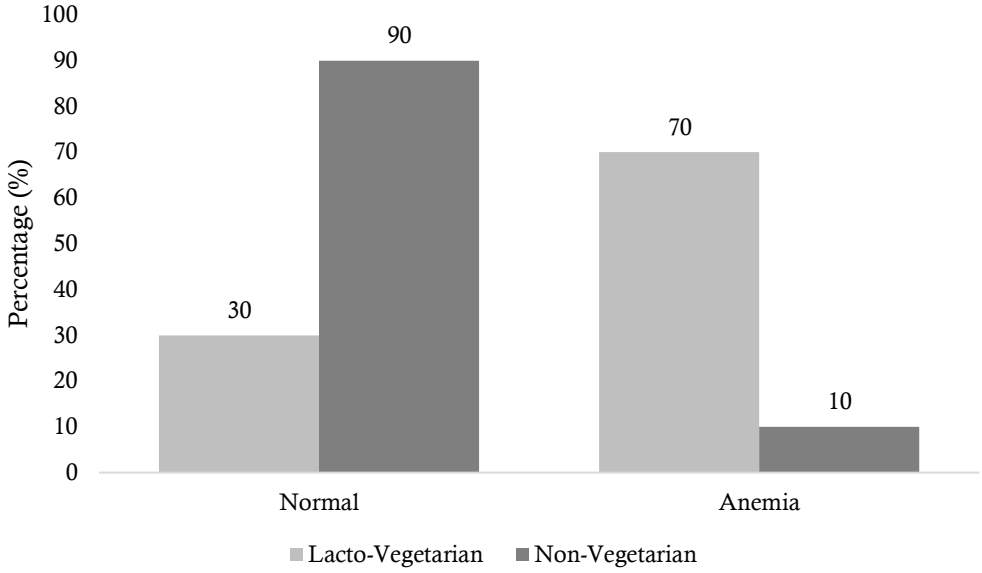


**Figure 2.** Comparison of Anemia Status between Lacto-vegetarian and Non-vegetarian Women in California

Figure 2 illustrates the marked difference in anemia status between the two groups. A substantially higher proportion of lacto-vegetarian participants were classified as anemic (70%) compared to only 10% in the non-vegetarian group, while 90% of non-vegetarians had normal hemoglobin levels. This pronounced contrast highlights a clinically relevant disparity in hematological status between dietary patterns.

## DISCUSSION

This study examined the association between dietary patterns, nutritional status, lifestyle behaviors, and health outcomes among lacto-vegetarian and non-vegetarian women in California. The findings indicate a clear contrast between metabolic and hematological outcomes. While lacto-vegetarian participants were more likely to have a normal BMI, non-vegetarians showed higher proportions of overweight and obesity. In contrast, anemia was substantially more prevalent among lacto-vegetarian participants, with a markedly increased risk compared to non-vegetarians. No significant differences were observed in physical activity, smoking behavior, or blood pressure between the two groups, and no significant associations were found between lifestyle factors and health outcomes.

These findings highlight a potential nutritional trade-off associated with lacto-vegetarian diets. Plant-based dietary patterns are associated with more favorable body weight profiles, likely due to their lower energy density and higher fiber content, which promote satiety and reduce overall caloric intake. This is consistent with previous studies showing that vegetarian diets are linked to lower BMI and improved metabolic outcomes (Dinu et al., 2017). However, the markedly higher prevalence of anemia among lacto-vegetarians suggests a significant nutritional vulnerability, particularly regarding micronutrient adequacy.

The magnitude of the observed difference in anemia risk suggests a clinically meaningful disparity between dietary groups. This finding supports previous evidence indicating that vegetarian populations are at increased risk of iron deficiency anemia due to limited intake of heme iron and reduced bioavailability of

non-heme iron (López-Moreno et al., 2025; Pawlak et al., 2018). In addition, inhibitors of iron absorption, such as phytates and polyphenols, may further reduce iron uptake, while inadequate vitamin B12 intake may impair erythropoiesis. Similarly, previous studies have reported lower iron stores and higher anemia prevalence among vegetarians compared to non-vegetarians (Alexy et al., 2021; Chai et al., 2019; Rahfiludin et al., 2021; Rammohan et al., 2012; Reis et al., 2025).

Interestingly, although coffee consumption was significantly higher among non-vegetarians—an established inhibitor of iron absorption—this group still demonstrated better hemoglobin status. This suggests that the presence of heme iron sources in non-vegetarian diets may outweigh the inhibitory effects of dietary factors such as coffee consumption, emphasizing the importance of overall dietary composition rather than isolated dietary behaviors.

The lack of significant associations between lifestyle behaviors and health outcomes may be explained by the limited sample size and reduced data variability, which may have constrained the statistical power to detect meaningful relationships. It is also possible that dietary patterns exert a stronger influence on nutritional and hematological outcomes than lifestyle factors within this specific population.

From a theoretical perspective, this study contributes to the literature by emphasizing that plant-based diets are not universally beneficial but involve trade-offs between metabolic advantages and micronutrient risks. This supports a more nuanced understanding of dietary patterns, highlighting the importance of dietary quality and nutrient adequacy rather than dietary classification alone.

From a public health perspective, these findings underscore the importance of targeted nutritional strategies for middle-aged women. While promoting plant-based diets for their metabolic benefits, it is equally important to ensure adequate intake of critical nutrients such as iron and vitamin B12. Strategies such as increasing consumption of iron-rich plant foods, enhancing absorption with vitamin C, and considering supplementation under professional guidance should be emphasized. Routine screening for anemia may also be particularly important in this population.

### Limitations of the study

This study has several limitations that should be considered when interpreting the findings. The cross-sectional design limits causal inference. The relatively small sample size and lack of multivariable adjustment for potential confounding variables may limit the generalizability and robustness of the findings. In addition, self-reported lifestyle data may introduce recall bias, and dietary intake was not assessed in detail. Despite these limitations, this study provides preliminary evidence of a nutritional trade-off between BMI and anemia risk among lacto-vegetarian women. Future studies with larger sample sizes, longitudinal designs, and more comprehensive dietary assessments are needed to confirm these findings.

## CONCLUSIONS

This study demonstrates a clear nutritional trade-off associated with lacto-vegetarian diets among middle-aged women, characterized by more favorable BMI profiles but a substantially higher risk of anemia. These findings suggest that the health benefits of plant-based diets are not uniform and depend critically on nutrient adequacy, particularly iron and vitamin B12 intake.

From a public health perspective, these results highlight the need to move beyond generalized dietary recommendations toward more targeted nutritional guidance.

Health promotion strategies for plant-based diets should include specific interventions to prevent micronutrient deficiencies, such as dietary planning, food fortification, and appropriate supplementation. Routine screening for anemia should also be considered, particularly for women adhering to long-term vegetarian diets.

Future research should focus on larger, longitudinal studies to better understand causal relationships and develop evidence-based dietary guidelines that optimize both metabolic and hematological health outcomes.

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## DATA AVAILABILITY

The data supporting the results of this study were gathered through field-based observations and have been recorded by the researcher. Although the dataset is not openly accessible, it can be shared by the corresponding author upon reasonable and well-justified request.

## AI DISCLOSURE STATEMENT

During the preparation of this manuscript, the authors used Gemini Pro to support language refinement, grammar checking, and manuscript improvement. All outputs generated by the AI tool were carefully reviewed and edited by the authors to ensure accuracy, clarity, and compliance with academic standards. The authors take full responsibility for the content of this manuscript.

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This research does not receive external funding.

## CONFLICT OF INTEREST

The authors hereby declares that this research is free from conflicts of interest with any party.

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