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Breastfeeding as a protective factor for acute respiratory infections: A cross-sectional study in Ecuadorian infants under six months of age

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Abstract:
Background*: Upper respiratory infections are the leading cause of infant morbidity and mortality in our environment. The National Health Organization recommends that all infants should be exclusively breastfed for the first six months of life. The aim of our work is to know the pattern of breastfeeding in our environment and its influence on the incidence of acute respiratory infections in infants in the first months of life.*
Materials and Methods*: A representative sample of 2793 children under 6 months 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 show that those children who were exclusively breastfed showed a greater protective factor against acute respiratory infections compared to those children who were not exclusively breastfed. That is, our results show that exclusive breastfeeding during the first six months of life increased 2-fold (OR= 2.01; CI=1.91-2.17) the probability of not suffering from respiratory diseases. This result is statistically significant (p<0.05). It was also shown that those infants who received breast milk earlier from the time of birth have greater protection or developed greater immunity to upper respiratory tract infections (OR= 1.65; CI=1.41-1.94). Other significant protective factors are mother's age, mother's educational level and mother's area of residence.*
Conclusion: *Breastfeeding is a protective factor against infections affecting the upper respiratory tract during the first 6 months of life. Therefore, our results coincide with several investigations that establish the potent immunomodulatory value of milk, which provides the infant with nutrients, precursors, probiotics, antimicrobial factors and anti-inflammatory agents, necessary for immune maturation and therefore reducing the incidence and severity of infectious diseases, and consequently infant morbidity and mortality.*
Key Word*: Breastfeeding, Respiratory infections, Infants.*

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I. Introduction

Currently, Acute Respiratory Infections (ARI) represent the most frequent pathology in the child population, especially in children under five years of age.[1]. Worldwide, a mortality rate of 20% has been reported, and in Latin America, the morbidity recorded annually is 4,000,000 medical care visits, representing between 25 and 30% of outpatient visits and around 30% of hospitalizations.[2]. According to data from the Pan American Health Organization (PAHO), in 2016 in Ecuador, Acute Respiratory Infections (ARI) remain the leading cause of disease in primary care, followed by diarrhea and intestinal parasitosis.[3].

The World Health Organization (WHO) states that poor nutrition is the main cause of half of the reported cases of upper respiratory tract infections in infants at 55%. [4]. Exclusive breastfeeding for six months provides the infant with essential nutrients for health and growth as well as immunological factors that are lacking in humanized formulas.[5]. In fact, studies have shown that the rates of respiratory tract infections, as well as deaths caused by these infections, are lower in exclusively breastfed infants than in those who are partially breastfed.[6]. Protection against germs such as *respiratory syncytial, rhinovirus, Haemophilus influenzae* and *pneumococcus* has been shown to last up to 2 years after cessation of exclusive breastfeeding, which is particularly important in otitis media and pneumonia.[7]

Exclusive breastfeeding refers to the infant receiving only breast milk from its mother, wet nurse, or expressed breast milk, and no other liquids or solids, except for vitamin supplements or any type of medication.[8]. In human milk, antibodies are secreted against bacteria that colonize the digestive tract, by the migration of B lymphocytes from Peyer's patches to the lamina propria of the mammary gland, where they differentiate into IgA-producing cells, which is the most abundant in the intestinal and respiratory mucosa.[9]. In the same context, the role of breastfeeding on thymic function has been described as showing that exclusively breastfed infants have a larger thymus size than those fed with artificial formula, which influences the cellular repertoire and subsequent immune function of the organ.[10]. Studies have shown that extending the period of breastfeeding could save the lives of 1 million infants under 1 year of age in developing countries each year.[11].

Other studies report that worldwide, for every 10 children born, only 4 or less receive exclusive breastfeeding up to 6 months of age, and that if exclusive breastfeeding were guaranteed for newborns, 1,301,000 deaths would be prevented, as well as a 13% decrease in the current number of deaths in children under 5 years of age.[20]. In spite of all these benefits, the last 60 years have seen a progressive decline in the practice of breastfeeding in the world.[12]. For developing countries, the early abandonment of breastfeeding has had a negative impact on infant health, increasing morbidity, hospitalizations, mortality, and the high economic cost of replacing it with artificial milks.[12].

Therefore, this study has considered the importance of encouraging exclusive breastfeeding, since in addition to the nutritional and immunological benefits, it also offers economic benefits for societies and avoids the high costs of artificial milk formulas and the costs generated in the treatment of respiratory tract infections, which include the economic cost of antibiotics and hospitalization, in addition to avoiding the permanent sequelae that can be caused by otitis, for example, in children under 6 years of age.[13] In our country, the issue of breastfeeding is of great importance, particularly at the primary health care level, which has among its main tools the promotion of health and the prevention of diseases, which is why we are motivated to study the behavior of these 2 recurrent and related topics in the transitional population. The main objective of this study is to establish the relationship between exclusive breastfeeding and its relation to the prevention of acute respiratory diseases in infants under 6 months of age in the Ecuadorian population.

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 2793 Ecuadorian infants under 6 months of age were obtained.

Inclusion and Exclusion Criteria: Data were included for infants younger than 6 months whose information was found in the questions on the form for women of childbearing age 10-49 years, child health and breastfeeding. Missing values for the variables used and infants older than 6 months were excluded.

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 referring to Women of Childbearing Age, Childhood Health and Breastfeeding, which aims to collect information on women aged 10-49 years to make representative estimates at the national level, urban-rural, by geographic domain for the 24 provinces of the country.

Study Variables. Our dependent variable of interest was upper respiratory tract infection. The information for this variable was obtained through the following question in section IV Childhood Health (Children under 5 years of age): In the last two weeks have you had (...), cough, runny nose, difficulty breathing, sore throat, fever and/or flu (including this day)? In our independent variable that refers to information on the age of the child, sex of the child, time of breastfeeding since birth, exclusive breastfeeding. In addition, control variables were considered through the sociodemographic information of the mother: age, educational level, place of birth and ethnicity.

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, the independent variable of interest being Acute Respiratory Infection. For the determination of the model of protective factors of breastfeeding against the incidence of Acute Respiratory Infections in infants under 6 months of age, binary logistic regression was applied to calculate the OR with its 95% confidence intervals; in addition, the sociodemographic characteristics were reported by absolute frequencies, the numerical variables were reported with the arithmetic mean.

Finally, for the determination of the predictor variables, the ROC curve was applied with the probabilities estimated by applying logistic regression under the method of introducing their confidence intervals and their statistical significance $p < 0.05$.

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. Results

Table 1 shows the descriptive statistics of the variables used in this study. Here we observe that 29.08% (CI=29.35% - 30.78%) of Ecuadorian infants have suffered from respiratory infections. We also observed that 95.27% (CI=94.35% - 96.78%) of infants have received exclusive breastfeeding. In the Ecuadorian context, 60.94% of mothers reported breastfeeding the child immediately after birth and 28.69% of mothers also reported that they only breastfed without any other liquid. The average age of the infants in the survey is 3 months. On the other hand, 58.29% of the infants and their mothers live in the urban area. In addition, 51.91% of infants are male, while the average age of the mother is 28 years old. We also observed that 75.61% of the mothers surveyed are of mestizo ethnicity and 42.64% of the mothers have an intermediate level of education (high school). Finally, 37.91% of the mothers are from the highlands region.

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

Variable	Mean-Percent	Std. Dev.	Min	Max
Respiratory infections				
Yes	29.08%	0.45	0	1
No	70.92%	0.45	0	1
Exclusive breastfeeding				
No	4.73%	0.21	0	1
Yes	95.27%	0.21	0	1
Breastfeeding time from birth				
Immediately after birth	60.94%	0.49	0	1
Less than one hour	16.89%	0.37	0	1
Between one hour and less than 24 hours	14.97%	0.36	0	1
More than one day	7.21%	0.26	0	1
Breastfeeding without any other liquid				
If you only breastfed	28.69%	0.45	0	1
Never breastfed only	42.76%	0.50	0	1
She is still only breastfeeding	26.85%	0.44	0	1
Do not remember	1.70%	0.13	0	1
Child's age				
Age in months	3.23	1.94	0	
Mother's area of residence				
Urban	58.29%	0.49	0	1
Rural	41.71%	0.49	0	1
Sex of child				
Man	51.91%	0.50	0	1
Woman	48.09%	0.50	0	1

Mother's age				
Age	27.88	7.62		
Mother's ethnicity				
Indigenous	14.73%	0.35	0	1
Afro-Ecuadorian	4.03%	0.20	0	1
Mongrel	75.61%	0.43	0	1
White	1.32%	0.11	0	1
Montubio	4.31%	0.20	0	1
Mother's level of education				
None	1.19%	0.11	0	1
Basic Education	36.21%	0.48	0	1
Middle/High School	42.64%	0.49	0	1
Superior	19.97%	0.40	0	1
Mother's region of origin				
Sierra	37.91%	0.49	0	1
Costa	37.07%	0.48	0	1
Amazon	23.16%	0.42	0	1
Insular	1.86%	0.14	0	1

The correlation matrix of the variables is shown below. Here the correlation between the variables is analyzed in detail in order to highlight possible multicollinearity problems. **Table 2** shows significant correlations between respiratory infections and the independent variables: exclusive breastfeeding, breastfeeding time since birth, child's age, mother's age, mother's ethnicity, mother's education level and mother's region of origin. All these variables have an expected sign which is correct. In addition, we note that no correlation between the independent variables is greater than 50%. This shows that there are probably no serious 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 1	1										
Var 2	0.76*	1									
Var 3	-0.0243*	-0.2025	1								
Var 4	0.0430	0.0205	0.0225	1							
Var 5	-0.1321*	-0.0096	0.0163	-0.0070	1						
Var 6	0.0069*	0.0515	-0.0480	-0.0138	-0.0121*	1					
Var 7	0.0465	-0.0118*	-0.0193	-0.0189	-0.0072	-0.0212	1				
Var 8	-0.0276*	0.3312*	0.0061	0.0217*	0.0689*	0.0787*	0.0489*	1			
Var 9	-0.0468*	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

Note: Var 1: Respiratory infections. Var 2: Exclusive breastfeeding. Var 3: Time of breastfeeding since birth. Var 4: Breastfeeding without any other liquid. Var 5: Age of the child. Var 6: Mother's area of residence Var 7: Child's sex. Var 8: Mother's age Var 9: Mother's ethnicity Var 10: Mother's level of education. Var 11: Mother's region of origin.

As mentioned above, 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 Inflator 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, so 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
Exclusive breastfeeding	1.33	1.55	0.9433	0.3305
Breastfeeding time from birth	1.21	1.11	0.9966	0.0004
Breastfeeding without any other liquid	1.01	1.54	0.9918	0.0082
Child's age	1.53	1.28	0.6101	0.3899
Mother's area of residence	1.54	1.28	0.6145	0.3855
Sex of child	1.97	1.01	0.9764	0.0236
Mother's age	1.45	1.06	0.8821	0.1179
Mother's ethnicity	1.66	1.05	0.8812	0.1188
Mother's level of education	1.58	1.45	0.6310	0.3690
Mother's region of origin	1.09	1.66	0.9146	0.0854
Mean VIF	1.49			

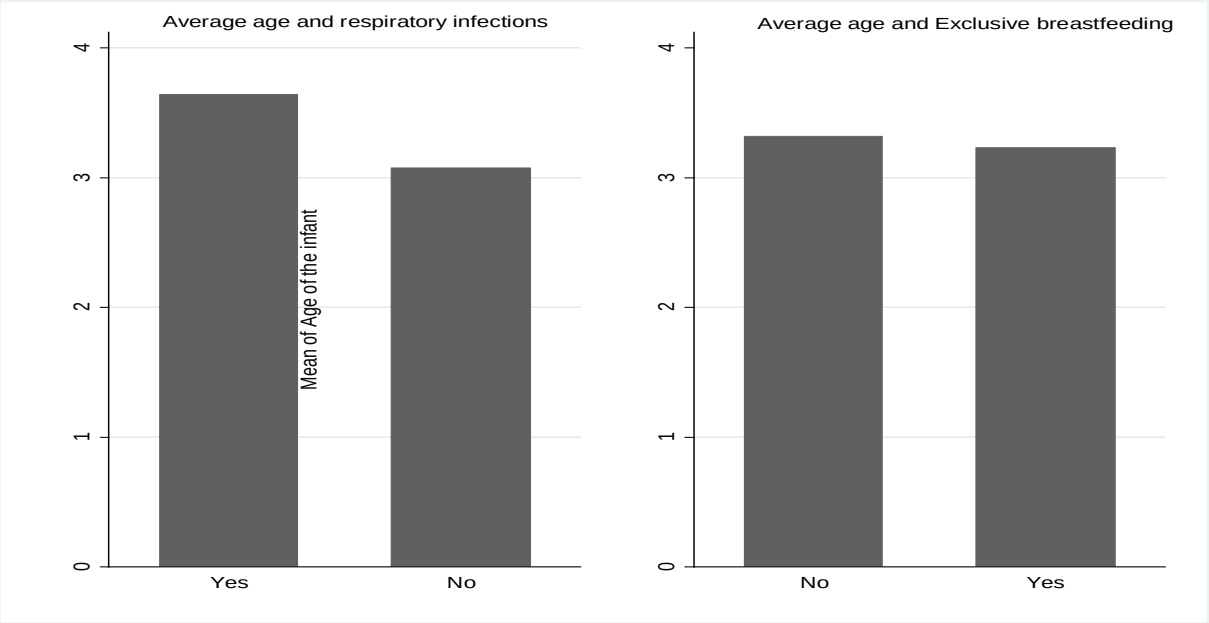
In **Table 4** we can observe the age (in months) and the number of infants who have and have not experienced respiratory infections. Here we observe that as age increases, the number of cases of respiratory infections also increases. On the other hand, we observe that the number of infants who received exclusive breastfeeding is higher compared to those who did not receive exclusive breastfeeding. In this table we can observe an interesting pattern: the number of infants who have not experienced respiratory infections is almost equal to the number of infants who received exclusive breastfeeding. This fact leads us to strongly suspect that there is a strong relationship between the variables.

Table N°4: Age and number of respiratory infections and exclusive breast feeding

	Respiratory infections		Exclusive breastfeeding	
Age in months	**Yes**	**No**	**No**	**Yes**
0	39	268	12	302
1	70	236	18	295
2	114	295	14	399
3	139	302	28	418
4	145	282	17	418
5	141	268	18	397
6	152	300	25	432

To reinforce the idea of the previous table, **Figure 1** shows the average age of infants and respiratory infections, as well as exclusive breastfeeding. In the first figure we observe that as age increases so do the cases of respiratory infections. A similar pattern is observed in the case of exclusive breastfeeding. Therefore, a strong relationship seems to exist between cases of respiratory infections and exclusive breastfeeding.

Figure N°1: Average age and exclusive breast feeding



A multivariate logistic regression analysis to analyze factors influencing respiratory infections is shown below in **Table 5.** Our logistic regression involves 2783 infants. Here we observe that the dependent variable is a dichotomous variable that takes the value of 1 if the infant did not have any respiratory illness and 0 if the infant had any respiratory illness. We show that, as expected, the odd ratio (OR) of having had exclusive breastfeeding is significant and greater than 1. Our results show that those children who had exclusive breastfeeding show a greater protective factor against acute respiratory infections compared to those children who did not have exclusive breastfeeding. That is, our results show that exclusive breastfeeding during the first six months of life increased 2-fold (OR= 2.01; CI=1.91-2.17) the probability of not suffering from respiratory diseases. This result is statistically significant ($p<0.05$). It was also shown that those infants who received breast milk earlier from the time of birth have greater protection or developed greater immunity to upper respiratory tract infections (OR= 1.65; CI=1.41-1.94). Other significant protective factors are mother's age, mother's educational level and mother's area of residence.

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 respiratory infections and exclusive breastfeeding

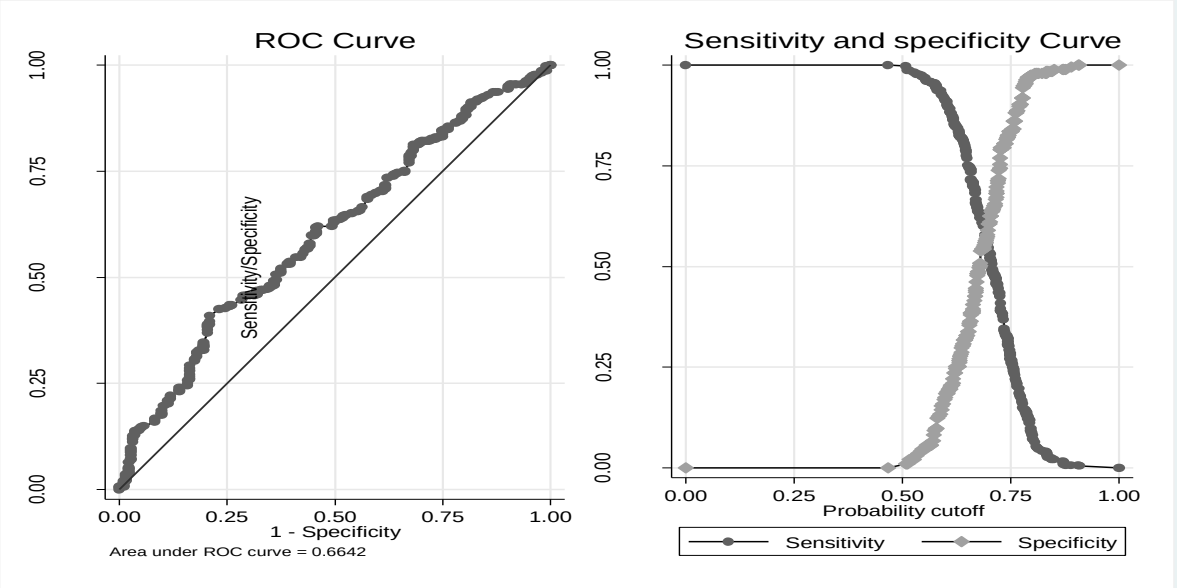
Variable	OR	Std. Err.	P>z	95% CI
Exclusive breastfeeding				
No	Ref.			
Yes	2.011**	0.982	0.002	1.91 - 2.17
Breastfeeding time from birth				
More than one day	Ref.			
Between one hour and less than 24 hours	-1.043	0.312	0.067	-1.012 - -1.231
Less than one hour	0.065	0.432	0.655	0.041 - 0.098
Immediately after birth	1.65**	0.082	0.011	1.41 - 1.94
Breastfeeding without any other liquid				
If you only breastfed	Ref.			
Never breastfed only	1.065	0.432	0.655	1.001 - 1.198
She is still only breastfeeding	-1.986	0.563	0.192	-1.452 - -2.004
Do not remember	1.654	0.643	0.431	1.594 - 1.865
Child's age				

Age in months	1.028***	0.003	0.000	1.022	-	1.033
Mother's area of residence						
Urban	Ref.					
Rural	1.085*	0.042	0.033	1.006	-	1.171
Sex of child						
Man	Ref.					
Woman	0.950	0.032	0.133	0.889	-	1.016
Mother's age						
Age	1.653	0.654	0.035	1.345	-	1.897
Mother's ethnicity						
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
Mother's level of education						
None	Ref.		.			
Basic Education	0.356	0.312	0.184	0.231	-	0.591
Middle/High School	1.614	0.432	0.286	1.467	-	1.875
Superior	1.739*	0.563	0.244	1.581	-	1.890
Mother's region of origin						
Sierra	Ref.					
Costa	0.663***	0.027	0.000	0.612	-	0.719
Amazon	0.996	0.045	0.932	0.912	-	1.089
Insular	0.875	0.112	0.297	0.681	-	1.125
Observations	2793					
AIC	24175.03					
BIC	25438.09					
R^2	0.068					
X^2	3.656***					
Log-likehood	-37861.51					

Notes: Asterisks mean: *p < 0.10,**p < 0.05, ***p < 0.01. In the table, the dependent variable is the dichotomous variable of respiratory infections that takes a value of 0=Yes and 1=No.

Finally, to determine the discriminatory power of the predictor variables, the ROC curve was applied with the probabilities estimated by applying logistic regression under the method of introducing their confidence intervals and their statistical significance $p < 0.05$. The ROC curve coincides with the probability of correctly distinguishing a case of respiratory infection from one that is not, through the significant predictor variables, the worst case scenario being when the area is equal to 0.50. In our case, having received exclusive breastfeeding and together with other significant variables, represented an area under the curve of 0.6642 (95% CI: 0.651-0.691), considering that they adequately predict cases of respiratory infections ($p < 0.001$). On the other hand, the sensitivity and specificity curve shows an adequate shape, given that it is observed to have a normal behavior. Specifically, we observed that the curves cross at an approximate value of 0.50, given a good formation of the curves.

Figure N°2: ROC curve and sensitivity and specificity curve for the determination of the sensitivity of the model of cognitive development and obesity



IV. Discussion

Breastfeeding is a unique process that provides essential nutrition to infants, contributing to their proper development and growth, and has a positive impact on the immune system, significantly reducing the incidence and severity of infectious diseases in children.[14]. Breast milk, due to its dynamic nature, adjusts to the needs of the growing child and constitutes the ideal transition for the infant's adaptation to extrauterine life. Exclusively breastfed infants are two and a half times less sick than formula-fed infants.[19].

In the present investigation, it was possible to prove the direct association between breastfeeding and the incidence of respiratory pathologies prevalent mainly in infants under 6 months of age, whose feeding is based exclusively on breastfeeding. Our results showed that 29.08% (CI=29.35% - 30.78%) of Ecuadorian infants have suffered from respiratory infections at some point in their lives. It was also found that 95.27% (CI=94.35% - 96.78%) of infants have received exclusive breastfeeding, which has a beneficial effect on the risk of suffering an upper respiratory tract infection. 60.94% of the mothers reported breastfeeding the child immediately after birth and 28.69% of the mothers also reported that they only breastfed without any other liquids.

The analysis of the variables showed that, as expected, those children who were exclusively breastfed showed a greater protective factor against acute respiratory infections than those who were not exclusively breastfed. That is, our results show that exclusive breastfeeding during the first six months of life increased 2-fold (OR= 2.01; CI=1.91-2.17) the probability of not suffering from respiratory diseases. This result is statistically significant ($p<0.05$). It was also shown that those infants who received breast milk earlier from the time of birth have greater protection or developed greater immunity to upper respiratory tract infections (OR= 1.65; CI=1.41-1.94). These results coincide with the study by Levine et al. carried out in the United States and Canada, which showed that children who were exclusively breastfed in the first 6 months of life not only significantly reduced the risk of infections, but also the disease process showed a shorter evolution time and fewer complications.[15]. Similarly, another study conducted in Brazil showed that non-breastfed children were more susceptible to pneumonia. [16]. In this context, different studies carried out in the United States, Canada and Sweden showed that infants exclusively breastfed for 4 months or more suffered fewer episodes of Acute Respiratory Infections, compared to children breastfed for less than 3 months, and those who were never breastfed had a higher risk of being hospitalized for Acute Respiratory Infections.[17].

Acute Respiratory Infections and nutrition have a double link, because poor nutrition means that a child with poor nutrition is more likely to present episodes of Respiratory Infections. If adequate attention is not paid to the nutrition of sick children, respiratory tract infections can cause deficits in the growth and development of the child, causing complications that can evolve into pneumonia, since malnutrition thins the membrane of the lungs, which can facilitate the entry of bacteria, and can also weaken the child's immune system. [19]Therefore, the bibliography consulted emphasizes the importance of breastfeeding in the nutrition and health of children, up to the sixth month of life, as the exclusive food.

Breastfeeding is a unique process that provides ideal nutrition to infants and contributes to their healthy growth and development, reduces the incidence and severity of infectious diseases, and decreases infant morbidity and mortality. In this research, the mixed variety of breastfeeding predominated. A reduction in morbidity was observed in children who are exclusively breastfed. The shorter the period of breastfeeding, the greater the risk of infections and the greater the susceptibility to complications. Two thirds of otitis media and all pneumonias occur in cases with short mixed or artificial breastfeeding.

V. Conclusión

Based on our findings we can evidence that it is a fact that exclusive breastfeeding for an adequate time of 6 months of age as established by the WHO significantly reduces the risk of suffering from respiratory infections. The superiority of breastfeeding over any other type of food, its content of fat, proteins, immune and biological active components play an important role in the protective effect for the health of both the infant and the mother, and at the infant level, the benefits of breastfeeding are: the reduction of infant mortality mainly due to the risk of respiratory and digestive infections. However, more studies are needed in this regard, since there is wide controversy in the literature about the benefits of breastfeeding due to design errors and biases in some of the studies presented. In addition, some of the outcome variables of the studies are not comparable, as each study measures different effects related to respiratory health. Furthermore, in many of these studies, the collection of information is limited to surveys, perhaps for operational reasons (costs, travel) and no clinical tests or medical diagnoses are carried out on the veracity of the presence or absence of respiratory infections, diagnoses that should be based on clinical practice guidelines on respiratory infections.

Therefore, it is necessary to open new lines of research and intervention to address the issue and promote exclusive breastfeeding for its health, social and economic benefits. The promotion of breastfeeding should be an objective of health policies to significantly reduce maternal and infant morbidity and mortality.

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