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Original Research Article

Reference values for babies' pulse oximetry recordings, highlighting the impact of cesarean sections and COVID-19 pandemic

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ABSTRACT

Background: With a focus on the consequences of caesarean delivery as a result of mother stress and the first wave of the COVID-19 epidemic as a source of maternal stress, the study sought to identify reference values for pulse oximetry recordings among both healthy full-term neonates and preterm and unhealthy neonates.
Methods: A comparative study of 170 neonates admitted to the Fayoum university NICU after being born in the department of obstetrics and gynaecology. Collected pulse oximetry readings at predetermined intervals was done. Patients were classified into group I (before 1st wave of COVID-19 pandemic) and group II (during 1st wave of COVID-19 pandemic).
Results: The 5th and 95th percentiles of SpO_2 after 1 minute after birth were (65% to 90%), with a mean of 77%, according to the study of 146 full-term healthy newborns. SpO_2 readings were (89% to 97.1%) with a mean of 92% after 5 minutes, and finally (90% to 98%) with a mean of 93% after 10 minutes. Statistically significant lower means of SpO_2 were found during 1st wave of COVID-19 pandemic after 10 minutes of delivery, and for Apgar score after 1 and 5 minutes of delivery. There was a negative impact of cesarean section delivery on gestational age.
Conclusions: This research reveals that after 10 minutes of delivery, a Spo2 recorded range of 90 to 98 for full-term healthy neonates and a mean of 86% for preterm and ill neonates may be appropriate. The first wave of the COVID-19 pandemic had a deleterious impact on neonates' SpO_2 recordings and Apgar scores, according to the study. There was a gestational age effect associated with caesarean delivery.

Keywords: SpO_2, Reference values, COVID-19

INTRODUCTION

As regards the cut-off value for oxygen saturation, the world health organization determines a pulse oximetry oxygen saturation threshold value of 90%.[1] The 90% cut-off threshold may not be as beneficial at elevations higher than 3,000 m asl (above sea level), where oxygen saturation rates are lower than at sea level.[2] The "normal" SpO_2 (Pulse oximetry oxygen saturation) at sea level has been determined to be between 95% and 100% in clinical practice; nevertheless, other writers consider readings between 95% and 96% to be abnormal.[1]

As previously discussed, it might be difficult to pinpoint the precise cut-off value for oxygen saturation as measured by pulse oximetry.

An essential technique for examining the need for oxygen in sick infants is pulse oximetry, a non-invasive way to measure the oxygen saturation of hemoglobin.[3]

Regular use may also be advantageous for identifying newborns with clinically concealed respiratory issues, where discharge frequently happens within the first 24 hours of life. The use of pulse oximetry requires

knowledge of typical oxygen saturation SpO_2 levels. For newborns of various gestational ages, normal SpO_2 levels must be established at various periods following birth.

The regulation of cardiovascular systems, including the ductus arteriosus and pulmonary blood flow, is significantly influenced by oxidative stress brought on by hypoxia-oxygenation.[4]

A significant portion of the population is affected by acute exposure to stress from traumatic life events like war, natural disasters, divorce, and job loss.[5]

A study demonstrated that maternal exposure to stress causes a considerable drop in birth weight and an increase in the percentage of low-birth-weight babies, using the severe stress caused by the 2005 earthquake in Chile as an example.[6]

The effect of stress on birth outcomes has been investigated in some studies using natural trials. The impact of stress on birth weight may be time-sensitive due to the fact that certain systems in the human body develop at specific gestational times. [7]

In a previous study, a 1-point rise on the pregnancy stress rating scale was associated with a 1.033-fold greater likelihood of having an unexpected cesarean section (95% CI=1.002 to 1.065), demonstrating that stress was a significant factor connected to the unscheduled C-sections. [8]

The study aimed to determine reference values for pulse oximetry saturation (SpO_2) measurements in both healthy term neonates and premature and unhealthy neonates. Focus on the effects of cesarean section as a result of maternal stress and impact of the 1st wave of COVID-19 pandemic as a source of maternal stress was done.

METHODS

The 170 neonates admitted to the pediatric department's neonatal intensive care unit at Fayoum university who were born in the department of obstetrics and gynecology were the subject of a comparison study. At predetermined intervals of 1 minute, 5 minutes, and 10 minutes, pulse oximetry recordings were made. Additional clinical information was logged, such as gestational age, sex, birth weight, Apgar score, delivery method, anesthetic type, maternal analgesia prior to delivery, respiratory distress, cardiac issues, and other issues during incubator care. In order to avoid issues with inter-equipment variability, this study exclusively used one model of pulse oximetry. In this investigation, newborn and pediatric SpO_2 connecting cords were utilized to connect a pulse oximetry probe to a bedside monitor (Nihon Kohden, Japan); SpO_2 data were then gathered.

Being born alive, at Fayoum university hospital between 15 November 2019 and 15 May 2020 qualified as an inclusion criterion. Based on the recent menstrual cycle and an early prenatal ultrasonography we estimate the gestational age.

The conventional values of low birth weight (2,500 gm) are determined by uterine growth expressed as the gestational age-specific birth-weight percentile.[9] Preterm birth (less than 37 weeks of gestation).[10]

All of the children in the sample had physical exams, medical records reviewed, and tests performed in the lab, including measurements of arterial blood gas, serum hemoglobin, and chest X-rays to rule out diseases not identified during clinical evaluation.

On assessment of reference values for pulse oximetry saturation SpO_2 recordings we classified patients into two groups, healthy full-term neonates and premature or unhealthy neonates.

However, when examining the effects of the COVID-19 pandemic's first wave, we divided patients into two groups: Group I (data gathered prior to 15 February 2020, i.e., before the pandemic's first wave), and group II (data collected from 15 February 2020 to 14 May 2020 i.e., during 1st wave of COVID-19 pandemic).

A cumulative frequency curve of time against SpO_2 value was created using the study group mean, 5th percentile, and 95th percentile (representing the reference values of SpO_2 profiles in healthy full-term neonates and in preterm or unhealthy neonates).

Data was gathered and examined.

Statistical analysis

Data collected and coded to facilitate data manipulation and double entered into Microsoft access and data analysis performed using the statistical package of social science (SPSS) software version 22 in windows 7 (SPSS Inc., Chicago, IL, USA). Simple descriptive analysis in the form of numbers, percentages and percentiles for qualitative data, in addition, arithmetic means as central tendency measurement, standard deviations as a measure of dispersion of quantitative parametric data. Independent samples T test was used to compare quantitative measures between two independent groups. Chi square test used to compare between two of more than two qualitative groups. The $p<0.05$ was considered as statistically significant.

Ethics approval and consent to participate

The study was reviewed and approved by the Fayoum University, Faculty of Medicine Research Ethical Committee. Written informed consent was obtained from the parents of all participants after the proper orientation of them regarding the study objectives.

RESULTS

Among study group the mean gestational age was (37.4±1.3) weeks, mean weight was (3137.7±364.7) gm. 93 (54.7%) were females versus 77 (45.3%) were males. The 28 (16.5%) needed O_2 supply. For mode of delivery 8 (4.7%) delivered normal vaginal labour versus 162 (95.3%) by cesarean section. Five (2.9%) of mothers received analgesia, and 168 (98.8%) did spinal anesthesia versus 2 (1.2%) did general anesthesia. As regards health problems 17 (10%) had respiratory distress syndrome, 3 (1.8%) had cardiac problems, and 22 (12.9%) had incubator problems.

Among full term neonate SpO_2 after 1 minute of delivery assessment ranged between (28% to 97%) with mean of (75.7%±10.2%). Among full term neonate SpO_2 after 5 minutes assessment ranged between (80% to 99%) with mean of (92%±3%).Among full term neonate SpO_2 after 10 minutes assessment ranged between (50% to 99%) with mean of (92.3%±6.7%)

At first, Table 1 illustrated reference values for pulse oximetry saturation (SpO_2) recordings in both healthy term neonates and preterm and unhealthy neonates among study group.

Table 1: Reference values of SpO_2 recordings percentiles in the preterm and unhealthy neonates and the healthy full term neonates among the study groups.

Groups	Percentile	SpO_2 at 1 min	SpO_2 at 5 min	SpO_2 at 10 min
Preterm and unhealthy	5th	0.42	0.80	0.50
	25th	0.60	0.88	0.85
	50th	0.60	0.90	0.90
	75th	0.735	0.92	0.95
	95th	0.88	0.95	0.98
Healthy full term	5th	0.65	0.89	0.90
	25th	0.70	0.90	0.90
	50th	0.80	0.92	0.95
	75th	0.833	0.95	0.95
	95th	0.90	0.971	0.98

We found that cumulative frequency curve of time against SpO_2 measurements revealed that among 24 preterm and unhealthy neonates, the 5th and the 95th percentiles of SpO_2 after 1 min of delivery (42% to 88%) with a mean of 65% (SD ±11.9) as shown in Figure 1.

For the assessment after 5 minutes, SpO_2 measurements were (80% to 95%) with a mean of 89% (SD ±4.5) Figure 2 and finally, SpO_2 measurements after 10 minutes were (50% to 98%) with a mean of 86% (SD± 14.2) Figure 3.

Cumulative frequency curve of time against SpO_2 measurements revealed that among 146 full-term healthy neonates, the 5th and the 95th percentiles of SpO_2 after 1 minute of delivery were (65% to 90%) with a mean of 77% (SD ± 9.1) as shown in Figure 4.

For the assessment after 5 minutes, SpO_2 measurements were (89% to 97.1%) with a mean of 92% (SD ±2.6) Figure 5 and finally, SpO_2 measurements after 10 min (90% to 98%) with a mean of 93% (SD ±3.3) Figure 6.

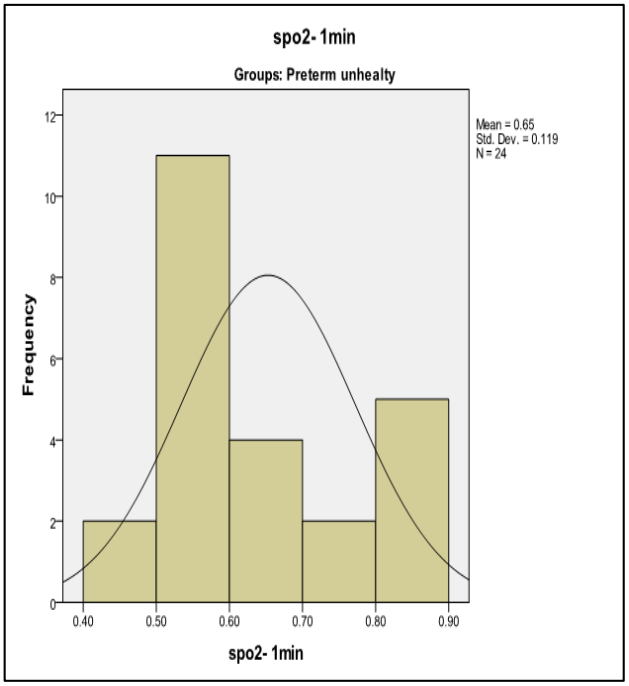

Figure 1: Pulse oximetry recordings percentiles at 1 minute among preterm and unhealthy neonates.

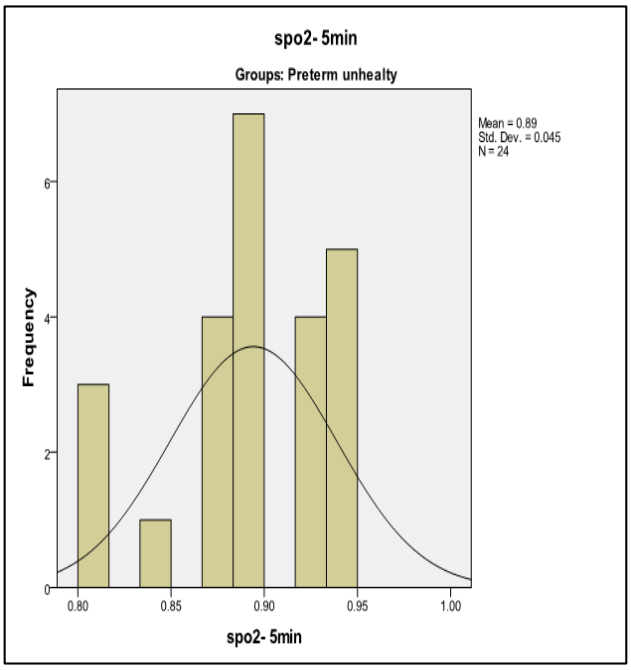

Figure 2: Pulse oximetry recordings percentiles at 5 minutes among preterm and unhealthy neonates.

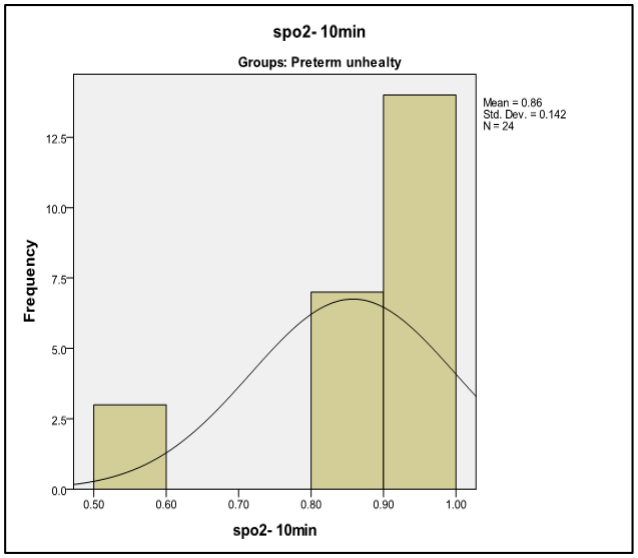

Figure 3: Pulse oximetry recordings percentiles at 10 minutes among preterm and unhealthy neonates.

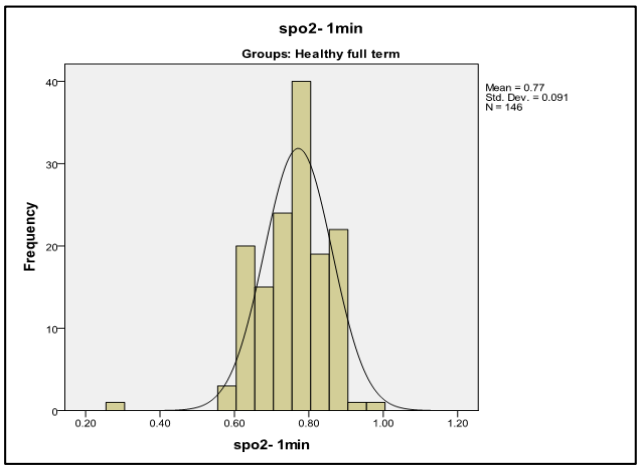

Figure 4: Pulse oximetry recordings percentiles at 1 minute among healthy full term neonates.

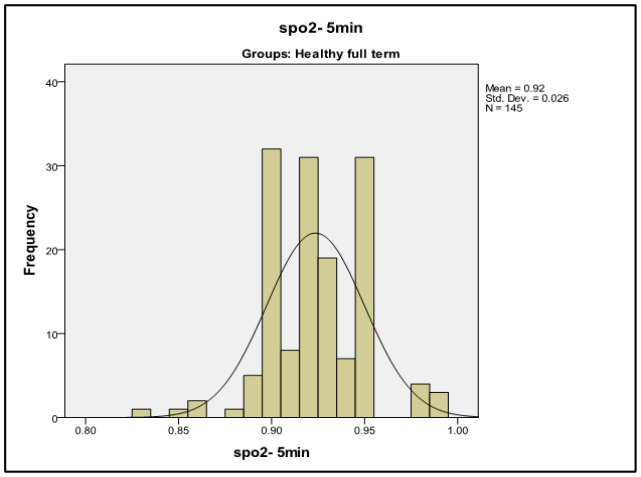

Figure 5: Pulse oximetry recordings percentiles at 5 minutes among healthy full term neonates

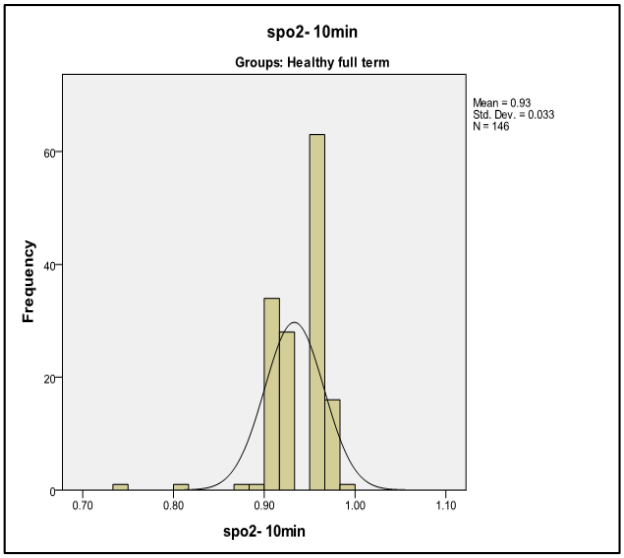

Figure 6: Pulse oximetry recordings percentiles at 10 minutes among healthy full term neonates.

Second, impact of the 1st wave of COVID-19 pandemic among study group was assessed. Table 2 illustrated that there was a statistically significant difference with $p<0.05$ between group I (data collected before 15 February 2020 i.e., before 1st wave of COVID-19 pandemic) and group II (data collected from 15 February 2020 to 14 May 2020 i.e., during 1st wave of COVID-19 pandemic) in SpO_2 after 10 minutes of delivery follow up, and Apgar score after 1 and 5 minutes of delivery with lower mean in group II with p=0.02, 0.001, and 0.02 respectively. In addition, there was a statistically significant higher percentage in normal vaginal mode of delivery and maternal analgesics before labor in group II. These findings are consistent with the hypothesis that there is an obvious effect of stress on SpO_2 and Apgar score. On the other hand, there was no statistically significant difference with $p>0.05$ as regards other study variables.

Table 3 illustrated that there was a statistically significant increase in SpO_2 at 5 minute and 10 minutes follow up in group I with $p<0.001$, and 0.002 respectively. However, in group II statistically significant increase in SpO_2 only after 5 minutes follow up ($p<0.001$) but no difference after 10 minutes follows up with p=0.4. These findings are consistent with the hypothesis that there is an obvious effect of stress on progression of increase in SpO_2 recording that reflect neonatal well-being. As regards Apgar score both groups show significant improvement after 5 minutes with $p<0.001$.

Third, effects of cesarean section versus vaginal mode of delivery were estimated. Study found that there was a statistically significant difference with $p<0.05$ between different mode of delivery in gestational age, with lower gestational age with p=0.03. On the other hand, there was no statistically significant difference with p=0.05 as regards other study variables.

Table 2: Impact of the 1st wave of COVID-19 pandemic on neonates among study group.

Variables		Group I*, (n=99)		Group II*, (n=71)		P value
		Mean	SD	Mean	SD	
Gestational age (W)		37	1	37	1	1
Weight (gm)		3125.3	361.5	3154.9	371	0.6
SpO_2 at 1 min		0.75	0.10	0.77	0.10	0.3
SpO_2 at 5 min		0.92	0.03	0.92	0.04	0.9
SpO_2 at 10 min		0.93	0.03	0.91	0.09	0.02*
Apgar score 1 min		7.1	0.73	6.6	0.78	0.001*
Apgar score 5 min		8.05	0.76	7.8	0.65	0.02*
Variables		**No.**	**%**	**No.**	**%**	**P value**
Sex	M	43	43.4	34	47.9	0.6
	F	56	56.6	37	52.1	
Mode of delivery	Vaginal	0	0	8	11.3	0.001*
	C. S	99	100	63	88.7	
Gestational age (Weeks)	Preterm	7	7.1	1	1.4	0.2
	Full term	92	92.9	70	98.6	
O_2 supply	Yes	15	15.2	13	18.3	0.7
	No	84	84.8	58	81.7	
Type of anesthesia	General	0	0	2	2.8	0.2
	Spinal	99	100	69	97.2	
Incubator	Yes	11	11.1	11	15.5	0.5
	No	88	88.9	60	84.5	
Maternal analgesics before labor	Yes	0	0	5	7	0.01*
	No	99	100	66	93	
RDS	Yes	10	10.1	7	9.9	0.9
	No	89	89.9	64	90.1	
Cardiac	Yes	0	0	3	4.2	0.07
	No	99	100	68	95.8	

*Statistical significance difference with p<0.05.

Table 3: Comparisons of pulse oximetry recordings and Apgar score at different time intervals in each study group.

Variables	Group I*, (n=99)		Group II*, (n=71)	
	Mean	SD	Mean	SD
SpO_2				
SpO_2 at 1 min	0.75	0.10	0.77	0.10
SpO_2 at 5 min	0.92	0.03	0.92	0.04
SpO_2 at 10 min	0.93	0.03	0.91	0.09
P value	<0.001*a, 0.002*b		<0.001*a, 0.4 b	
Apgar score 1 min	7.1	0.73	6.6	0.78
Apgar score 5 min	8.05	0.76	7.8	0.65
P value	<0.001*		<0.001*	

*a: significance between SpO_2 at 1-and 5-min and *b: significance between SpO_2 at 5-and 10-min-time intervals follow up.

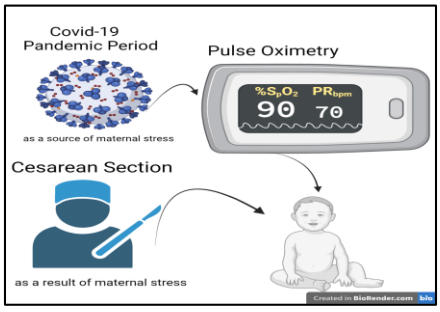

Figure 7: Illustration of babies; pulse oximetry recordings, impact of c-sec and COVID-19 pandemic period.

DISCUSSION

Without pulse oximetry, managing pediatric patients depends on the identification of clinical hypoxemia symptoms, which are not always simple to find in all patients. Clinical indicators by themselves are insufficient to identify hypoxaemia.

The reference values provided in this study can be utilized to guide clinical judgment. It showed that the mean of the 5th and 95th percentiles of SpO_2 after 1,5, and 10 minutes after delivery was 65%, 89%, and 86%, respectively, among 24 preterm and unwell newborns.

Similar to this, a prior study found that the median SpO2 value for all newborns was 95% (with a range of 92-99%).[11]

The 5th and 95th percentiles of SpO_2 after 1 minute of delivery range from 65% to 90% among 146 full-term healthy newborns in our study, with a mean of 77%. SpO2 measurements vary from 89% to 97.1% with a mean of 92% for the evaluation after 5 minutes, and from 90% to 98% with a mean of 93% for the assessment after 10 minutes.

Neonatal mortality is very prevalent in low-income nations. A large percentage of neonates in hospitals experience hypoxaemia, which is strongly related to mortality.[12]

There is a growing understanding that people are susceptible to environmental cues in pregnancy and that these stimuli can have long-term effects.[13]

With statistically significant differences in SpO_2 after 10 minutes of birth, and Apgar score after 1 and 5 minutes of delivery with p=0.02 and 0.01 respectively, lower means were discovered during the first wave of the COVID-19 pandemic within the study group.

The existence of high levels of maternal anxiety in the pre- and postnatal phase has been linked with emotional and behavioral issues during children and adolescence, according to research that looked at maternal anxiety and depression levels in the postnatal era.[14]

In group I, we saw an increase in SpO_2 at the 5- and 10-minute follow-ups, whereas in group II, we only observed a statistically significant increase in SpO_2 at the 5-minute follow-up. Surprisingly, our study found that stress clearly had an impact on the trajectory of increase in SpO_2 recording, a marker of newborn well-being.

In agreement with our findings, a different study shown that newborns delivered vaginally had a lower gestational age than those delivered via caesarean section, with no difference in SpO_2 measurements.[15]

In contrast, a prior study found that infants delivered vaginally had higher SpO_2 levels than those delivered via caesarean section.[16]

Limitations

This research contains some flaws, based on a modest sample size of 24 infants, our findings for preterm infants. It was challenging to include well-preterm newborns because so many of them were admitted for medical treatment, which rendered them unsuitable for searching. It is necessary to conduct more study on the SpO_2 reference ranges in preterm and full-term infants delivered at various elevations.

Although we established that staff members used pulse oximetry consistently, we cannot completely exclude out percentage errors in the SpO_2 readings due to inadvertent probe placement or insufficient perfusion.

CONCLUSION

After 10 minutes of delivery, this study reveals that a SpO_2 recording range of 90 to 98 among full-term healthy neonates and a mean of 86% for preterm and ill neonates may be reasonable. Additionally, the study found that the first wave of the COVID-19 pandemic had a deleterious impact on neonates' SpO_2 readings and Apgar scores as a result of stressing out mothers. Due to maternal stress, there was a negative effect of Caesarean birth with regard to gestational age.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Andrade V, Andrade F, Riofrio P. Pulse oximetry curves in healthy children living at moderate altitude: a cross-sectional study from the Ecuadorian Andes. BMC Pediatr. 2020;20(1):1-7.
2. Mayorga VA, Andrade F, Riofrío P. Pulse oximetry curves in healthy children living at moderate altitude: a cross-sectional study from the Ecuadorian Andes. 2020;10.
3. Sarkar A, Sinha V, Mandlik SA. Non-Invasive blood oxygen saturation monitoring (SpO2) using transmittance for pulse oximeter. Biomed Engineering: Applications, Basis Communications. 2019;31(06):1950043.
4. Villamor E, Moreno L, Mohammed R,et al. Reactive oxygen species as mediators of oxygen signaling during fetal-to-neonatal circulatory transition. Free Radical Biology and Medicine. 2019;142:82-96.
5. Torche F. The effect of maternal stress on birth outcomes: exploiting a natural experiment. Demography. 2011;48(4):1473-91.
6. Duncan B, Mansour H, Rees DI. Prenatal stress and low birth weight: Evidence from the super bowl. 2015. Available at: https://www.iza.org/publications/dp/9053/prenatal-stress-and-low-birth-weight-evidence-from-the-super-bowl. Accessed on 25 Oct, 2022.
7. Narang K, Enninga EAL, Gunaratne MD. SARS-CoV-2 infection and COVID-19 during pregnancy: a multidisciplinary review. Mayo Clin Proceedings Elsevier. 2020.
8. Ko YL, Lin PC, Chen SC. Stress, sleep quality and unplanned Caesarean section in pregnant women. Int J Nursing Pract. 2015;21(5):454-61.
9. Miao H, Yao F, Wu Y. Birth weight percentiles by sex and gestational age for twins born in southern China. Scientific Rep. 2019;9(1):1-8.

10. Gezer C, Ekin A, Solmaz U. Identification of preterm birth in women with threatened preterm labour between 34 and 37 weeks of gestation. J Obstetr Gynaecol. 2018;38(5):652-7.
11. King C, Mvalo T, Sessions K. Performance of a novel reusable pediatric pulse oximeter probe. Pediatr Pulmonol. 2019;54(7):1052-9.
12. Goldenberg RL, McClure EM. Maternal, fetal and neonatal mortality: lessons learned from historical changes in high income countries and their potential application to low-income countries. Maternal Heal Neonatol Perinatol. 2015;1(1):1-10.
13. Fraga S, Amorim M, Soares S. Childhood Exposure to Violence: Looking through a Life-Course Perspective. 2022;102581.
14. Correia LL, Linhares MBM. Maternal anxiety in the pre-and postnatal period: a literature review. Revista latino-americana de enfermagem. 2007;15:677-83.
15. Zubarioglu U, Uslu S, Can E. Oxygen saturation levels during the first minutes of life in healthy term neonates. Tohoku J Exp Med. 2011;224(4):273-9.
16. Saugstad OD, Aune D. Optimal oxygenation of extremely low birth weight infants: a meta-analysis and systematic review of the oxygen saturation target studies. Neonatology. 2014;105(1):55-63.

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