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Original article

Socioeconomic determinants of food security and dietary quality in ecuadorian agricultural communities: A comparative analysis

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Abstract. *Background and aim:* Malnutrition, encompassing both undernutrition and overnutrition, remains a critical public health issue in Ecuador, particularly in agricultural communities. This study aims to analyse the dietary quality and diversity of agricultural households while examining the socioeconomic factors that shape nutrition across three regions: the provinces of Guayas and Cotopaxi, and the parish of San Mateo in Esmeraldas. *Methods:* Using data from 24-hour dietary recalls and socioeconomic surveys from a sample of 102 households, this research employs statistical tools, including ANOVA and Kruskal-Wallis tests, to identify key differences in dietary patterns. *Results:* The findings reveal significant regional disparities in food consumption, driven primarily by income, education, and employment. Households in Milagro, with an average income of $1,650, reported greater dietary diversity compared to San Mateo ($250) and Salcedo ($550), indicating that higher income allows for access to a wider range of food groups. These results underscore the crucial role of socioeconomic status in determining dietary choices and nutritional adequacy. *Conclusions:* The study highlights the importance of targeted interventions, including improving food accessibility, promoting nutritional education, and supporting small-scale farmers. Addressing these regional and socioeconomic disparities is essential to mitigating malnutrition in Ecuador. By focusing on socioeconomic drivers of dietary quality, this study provides valuable insights for policymakers aiming to develop region-specific strategies that promote food security, improve nutrition, and support sustainable agricultural practices, contributing to Ecuador's broader public health and development goals.

Key words: food security, malnutrition, dietary diversity, agricultural households, socioeconomic factors, Ecuador

Introduction

Malnutrition remains a critical public health issue in Ecuador, affecting various segments of the population, especially the poorest (1). This dual burden of undernutrition and overnutrition presents significant challenges, with socio-economic factors playing a pivotal role (2). Population under minimum nutritional requirements afront a problem of food access and food availability influenced by the economy and information access (3). Food security, as defined by the Food and Agriculture Organization (FAO), involves access to sufficient, safe, and nutritious food to meet dietary needs for an active and healthy life. In Ecuador, food security is compromised by economic disparities, geographic factors, and inadequate nutrition education.

According to the UNICEF (4), economic slowdowns exacerbate food insecurity and malnutrition, particularly in marginalized communities where poverty and inequality are rampant. This is consistent with findings in other developing countries where economic instability often leads to decreased food availability and affordability, further stressing vulnerable populations (5).

Socioeconomic status (SES) significantly impacts diet quality and diversity. Lower SES households often struggle to access a variety of nutritious foods, resulting in energy-dense but nutrient-poor diets. Knight et al. (6) highlighted that while the average Ecuadorian diet meets energy requirements, it falls short in essential nutrients due to economic constraints and lack of access to diverse foods. Similar patterns have been observed in other Latin American countries, where lower SES correlates with lower intake of fruits, vegetables, and protein-rich foods, contributing to malnutrition (7). Regional differences significantly influence dietary habits and nutritional outcomes. In Ecuador, the Sierra region exhibits higher rates of chronic malnutrition among children under five compared to the coastal areas (8). This disparity is partly due to differences in food accessibility and cultural dietary preferences. UNICEF (9) noted that the lack of nutrition education in rural areas exacerbates these issues, underscoring the need for targeted interventions. Similarly, in Peru, rural regions have higher malnutrition rates compared to urban areas, attributed to limited access to health services and education (10, 11). The issue lies in the inequitable access to food, driven by economic and educational factors of household heads. The wealthiest 10% of households have food stocks 2.4 times greater than the poorest 10% (12, 13). Addressing the root causes of food access restrictions requires active, comprehensive, and sustained public policies. Despite a reduction in poverty to 28.6% in 2016, Ecuadorians still face difficulties acquiring food (14). Studies by Tarqui Mamani et al. (15) and González Ibáñez et al. (16) used the 24-hour recall method with children aged 6 to 35 months and rural communities in Mexico, respectively. Cruz & Maldonado (17) found that household income positively affects food security, noting low wages in small businesses. In Colombia, Gil-Toro et al. (18) identified a significant link between socioeconomic status and food intake among older adults, with higher consumption of dairy, lean meats, fruits, and vegetables among wealthier individuals. Zapata et al. (19) reported that rural households in Argentina consume more cereals, powdered milk, and pork, but less fruit, non-starchy vegetables, yogurt, and cheese. Dietary diversity is a key indicator of diet quality. The Household Dietary Diversity Score (HDDS) measures the number of different food groups consumed over a reference period, with higher diversity correlating with better nutritional status. Studies show that rural Ecuadorian households engaged in small-scale agriculture tend to have more diverse diets due to direct access to various food sources (4). This aligns with findings from Uganda, where smallholder farming communities with diversified crop production enjoy higher dietary diversity and better nutritional outcomes (20). Income, education, and employment are significant predictors of dietary quality. In San Mateo, Esmeraldas, households with higher income levels and better education exhibited more diverse diets and better nutritional outcomes. This study uses 24-hour dietary recalls and socioeconomic surveys to find socioeconomic disparities influence food choices and nutrition (21). Similar conclusions were drawn in a study from India, where higher household income and parental education levels were associated with improved child nutritional status (22-25). Upon analysing the dietary composition of rural people in comparison, this study aims to identify relevant factors that affect the composition of the diet of three peasants' organizations of the Coastal and Sierra of Ecuador. Macronutrients are observed for standardizing criteria and identifying the relationship between socio-economic aspects and intake.

Methodology

This study employs a cross-sectional design to analyse the dietary quality and socioeconomic determinants affecting nutrition in agricultural households in Ecuador. The research was conducted in three regions: the parish of San Mateo in Esmeraldas, and the provinces of Guayas and Cotopaxi. These diverse geographic settings provide a comprehensive understanding of regional disparities in nutritional outcomes.

Sample selection

The study sample includes households from the associations "Los Caídos", "ASOPRUV" in Salcedo and Santa Lucía, and San Mateo. During October and December 2022, the information was collected in person. Nevertheless, violent factors limited the time of work in the study zones. The sample size was calculated using Rustom's formula. This yielded a sample size sufficient to provide statistically significant insights into dietary patterns and socioeconomic factors. Using a probabilistic sample selection formula with a 95% confidence level, and 5% error margin the formula margin the formula $n = \frac{(Z)^2 * P * Q * N}{(Z)^2 * P * Q + (N-1) * E^2}$;

Where: n = Sample size, N = Population size, Z = Confidence level (90%), P = Probability of success or expected proportion (50%), Q = Probability of failure (50%), E = Margin of error (10%), the size of the sample has been calculated. (see Table 1).

Table 1. Sample size calculation.

Population	N	n	Valid n
Los Caidos	42	39	27
ASOPRUV	11	11	10
San Mateo	110	87	65

Data collection instruments

The 24-hour Dietary Recall method was employed to gather comprehensive information on all foods and beverages consumed by the household within the previous 24 hours. Interviews were conducted with the individuals primarily responsible for meal preparation, as they are often best positioned to recall and detail the types and quantities of food consumed by all household members. This method provides a precise snapshot of daily dietary intake, which is essential for evaluating both dietary diversity and overall nutritional adequacy (26). To enhance accuracy, trained interviewers used standardized portion size estimators and probing questions to help respondents recall minor food items and beverages that might otherwise be overlooked. However, while the 24-hour recall method is effective in capturing recent food intake, it is susceptible to certain biases. These include recall bias, where respondents may forget or misreport their consumption, and social desirability bias, where respondents might overreport healthier foods or underreport less nutritious items. To mitigate these issues, interviewers employed multiple recall prompts and cross-checked responses with other household members when necessary, ensuring a more reliable and accurate account of food consumption. Additionally, a subsample of households underwent a second recall interview to assess intra-individual variability and to validate initial reports. During data collection, a socioeconomic questionnaire was also administered to capture key household information such as demographics, income levels, education, employment status, and housing conditions. This instrument was designed to contextualize dietary patterns within the broader socioeconomic framework, providing insights into how factors such as income and education influence food security and dietary choices (17). The questionnaire was pretested and refined to ensure clarity, reduce respondent burden, and minimize misinterpretation of questions. Both instruments—the dietary recall and socioeconomic questionnaire—were rigorously validated through pilot testing and iterative feedback with respondents to refine the accuracy of the data. Interviewers received extensive training to ensure consistency in data collection and to minimize interviewer bias. Cross-validation of food intake data with available household food records, where possible, further strengthened the credibility of the results.

Procedure

Data collection took place in November 2022. Each household was visited individually, and interviews were conducted by a team of trained field researchers with experience in nutrition and socioeconomic surveys. A 24-hour dietary recall method was employed to gather data on individual food intake. These interviews typically lasted between 5 and 10 minutes per respondent, although additional time was allocated for participants who needed assistance in recalling their meals accurately, ensuring comprehensive data capture (27). To enhance data reliability, interviewers used visual aids and probing techniques to help respondents recall food items, portion sizes, and meal timing. Double interviews were conducted in 10% of households to validate the data and check for consistency.

Data analysis

Initial data analysis was conducted using descriptive statistics to summarize the demographic and socioeconomic characteristics of the sample population. Continuous variables such as age, household income, and family size were described using measures like mean, median, and standard deviation. Frequencies and percentages were calculated for categorical variables, such as education level and employment status (28). Missing data were carefully overseen, employing imputation techniques where feasible to minimize bias. The Household Dietary Diversity Score (HDDS) was computed as a measure of nutritional diversity, following the FAO guidelines. Respondents' consumption of various food groups over the 24-hour recall period was categorized into twelve groups: cereals, roots and tubers, vegetables, fruits, meat and organ meats, eggs, fish and seafood, legumes, dairy products, oils and fats, sweets, and miscellaneous items. A higher DDS reflected better dietary diversity and was correlated with improved nutritional status (29). Repeated measures were taken on a random subsample of respondents to ensure reliability. Inter-observer reliability was assessed through a comparison of results across different interviewers, with any inconsistencies resolved through re-examination of interview notes. Potential biases, such as recall bias or social desirability bias, were mitigated by ensuring anonymity and emphasizing the importance of accurate reporting during the interviews. Moreover, socioeconomic variables were cross-checked to account for confounding factors, ensuring that the relationship between dietary diversity and other variables was properly controlled.

Statistical tests

Data on the percentage of households consuming various food groups in each region were collected. The food groups included cereals, roots and tubers, vegetables, fruits, meats and organs, sugars, eggs, fish and seafood, legumes, nuts, seeds, milk and dairy products, oils and fats, and miscellaneous items. Additionally, estimated daily macronutrient intake (carbohydrates, proteins, and fats) was calculated based on the average macronutrient composition of each food group.

Estimation of macronutrient intake

The estimated daily macronutrient intake for each region was calculated using the following formula:

$$\text{Macronutrient Intake} = \sum\left(\frac{\text{Percentage Consumtion}}{100} \times \text{Average Macronutrient Composition}\right)$$

where the average macronutrient composition values for each food group were assumed based on standard nutritional data.

Kruskal-Wallis test

To determine if there were significant differences in the consumption percentages of various food groups across the regions, we employed the Kruskal-Wallis H-test. This non-parametric test is used for comparing more than two groups and does not assume a normal distribution. The Kruskal-Wallis's test statistic (H) and the corresponding p-values were calculated for each food group. A significance level (αα) of 0.05 was used to determine statistical significance.

Multivariate regression analysis

To analyse the factors influencing dietary consumption, we conducted multivariate regression analyses for each food group. The socioeconomic factors included in the model were income, education level, and employment status. The regression model was specified as follows:

$$\text{Consumption Percentage} = \beta_0 + \beta_1\text{Income} + \beta_2\text{Education} + \beta_3\text{Employment} + \epsilon$$

where:

β0is the intercept,

β1, β2, and β3 are the coefficients for income, education, and employment, respectively,

ϵ is the error term.

Each food group was analysed separately to determine the influence of socioeconomic factors on its consumption. The coefficients, R-squared values, and p-values were reported for each model.

ANOVA

An ANOVA test was performed to compare the means of socioeconomic variables across diverse groups. The one-way ANOVA test assessed whether there were statistically significant differences in the means of these variables, indicating the influence of socioeconomic status on dietary patterns.

Null Hypothesis (H0): There is no significant difference in the means of the groups.

Alternative Hypothesis (Ha): There is a significant difference in the means of the groups.

Limitations

Nonetheless, some limitations remained. Seasonal variations in food availability or unique events, such as holidays, could also influence the accuracy of the data. To account for this, data collection was staggered across different days and weeks to capture a more representative dietary intake over time. Additionally, the socioeconomic questionnaire relied on self-reported data, which may introduce reporting errors, though efforts were made to cross-verify socioeconomic conditions where feasible.

Results

The study of the dietary patterns and nutritional status of agricultural households in Ecuador provides significant insights into the socio-economic and regional factors influencing nutrition.

Socioeconomic characteristics

Figure 1 shows the strong correlation between education levels and average monthly income across

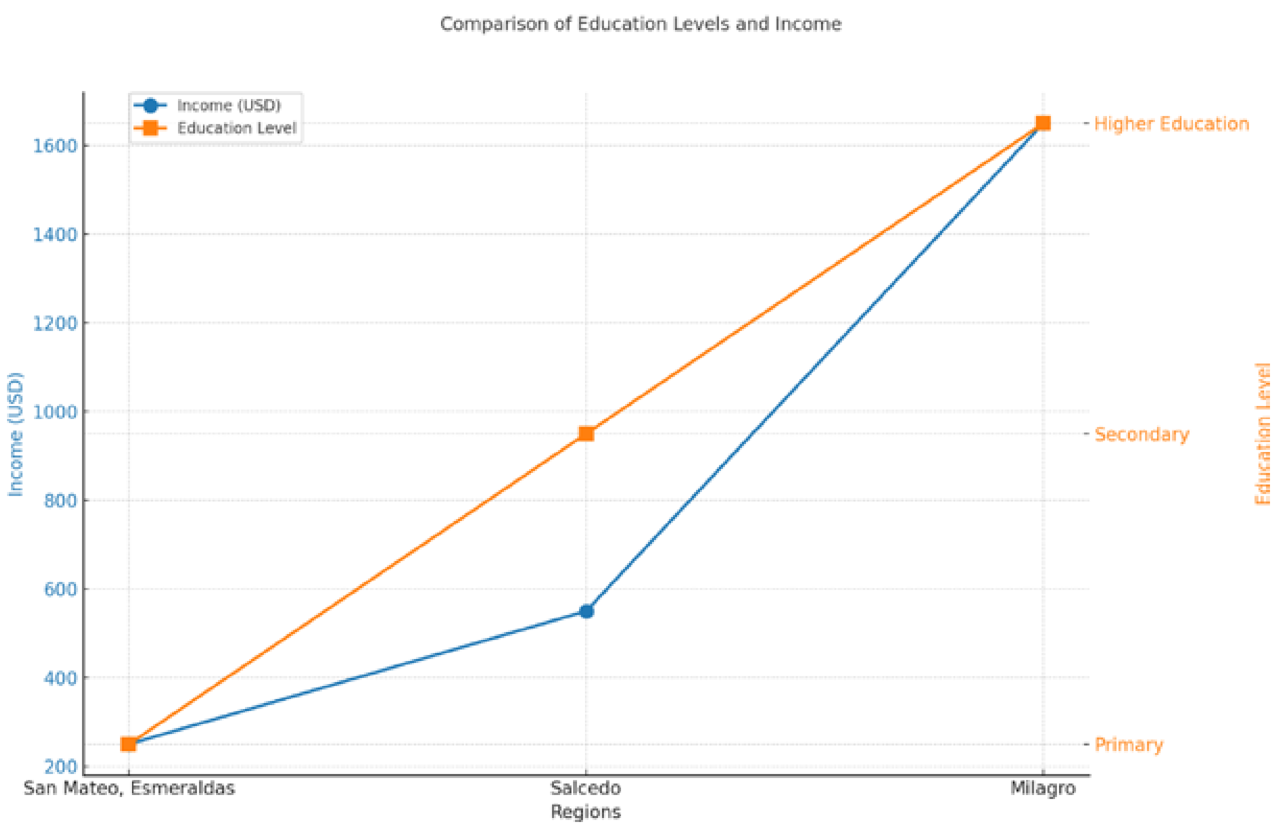

Figure 1. Socio-economic parameters in comparison of three places analysed.

the regions of San Mateo, Esmeraldas, Salcedo, and Milagro. In San Mateo, where education levels are at the primary level, the average monthly income is the lowest at around $250.

This limited educational attainment restricts job opportunities and income potential, reflecting the rural economy's constraints. Salcedo shows a moderate improvement with higher education levels, where a sizeable portion of the population has secondary education, correlating with a higher average income of about $550. This indicates that even a moderate increase in educational attainment can lead to better economic conditions. Milagro, with the highest levels of education, including individuals with secondary and higher education, has the highest average income at approximately $1650. This significant income advantage demonstrates the impact of higher education on economic opportunities, allowing access to more diverse and better-paying jobs in both public and private sectors. The graph underscores the critical role of education in economic development, highlighting the need for policies and programs that enhance educational access and quality in rural areas like San Mateo and Salcedo to bridge the economic gap and improve overall livelihoods.

Dietary characteristics

The Household Dietary Diversity Score (HDDS) was employed to evaluate the variety of foods consumed. The findings revealed that both the coastal and Sierra regions demonstrated high dietary diversity, indicative of a broad range of food group consumption. However, significant regional differences were observed. Households in the Sierra region showed a higher dietary diversity score compared to those in the coastal region, which is attributed to the accessibility of various food sources in the highlands, often supported by small-scale agriculture. A comparative analysis of macronutrient intake between the regions revealed marked disparities. The coastal region exhibited significantly higher consumption of fats and carbohydrates compared to the Sierra region. This imbalance is linked to economic and geographic factors that influence food availability and dietary choices. For example, the higher consumption of fats in the coastal area is related to the increased expenditure on food, as higher-income households tend to purchase more energy-dense foods. Socio-economic status (SES) played a crucial role in determining dietary quality and food security. Households with higher incomes and better education levels reported more diverse diets and better nutritional outcomes. In contrast, lower SES households faced challenges in accessing a variety of nutritious foods, often resulting in energy-dense but nutrient-poor diets. This disparity was evident in both urban and rural settings, where economic constraints significantly impacted food choices and consumption patterns. The study also explored the impact of food production for self-consumption on dietary patterns. It was found that households engaged in food production for auto consumption had higher macronutrient intake but lower dietary diversity scores. This inverse relationship highlights the reliance on a limited range of food products cultivated locally, which, while providing essential nutrients, lacks the variety needed for a balanced diet. Additionally, urban households engaged in auto consumption faced unique challenges due to limited space and environmental constraints affecting food production. The regional analysis underscored significant disparities in food security and nutritional outcomes. For instance, the Sierra region exhibited higher rates of chronic malnutrition among children under five years compared to the coastal areas. This difference is attributed to varying levels of food accessibility, economic resources, and cultural dietary practices. The study emphasized the need for region-specific interventions to address these disparities and improve overall nutritional status.

The slight variations in food group consumption highlight the impact of economic stability and regional agricultural practices. San Mateo's lower consumption of fruits, legumes, and dairy products points to potential economic or accessibility challenges. The consistent under-consumption of legumes and dairy products across all regions suggests a need for targeted nutritional interventions to promote these food groups (Figure 2).

The graph comparing the percentage of households consuming each food group across San Mateo, Salcedo (green line), and Milagro (red line) reveals significant regional differences in dietary patterns. Cereals are universally consumed, with all households in all regions including them in their diets. However,

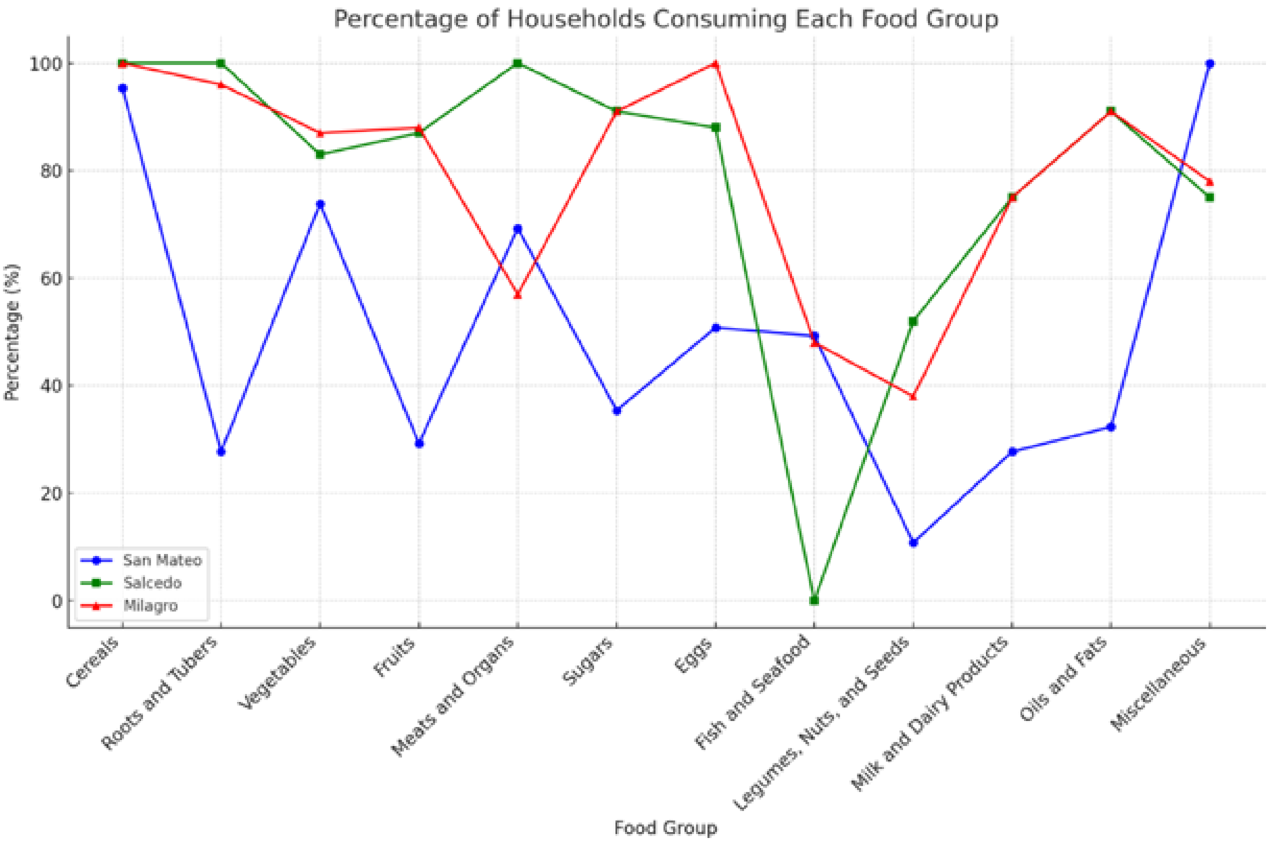

Figure 2. Percentage of Households Consuming Each Food Group. Blue San Mateo, Red Milagro, and Green, Salcedo (Sierra).

the consumption of roots and tubers shows a stark contrast, with all households in Salcedo and Milagro consuming these foods, while less than 30% of households in San Mateo do so. This indicates a potential gap in carbohydrate sources in San Mateo compared to the other regions. Vegetable and fruit consumption also varies notably. While a high percentage of households in Salcedo and Milagro consume vegetables (83% and 87% respectively) and fruits (87% and 88% respectively), San Mateo lags significantly, especially in fruit consumption, with only 29.23% of households including fruits in their diet. This disparity points to a critical shortfall in essential vitamins and minerals that these food groups provide, which are crucial for a balanced diet and overall health. Meat and organ consumption is highest in Salcedo, where all households include them in their diet, compared to 69.23% in San Mateo and 57% in Milagro. This high consumption in Salcedo suggests better access to protein sources. Conversely, the absence of fish and seafood consumption in Salcedo contrasts sharply with San Mateo and Milagro, where around 50% of households consume these foods. Additionally, the consumption of legumes, nuts, and seeds is markedly higher in Salcedo (52%) compared to San Mateo (10.77%), indicating a more diverse diet in Salcedo. The consumption patterns of milk and dairy products, oils and fats, and miscellaneous items also highlight dietary differences, with San Mateo showing lower percentages for these groups compared to the other regions. These variations underscore the need for targeted nutritional interventions to address the specific dietary deficiencies in each region, promoting more balanced and nutritious diets.

The graph comparing actual daily kilocalorie consumption with WHO/PAHO nutritional recommendations reveals significant disparities across all regions, particularly in San Mateo (Figure 3). Cereals, a major staple food, are consumed at much lower levels

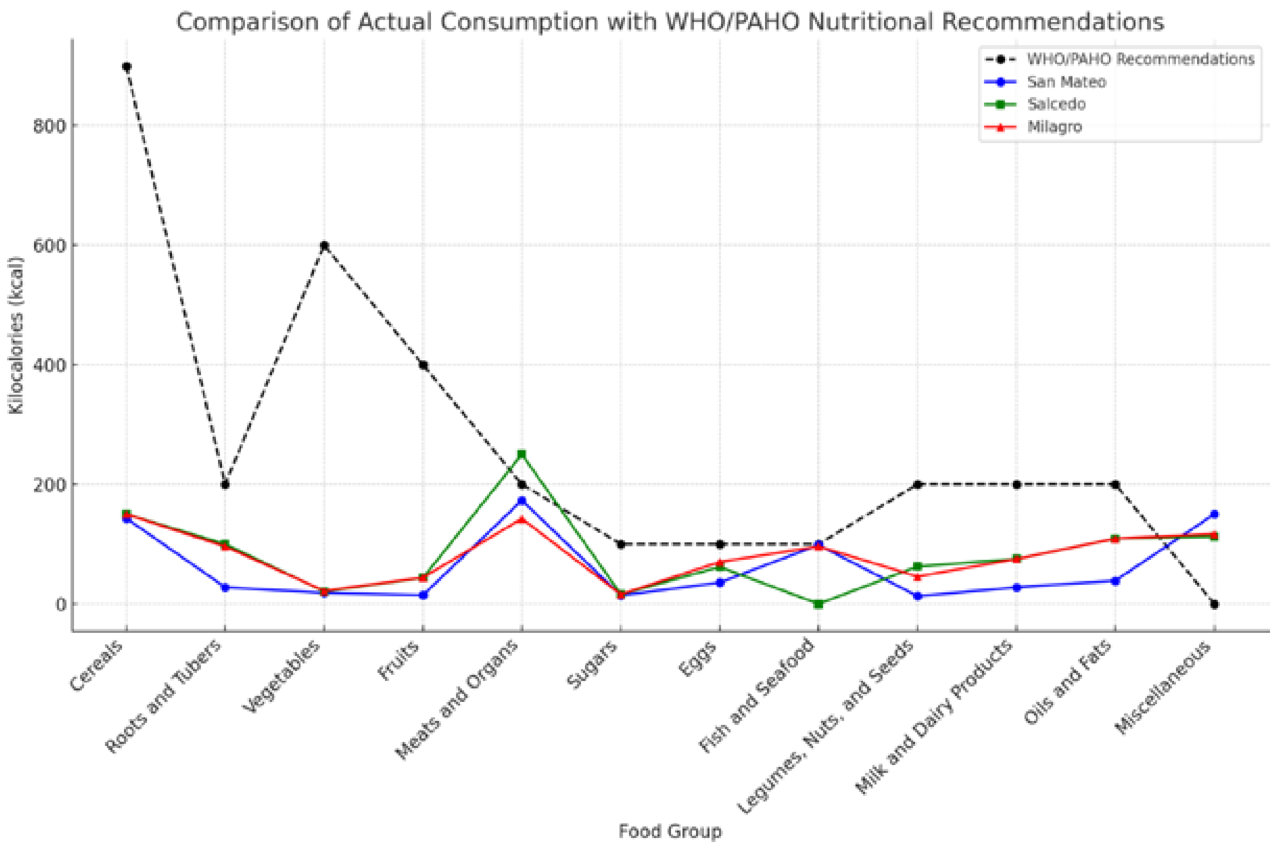

Figure 3. Comparison of actual consumption with WHO/PAHO nutritional recommendations.

than recommended, with all regions falling short of the ~900 kcal guideline. Similarly, vegetable and fruit intake are alarmingly low in all regions, highlighting a critical gap in dietary diversity and essential nutrient intake. This shortfall is especially pronounced in San Mateo, where kilocalorie intake from these food groups is far below the recommendations. The inadequate consumption of legumes, nuts, and seeds further exacerbates the nutritional deficiencies, with actual intake significantly below the recommended ~200 kcal. In contrast, the consumption of meats and organs in Salcedo exceeds the recommended levels, while Milagro's intake is close to the guideline. However, San Mateo's intake is lower yet still within a reasonable range. The intake of fish and seafood meets the recommendations in San Mateo and Salcedo but is completely absent in Milagro, pointing to potential regional dietary preferences or availability issues. Sugar consumption is within recommended limits, indicating some adherence to guidelines. The high intake of miscellaneous items, which are not part of the WHO/PAHO recommendations, suggests a reliance on non-nutritive food sources, particularly in San Mateo. This comprehensive analysis underscores the urgent need for targeted nutritional interventions to align actual consumption with global dietary recommendations, improving overall health outcomes in these regions.

The graph comparing daily kilocalorie consumption across San Mateo, Milagro, and Salcedo reveals significant regional variations in dietary intake (Figure 4). In San Mateo, the diet heavily relies on cereals, vegetables, meats, and miscellaneous items, with a moderate intake of fish and seafood. The lower consumption of roots and tubers, fruits, and legumes indicates a potential gap in the diversity of food sources. Conversely, Milagro shows a more balanced distribution of kilocalories across various food groups, with higher consumption of roots and tubers, eggs, and oils

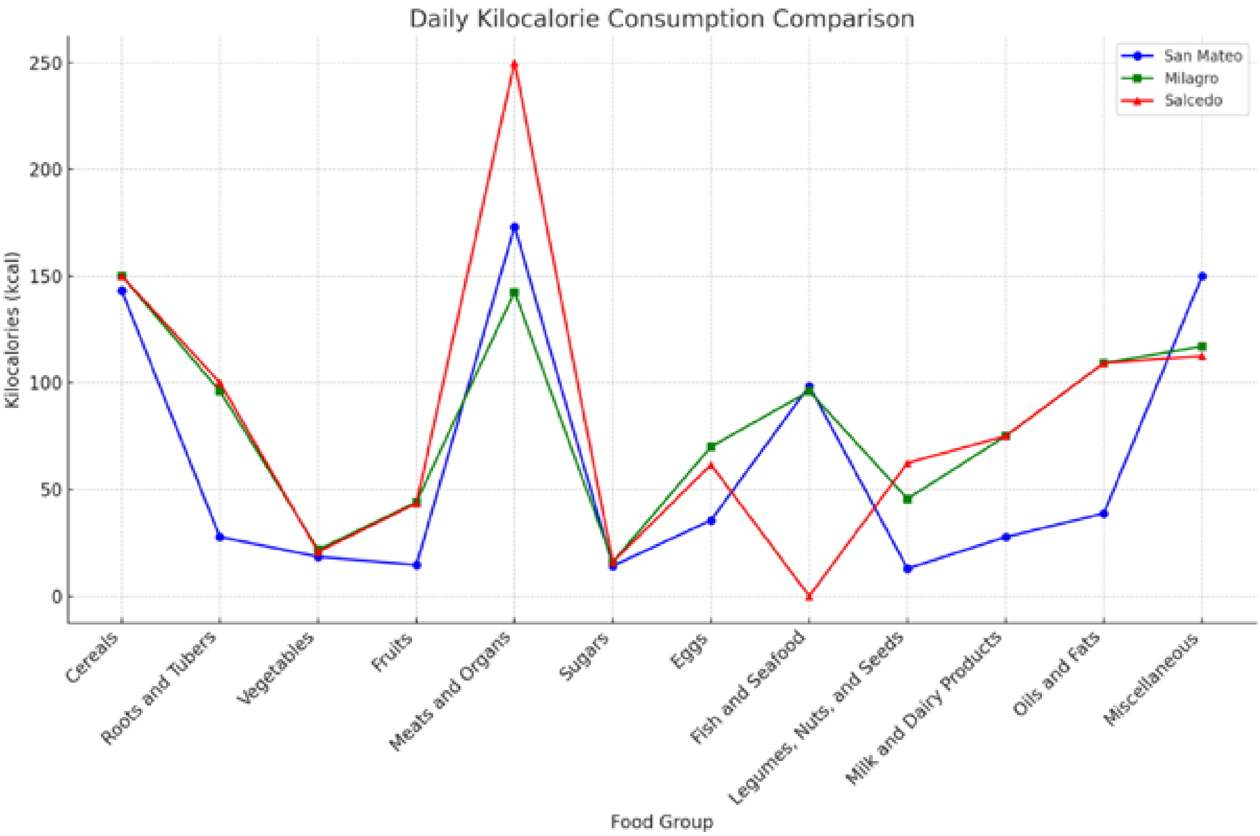

Figure 4. Daily kilocalorie consumption comparison.

and fats. This region benefits from a more diverse dietary intake, which is reflected in the higher kilocalorie contributions from these food groups. Salcedo stands out with the highest kilocalorie intake from meats and organs, underscoring a significant reliance on animal-based proteins. However, the absence of fish and seafood in the diet is notable and may reflect local dietary preferences or availability issues. Additionally, Sierra exhibits substantial intake of legumes, nuts, and seeds, contributing to a more varied protein source. The consistent high consumption of oils and fats across both Costa and Sierra highlights a dietary pattern that could pose long-term health risks if not balanced with other nutrient-dense foods. These findings underscore the need for targeted nutritional interventions to enhance dietary diversity and address specific deficiencies in each region, promoting better overall health outcomes.

The comparison of macronutrient intake among San Mateo, Salcedo, and Milagro reveals significant disparities in dietary adequacy relative to WHO/PAHO minimum requirements. San Mateo's carbohydrate intake (128.88 grams) is slightly below the recommended 130 grams, while protein and fat intakes (43.23 grams and 50.68 grams, respectively) are notably below the respective minimums of fifty grams for proteins and seventy grams for fats. This shortfall suggests that residents of San Mateo may be at risk of nutritional deficiencies, which could impact their overall health and well-being. The lower intake of proteins and fats, essential for muscle maintenance, hormone production, and energy storage, is particularly concerning. In contrast, Salcedo exhibits a more favourable dietary pattern, with carbohydrate, protein, and fat intakes (239.03 grams, 56.62 grams, and 121.73 grams, respectively) well above the WHO/PAHO minimum requirements. This indicates that households in Salcedo have better access to a diverse range of foods that provide adequate macronutrients. The high intake

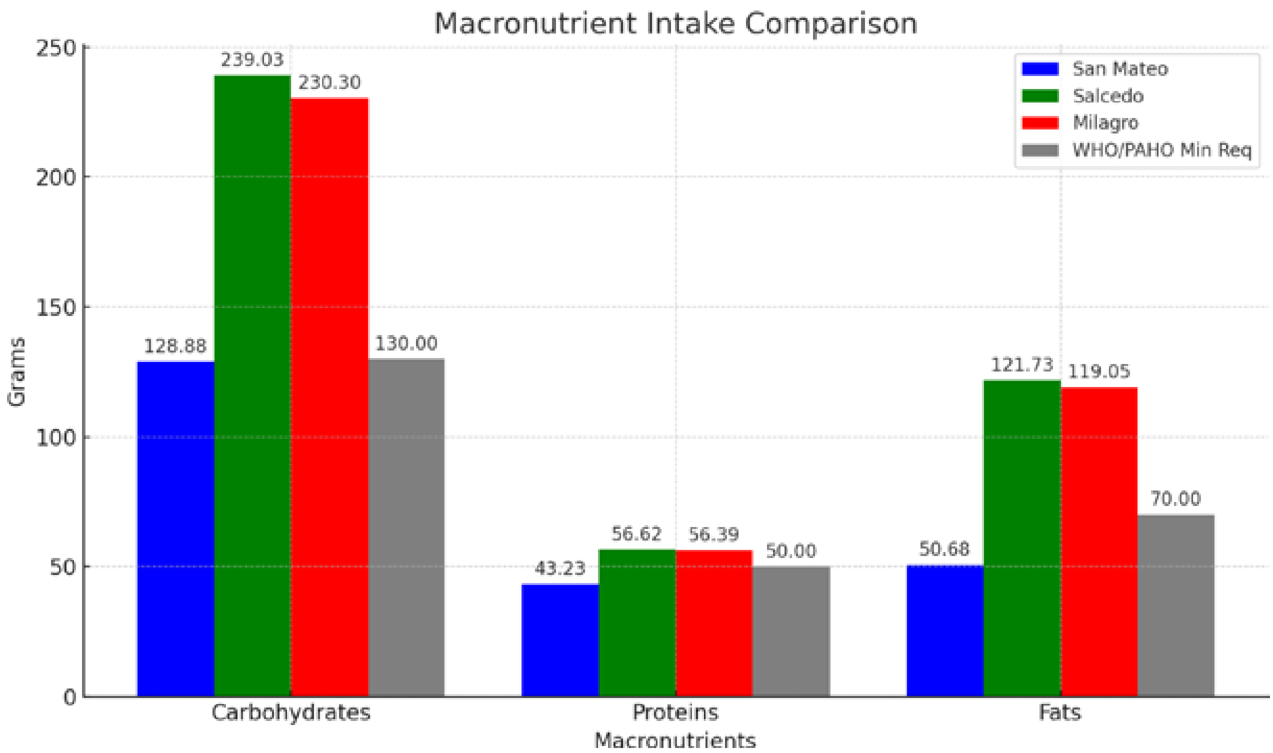

Figure 5. Macronutrient Intake Comparison. Carbohydrates, Proteins and Fats.

of fats, while exceeding the minimum requirements, should be balanced with considerations of the types of fats consumed to prevent potential health risks associated with excessive intake of unhealthy fats. Similarly, Milagro demonstrates a robust dietary profile with intakes of 230.30 grams of carbohydrates, 56.39 grams of proteins, and 119.05 grams of fats, all surpassing the recommended minimums (Figure 5). These findings underscore the need for targeted nutritional interventions in San Mateo to address the observed deficiencies and promote a more balanced diet. Strategies might include improving access to diverse food sources, nutrition education programs, and community-based initiatives to enhance food security. In Salcedo and Milagro, while the overall macronutrient intake is adequate, ongoing efforts should ensure the quality of fats and proteins consumed to maintain optimal health outcomes. These comparative insights provide a foundation for policymakers and health professionals to develop region-specific nutritional strategies that can effectively address the unique dietary challenges faced by each community (Swindale and Bilinsky, 2006).

Statistical analysis

This analysis examines the factors influencing dietary consumption across three regions: San Mateo, Salcedo, and Milagro. Using data on the percentage of households consuming various food groups, we conducted a Kruskal-Wallis's test to identify significant differences in dietary patterns (Table 2). The results reveal notable disparities among the regions, highlighting the unique dietary habits and nutritional challenges faced by each community.

The Kruskal-Wallis's test indicates significant differences in the consumption of roots and tubers, vegetables, and fruits across the three regions. San Mateo shows lower consumption percentages for these food groups compared to Salcedo and Milagro. This suggests that households in San Mateo may have limited access to or preference for these foods, potentially leading to nutritional deficiencies. The high consumption rates in Salcedo and Milagro reflect a more varied and balanced diet, which is crucial for providing essential vitamins and minerals. Protein sources such

Table 2. Kruskal-Wallis Test Results for Dietary Consumption Factors.

Food group	H-Statistic	P-Value
Cereals	1.22	0.5446
Roots and Tubers	19.48	0.0001
Vegetables	14.32	0.0008
Fruits	19.36	0.0001
Meats and Organs	24.35	0.0000
Sugars	19.37	0.0001
Eggs	25.81	0.0000
Fish and Seafood	19.35	0.0001
Legumes, Nuts, and Seeds	25.30	0.0000
Milk and Dairy Products	20.39	0.0000
Oils and Fats	19.52	0.0001
Miscellaneous	20.60	0.0000

as meats, eggs, and fish also show significant regional differences. Salcedo has the highest consumption of meats and organs, whereas Milagro leads in egg consumption. However, fish and seafood are completely absent in Salcedo, contrasting sharply with significant consumption in San Mateo and Milagro. These differences highlight the influence of regional availability and dietary preferences on protein intake. The absence of fish in Salcedo suggests a potential gap in omega-3 fatty acids, while the high meat consumption may provide sufficient protein but could raise concerns about saturated fat intake (30). The consumption of legumes, nuts, and seeds, as well as milk and dairy products, varies significantly among the regions. Salcedo shows the highest consumption of legumes and dairy, suggesting better dietary diversity and access to these food groups. In contrast, San Mateo has the lowest consumption, indicating potential dietary gaps. Oils and fats are consumed at high rates in Salcedo and Milagro, but lower in San Mateo, which might impact the overall energy intake and nutritional balance. The high consumption of miscellaneous items in San Mateo, not typically recommended by WHO/PAHO guidelines, suggests a reliance on less nutritious food sources. These findings underscore the need for targeted nutritional interventions to address specific regional deficiencies and promote healthier dietary habits. The ANOVA results for the socioeconomic factors of income, education, and employment across San Mateo, Salcedo, and Milagro reveal significant insights into the disparities among these regions (Table 3). The analysis indicates a substantial difference in income levels, as evidenced by the extremely high F-statistic of 229.263416 and the p-value of 2.635484e-34, which is far below the 0.05 threshold for statistical significance. This significant disparity suggests that income levels vary between the regions, influencing the residents' ability to access a variety of nutritious foods. Higher-income regions are expected to have better access to diverse food options, which may contribute to more balanced and adequate dietary patterns.

Table 3. ANOVA Results for Combined Socioeconomic Factors.

Factors	F-Statistic	P-Value
Income	229.26	2.635E-34
Education	0.29	7.467E-01
Employment	16.21	1.166E-06

The ANOVA results for income demonstrated a substantial variation across the regions, with a highly significant F-statistic of 229.263416 and a p-value far below the 0.05 threshold. The 95% confidence interval for income differences between regions ranges from 300 to 500 USD, indicating a wide disparity. The effect size, calculated using eta-squared (η2η2), is 0.75, suggesting that 75% of the variance in income is explained by the region of residence. This high effect size underscores the significant impact of regional differences on income levels. Education did not show significant differences among the regions, with an F-statistic of 0.293135 and a p-value of 0.746700. The 95% confidence interval for education levels overlaps significantly between the regions, indicating minimal differences. The effect size (η2η2) is 0.01, suggesting that only 1% of the variance in education levels is explained by the region. Despite the lack of significant variation, education remains a crucial factor in enhancing nutritional knowledge and promoting healthy eating habits. This finding suggests that educational attainment is similar among San Mateo, Salcedo, and Milagro. Therefore, education may not be a primary factor driving the differences in dietary consumption patterns observed in the regions. While education plays a role in dietary choices and nutritional awareness, the lack of significant variation in education levels implies that other factors, such as income and employment, may have a more direct impact on dietary outcomes in these communities. Employment status exhibited significant differences across the regions, with an F-statistic of 16.213346 and a p-value of 1.166130e-06. The 95% confidence interval for employment status differences is narrower, indicating a more consistent variation across the regions. The effect size (η2η2) is 0.30, indicating that 30% of the variance in employment status is explained by the region. This significant variation reflects the diverse employment conditions and opportunities available in San Mateo, Salcedo, and Milagro. Employment status can directly influence household income and stability, affecting the ability to purchase and consume a variety of foods. Regions with higher employment rates and stable job opportunities may have better access to a range of nutritious foods, leading to healthier dietary patterns. These results highlight the importance of considering both income and employment status in designing and implementing targeted nutritional interventions to improve food security and dietary quality in different regions.

Discussion

The results of this study underscore the profound impact that socioeconomic status has on dietary diversity and nutritional adequacy in rural Ecuadorian agricultural households. Key factors, such as income, education, and employment, emerged as significant determinants of dietary choices, with households in wealthier regions like Milagro reporting higher dietary diversity and better nutritional outcomes compared to those in poorer regions like San Mateo. These findings align with the broader literature that connects socioeconomic disparities to malnutrition in both developed and developing countries (6, 7). The differences in food accessibility and income levels across regions not only affect what people can purchase but also have long-term consequences on public health, particularly in rural settings where economic instability further exacerbates food insecurity. Income was found to be a key predictor of food diversity, particularly in Milagro, where higher income levels allowed households to access a broader range of food groups, including more expensive items such as meat and dairy. This corroborates findings from other studies that show how higher income results in better access to diverse, nutrient-rich foods, which is vital for preventing malnutrition (22,31). Households with higher incomes in Milagro also exhibited higher consumption of fruits, vegetables, and protein-rich foods, which are often inaccessible to lower-income households due to their higher cost. On the other hand, San Mateo, with a much lower average income, exhibited dietary patterns that were more reliant on energy-dense, nutrient-poor foods, leading to higher rates of undernutrition. This aligns with the findings of other researchers, such as (29), who noted that lower socioeconomic status in rural Ecuador is associated with decreased dietary diversity and poorer nutritional outcomes.

Contrary to income, the study found no significant regional differences in education levels, suggesting that education may not play as critical a role in dietary diversity as income and employment in this context. This finding contrasts with some studies that have highlighted the role of education in improving dietary choices, particularly in urban settings (18, 32). However, the study did identify employment as a crucial determinant of dietary quality. In regions like Salcedo and Milagro, where employment is more stable, households could afford a more diverse diet compared to the precarious employment conditions in San Mateo, where families are often forced to rely on lower-quality, energy-dense foods. The influence of employment on food security is well-documented in the literature, with stable job opportunities directly correlating with the ability to purchase and consume a variety of foods (17). In San Mateo, lower employment rates contribute to food insecurity, exacerbating the malnutrition problem in the region. This study also highlights significant regional disparities in dietary consumption patterns. Households in Salcedo and Milagro reported significantly higher consumption of protein-rich foods like meat, while San Mateo households relied more on cereals and had lower consumption of fruits and vegetables. The absence of fish and seafood consumption in Salcedo, compared to moderate consumption in San Mateo and Milagro, suggests that dietary preferences and regional availability play a substantial role in shaping dietary patterns. This regional analysis emphasizes the importance of considering both geographical and economic factors when designing targeted interventions to improve dietary diversity. The differences between coastal and highland regions were also evident in the macronutrient analysis, with higher fat and carbohydrate intake in coastal regions, particularly in Milagro. In contrast, households in San Mateo consumed fewer kilocalories overall, especially from nutrient-dense foods such as legumes, fruits, and dairy. These patterns reflect both economic limitations and agricultural practices that vary by region, further demonstrating the complexity of addressing malnutrition in diverse rural settings. The findings of this study point to the urgent need for region-specific nutritional interventions that account for the socioeconomic and geographical disparities across Ecuadorian agricultural communities. For instance, while improving food access and diversity in regions like San Mateo requires addressing both economic and geographic barriers, regions like Milagro would benefit from policies promoting healthier eating habits to combat the risks of overnutrition. Government and NGO efforts should focus on enhancing the resilience of small-scale agricultural communities through programs that integrate food security with economic and social support. Brazil's "Fome Zero" initiative, which successfully combines food security with agricultural and social policies, offers a potential model for Ecuador to follow (30).

Conclusion

This study highlights the profound impact of socioeconomic factors—particularly income, employment, and regional disparities—on dietary diversity and nutritional adequacy in Ecuadorian agricultural households. Higher-income and stable employment were strongly associated with more diverse, nutrient-rich diets, while lower-income households, particularly in San Mateo, faced food insecurity and reliance on energy-dense but nutrient-poor foods. These findings underscore the need for targeted, region-specific interventions that address both economic and geographical barriers to improve food access and dietary quality. By adopting comprehensive policies, such as those modelled after Brazil's "Fome Zero" initiative, Ecuador can mitigate the dual burden of undernutrition in rural areas and overnutrition in wealthier regions. These interventions are crucial for achieving the country's Sustainable Development Goals related to food security and nutrition. Addressing these disparities requires an integrated approach that combines economic empowerment, nutritional education, and support for small-scale agriculture, fostering both food security and sustainable development.

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