

## Childhood undernutrition and micronutrient intake: A cross-sectional data analysis for Ecuador

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### Abstract:

**Background:** Chronic child malnutrition worldwide is responsible for 45% of deaths in children under 5 years of age. In Ecuador, 27.2% of children suffer from any type of malnutrition. This problem has alarming consequences since it affects the country's productivity and has an impact throughout the individual's life, since at this stage the greatest impact is suffered by the child's brain, in which irreversible metabolic and structural alterations occur. However, child malnutrition is not only a problem of lack of food, it is a deeper social conflict that must be taken into account when providing solutions.

**Materials and Methods:** A nationally representative sample of children under 5 years of age from the National Health and Nutrition Survey 2018 (ENSANUT) was used. A binary logistic linear regression model was used where Odds Ratio (OR) with their 95% confidence intervals (95% CI) were estimated for each of the independent variables.

**Results:** Our results reveal that micronutrient intake during 6 months to 2 years of age (OR= -2.32; CI=-1.91,-3.02) reduces the probability of childhood malnutrition. This result is statistically significant ( $p < 0.05$ ). It was also shown that children from rural areas, with lower income and low schooling are more susceptible to malnutrition compared to the rest of the population. Another interesting result is that children whose mothers have more schooling have a lower risk of child malnutrition (OR= -1.685; CI=-1.54,-1.75). In addition, we found that girls have a higher risk of malnutrition (OR= 1.342; CI=0.872-1.621).

**Conclusion:** Malnutrition is one of the main health problems in Ecuador. It affects a significant percentage of the population and, associated with other factors, is responsible for most of the avoidable mortality and considerable damage to children's health. It is therefore necessary to strengthen programs aimed at improving the nutritional status of the population; strategies should include epidemiological surveillance, promotion of healthy eating styles, disease prevention and, if necessary, nutritional supplementation in the most affected groups. Malnutrition and micronutrient deficiencies in the population could also be reduced with strategies aimed at improving the socioeconomic situation of the family.

**Key words:** Malnutrition, micronutrients, child development.

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### I. Introduction

Childhood is considered a transcendental stage in the evolutionary process of the human being, characterized mainly by two phenomena: growth and development. In order for these phenomena to occur normally, proper nutrition is essential.<sup>1</sup> The World Health Organization (WHO) defines malnutrition as the lack of nutrients that delay a child's normal development.<sup>2</sup> Child malnutrition is registered as one of the main problems of public health and social welfare in Latin America, as it is one of the major causes of mortality and

avoidable morbidity in children in Latin America, which is also related to the poor social and economic determinants and health policies of the vast majority of countries in the region.<sup>3</sup>

According to WHO in 2016 worldwide it was estimated that 52 million children under 5 years of age presented a state of wasting, 17 million suffer from severe wasting, and 155 million are stunted, about 45% of deaths of children under 5 years of age are related to malnutrition, mostly recorded in low- and middle-income countries<sup>2</sup>. In Latin America, it has been recognized that about 25% of children under 5 years of age are undernourished.<sup>4</sup> Nowadays, there is greater awareness of the importance of nutrition in Ecuador, since child nutrition has an impact on the developmental outcomes of children.<sup>5</sup> In this sense, Ecuador, as a middle-income country, has a high level of malnutrition, since it is estimated that 25% of the child population under 5 years of age suffers from malnutrition. Although a decrease in the figures can be identified, however, the level of malnutrition is close to double the average in Latin America.<sup>6</sup>

Poor nutrition over long periods is mainly reflected in growth retardation and is associated with poor socioeconomic conditions, poor maternal nutrition and health, and inappropriate infant and young child feeding or care. In addition, it is believed that nutrient deficiency experienced over the long term can manifest itself in short stature and can cause irreversible damage to brain development, preventing children from fully developing their physical and cognitive potential.<sup>7</sup>

Insufficient intake of vitamins and minerals (micronutrients) does not allow the body to produce enough enzymes, hormones and other substances essential for proper growth.<sup>5</sup> Micronutrients, which are necessary vitamins and minerals in small amounts, are essential for a good start in life and optimal growth and development. In particular, iron and vitamin "A" play a fundamental role in maintaining healthy and productive populations. With them, children under 5 years of age have the opportunity for normal, healthy growth and to become a productive adult. Without these micronutrients, human beings can lose the potential of life, becoming ill and dying.<sup>8</sup> With micronutrient supplementation, children from three months to five years of age were observed to have small gains in weight (0.24 kg per year) and height (0.54 cm per year) and moderate increases in hemoglobin (0.54 cm per year).<sup>9</sup> The percentage of households consuming Chispaz of micronutrients in 2014 was 24%. This percentage has been increasing to between 41% and 43% in 2015-2017.<sup>10</sup>

Children who become malnourished and deficient in vitamins and minerals in the early years of life are at greater risk of death during childhood and of morbidity and malnutrition throughout the life cycle, limiting their potential physical and intellectual development and restricting their ability to learn and work in adulthood, thus limiting opportunities for professional and economic development, which contributes to perpetuating the cycle of poverty.<sup>11</sup> Hunger and malnutrition hinder the achievement of all the Millennium Development Goals, not only because of their impact on poverty, but also because they have repercussions on health, education and mortality, among many other aspects. Countless studies and research show important evidence of the causal and associative relationships and interrelationships between hunger and undernutrition on the one hand, and poverty on the other, as well as revealing how hunger and undernutrition undermine school attendance and learning, and hinder access to markets and resources, maternal and child health, the immune system, education and employment for women and girls.<sup>12</sup>

These antecedents mark the importance of nutrition in the health of the population, a responsibility that falls on the health sector, which, due to its relevance, is in charge of implementing programs aimed at reversing these problems.<sup>8</sup> In this context, the country has a historical debt translated into the challenge of chronic malnutrition, which has been linked to the deep social inequality and economic problems that generally affect the poorest population and adverse living conditions.<sup>13</sup> For this reason, the preparation of the Intersectoral Plan for Food and Nutrition Ecuador, 2018-2025 was proposed in order to analyze the main nutrition problems and their respective solutions, the delivery of micronutrient supplementation to children between 6 to 24 months of age was established. The administration of sixty sachets of Chis Paz optimally, in sixty days, one sachet per day, is sufficient to rapidly improve hemoglobin concentrations and iron stores in a large proportion of infants and young children. After ingestion of 60 sachets, the hematological benefits are maintained for a period of six months.<sup>14</sup>

Micronutrient interventions have received much attention internationally, as it is considered a cost-effective strategy in terms of cost-benefit. Based on these considerations, the Ecuadorian state, through the Ministry of Public Health, has implemented during the last years, some supplementation programs for children through the "Chis Paz" of micronutrients, therefore, the present research seeks to answer the following question: Does the delivery of micronutrient sachets have an impact on the reduction of chronic child malnutrition?

## **II. Material And Methods**

**Study Design and Population:** A cross-sectional study was conducted with data obtained from the 2018 National Health and Nutrition Survey of Ecuador (ENSANUT), whose data were obtained and presented by the National Institute of Statistics and Census (INEC). After cleaning the database, a total of 3877 Ecuadorian children under 5 years of age were obtained.

**Inclusion and Exclusion Criteria:** The working universe was considered to be children under 5 years of age whose anthropometric measurements were reported in the Home form of the 2018 ENSANUT survey. All children with normal and high weight were excluded, i.e. all children above the 5th percentile.

**Source of Information:** ENSANUT 2018 is a survey included in the National Statistical Program that employs probability sampling applied every 5 years and whose target population is all household members in the 24 provinces of Ecuador. The ENSANUT 2018 includes the form Household, in section 7: Anthropometry for all persons in the household.

**Study Variables.** Our dependent variable of interest is underweight for age. The information for this variable was obtained through section 7: Anthropometry for all persons in the Household, of the Household form. In addition, our independent variable was obtained through the Women of childbearing age form in section IV called Childhood health (Children under 5 years of age). The question: In the last 12 months, (...) Did you receive from the health personnel, iron powder as micronutrients (sparks) to prevent anemia?

**Statistical Analysis.** The ENSANUT 2018 survey database was analyzed with the statistical package Stata v15 (Stata Corporation, College Station, Texas, USA). A value of  $p < 0.05$  was considered to determine statistical significance between variables. The Chi-square test was used to determine the overall correlation between the variables of interest. The association was evaluated by prevalence ratios with their respective 95% confidence intervals with an analysis for each of the variables included in the study, with the independent variable being

In this context, taking into account the models used in previous works, this study uses a logit model to define how micronutrient intake impacts child malnutrition. Thus, the model would have the following general form:

$$\Pr(Y = 1|X) = F(\alpha + X_i + e_i) \tag{1}$$

$$\Pr(Y = 0|X) = 1 - F(\alpha + X_i + e_i) \tag{2}$$

Where we study the probability of a child being malnourished or not ( $Y = 1$  if malnourished and  $Y = 0$  otherwise), according to a series of determinant variables ( $X$ : explanatory variables), which are specified in **Table 2**. The logit model assumes that the cumulative distribution function for the error term is normally distributed, in the form  $\Phi(-)$ . This means that the probability of suffering from child malnutrition (in our case) can be defined as:  $\Pr[\text{Desnutrición}_{kj} = 1] = \Phi[\text{Desnutrición}]$ . This model estimates the parameters by maximizing the value of the log likelihood function, which is defined as:

$$\text{LogL}(\theta) = \sum_{k=1}^k \text{Log}P_{kj}(\theta) \tag{3}$$

Where  $\theta = (\beta, \delta, \gamma, \sigma)$  and

$$P_{kj}(\theta) = \Pr[\text{Desnutrición}_{kj} = 1]^{Desnutrición_{kj}} * [1 - \Pr[\text{Desnutrición}_{kj} = 1]]^{1 - Desnutrición_{kj}}$$

The parameters are estimated using the maximum likelihood (ML) procedure. Therefore, in order to estimate a discrete choice model that estimates the probability of suffering from malnutrition:

$$UN_i = \beta_0 + \beta_1 X_i + \sum_{j=2}^{12} \beta_j Z_i + \varepsilon_i \tag{4}$$

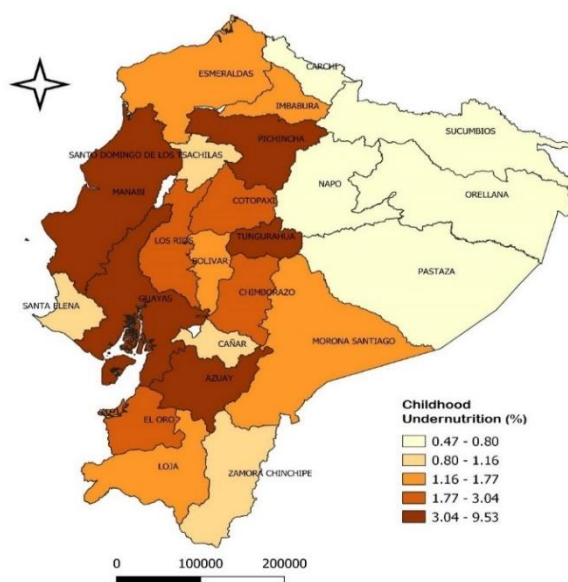
Where  $UN_i$  represents undernutrition (measured by asking whether or not a child is undernourished),  $X_i$  represents the micronutrient consumption variable, and  $Z_i$  represents a set of control variables of the linear regression model. Finally,  $\varepsilon_i$  represents the stochastic error term.

**Ethical considerations.** The present study did not require the approval of an institutional ethics committee for its execution, since it is an analysis of data freely available to the public and it was not necessary to use informed consent.

### III. Result

First, to highlight the case study, **Figure 1** shows the spatial distribution of child malnutrition. In general, the provinces with a more intense color are those with a higher percentage of child malnutrition. This fact shows that child malnutrition mainly affects the provinces of the Ecuadorian Coast and Highlands.

**Figure 1.** Spatial distribution of child malnutrition in Ecuador.



**Table 1** shows the descriptive statistics of the variables. Here we analyze all the variables used in this study and we see that the sample is 9211 infants. We observe that 9.89% (CI=8.02% - 10.77%) of the sample suffers from child malnutrition. This fact makes it evident that policies to mitigate child malnutrition should be a priority in a developing country like Ecuador. In addition, we observed that 71.45% (68.45% - 73.45%). The average age of the infants in the sample is 15 months and 53.33% of infants are male. Also, the average number of children of Ecuadorian women is 4. On the other hand, the average household income of Ecuadorian households is \$444.01 USD. The average years of schooling of mothers is 7 years of schooling. This shows that the level of schooling of mothers is relatively low in Ecuador. Unemployment among mothers is reported at 30.55% and the average number of working hours for mothers is 42.78. In addition, 82.52% of mothers reported that they had migrated at some point. This fact is evidence that Ecuador is a country of high internal migration. In terms of ethnicity, 75.61% of the mothers are mestizo, the average urban density is 157 people per square kilometer, while we observe that 55.51% of people are from the urban area.

**Table N°1:** Descriptive statistics of the variables used in this study

Variable	Mean-Percent	SD	Min	Max	95% CI
<b>Child malnutrition</b>					
Yes (Body Mass Index < 5th percentile)	9.89%	0.44	0	1	8.02% - 10.77%
No (Body Mass Index ≥ 5th percentile)	90.11%	0.89	0	1	88.17% - 92.43%
<b>Micronutrient intake</b>					
Yes	71.45%	0.12	0	1	68.45% - 73.45%
No	28.55%	0.43	0	1	25.55% - 30.55%
<b>Age of infant</b>					
Age in months		0.12			14.13 - 16.22
<b>Sex of infant</b>					
Woman	46.67%	0.14	0	1	43.67% - 48.67%
Man	53.33%	0.33	0	1	50.33% - 55.33%
<b>Number of children</b>					
Number of children at home	4.12	0.25	0		4.01 - 4.98
<b>Household income</b>					
Income in dollars	444.01		0	2033	441.68 - 448.49
<b>Mother's years of schooling</b>					
Years of schooling	7.08	1.77	0		2.97 - 3.96
<b>Mother's way of working</b>					

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Employee	69.45%	0.66	0	1	66.45%	-	71.45%
Unemployed	30.55%	0.26	0	1	27.55%	-	32.55%
Out of the workforce	3.55%	0.26	0	1	2.67%	-	3.77%
<b>Mother's working hours</b>							
Number of working hours	42.78	0.55			41.54	-	46.86
<b>Are you a migrant?</b>							
No	17.48	0.89	0	1	14.48%	-	19.48%
Yes	82.52%	0.67	0	1	79.52%	-	84.52%
<b>Ethnicity of infant</b>							
Indigenous	14.73%	0.35	0	1	14.26%	-	15.20%
Afro-Ecuadorian	4.03%	0.20	0	1	3.77%	-	4.29%
Mongrel	75.61%	0.43	0	1	75.04%	-	76.18%
White	1.32%	0.11	0	1	1.17%	-	1.47%
Montubio	4.31%	0.20	0	1	4.04%	-	4.58%
<b>Urban density</b>							
Inhabitants per square kilometer	157.01	1152.5	321	2653.12	146.32	-	160.33
<b>Area</b>							
Urbana	55.51%	0.54	0	1	52.51%	-	57.51%
Rural	44.49%	0.36	0	1	41.49%	-	46.49%

Subsequently, we performed a correlation matrix to perform a detailed analysis of correlation between the variables and to highlight possible multicollinearity problems. **Table 2** shows significant correlations between our variables of interest, i.e. between child undernutrition and micronutrient intake, showing a negative coefficient of -0.4505. In addition, we observed some other variables with significant correlations such as household income, mother's schooling, mother's working hours, number of children at home and urban density. All these variables have an expected sign which is correct. In addition, we observe that some correlations between the independent variables are not greater than 50%. This shows that there are probably no multicollinearity problems among the variables. Below we perform a formal test to test for multicollinearity among the variables.

**Table N°2: Correlation matrix of the variables**

	Var 1	Var 2	Var 3	Var 4	Var 5	Var 6	Var 7	Var 8	Var 9	Var 10	Var 11	Var 12	Var 13
Var 1	1												
Var 2	-0.8505*	1											
Var 3	-0.0045	0.0042	1										
Var 4	0.0826*	0.0739*	-0.0023	1									
Var 5	0.1501*	0.0598*	-0.0045	-0.0116	1								
Var 6	-0.6340*	0.0107*	0.0046	-0.0119	0.6216*	1							
Var 7	-0.0113	0.0394*	-0.0054	0.0014	0.0220*	0.0251*	1						
Var 8	-0.0276*	0.2212*	0.0061	0.0217*	0.0689*	0.0787*	0.0489*	1					
Var 9	0.0568*	0.0058	0.0073	0.0000	0.0114	0.0148*	0.0547*	-0.0697*	1				
Var 10	0.0716*	0.4734*	0.0021	0.0529*	-0.0685*	-0.0404*	-0.0471*	0.1700*	-0.1847*	1			
Var 11	-0.0393	-0.0979*	0.0080	0.0074	-0.0207*	-0.0267*	-0.0781*	-0.0228*	-0.2026*	0.1239*	1		
Var 12	0.0098*	0.0531*	0.0099	-0.0440*	0.0219*	0.0187*	0.1295*	0.1134*	0.1410*	-0.3042*	-0.1964*	1	
Var 13	-0.0087	0.0432*	-0.0007	0.0015	-0.0123	-0.0021	0.0529*	0.0065	0.2222*	-0.1598*	-0.1992*	0.3081*	1

Note: Var 1: Child undernutrition Var 2: Micronutrient intake. Var 3: Age of infant. Var 4: Sex of infant. Var 5: Number of children at home. Var 6: Household income. Var 7: Mother's years of schooling. Var 8: Mother's form of work. Var 9: Mother's hours of work. Var 10: Is she a migrant? Var 11: Mother's ethnicity. Var 12: Urban density. Var 13: Urban area. Asterisks mean: \*p < 0.05.

Next, we performed a formal test to rule out the presence of multicollinearity among our independent variables. In **Table 3** we present a multicollinearity analysis. We use the Variance Inflation Factor (VIF) to

perform this test. Previous literature indicates that a VIF greater than 5 can demonstrate that multicollinearity exists in our data. As we can see, no variable has a VIF greater than 5, therefore we rule out multicollinearity problems in our independent variables. This analysis is important since multicollinearity problems cause instability of the parameters of a regression, incorrect signs and higher standard errors, which translates into statistical insignificance of the parameters.

**Table N° 3: Multicollinearity test of the variables**

Variable	VIF	SQRT VIF	Tolerance	R-Squared
Micronutrient intake	2.88	1.33	0.9966	0.0004
Age of infant	1.44	2.71	0.9918	0.0082
Sex of infant	2.89	1.09	0.6101	0.3899
Number of children	1.88	1.76	0.6145	0.3855
Household income	1.97	1.65	0.9764	0.0236
Mother's years of schooling	1.45	1.88	0.8821	0.1179
Mother's way of working	1.66	1.43	0.8812	0.1188
Mother's working hours	1.44	1.75	0.6310	0.3690
Are you a migrant?	1.12	1.86	0.9146	0.0854
Ethnicity of infant	1.88	1.67	0.7746	0.2254
Urban density	1.67	1.09	0.8583	0.1417
Urban area	1.05	1.32	0.9537	0.0463
<i>Mean VIF</i>	1.90			

The confusion matrix of the model is shown below. **Table 4** shows that the model is correctly specified in 73.06% of the cases. That is, the independent variables predict child malnutrition in 73.06% of the cases. It is worth mentioning that this percentage is relatively high, being an acceptable level higher than 60%.

**Table N° 4: Confusion matrix of the estimated model**

Classified	True		Total
	D	~D	
+	7948	3569	11517
-	5192	15812	21004
Total	13140	19381	32521

Classified + if predicted Pr(D) >= .5  
 True D defined as sectores != 0

Sensitivity	Pr( +   D)	60.49%
Specificity	Pr( -   ~D)	81.59%
Positive predictive value	Pr( D   +)	69.01%
Negative predictive value	Pr( ~D   -)	75.28%
False + rate for true ~D	Pr( +   ~D)	18.41%
False - rate for true D	Pr( -   D)	39.51%
False + rate for classified +	Pr( ~D   +)	30.99%
False - rate for classified -	Pr( D   -)	24.72%
Correctly classified		73.06%

A multivariate logistic regression analysis to analyze the impact of micronutrient intake on child undernutrition is shown below in **Table 5**. Our logistic regression involves 9211 infants. Here we observe that the dependent variable is a dichotomous variable that takes the value of 1 if an infant suffers from child malnutrition. We find that, as expected, the odd ratio (OR) of having consumed micronutrients is significant and negatively greater than 1. Our results show that those children who consumed micronutrients have a lower risk of suffering from child malnutrition. That is, our results specifically show that the consumption of micronutrients reduces by 2.32 times (OR= -1.91 - -3.02) the probability of suffering from child malnutrition. This result is statistically significant. It was also shown that other variables that influence child malnutrition are

the number of children at home, positively affecting the probability of suffering from child malnutrition. Likewise, family income reduces the probability of suffering from child malnutrition by 2.03 times. A similar result is observed in the variable of years of schooling of the mother. Unemployment and being out of the labor force (in the mother) also positively predict the probability of suffering from child malnutrition. An interesting variable is migration, as we find that migrant mothers are more likely to have children with child malnutrition. Finally, we also observed that living in a more densely populated city increases the risk of child malnutrition.

In **Table 5** we observe that the chi-square ( $X^2$ ) and log-likelihood statistics are stable and statistically correct. The chi-square statistic is significant suggesting that, as a whole, the independent variables together explain the variability of the dependent variable. On the other hand, the log-likelihood statistic is negative and is observed to collect as much information as possible.

**Table N° 5:** Logistic regression analysis between child malnutrition and micronutrients intake

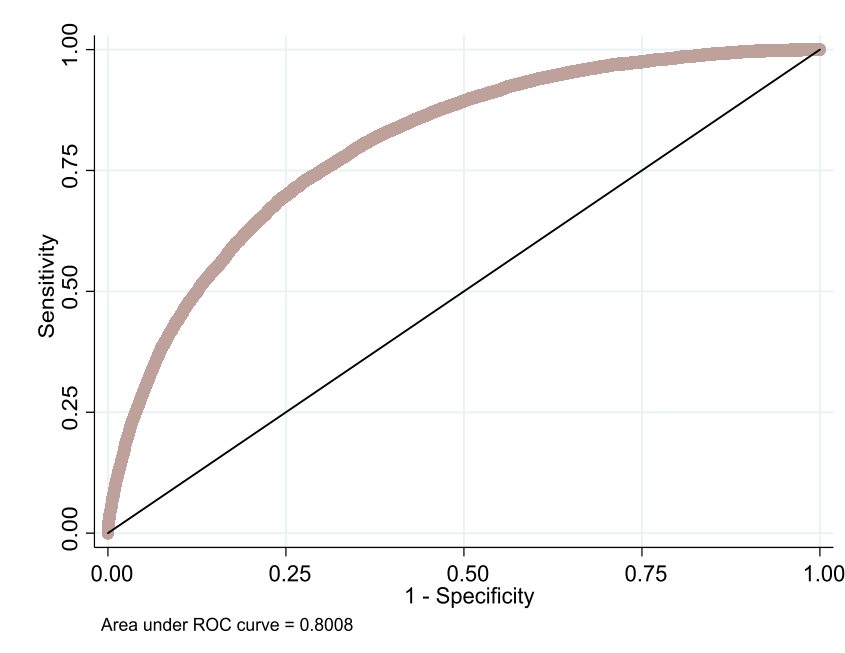
<b>Variable</b>	<b>OR</b>	<b>Std. Err.</b>	<b>P&gt;z</b>	<b>95% CI</b>	
<b>Micronutrient intake</b>					
No	Ref.				
Yes	-2.32**	0.982	0.002	-1.91	- 3.02
<b>Age of infant</b>					
Age	1.001	0.863	0.057	0.872	- 1.321
<b>Sex of infant</b>					
Man	Ref.				
Woman	1.342**	0.723	0.034	0.872	- 1.621
<b>Number of children</b>					
Number of children at home	1.032**	0.054	0.004	1.012	- 1.453
<b>Household income</b>					
Income in dollars	-2.981**	0.687	0.872	-2.001	- -1.321
<b>Mother's years of schooling</b>					
Years of schooling	-1.686***	0.542	0.001	-1.543	- -1.754
<b>Mother's way of working</b>					
Employee	Ref.				
Unemployed	1.455*	0.216	0.032	1.321	- 1.765
Out of the workforce	1.032*	0.321	0.021	1.321	- 1.765
<b>Mother's working hours</b>					
Number of working hours	1.653	0.654	0.035	1.345	- 1.897
<b>Are you a migrant?</b>					
No	Ref.				
Yes	1.567*	0.535	0.045	1.354	- 1.853
<b>Ethnicity of infant</b>					
Indigenous	Ref.				
Afro-Ecuadorian	-1.043	0.312	0.067	-1.012	- -1.231
Mongrel	-1.065	0.432	0.655	1.001	- 1.198
White	-1.986	0.563	0.192	-1.452	- -2.004
Montubio	1.654	0.643	0.431	1.594	- 1.865
<b>Urban density</b>					
Inhabitants per square kilometer	1.654**	0.543	0.031	1.493	- 1.985
<b>Area</b>					
Urbana	Ref.				
Rural	1.456	0.753	0.912	1.321	- 1.764
Observations	9211				
AIC	23975.03				

BIC	23138.09
R <sup>2</sup>	0.025
X <sup>2</sup>	3.956***
Log-likelihood	-31461.51

Notes: Asterisks mean: \* $p < 0.10$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$ . In the table, the dependent variable is the dichotomous variable of psychological problems which takes a value of 1=Yes and 0=No.

Finally, to determine the fit and explanation of the independent variables, the ROC curve was applied with the probabilities estimated by applying logistic regression. The ROC curve in **Figure 2** coincides with the probability of correctly distinguishing a case of psychological problems from one that is not, through the significant predictor variables, the worst scenario being when the area equals 0.50. In our case, suffering from obesity together with other significant variables, such as family income, mother's schooling, number of children at home, having been a migrant, infant's age, mother being unemployed or out of the labor force, and urban density, represented an area under the curve of 0.80880 (95% CI: 0.752-0.854), considering that they adequately predict (positively or negatively) cases of child malnutrition ( $p < 0.001$ ).

**Figure 2.** ROC curve of the estimated model.



#### IV. Discussion

Child malnutrition is a multidimensional problem that has short-, medium- and long-term repercussions. Not only does it affect the individual in this situation, but it also harms society in general, since childhood is the most important stage in human life, as it is a determining factor for physical and mental development. That is why international health organizations set global objectives aimed at eradicating them. Ecuador is not far from the reality of other countries in the field of nutritional deficiencies, observing a figure of iron deficiency anemia in children under 5 years of age above 50%. This background shows the importance of nutrition in Ecuador's child population.

The present work has examined the nutritional status of Ecuadorian children who have been considered as beneficiaries of a state micronutrient supplementation program. The results of this research showed that 9.89% (CI=8.02% - 10.77%) of the sample out of 9211 children under 5 years of age suffered from child malnutrition. This fact makes it evident that policies to mitigate child malnutrition should be a priority in a developing country like Ecuador. In addition, we observe that 71.45% (68.45% - 73.45%). Here we observe that the dependent variable is a dichotomous variable that takes the value of 1 if an infant suffers from child malnutrition. We found that, as expected, the odds ratio (OR) of having consumed micronutrients is significant and negatively greater than 1. Our results show that those children who consumed micronutrients have a lower risk of suffering from child malnutrition. That is, our results specifically show that the consumption of micronutrients reduces by 2.32 times (OR= -1.91 -- -3.02) the probability of suffering from child malnutrition.



This result is statistically significant. Likewise, family income reduces the probability of suffering from child malnutrition by 2.03 times. A similar result is observed for the variable of the mother's years of schooling. Unemployment and being out of the labor force (in the mother) also positively predicts the probability of suffering from child malnutrition.

Our results coincide with a study conducted in Tena, in a population of children under 4 years of age, in a sample of 74 children, showed the positive influence of chispaz supplementation on the hemoglobin levels of the study participants, which contributed to improve the anemia symptoms presented at the beginning of the study.<sup>15</sup> Another study conducted in a population of 337 children aged 0-59 months showed improvement in hemoglobin levels with chispaz supplementation, a significant relationship was found between anemia and lack of micronutrient supplementation ( $p=0.022$ , CI: 95%: 1.01-1.33).<sup>16</sup> Similarly, Ocaña et al. were able to demonstrate that the impact of chispaz supplementation in infants with anemia significantly improves hemoglobin levels.<sup>17</sup>

However, our results differ from those of other studies, such as a study in which the supplementation of chispaz was evaluated in relation to the nutritional status of children in the Centros Infantiles del Buen Vivir (CIVB) and Centros Infantiles Creciendo con nuestros Hijos (CNH), where it was observed that there is no statistical significance between the use (87.5%) or not (93.1%) of micronutrients to maintain an adequate nutritional status (OR 0.5; CI 0.11-2.44;  $p=0.3989$ ).<sup>18</sup> Similar results were found in a meta-analysis which revealed that micronutrients had no effect on growth or psychomotor development, but a positive effect in relation to child weight for age ( $p<0.05$ ).<sup>19</sup> At the Latin American level, something similar could also be found in a Peruvian study in children aged 6 to 17 months in which micronutrient supplementation has no additional long-term effects on nutritional status.<sup>20</sup> Another Japanese study found no evidence to quantitatively assess the efficacy of multiple micronutrient supplementation in improving infant health outcomes.<sup>21</sup>

The average years of schooling of the mothers is 7 years of schooling. This shows that the level of schooling of mothers is relatively low in Ecuador. Unemployment among mothers is reported at 30.55% and the average number of working hours of mothers is 42.78. Our results showed that family income reduces the probability of suffering from child malnutrition by 2.03 times. A similar result was observed in the variable of the mother's years of schooling. Unemployment and being out of the labor force (in the mother) also positively predict the probability of suffering from child malnutrition.<sup>22</sup> These results coincide to a large extent with studies in which sociodemographic factors such as the mother's level of education act as a protective factor against child malnutrition (OR=0.08; CI= 0.009-0.71;  $p= 0.0049$ ).<sup>23</sup> On the other hand, significant and similar data were evidenced in a Chinese study where higher education and breastfeeding for mothers were optimistic factors in the nutrition of infants under 6 months, concluding that family factors strongly influence the nutritional status of children.<sup>24</sup> The low educational level of mothers is related to the nutritional status of children. An Argentine study observed that children with malnutrition were born to mothers with incomplete primary education (44.32%) in relation to higher education level.<sup>25</sup>

Finally, it can be concluded that there is a significant relationship between the consumption of micronutrients, this is mainly reflected in the anthropometric evaluation of the children included in the present investigation since the body weight was preserved for the height, indicating that there is a nutritional balance only recently achieved. Such nutritional balance would imply an improvement in the situation of nutritional vulnerability of the child, or the resolution of those diseases that affected the absorption, distribution and peripheral utilization of ingested nutrients, reflecting the impact of the nutritional supplementation programs conducted by the Government of Ecuador in the nutritionally vulnerable areas of the country. Therefore, it is expected that government authorities and health regulators (Ministry of Public Health) in coordination with other ministries develop different education and nutrition programs for the benefit of the maternal and child population, which should maintain a respective monitoring, control and evaluation of both the people in charge of management, distribution and caregivers in general and implement updated training to strengthen the administration of micronutrients (Chispaz) to the entire child population, especially in the most vulnerable areas.

## **V. Conclusion**

It can be concluded that child malnutrition is caused by biopsychosocial, economic factors and intersectoral plans that are not strategically focused on common needs, affecting the growth and development of children with the appearance of nutritional diseases, low productivity, thus increasing public health spending; therefore it is necessary to have adequate access to basic and health services, with a multidisciplinary team of professionals focused on comprehensive care for infants and children. Thousands of people die daily because of this problem, especially children, so it is necessary a social commitment towards its eradication, a way to fight against them are public policies.

In the case of Ecuador, a country in the region still highly affected by its high rate of malnutrition, the "National Plan for Good Living" is being implemented, with undeniable successes and achievements in various areas, which currently has to face the threat posed by child malnutrition in children under five years of age and

teenage pregnancy. Child malnutrition currently indicates that one in four children suffers from chronic malnutrition, which leads to a school population with limited performance, which implies to undertake food supplementation strategies to reduce this problem, in addition to training as a right to food sovereignty in rural families of the Sierra as the most affected child population.

A major challenge will be to translate the political commitment to reduce inequities into policies and programs that involve the poorest communities from the outset.

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