Artículo Original

Revista Ecuatoriana de Pediatría

Editorial: Sociedad Ecuatoriana de Pediatría (Núcleo de Quito, Ecuador)
Tipo de estudio: Artículo Original
Área de estudio: Odontopediatría
Páginas: 10-20
Codígo DOI: https://doi.org/10.52011/RevSepEc/e266
URL: https://rev-sep.ec/index.php/johs/article/view/266

Impact of COVID-19 on Neonatal Anthropometrics: A Comparative Analysis of Public and Private Hospital Admissions in Quito (2019-2020)

Impacto del COVID-19 en la antropometría neonatal: un análisis comparativo de los ingresos hospitalarios públicos y privados en Quito (2019-2020)

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ABSTRACT

Introduction: The health of mothers and newborns has been of particular interest during the COVID-19 pandemic in Quito. This study aims to compare the admissions and anthropometric data of newborns between a public and a private Ecuadorian hospital before and during the COVID-19 pandemic. **Material and Methods:** This study used anthropometric data from 5,375 newborns collected from medical records of "Hospital General Docente de Calderón" (a public institution) and the "Hospital Metropolitano de Quito" (a private institution) between September 2019 and October 2020. Data on sex, gestational age, birth weight, length, and head circumference were obtained for each newborn. The z-score and centile were calculated according to international standards for newborns from the Intergrowth-21st Project. **Results:** Newborns in public hospitals had a higher gestational age (OR=1.16, 95%CI 1.12-1.21). During the pandemic, births were more likely to occur in private hospitals than in public hospitals (OR=0.45, 95%CI 0.38-0.54). Private hospitals were more likely to have newborns with a lower head circumference (HC) z-score compared to public hospitals (OR=0.68, 95%CI 0.63-0.73). **Conclusions:** The COVID-19 pandemic has led to a higher incidence of births in private hospitals. No differences were found in the birth weights of newborns for their gestational age between those born in public and private hospitals.

Key Words: neonatology, parturition, SARS-CoV-2, COVID-19.

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Recibido: 10/feb/2024 - Aceptado: 12/mayo/2024 - Publicado: 30/ago/2024

RESUMEN

Introducción: La salud de madres y recién nacidos ha sido de particular interés durante la pandemia de COVID-19 en Quito. Este estudio tiene como objetivo comparar las admisiones y los datos antropométricos de los recién nacidos entre un hospital público y un hospital privado en Ecuador antes y durante la pandemia de COVID-19. **Material y Métodos:** Este estudio utilizó datos antropométricos de 5,375 recién nacidos recogidos de los registros médicos del "Hospital General Docente de Calderón" (una institución pública) y el "Hospital Metropolitano de Quito" (una institución privada) entre septiembre de 2019 y octubre de 2020. Se obtuvieron datos sobre el sexo, la edad gestacional, el peso al nacer, la longitud y la circunferencia de la cabeza del neonato. El puntaje z y el percentil se calcularon según los estándares internacionales con el Proyecto Intergrowth-21st. **Resultados:** Los recién nacidos en hospitales públicos tenían una mayor edad gestacional (OR=1.16, IC95% 1.12-1.21). Durante la pandemia, era más probable que los nacimientos ocurrieran en el hospital privado que en hospital público (OR=0.45, IC95% 0.38-0.54). En el hospital privado tenían más probabilidades de tener recién nacidos con un menor puntaje z de circunferencia de la cabeza (HC) en comparación con el hospital público (OR=0.68, IC95% 0.63-0.73). **Conclusiones:** La pandemia de COVID-19 ha llevado a una mayor incidencia de nacimientos en hospitales privados. No se encontraron diferencias en los pesos al nacer de los recién nacidos según su edad gestacional entre los nacidos en hospitales públicos y privados.

Palabras Claves: neonatología, parto, SARS-CoV-2, COVID-19.

Introducción

The first case of COVID-19 in Ecuador was reported in Guayaquil on February 29, 2020, concerning a citizen who had recently returned from Spain[1]. On March 11, the Ecuadorian government declared a "State of Health Emergency in all national health system establishments"[1] and by July 2024, there were 732.038 cumulative cases of COVID-19 confirmed in the country, with 34.533 deaths[2]. In the early months of the pandemic, the coastal regions were most affected by COVID-19, with higher mortality rates than those reported in the highland regions[3]. The concentration of the pandemic in some regions of Ecuador was directly proportional to some indicators of poverty and health[4]. There was a late implementation of restrictive measures of social distancing and limited capacity in health services(5). Guayaquil, for example, is regarded as an important industrial and commercial center of the coastal region and has experienced the highest poverty rate among Ecuador's largest cities over the past five years[4]. In sum, the literature has to highlight the associations between socioeconomic determinants and the dynamics of the COVID-19 spread, and inequities in access to basic health services can contribute to worsening the health of people in situations of social and economic vulnerability. The availability of vaccines for COVID-19 has brought hope for the mitigation of the disease. Still, studies on the ability of health care facilities to provide adequate resources to the population in times of pandemics are essential for planning new interventions that can reduce inequalities and improve health. Among these facilities are those focused on maternal and child health.

The health of mothers and newborns has been of particular interest to the medical community, given that pregnant mothers and young children are considered a vulnerable population. The current literature supports that pregnant women with COVID-19 may be at an increased risk of adverse pregnancy and birth outcomes. SARS-CoV-2 infection at the time of birth is associated with higher fetal death rates, iatrogenic preterm labour, preeclampsia, and emergency caesarean delivery[6–8]. The risk of vertical transmission of COVID-19 is suggested to be low and may not be affected by the severity of maternal disease[9–11]. However, in addition to clinical factors, a North-American multicentre cohort study showed that high maternal social vulnerability is associated with a higher likelihood of neonatal test result positivity[12]. In this study, 2.2% of the neonates born to mothers with SARS-CoV-2 infection had positive results during the birth hospitalization[12]. The au-

thors argued that the particular pathways by which social disadvantage may affect mother-to-child transmission of SARS-CoV-2 include differential access to care and clinician bias. Therefore, the evaluation of neonatal outcomes during the pandemic, the social aspects and vulnerability situation of mothers, and the monitoring and evaluation of health facilities are still needed to prevent and protect neonatal health in times of pandemic by COVID-19.

A retrospective medical record-based study carried out in one of the largest public birth clinics in Vienna, Austria, showed that the rate of very low gestational age was significantly lower during the lockdown phase due to COVID-19 (March to July 2020) than during the pre-lockdown phase[13]. In addition, the mean birth weight was higher during the lockdown phase, and the rates of low, very low, and extremely low birth weight were lower during the lockdown phase[13]. Other studies also showed a decrease in preterm births during the COVID-19 lockdown[14–18], suggesting that the stressful lockdown phase have no significantly negative effect on the preterm birth rates and newborn weight among non-infected mothers. However, Cuestas et al.[19] cautioned that most of these studies originated in high-income countries and all of them assessed a short lockdown period. As a result, more attention must be paid to these indicators in middle- and low-income countries in order to gain a better understanding of the potential effects of COVID-19 social distancing measures on neonatal health indicators in different populations. Ecuador is a medium-income country with a Human Development Index score of 0.759 and about 25% of its population lives below the poverty threshold (United Nations Development Programme[20]. It was conceived as interesting to think about what happened in Ecuador in this period because this information could be useful in the future.

This study aims to compare maternal and neonatal outcomes of women who gave birth in two Ecuadorian maternity hospitals (a public and a private), between a pre-pandemic COVID-19 period (from September 2019 to February 2020) and a pandemic period (from March to October 2020).

Methods

Design and participants

This study was designed as an observational, cross sectional study with retrospective data collection. Data were obtained from medical records of 4,625 newborns at the Calderón General Teaching Hospital (CGTH), a public facility, and 750 newborns at the Quito Metropolitan Hospital (QMH), a private facility, between September 2019 and October 2020. Both maternity hospitals are located in Quito, Ecuador. For comparisons, the study period was divided into pre-pandemic (before March 2020) and during pandemic (after March 2020). Neonates were excluded from the study population for missing data, gestational age less than 24 weeks or greater than 42 weeks, or major congenital anomalies. Twin births are also excluded.

Ethical issues

The study protocol was approved by the medical ethical committees of the Universidad Central del Ecuador (UCE), Ministerio de Salud Pública and Hospital General Docente de Calderón . All mothers gave their written informed consent for themselves and their children. After signing the consent form, no personal contact was made with any of the subjects, and all information was obtained from medical records.

Variables

Data collected included sex, gestational age (GA), birth weight, length, and head circumference. The z-scores for neonatal weight, length, and head circumference (HC) according to sex and gestational age at birth were determined using the online Intergrowth-21st calculator (21,22). The neonates were classified according to gestational age on admission into three groups. The first group included the preterm infants (GA less than 37 weeks), the second group included the term infants (GA ranged from

370/7 to 416/7 weeks), and the third group included the post-term infants (GA greater than 420/7) (23). According to the Intergrowth-21st, infants born with a birth weight below the 10th percentile were classified as small for gestational age (SGA), infants with a birth weight between the 10th and 90th percentile for gestational age were classified as appropriate for gestational age (AGA), and infants above the 90th percentile were classified as large for gestational age (LGA).

Statistical methods

The variables were present in means with standard deviations for continuous variables or proportions for categorical variables. The differences between pre-pandemic and during a pandemic, and between public and private hospitals, were evaluated with a significance level of 0.05. Student t-tests were used for variables with a no-skewed distribution and chi-square tests were used to evaluate differences in proportions.

For the purpose of classification among hospital types, a logistic regression model was used with the type of hospital as the dependent variable (classified as a dummy variable where 0 is a private hospital and 1 is a public hospital). The following independent variables were included: GA (weeks), time (before pandemic=0, during pandemic=1), length z-score, weight z-score, HC z-score, and sex (female=0, male=1). First, univariate models were used with the dependent variable with each independent variable, with a significance level of 0.05. The significant variables were used in a final logistic regression model. Results were presented as odds ratios (OR) with their 95% confidence intervals (95%CI).

In addition, three univariate linear regression models were fitted, including the length z-score, weight z-score, and HC z-score as dependent variables. The independent variables were the type of hospital (private = 0, public = 1), time (before pandemic = 0, during pandemic = 1) and sex (female = 0, male = 1). A final linear regression model was fitted, considering the independent variables "significant" at a significance level of 0.05 in the univariate models. The data was presented as "beta" coefficients with their corresponding 95%CI. All statistical analysis was performed using Stata version 16 (StataCorp, Cary, USA).

Results

The sample comprised an equal number of male and female newborns, with the general characteristics detailed in Table 1. Notably, the gestational age (GA) of children born in public hospitals was higher than those born in private hospitals (p<0.001). Across all neonates, the mean weight was 3.03 kg and the mean height was 47.99 cm. Although the tests comparing the means showed relatively small p-values, no clinically significant differences were found in the weight, height, and length of children between the public and private hospitals. Additionally, there was a significant increase in births in private institutions (73.6%) during the pandemic (p<0.001).

Tabla 1. Population characteristics.

Variables	Total n=5375	Public n= 4625	Private n= 750	p-value
Maternal delivery; % (n)				
Pre-pandemic	41.9 (2254)	44.5 (2056)	26.4 (198)	<0.001
During pandemic	58.1 (3121)	55.5 (2569)	73.6 (552)	
Female; %(n)	49.4 (2657)	49.5 (2289)	49.1 (368)	0.829
GA; (days); mean (SD)	271.28 (11.70)	271.75 (11.78)	268.39 (10.82)	<0.001
Weight; (kg); mean (SD)	3.03 (0.46)	3.03 (0.47)	2.99 (0.43)	0.011
Weight; (Z-score); mean (SD)	-0.27 (0.93)	-0.28 (0.95)	-0.22 (0.84)	0.068
Length; (cm); mean (SD)	47.99 (2.56)	48.03 (2.55)	47.71 (2.57)	0.001
Length; (Z-score); mean (SD)	-0.4 (1.14)	-0.4 (1.15)	-0.43 (1.06)	0.439
HC; (cm); mean (SD)	34.06 (1.45)	34.01 (1.46)	34.34 (1.40)	<0.001
HC; (Z-Score); mean (SD)	0.44 (1.06)	0.38 (1.06)	0.82 (0.96)	<0.001
GA= gestational age; HC=head circumference; SD=standard deviation. P-values refer to chi-square tests or Student t tests as appropriate				

On the other hand, Table 2 shows that there is no evidence of differences in the frequency of preterm or post-term births before or during the pandemic (p=0.161). Additionally, we did not find significant differences in the frequency of births with small, adequate, or large head circumference and weight according to the z-score for gestational age before and during the pandemic (p=0.471 and p=0.310, respectively). However, during the pandemic, the number of SGA (Small for Gestational Age) and LGA (Large for Gestational Age) neonates increased, and the number of AGA (Appropriate for Gestational Age) neonates decreased according to length (p<0.001).

Table 2. Anthropometric variables pre-pandemic and during pandemic.

Variables	Total n=5375	Pre-pandemic n= 2254	During pandemic n= 3121	p-value
Gestational age; %(n)				
Preterm	9.1 (489)	8.5 (192)	9.5 (297)	0.161
Term	90.3 (4853)	90.7 (2044)	90.0 (2809)	
Post term	0.6 (33)	0.8 (18)	0.5 (15)	
Weight; (Z-Score); %(n)				
SGA	21.3 (1146)	21.8 (492)	21.0 (654)	0.310
AGA	70.4 (3785)	70.6 (1590)	70.3 (2195)	
LGA	8.3 (444)	7.6 (172)	8.7 (272)	
Length; (Z-Score); %(n)				
SGA	27.4 (1475)	24.9 (562)	29.3 (913)	0.002
AGA	63.7 (3422)	66.2 (1492)	61.8 (1930)	
LGA	8.9 (478)	8.9 (200)	8.9 (278)	
HC; (Z-Score); %(n)				
SGA	8.1 (438)	8.3 (187)	8.1 (251)	0.471
AGA	62.5 (3358)	63.2 (1425)	61.9 (1933)	
LGA	29.4 (1579)	28.5 (642)	30.0 (937)	
SGA=small for gestational age; AGA= adequate for gestational age; LGA= large for gestational age. P-values refer to chi-square test				

The logistic regression analysis reveals several key findings. Neonates born in public hospitals are more likely to have a higher gestational age (OR=1.16, CI=1.12-1.21). Furthermore, during the pandemic, there was a higher likelihood of births occurring in private hospitals compared to public hospitals (OR=0.45, CI=0.38-0.54). Neonates born in private hospitals also exhibited a lower HC z-score than those born in public hospitals (OR=0.68, CI=0.63-0.73). However, no significant associations were found with length z-score, weight z-score, and sex. These results are detailed in Table 3.

Table 3. Results of the logistic regression model. Associations between public hospital, gestational age, during pandemic, and anthropometrics z-score measurements.

Model: Private=0	**Univariate**	**Multiple model**
Public=1	OR (95%CI); p-value	OR (95%CI); p-value
GA (weeks)	1.164 (1.12, 1.21), p = 0.001	1.143 (1.09, 1.19), p = 0.001
During pandemic	0.448 (0.38, 0.53), p = 0.001	0.451 (0.38, 0.54), p = 0.001
Length z-score	1.027 (0.96, 1.10), p = 0.439	--
Weight z-score	0.932 (0.86, 1.01), p = 0.094	--
HC z-score	0.672 (0.62, 0.72), p = 0.001	0.678 (0.63, 0.73), p = 0.001
Male	0.983 (0.84, 1.15), p = 0.829	--
GA= gestational age; HC=head circumference; CI=confidence interval		

Regarding the length z-score, the regression model indicates that the z-score decreases by β=-0.027 (CI=-0.05; -0.01) with each increase in gestational age, and there was an average decrease of β=-0.102 (CI=-0.16; -0.04) during the COVID-19 pandemic. For the weight z-score, the model shows an increase of β=-0.06 (CI=-0.11; -0.01) if the newborn is male, and a change of β=-0.033 (CI=-0.05; -0.02) with each increase in gestational age. Lastly, the HC z-score decreases by β=-0.100 (CI=-0.16; -0.04) if the newborn is male, changes by β=-0.05 (CI=-0.07; -0.03) with each increase in gestational age and increases by β=-0.417 (CI=-0.5; -0.34) if born in a public hospital. These results are detailed in Table 4, which presents the findings of the linear regression used to identify changes in the z-scores of the newborns' anthropometric variables.

Table 4. Results of the univariate and multiple regression models for neonate length z-score, weight z-score and HC z-score with sex, gestational age, public hospital, during COVID-19 pandemic.

Models	**Male β; (95%CI) p-value**	**GA (weeks) β; (95%CI) p-value**	**Public β; (95% CI) p-value**	**During pandemic β; (95% CI) p-value**
Length z-score				
Univariate	-0.018 (-0.08, 0.04) 0.552	-0.025 (-0.04, -0.01) 0.007	0.035 (-0.05, 0.12) 0.439	-0.097 (-0.16, -0.04) 0.002
Multiple	--	-0.027 (-0.05, -0.01) 0.004	--	-0.102 (-0.16, -0.04) 0.001
Weight z-score				
Univariate	-0.056 (-0.11, -0.01) 0.028	-0.032 (-0.05, -0.02) 0.001	0.061 (-0.13, 0.01) 0.094	0.025 (-0.03, 0.08) 0.337
Multiple	-0.06 (-0.11, -0.01) 0.019	-0.033 (-0.05, -0.02) 0.001	--	--
HC z-score				
Univariate	-0.093 (-0.15, -0.04) 0.001	-0.057 (-0.07, -0.04) 0.001	-0.44 (-0.52, -0.36) 0.001	0.022 (-0.04, 0.08) 0.447
Multiple	-0.100 (-0.16, -0.04) 0.001	-0.05 (-0.07, -0.03) 0.001	-0.417 (-0.5, -0.34) 0.001	--
GA= gestational age; HC=head circumference; CI=confidence interval				

Finally, Figure 1 shows the z-score varies for the weight, height, and brain circumference of the newborn depending on the month of gestation. It is observed that before the pandemic of COVID-19, the weight z-score of children born up to week 36 has more variation, but after this point it stabilizes. This trend is also observed for the z-scores of height and head circumferences. During the pandemic, the z-score is less variable throughout the weeks of gestation. For this reason, differences in weight, height, and brain circumference were not observed, although quantitative analysis showed that the number of SGA and LGA newborns increased according to the height z-score.

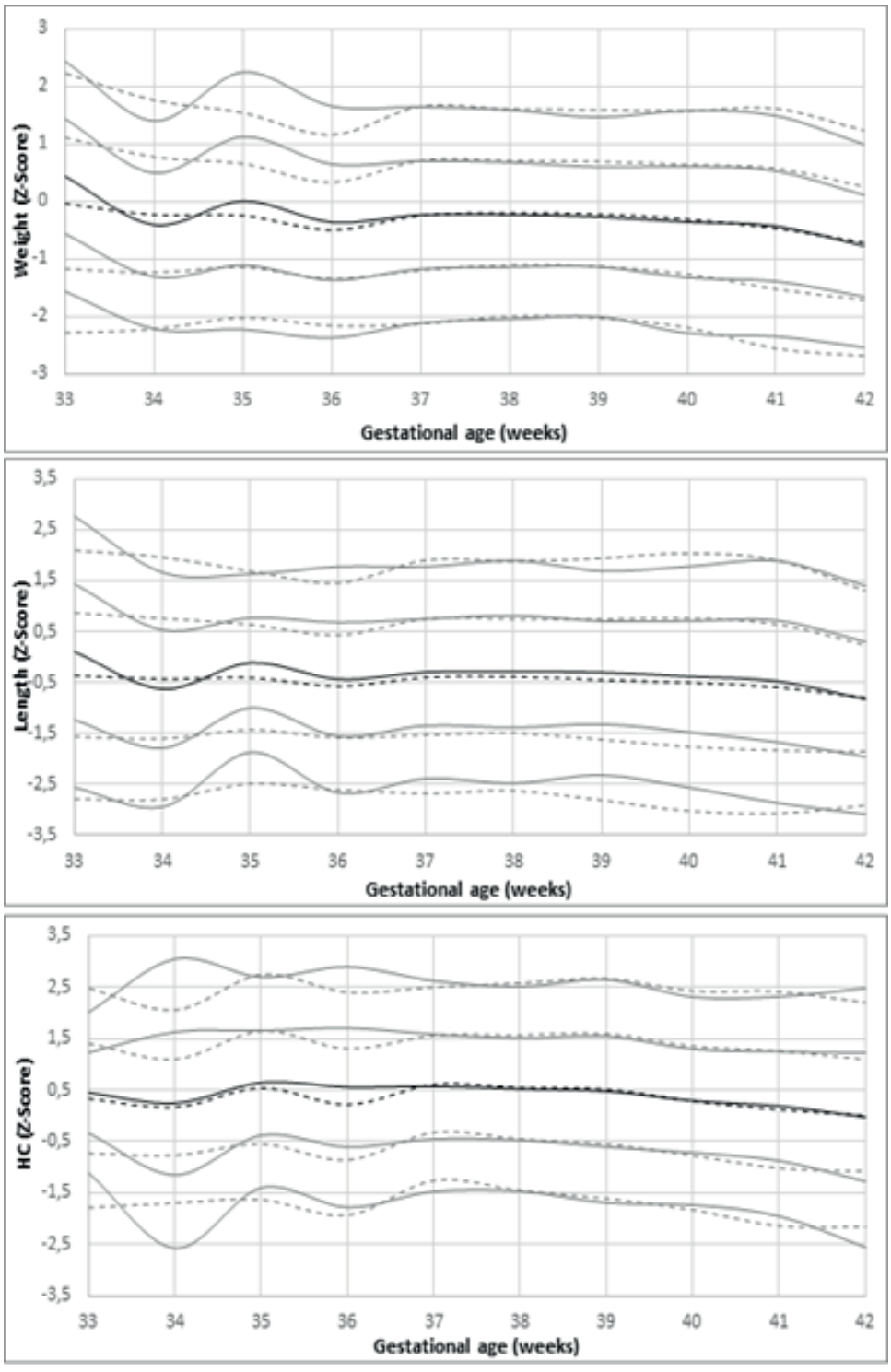

Figure 1. The variation of the Z-score for weight, height and HC for -2SD, -1SD, mean, 1SD and 2SD is shown. Solid Line = before pandemic; broken Line = during pandemic.

Discussion

Our results showed that the increase in deliveries performed in a private hospital was higher than that observed for the public hospital. A possible explanation is that, because of the pandemic, many mothers are afraid of contagion during care in the public system, so they prefer private care. This increase has been more evident in Ecuador, according to data from Alfredo Paulson Hospital, of the Guayaquil Board of Charity. Evidence shows that the private sector handles a lower incidence of COVID-19 positive patients as compared to the public sector[24], mainly due to the Ecuadorian government's plan to centralize those infected with COVID-19 in public hospitals.

In this study, the average weight of newborns was 3.03 kg and the average length was 47.99 cm, with no clinically important differences when comparing between the public and private hospitals. These averages are similar despite the lower proportion of caesarean sections (C-sections) in the public sector of Ecuador when compared to the private one.

No significant differences were found in the weight, height, and length of the neonates in Ecuador. The Sanitary Regulation for the Certification of Health Facilities as Mother and Child Friendly (ESAMyN), adapted from the WHO Baby-Friendly Hospital Initiative, is in force and mandatory for both public and private hospitals, ensuring quality standards in maternal and neonatal care[(25)]. A 2019 study in second-level hospitals showed that obstetrics and medical interns largely comply with these standards, although there is a need to improve the practice of cutting the umbilical cord at the appropriate time[26]. The widespread compliance with ESAMyN regulations might explain the lack of significant differences in the anthropometric measurements of neonates, ensuring similar health conditions at birth. However, other factors such as genetic predispositions, environmental influences, maternal health conditions during pregnancy, and access to postnatal care should be considered. Future research should explore these additional variables to provide a more comprehensive understanding of the factors affecting neonatal health and development in Ecuador.

The C-section rate in Ecuador was 41.3% from 2015 to 2022[27]. Many C-sections are planned for convenience rather than medical necessity[28], leading to earlier births compared to vaginal delivery, which allows neonates more time to gain weight and length[29-31]. Studies in Ecuador indicate that women giving birth in private sectors tend to have higher incomes than those in public sectors[32,33], influencing their dietary habits and maternal nutritional status, which affects fetal nutrition. Private sector care often includes nutritional counseling, unlike the public sector, where such counseling may be brief or absent[34]. Additionally, higher-income mothers can afford healthier diets, while those in the public sector may rely on low-cost, carbohydrate-based diets[35]. Excessive and inadequate maternal nutrition can lead to excessive weight gain, potentially linked to a sedentary lifestyle during lockdown or online work. High birth weight in newborns has been associated with mothers with gestational diabetes who may not have had adequate preventive care[36].

In this study, no significant differences were found in the percentage of preterm or term births between before the pandemic and during it (p = 0.161). This is noteworthy because the pandemic's drastic changes in lifestyle had the potential to change the frequency in either direction: a decrease in preventive controls in pregnant women could have resulted in more pregnancy problems ; on the other hand, the more relaxed conditions of improved nutrition, home rest, and less workload could have resulted in a lower rate of preterm deliveries[37]. It was previously mentioned that the anecdotal experience observed by some physicians pointed towards a reduction in the percentage of preterm babies. However, no evidence of this assertion was found in this study. This may be due to its scope, which covered only one private hospital and one public hospital. Both are big and serve a large population of patients, as evi-

denced by the sample size, so there is high confidence in the results, though the results at a national level may certainly be different. Another, national-scale study would be necessary to confirm this.

The limitations of the present study include a lack of information on important variables such as the C-section rate in each facility and maternal socioeconomic characteristics. Due to the cross-sectional design of the study, no conclusions on causality can be drawn.

Contribución de los autores

JJ, SD, CA: Concepción y diseño del trabajo.

JJ, SD, CA: Recolección de datos y obtención de resultados.

JJ, SD, CA: Análisis e interpretación de datos

JJ, SD, CA: Redacción del manuscrito.

JJ, SD, CA: Revisión crítica del manuscrito.

JJ, SD, CA: Aprobación de su versión final.

JJ, SD, CA: Aporte de pacientes o material de estudio.

JJ, SD, CA: Obtención de financiamiento.

JJ, SD, CA: Asesoría estadística.

JJ, SD, CA: Asesoría técnica o administrativa.

Aspectos éticos

El trabajo de investigación fue desarrollado, bajo el método descriptivo con la tabulación de las historias clínicas, para lo cual no se necesitó la aprobación del Comité de Ética al no tener intervenciones humanas si no estadísticas.

Financiamiento

Se trabajó con fondos propios.

Conflictos de interés

Los autores reportaron no tener ningún conflicto de interés, personal, financiero, intelectual, económico y de interés corporativo.

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Para referenciar aplique esta cita:
Jácome Navarrete J, Dueñas Matute SE, Yánez E, Chipe M, Sánchez L, Aguinaga F, Ponce F, Guzmán V, Benavides P, Gallardo A, Castillo L, Zangiacomi-Martínez E, Salvador-Pinos CA. Impacto del COVID-19 en la antropometría neonatal: un análisis comparativo de los ingresos hospitalarios públicos y privados en Quito (2019-2020). REV-SEP [Internet]. 26 de agosto de 2024; 25(2): 10-20. Disponible en: https://rev-sep.ec/index.php/johs/article/view/266