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| RESEARCH ARTICLE

Association between Prenatal Control and the Incidence of Preeclampsia in Ecuadorian Pregnant Women: A Cross-Sectional Study

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| ABSTRACT

Hypertensive disorders are one of the main complications that affect pregnancy, which makes them one of the most important causes of high maternal and fetal morbimortality. Approximately 80% of cases occur at term gestational age, while the remaining percentage begin at earlier gestational ages. Most cases of preeclampsia occur in healthy pregnant women. Therefore, it is important to establish the risk factors in prenatal control visits. Prenatal control is fundamental in which comprehensive surveillance of the pregnant woman is performed. It is known that hypertension in pregnancy is a frequent and potentially dangerous complication for the mother, fetus and newborn. For this reason, one of the objectives of prenatal care is to detect pre-pregnancy hypertension and pregnancy-induced hypertension syndrome (preeclampsia). A nationally representative sample of 20648 mothers from the National Health and Nutrition Survey 2018 (ENSANUT) was used. We used multicollinearity tests to rule out possible statistical modeling problems and a binary logistic linear regression model where Odds Ratio (OR) with their 95% confidence intervals (95% CI) were estimated for each of the independent variables. In addition, we used specificity tests to test the fit between our dependent and independent variables. Our results reveal that prenatal control reduced 2 times (OR= -2.0005; CI=-1.981;-2.055) the probability of suffering complications during pregnancy such as preeclampsia. This result is statistically significant ($p<0.05$). It was also demonstrated that women from rural areas, with lower income and low schooling are more susceptible to suffer complications during pregnancy compared to the rest of the population. Preeclampsia-eclampsia continues to be one of the pathologies that has the greatest impact on maternal and perinatal morbidity and mortality, so work should continue to find ways to prevent its onset or modify its evolution, avoiding eclampsia or other severe forms of the disease. The results found in this study showed that adequate prenatal care (more than five visits starting in the first trimester of pregnancy) has an impact on the prevention of pregnancy complications such as preeclampsia, since identifying and avoiding it is one of the main purposes of prenatal care.

| KEYWORDS

Prenatal care, High-risk pregnancy, Interventions, Risk factor, Mortality.

| ARTICLE INFORMATION

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1. Introduction

Prenatal care reduces maternal and perinatal morbidity and mortality, premature births and the number of low birth weight babies; it also makes it possible to identify risk factors, which makes it possible to establish timely preventive and therapeutic actions

during pregnancy (del Valle Llagostera et al., 2010). (del Valle Llagostera et al., 2010). . Mortality and complications of the maternal-infant binomial that occur during childbirth, puerperium and their care processes are currently considered avoidable with the advances and resources of current medicine (Glas & Hernández, 2000).(Glas & Hernández, 2000).

Reducing maternal and infant mortality and morbidity is currently considered a health priority worldwide, so that in the year 2000 it was proposed to achieve a 75% reduction in maternal mortality indicators by the year 2015. However, this objective is far from being achieved, since according to the World Health Organization (WHO) it shows an annual reduction of only 1% (Donoso S., 2003). (Donoso S., 2003).. In 2015 worldwide, 303 000 women were reported to have died from obstetric causes, in addition 2.7 million newborns died in the first 28 days of life and the number of stillbirths reached 2.6 million(WHO, 2016)In the Latin American context, 7600 maternal deaths have been registered in 2015 due to obstetric causes such as postpartum hemorrhage and hypertension, at present, the death of thousands of women due to preventable causes related to pregnancy and childbirth can still be evidenced. In addition, with regard to the high rates of perinatal mortality, causes such as prematurity, low birth weight, hypertension in pregnancy, maternal-fetal isoimmunization, infectious processes, diabetes, low fetal reserve, birth complications, etc.; and in the neonate, respiratory diseases, asphyxia, hemolytic disease, among others, are evident(García-Balaguera & García-Balaguera, 2017).

Therefore, prenatal care (PCN) is a set of actions that involves a series of visits by the pregnant woman to the doctor's office, with the objective of monitoring the evolution of the pregnancy, detecting risks early and preventing complications (Cáceres-Manrique, 2009).(Cáceres-Manrique, 2009)based on a series of interventions aimed at identifying and modifying medical, behavioral and psychosocial risks, with the sole objective of caring for the woman's health and obtaining a perinatal outcome without morbidities(Garcia-Balaguera, 2017) The quality health approach during pregnancy and childbirth can prevent maternal and infant mortality in a large percentage; however, worldwide it has been recorded that only 64% of women receive prenatal care four or more times throughout their pregnancy. There is a wide gap in development conditions, which predisposes to a limitation of access to quality health services, mainly in groups of vulnerability or greater social exclusion. Thus, it can be seen that indigenous and Afro-descendant women, as well as women with low income and fewer years of formal education are three times more likely to die from causes related to pregnancy and childbirth than non-indigenous women due to a lack of health services (prenatal and perinatal care) or personal beliefs(Arispe et al., 2011).. This situation is alarming, as studies have estimated that women who do not receive prenatal care and give birth at home are 19 times more likely to die than those who receive prenatal care and give birth in a health facility (Betancourt Ruiz & García, 2011).(Betancourt Ruiz & García, 2020).

On the other hand, prenatal care does not only imply the number of visits, but also the time during which they were made during the course of pregnancy and the quality of the visits (del Valle Llagostera et al., 2010).(del Valle Llagostera et al., 2010).. Adequate coverage of pregnant women is necessary to generate a positive impact on morbidity and mortality, in addition, care with minimum quality standards is required, such as generating an atmosphere of trust between the physician and the patient, as well as guaranteeing the privacy of pregnant women(García-Balaguera & García-Balaguera, 2017).

The prenatal care program, starting with a first visit before 12 weeks gestation, is accompanied by better perinatal outcomes, followed by two visits in the second trimester and three in the third trimester. The earlier you receive care, the better the opportunity to prevent, identify and correct in time the problems that may affect the mother's health and any type of pregnancy complication. (Miranda Mellado & Castillo Avila, 2016).. However, despite this, there are negative factors that directly affect the health of the mother, among these: preeclampsia, defined as hypertensive pathology typical of the second half of pregnancy, which leads to hypertension, proteinuria and damage to a target organ (Calvo et al., 2020).. Therefore, this leads to harmful effects such as intrauterine growth restriction for the fetus and increased risk of hypertension for the mother (Rivas et al., 2012).(Rivas et al., 2012). Although this pathology is commonly detected in obstetrics and gynecology hospital offices and in their emergency rooms, there is no data on the impact that compliance with prenatal care may have on this pathology and its consequences (Álvarez-Fernández et al. (Álvarez-Fernández et al., 2016).. Therefore, taking into account that this pathology and its early detection are of relevance, this retrospective case-control study was conducted in search of an association.

2. Methodology

2.1 Survey and Population

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. ENSANUT 2018 includes the form Women of childbearing age.

2.2 Source of Information

A cross-sectional study was conducted using data from the National Health and Nutrition Survey of Ecuador (ENSANUT) 2018, whose data were obtained by the National Institute of Statistics and Census (INEC). After database cleaning, a total of 8413

Ecuadorian women were obtained. Data from prenatal checkups performed by women who reported a pregnancy in the last 5 years were included.

2.3 Study Variables

Our dependent variable was preeclampsia (produced by blood pressure). The information for this variable was obtained through the ENSANUT question on whether a woman suffered preeclampsia (1=yes, 0=no). In our independent variable the number of prenatal controls reported by a woman.

2.4 Inclusion and Exclusion Criteria

All women who responded to the questions in section IV Health of the ENSANUT survey, referring to Prenatal Control and preeclampsia, were included. Missing values in the variables were excluded.

2.5 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.

2.6 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.

Therefore, in order to estimate a discrete choice model that estimates the probability preeclampsia:

$$Preclampsia_i = \beta_0 + \beta_1 X_i + \sum_{j=2}^{12} \beta_j Z_i + \varepsilon_i \quad (1).$$

Where $Preclampsia_i$ represents preeclampsia (which is a dichotomous variable), X_i represents the number of prenatal controls, and Z_i represents a set of control variables. Finally, ε_i represents the stochastic error term.

3. Result

Table 1 presents the descriptive statistics of the variables used in this study. Here we observe that 23.17% (with a CI 22.33-23.55) of women reported that they suffered from preeclampsia. Regarding our independent variable of interest, we observed that the number of prenatal controls reported by the mothers is 7.36 prenatal controls. Regarding the characteristics of the mother, 42.7% were women from the coastal region and 81.03% were of mixed race. It is also reported that 43.4% of the women have a high school education and 71.3% are women from the urban area. In addition, 70.4% of the women reported that they had prenatal checkups in the health facilities of the Ministry of Public Health (MOH). 88.5% of the women reported that they consumed micronutrients daily and 80.3% reported that they consumed micronutrients such as iron plus folic acid. Interestingly, 80.5% and 78.9% of mothers reported that they received micronutrient intake counseling and counseling on risk signs, respectively. Also, 53.1% of the mothers reported that they had a normal delivery. Likewise, when looking at the territorial variables we observe that on average there are 151 inhabitants per square kilometer, the average per capita production (GVA) is $1297 USD and 59.33% live in the urban area. These descriptive statistics reveal important patterns of the individuals considered in this study.

Table 1. Descriptive statistics of the variables used in this study.

Variable	Mean-Percent	Min	Max	95% CI
Preeclampsia				
No	76.83%	0	1	76.05-77.66
Yes	23.17%	0	1	22.33-23.55
Prenatal checkups				
Number of prenatal checkups	7.36	0	30	7.27 -7.45
Frequency of micronutrient consumption				
Frequency of micronutrient consumption (daily=1)	88.5%	0	1	88-89.3
Frequency of micronutrient consumption (passing a day=2)	7.6%	0	1	7.01-8.41
Frequency of micronutrient consumption (passing two days=3)	4.81%	0	1	3.98-5.10
Frequency of micronutrient consumption (more than two days=4)	0.42%	0	1	0.32-0.51
Micronutrient intake				
Consumed micronutrients micronutrients micronutrients (iron=1)	13.2%	0	1	13-13.5
Consumed micronutrients micronutrients micronutrients (Folic acid=1)	6.13%	0	1	5.15-6.29
Ingested micronutrients micronutrients (iron plus folic acid=1)	80.3%	0	1	79.2-80.5
Region of origin				
Sierra	38.5%	0	1	38-39
Costa	42.7%	0	1	41.21-43.09
Amazon	16.3%	0	1	15.98-17.01
Galapagos	2%	0	1	1.96-2.51
Ethnicity				
Indigenous	7.1%	0	1	6.6-7.28
Afro-Ecuadorian	5.3%	0	1	4.90-5.98
Mongrel	81.03%	0	1	80.22-81.86
White	1.4%	0	1	1.2-1.9
Montubio or Others	4.6%	0	1	4-5.1
Educational level				
None	0.7%	0	1	0.3-1.1
Basic Education	27.3%	0	1	27.1-28.3
Middle/High School Education	43.4%	0	1	43.41-44.12
Higher Education	27.1%	0	1	26.87-27.98
Residential area				
Urban Area	71.3%	0	1	70.3-72.1
Place where prenatal checkups were performed				
Place where prenatal check-ups were performed (HPM health facilities)	70.4%	0	1	69.76-71.92
Did you receive advice on micronutrients?				
Did you receive advice on micronutrients? (yes=1)	80.5%	0	2	79.87-81.72
Did you receive advice on risk signs?				
Did you receive advice on micronutrients? (yes=1)	78.9%	0	2	77.3-79.1

Week of the first prenatal checkup				
Weeks first control	7.32	1	40	7.16 -7.48
Urban density				
Inhabitants per square kilometer	151.01	1152.5	321	146.32-160.33
Economic development of the province				
Provincial GVA per capita	1297.65	540.5	321	836.43-1456.67
Area				
Urbana	59.33%	0.54	0	55.51-61.51
Rural	44.49%	0.36	0	41.49-46.49

Table 2 shows the percentage of women with preeclampsia and the number of prenatal checkups. We observe that as the number of controls increases, the percentage of women with preeclampsia decreases. An interesting pattern stands out here, as a negative relationship between the variables is observed. In general, we observed that a higher number of prenatal controls is associated with lower levels of preeclampsia.

Table 2. Average birth weight of low birth weight and normal birth weight infants.

Number of prenatal checkups	Percentage of women with preeclampsia
0	88%
1	86%
2	81%
3	78%
4	78%
5	67%
6	45%
7	33%
8	21%
9 or more	20%

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 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, thus 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 3. Multicollinearity test of the variables

Variable	VIF	SQRT VIF	Tolerance	R-Squared
Preeclampsia	1.33	1.86	0.6125	0.3355
Number of prenatal checkups	1.22	2.81	0.9913	0.0032
Frequency of micronutrient consumption	1.98	1.65	0.9862	0.0236
Micronutrient intake	1.25	1.33	0.3321	0.1189
Region of origin	1.98	1.65	0.9862	0.0236
Ethnicity	1.66	1.23	0.3312	0.1133
Educational level	1.22	1.85	0.6310	0.3690
Residential area	1.12	1.36	0.9126	0.0352
Place where prenatal checkups were performed	1.33	1.68	0.8826	0.2252
Did you receive advice on micronutrients?	1.22	1.85	0.6310	0.3690
Did you receive advice on risk signs?	1.57	1.85	0.6310	0.3690
Week of the first prenatal checkup	1.44	1.75	0.9653	0.0352
Urban density	1.68	1.09	0.3533	0.1218
Economic development of the province	1.33	1.68	0.8826	0.2252
Urban area	1.05	1.32	0.9538	0.0263
Mean VIF	1.86			

Then, the confusion matrix of the model is shown. In **Table 4** we can see that the models we estimated are correctly specified. In the first model we use preeclampsia as the dependent variable, which is 71.22% specified by the independent variables. That is, the independent variables predict preeclampsia in 71.22% of the cases.

Table 4. Confusion matrix of the estimated models

Model			
	True		
Classified	D	~D	Total
	1281	523	4736
	1115	303	2518
Total	4288	2966	7254
Correctly classified			71.22%
Mortality Model			
	True		
Classified	D	~D	Total
	1198	763	4736
	1102	1344	2518
Total	4288	2966	7254
Correctly classified			80.42%

Next, to further explore this proposed relationship, and given that our dependent variable is dichotomous, as shown in **Table 5** we used a logit model. In **Table 5**, the dependent variable is the dichotomous variable of preeclampsia which takes a value of 1 if the woman reported having preeclampsia and 0 if not. Here we observe that, as expected, the odd ratio (OR) is negative (greater than 1) and significant, showing that an increase in an additional prenatal checkup decreases the risk of preeclampsia by 2 times (CI= -1.981;-2.055) compared to those women who did not have any prenatal checkup. Other factors with negative odds ratios are the mother's education, which decreases as the mother's level of schooling increases, with a mother with higher education (OR= -2.783, CI= -2.042;-2.889) being the category with the highest magnitude. Another factor with a negative odds ratio is micronutrient intake, which has an OR= -2.099 (CI= -1.055;-2.155).

Table 5. Logistic regression analysis between the number of prenatal controls and preeclampsia**.**

	OR	P-value	95% CI
Var. dep.: Had preeclampsia =1, 0 in other case			
Number of times of prenatal checkups			
Prenatal checkups	-2.005***	0.004	-1.981;-2.055
Region of origin			
Sierra	Ref.		
Costa	1.083	0.590	1.010;1.369
Amazon	1.511**	0.049	1.002;1.824
Galapagos	2.402	0.152	2.322;2.575
Ethnicity			
Indigenous	Ref.		
Afro-Ecuadorian	1.035	0.932	1.003;1.056
Mongrel	0.933	0.806	0.626;2.086
White	0.903	0.864	0.276;1.071
Montubio or Others	0.818	0.620	0.692;0.991
Educational level			
None	Ref.		
Basic Education	2.262	0.125	2.221;2.860
Middle/High School Education	-2.337	0.109	-2.191;2.889
Higher Education	-2.783*	0.060	-2.042;2.889
Residential area			
Rural	Ref.		
Urban	1.078	0.635	1.035;1.086
Place where prenatal checkups are performed			
Other establishment	Ref.		
HPM health facilities	0.822	0.235	0.521;1.128
Consumed micronutrients during pregnancy			
iron?	Ref.		
Folic acid	1.496	0.188	1.197;1.903
iron plus Folic Acid?	-2.099**	0.023	-1.055;-2.155
Frequency of micronutrient intake			
daily	Ref.		
spending a day	-0.652*	0.050	-0.058;-1.001
spending two days	-0.693	0.799	-0.593;-1.770
More than two days	-0.976	0.981	-0.083;-2.034
Did you receive advice on micronutrients?			
No	Ref.		
Yes	-1.099	0.634	-1.0093;-1.482
Did you receive advice about alarming signs?			
No	Ref.		
Yes	-1.715*	0.092	-1.027;-1.955
Week of the first prenatal checkup			
Weeks first control	0.985	0.246	0.040;1.010
Urban density			
Inhabitants per square kilometer	1.654**	0.023	1.570;7.242
Economic development of the province			
Provincial GVA per capita	1.092**		1.017;2.097
Area			
Urbana	Ref.		
Rural	-1.456	0.123	-1.570 ; -1.242
Constant	5.790***	0.007	5.472;5.940
Observations	12489		
AIC	1848.35		
BIC	2011.41		
Chi^2	152.4		
Chi^2 *p-value*	0.000		
Log-likehood	-898.174		

Notes: Asterisks mean: *p < 0.10,**p < 0.05, ***p < 0.01.

After estimating the logit model, we can estimate the marginal impacts (MI) of the independent variable on the probability of preeclampsia. **Figure 1** shows that as prenatal controls increase, the probability of preeclampsia decreases. Specifically, we observe that with each additional prenatal checkup the health and life of the woman is better.

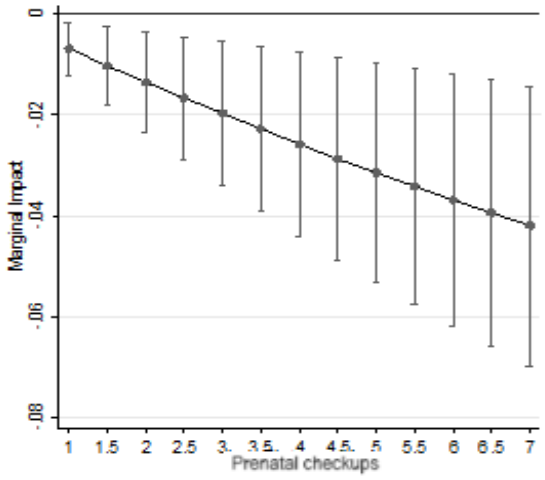

Figure 1. Marginal impacts of the number of prenatal controls and preeclampsia and their respective 95% confidence intervals.

4. Discussion

Currently, medical research is mainly aimed at reducing maternal and infant mortality and morbidity through access to quality obstetric and perinatal medical care. In the present study, a positive association was found between having a greater number of prenatal check-ups, a higher educational level of the mother, consuming iron and folic acid more frequently and with a daily frequency with a considerable reduction in the risk of suffering preeclampsia and its complications. We conclude that prenatal consultations are an essential means of bringing health professionals closer to mothers, and with adequately trained health personnel, preventive activities during pregnancy can be promoted and healthy diets can be encouraged.(Di Vincenzo et al., 2023).. Our results show that 70.4% of the mothers reported that they had prenatal check-ups in the health facilities of the Ministry of Public Health (MOH). The 23.17% CI (22.33-23.55) of women reported that they had preeclampsia. Interestingly, 80.3% and 78.9% of mothers reported that they received micronutrient intake counseling and counseling on risk signs, respectively. Also, 53.1% of the mothers reported that they had a normal delivery. Thus, territorial variables show that there are 151 inhabitants per square kilometer, the average per capita production (GVA) is $1297 USD and 59.33% live in the urban area. These descriptive statistics reveal important patterns of the individuals considered in this study.

Rivera et al., that some factors that have been described in the literature in relation to inadequate use of prenatal care are age, schooling and distance from home. In this research, there were no significant differences between the access of adolescents, neither in their schooling nor in the distance they had to travel from their home to the health center, probably because more than 70% of the respondents were between 15 and 29 years old, and lived close to the health services(Rivera Mejía et al., 2014)These results coincide with our research, where prenatal checkups are more consecutive in the face of factors such as the mother's education, which increase as the mother's level of schooling increases, with a mother with higher education (OR= 2.783, CI= 2.042-2.889) being the category with the highest magnitude. Another factor with a positive odds ratio is micronutrient intake, which has an OR= 2.099 (CI= 1.055-2.155).

In our results we can observe that as prenatal controls increase, the probability of preeclampsia decreases, results that agree with another study in our same line of research, where they were able to identify that the implementation of health services in Peru, led to a reduction in the number of births with birth weights less than 2 500 g, prematurity and reduced the risk of preeclampsia in mothers.(Pally Callisaya & Mejía Salas, 2012).. Similar results were found by Alfaro et al., where they emphasize the timeliness and effectiveness of prenatal care and point out the impact on complications such as type of delivery and low birth weight (Alfaro Alfaro et al., 2012).(Alfaro Alfaro et al., 2002).. Another interesting result we were able to find is that we observed that, as expected, the odd ratio (OR) is positive (greater than 1) and significant, which shows that an increase of an additional prenatal check-up increases by 2 times a lower risk of infant morbidity (CI= 1.981-2.055) compared to those women who did not have any prenatal check-up.

Regarding infant mortality, it was observed that, as expected, the odd ratio (OR) is positive (greater than 1) and significant, which shows that an additional prenatal check-up increases the probability of a live birth by 2 times (CI= 1.989-2.026) compared to those

women who did not have any prenatal check-up.026) compared to those women who did not undergo any prenatal care. Similarly, a Colombian study showed that complications such as preterm delivery (13.8%), abortion (22.8%), maternal deaths, generally due to infections and hemorrhages, as well as approximately 75% of neonatal deaths, can be avoided with timely gestational care (Royert & Peñate, 2006).(Royert & Peñate, 2015).. The decrease in perinatal mortality observed in the present study, which confirms the results of previous research in which there was evidence of a decrease in the number of perinatal deaths whose number was reduced from an initial rate of 24.3 per thousand births to 13.0, with statistically significant linear correlation coefficients in a health institution in Colombia (Arias et al., 2001).(Arias et al., 2001)Therefore, the effect of better prenatal care, better identification of risk factors and better detection of pregnancy pathology drastically reduces the risk of morbidity and mortality in the mother-child binomial.

We consider that having a greater number of prenatal check-ups, that the mother has a higher level of education, consuming more iron and folic acid and with a daily frequency, in addition to receiving advice on how to consume it and advice on risk signs during pregnancy, are predictors and reduce the risk of complications such as preeclampsia, low birth weight in the case of the product and should be part, together, of the processes of training, prevention and follow-up of pregnant women; these four factors, which in the proposed model adequately predict the event, their probabilities are predictive as well. Therefore, the factors that can be managed by the health system would be those corresponding to: prenatal controls, they should have clear objectives in each control, especially in pregnant women, identify alarm signs in the pregnant woman and in the product, identify the risk of low birth weight; it is also essential the consumption of iron and folic acid and its adequate counseling, because this event is a function of the gestation planning of hospitals (or health centers) and also the factor of counseling on alarm signs would be associated in the same sense.

5. Conclusion

Our results found that an adequate number of prenatal controls are related to a better birth weight, and that mothers with a higher level of education have a better control of pregnancy. We also identified that our correlations were statistically significant, thus demonstrating that a close control of pregnancy is related to a more effective detection of complications related to preeclampsia. Some symptoms associated with this disease are swelling, sudden weight gain, headaches and vision changes, which can be detected at each medical visit. Therefore, this study shows us that it is very important for the pregnant woman to keep track of her risk factors, as well as the clinical picture so that she can go to the emergency room in a timely manner at any sign of alarm, since preeclampsia entails serious complications for the mother and the fetus.

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Ethical approval: The authors should indicate whether or not ethical approval has been requested for the present study, especially if it is a clinical trial or an animal experiment.

Informed consent: It was not necessary to apply informed consent to the participants since the data were obtained through a database available at the National Institute of Statistics and Census of Ecuador.

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