Acta Paediatrica

WILEY

ACTA PÆDIATRICA
NURTURING THE CHILD

ORIGINAL ARTICLE OPEN ACCESS

Adverse Neonatal Outcomes Following Planned Vaginal Birth Compared to Planned Caesarean Birth: A Population-Based Study

Viktoria El Radaf[1,2] | Wilma Pettersson[3] | Johanna Brondin[3] | Charles Savona-Ventura[4] | Tahir Mahmood[5] | Mehreen Zaigham[2,6]

[1]Department of Obstetrics and Gynaecology, Lasarettet I Ystad, Ystad, Sweden | [2]Obstetrics and Gynaecology, Institution of Clinical Sciences Lund, Lund University, Lund, Sweden | [3]Faculty of Medicine, Lund University, Lund, Sweden | [4]Department of Obstetrics and Gynaecology, University of Malta, Msida, Malta | [5]Spire Murrayfield Hospital, Edinburgh, UK | [6]Department of Obstetrics and Gynaecology, Skånes University Hospital, Lund, Sweden

Correspondence: Mehreen Zaigham (mehreen.zaigham@med.lu.se)

Received: 10 June 2025 | **Revised:** 14 December 2025 | **Accepted:** 18 December 2025

Keywords: apgar score | caesarean section | continuous positive airway pressure | neonatal outcomes | planned caesarean | planned vaginal | umbilical cord arterial pH | vaginal birth

ABSTRACT

Aim: To compare adverse outcomes in neonates born by planned vaginal birth to those born by planned caesarean section.

Method: This retrospective cohort study analysed data from southern Sweden between 1995 and 2015, using the perinatal revision South Register. Only women with singleton, term (≥37 + 0 weeks) and cephalic presentation were included. Planned vaginal birth included all vaginal non-instrumental, instrumental, and emergency caesarean births. Logistic regression was used to study the relationship between neonates born via planned vaginal birth and planned caesarean section to adverse neonatal outcomes.

Results: Of 97,886 included, 91,834 (8.9%) underwent planned vaginal birth, and 6052 (91.1%) underwent planned caesareans. After adjustment, neonates with planned caesarean birth had lower odds for UApH < 7.05 [OR 0.64; 95% CI, 0.46–0.88, $p = 0.006$] but higher need for continuous positive airway pressure [OR 2.22; 95% CI, 1.74–2.85, $p < 0.001$]. No differences were seen for apgar score < 7 at 5 min, seizures, central nervous system disease or hypoxic ischemic encephalopathy.

Conclusion: While planned caesarean birth may reduce the risk of neonatal acidemia, it is associated with a higher odds of respiratory support after birth. Overall, both planned birth modes demonstrated comparable risks for other serious neonatal outcomes, indicating that decisions should balance these specific differences alongside individual clinical circumstances.

1 | Introduction

Over recent decades, there has been a notable increase in caesarean sections (CS) globally, with research indicating a continued prominent rise in the upcoming decade [1, 2]. CS rates are expected to rise to nearly one third of all births worldwide by 2030 [1], and a marked increase has also been seen in Europe [3]. Within this trend, a particular increase in caesarean births has also been witnessed in Sweden [4–6]. Multiple factors and their complex interplay affect the choice of birthing method [5, 7].

Abbreviations: BMI, body mass index; CNS, central nervous system; CPAP, continuous positive airway pressure; CS, caesarean section; HIE, hypoxic ischemic encephalopathy; NICU, neonatal intensive care unit; UApH, umbilical cord arterial pH.

Wilma Pettersson and Johanna Brondin are joint second authors.

Summary

- Large, retrospective population-based cohort study of 97,886 neonates examined the association between adverse neonatal outcomes and planned mode of birth.
- Planned caesarean birth was associated with lower odds of neonatal acidemia but a higher need for respiratory support, while other serious neonatal outcomes did not differ between planned birth modes.
- Findings highlight specific trade-offs between modes of planned birth that can inform clinical decision-making.

The marked rise in CS rates has been linked to adverse short- and long-term outcomes for both mothers and neonates [5, 6, 8–10]. Evidence suggests that neonates born by planned CS may be at increased risk of adverse outcomes such as respiratory morbidity, admission to the neonatal intensive care unit (NICU), respiratory tract infection, gastroenteritis, asthma, and rheumatoid arthritis [5, 6, 8–10]. Nevertheless, the literature remains inconclusive in several areas. For instance, studies examining respiratory distress among neonates born via planned CS have reported conflicting findings. Kolås et al. [11] showed in a study including a total of 18 653 cases divided into two groups, one comprising planned vaginal births and emergency CS during labour, and the other including planned CS and emergency CS before labour onset- found that planned CS was associated with an elevated risk of respiratory difficulties. In contrast, Maharlouei et al. [12], analysing 2438 cases, reported no difference in respiratory distress between the two birth groups. Both studies excluded high-risk pregnancies complicated by maternal or foetal factors.

There is a notable lack of published literature that distinguishes neonatal outcomes according to the planned mode of birth. In clinical practice, women are typically managed based on an intended plan, either planned vaginal birth or planned caesarean birth, and subsequent intrapartum decisions or complications may alter the final mode of birth. Therefore, research that classifies outcomes solely by the actual mode of birth (e.g., spontaneous vaginal birth, instrumental birth, emergency caesarean section, or planned caesarean section) does not accurately reflect the clinical decision-making pathway, and studies must evaluate neonatal outcomes based on the intended mode of birth at the outset, rather than only on the final birth outcome.

Hence, the objective of the present study was to compare adverse neonatal outcomes: specifically umbilical artery pH (UApH) <7.05, apgar score <7 at 5 min, requirement for continuous positive airway pressure (CPAP), occurrence of seizures, and suspected central nervous system disease in neonates born by planned vaginal birth compared to planned CS. Secondary analysis of outcomes based on the final birth outcome was also performed.

2 | Methods

2.1 | Study Design

A retrospective cohort study was conducted across seven maternity centres in the south of Sweden, including the provinces of Skåne, Halland, Blekinge, and Kronoberg. The perinatal revision South register (PRSR) was utilised to collect data on labour and clinical outcomes for both mothers and neonates. Data was collected over a 20-year period, from 1995 to 2015.

2.2 | Participant Selection

The inclusion criteria consisted of women with singleton, term births in cephalic presentation. 'Term' was defined as a gestation age of at least $37+0$ weeks. To be included in the study, documentation of birth mode was required. The exclusion criteria involved removing all individuals with incomplete or unrealistic pH data from the umbilical cord analysis. That included cases where the veno-arterial difference was less than 0.02, indicating blood samples likely taken from the same vessel [13, 14]. In addition, participants with UVpH ≥ 7.50 and UApH ≤ 6.50 were excluded, as these values are incompatible with life. Erroneous values and participants born preterm, defined as $<37+0$ weeks, were also removed. Planned vaginal birth was defined as all non-instrumental vaginal, instrumental vaginal, and emergency CS. Planned CS was defined as only elective operations coded in the database. Participants who gave birth in breech position were excluded.

2.3 | Outcomes

The studied adverse neonatal outcomes included UApH, Apgar score at 5 min, use of CPAP, presence of seizures, CNS disease, and HIE. The incidence of the studied outcomes was partially based on diagnosis codes in patients' records, established by physicians, primarily neonatologists and obstetricians. Acidosis in the umbilical artery was determined by a pH level lower than 7.05. This cutoff value was based on the normal distribution of UApH in the study population, with <7.05 representing 2.5 standard deviations below the mean to include the lowest extremes. An Apgar score <7 was selected as the threshold to distinguish between neonates with and without signs of health complications [15]. CNS disease was indicated by potential damage to the brain or spinal cord at birth that necessitated additional medical evaluation by neonatologists.

2.4 | Umbilical Cord Blood Gas Sampling

Since the 1980s, all included hospitals have had routines for sampling umbilical cord blood after birth [16, 17]. Immediately after birth, blood samples are collected from one of the umbilical arteries and the umbilical vein using 2 mL pre-heparinized syringes [16, 17]. Since the artery is smaller and empties of blood before the vein, it is common practice to sample it first [17, 18]. Samples should be analysed promptly, ideally within 15 min of collection, but no later than 30–60 min [17].

2.5 | Statistical Analyses

Background characteristics of the study population were presented as absolute numbers and percentages. Characteristics such as maternal age, parity, maternal BMI, maternal smoking, birth mode, gestational duration, gender and birth weight were categorised into specific groups. These characteristics were then compared between planned vaginal and planned caesarean births using the Chi-2 test to assess differences. Logistic regression was performed to investigate the relationship between mode of birth and adverse neonatal outcomes using odds ratios (OR), confidence intervals (CI), and *p*-values. All outcomes were recoded into binary variables in our database, indicating the presence or absence of the outcome as 1 and 0 respectively. Multiple logistic regression analyses were performed to examine the relationship between the dependent variable, mode of birth, and neonatal outcomes, adjusting for maternal age, parity, maternal BMI, gestational duration and birth weight. Results with two-sided *p*-value below 0.05 were considered statistically significant. Further analyses comparing non-instrumental vaginal birth to emergency CS, and emergency CS to planned CS were conducted separately and attached as supporting information. Data analyses were performed using SPSS (version 29.0.2.0) (IBM Corp, Armonk, NY) and STATA (StataCorp. 2023. Stata Statistical Software: Release 18. College Station, TX: StataCorp LLC).

3 | Results

3.1 | Study Population

Figure 1 illustrates the flow chart of participants included in the study. A total of 97886 neonates met the inclusion criteria after exclusions from the original population of 118,979 participants. Of these, 6052 (6.2%) neonates were born by planned CS and 91,834 (93.8%) were born by planned vaginal birth. Of the planned vaginal births, 77,564 (79.2%) were non-instrumental, 7567 (7.7%) emergency CS and 6676 (6.8%) instrumental vaginal births (ventouse and forceps).

The background characteristics of the study population are presented in Table 1. The majority of mothers giving birth were between 20 and 34 years old (77 085/97886; 78.8%) and multiparous (52 216/97886; 53.3%). Most mothers had a normal BMI (33 734/97887; 34.5%) and did not smoke during pregnancy (63 474/97886; 64.8%). There were significant differences between the planned vaginal and planned CS groups for maternal age, parity, maternal BMI, gestational age and birth weight ($p < 0.001$). Understandably, the vast majority of women who underwent planned CS had a gestational age ranging from 37 + 0–40 + 6 (97.4% as compared to planned vaginal birth 76.5%).

Table 2 illustrates the logistic regression analyses between planned vaginal birth and planned CS according to adverse neonatal outcomes. The unadjusted logistic regression showed that neonates born via planned CS had lower ORs for UApH < 7.05 [OR 0.41; 95% CI, 0.31–0.54, $p < 0.001$] and apgar score < 7 at 5 min [OR 0.59; 95% CI, 0.41–0.83, $p = 0.003$]. No differences were seen for seizures, CNS disease and HIE. However, planned CS was associated with a higher risk of requiring CPAP [OR 2.11; 95% CI, 1.77–2.53, $p < 0.001$]. After adjustment for maternal age, parity, maternal BMI, gestational duration and birth weight, UApH < 7.05 remained lower for planned CS [OR 0.64; 95% CI, 0.46–0.88, $p = 0.006$], but Apgar score < 7 at 5 min was no longer significant [OR 0.65; 95% CI, 0.40–1.07, $p = 0.09$]. On the other hand, the relationship between planned CS and need for CPAP after birth strengthened [OR 2.22; 95% CI, 1.74–2.85, $p < 0.001$]. These findings are illustrated in Figure 2.

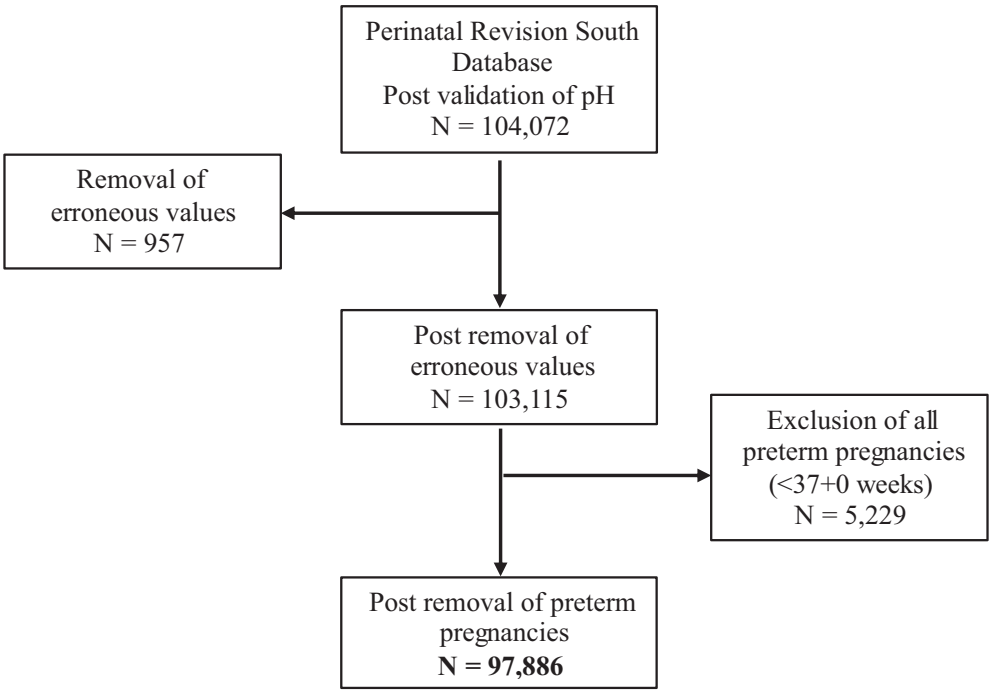

FIGURE 1 | Flowchart illustrating the formation of the total study population after exclusions.

TABLE 1 | Background characteristics compared between the two study groups, vaginal birth and emergency caesarean section, analysed using the Chi-2 test.

	Total study population		Planned vaginal birth		Planned caesarean section		Chi²-test
	N	%	*N*	%	*N*	%	*p*-value
Total *N*	97 886	100	91 834	100	6052	100	
Maternal age **(years)**							< 0.001
< 20	1842	1.9	1807	2.0	35	0.6	
20–34	77 085	78.8	73 098	79.6	3987	65.9	
35–39	15 889	16.2	14 311	15.6	1588	26.2	
≥ 40	3060	3.1	2618	2.9	442	7.3	
Parity							< 0.001
Primiparous	44 603	45.6	42 661	46.5	1942	32.1	
Multiparous	52 216	53.3	48 179	52.5	4037	66.7	
Missing data	1067	1.1	994	1.1	73	1.2	
Maternal BMI							< 0.001
< 18.5	1316	1.3	1257	1.4	59	1.0	
18.5–24.9	33 734	34.5	31 869	34.7	1865	30.8	
25–29.9	15 590	15.9	14 495	15.8	1095	18.1	
≥ 30	7858	8.0	7178	7.8	680	11.2	
Missing data	39 388	40.2	37 035	40.3	2353	38.9	
Maternal smoking							0.470
No	63 474	64.8	59, 692	65.0	3782	62.5	
Yes 1–9/day	4165	4.3	3915	4.3	250	4.1	
Yes ≥ 10/day	1535	1.6	1432	1.6	103	1.7	
Missing data	28, 712	29.3	26 795	29.2	1917	31.7	
Gestational duration (weeks)							< 0.001
37 + 0–40 + 6	76 187	77.8	70 294	76.5	5893	97.4	
41 + 0–41 + 6	16 165	16.5	16 078	17.5	87	1.4	
≥ 42 + 0	5534	5.7	5462	6.0	72	1.2	
Gender							0.393
Male	50 731	51.8	41 637	51.9	3094	51.1	
Female	47 082	48.1	44 127	48.1	2955	48.8	
Unknown	73	0.1	70	0.1	3	0.1	
Birth weight (grams)							< 0.001
< 2500	789	0.8	712	0.8	77	1.3	
2500–3999	76 918	78.6	71 983	78.4	4935	81.5	
4000–4499	16 024	16.4	15 300	16.7	724	12.0	
≥ 4500	4106	4.2	3796	4.1	310	5.1	
Missing data	49	0.1	43	0.1	6	0.1	

Abbreviation: BMI, body mass index.

TABLE 2 | Logistic regression analysis assessing relationship between mode of birth and adverse neonatal outcomes, with results presented as odds ratio (OR), 95% confidence intervals (CI) and *p*-values before and after adjustments.

	Planned vaginal birth *N* = 91 834		Planned caesarean section *N* = 6052		Unadjusted			Adjusted[a]		
Outcomes	***N***	**%**	***N***	**%**	**OR**	**95% CI**	***p*-value**	**OR**	**95% CI**	***p*-value**
UApH < 7.05	1961	2.1	54	0.9	0.41	0.31–0.54	< 0.001	0.64	0.46–0.88	0.006
Apgar score < 7 at 5 min	826	0.9	32	0.5	0.59	0.41–0.83	0.003	0.65	0.40–1.07	0.09
CPAP	1010	1.1	139	2.3	2.11	1.77–2.53	< 0.001	2.22	1.74–2.85	< 0.001
Seizures	142	0.2	12	0.2	1.28	0.71–2.31	0.408	1.96	0.85–4.49	0.114
CNS disease	678	0.7	58	1.0	1.3	0.99–1.70	0.056	1.10	0.78–1.55	0.598
HIE	100	0.1	1	0.02	0.15	0.02–1.09	0.061	—	—	—

Abbreviations: CNS, central nervous system; CPAP, continuous positive airway pressure; HIE, hypoxic ischemic encephalopathy; UApH, Umbilical artery pH.
[a]Adjusted for maternal age, parity, maternal BMI, gestational duration and birth weight.

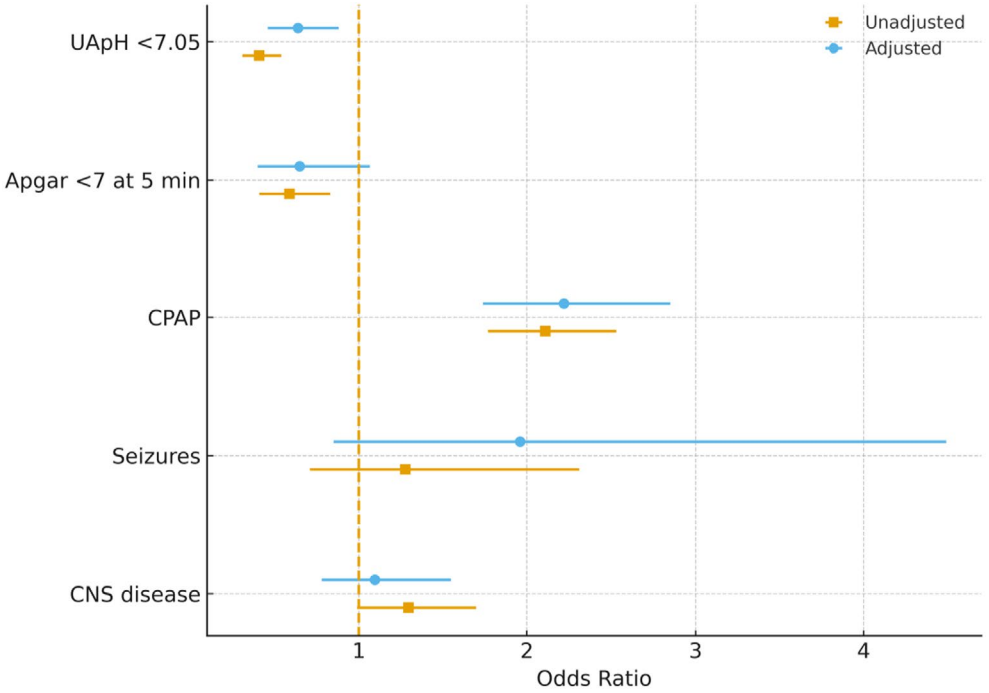

FIGURE 2 | Unadjusted and adjusted odds ratios for adverse neonatal outcomes comparing planned caesarean section with planned vaginal birth. CNS, central nervous system; CPAP, continuous positive airway pressure; UApH, umbilical artery pH.

3.2 | Vaginal Non-instrumental Birth versus Planned CS

Fron the total study population, 77 564 (92.8%) were non-instrumental vaginal births and 6052 (7.2%) were planned CS. Background characteristics are illustrated in Table S1. The differences between the two groups were significant ($p < 0.001$) in all studied parameters apart from maternal smoking and neonatal gender. Regarding adverse neonatal outcomes, after adjusting for maternal age, parity, maternal BMI, gestational duration, and birth weight, neonates born by planned CS were associated with higher odds of requirement of CPAP [OR 3.17; 95% CI, 2.42–4.16, $p < 0.001$] and occurrence of seizures [OR 3.65; 95% CI, 1.45–9.17, $p = 0.006$] (Table S2).

3.3 | Non-Instrumental Vaginal Birth versus Emergency Caesarean Section

Of the total study population, 77 564 (91.1%) were born non-instrumental vaginally and 7567 (8.9%) neonates by emergency CS. Table S3 presents the background characteristics.

Most women who underwent non-instrumental vaginal births were multiparous (43 903/77564: 56.6%). In contrast, a higher proportion of women who had emergency CS were primiparous (4708/7567: 62.2%). In pregnancies beyond 42 weeks, a higher percentage of neonates were born via emergency CS (1076/7567: 14.2%) compared to vaginal birth (3727/77564: 4.8%). Additionally, a higher proportion of women who underwent emergency CS gave birth to neonates with either low (223/7567: 2.9%) or high birth weight extremes (607/7567: 8.0%), compared to vaginal birth (444/77564: 0.6% and 2932/77564: 3.8%, respectively). Table S4 illustrates the logistic regression analyses between the modes of birth and adverse neonatal outcomes. The unadjusted logistic regression presented significantly higher ORs for all studied adverse neonatal outcomes in emergency CS compared to vaginal birth. Neonates born via emergency CS continued to have notably higher ORs for adverse neonatal outcomes after the regressions were adjusted for maternal age, parity, maternal BMI, gestational duration and birth weight. Specifically, higher ORs were observed for UApH < 7.05 [OR 2.16; 95% CI: 1.81–2.58, $p < 0.001$], an Apgar score < 7 at 5 min [OR 7.11; 95% CI: 5.75–8.80, $p < 0.001$], CPAP [OR 5.06; 95% CI: 4.17–6.14, $p < 0.001$], seizures [OR 6.24; 95% CI: 3.63–10.73, $p < 0.001$], CNS disease [OR 4.23; 95% CI: 3.38–5.29, $p < 0.001$] and HIE [OR 10.35; 95% CI: 5.14–20.84, $p < 0.001$].

4 | Discussion

In this large, population-based cohort study, adverse neonatal outcomes associated with planned vaginal birth were compared with those associated with planned caesarean section (CS). Planned CS was associated with an increased requirement for continuous positive airway pressure (CPAP) after birth but protective against neonatal acidemia. This was, of course, due to the inherent composition of the planned vaginal group including all emergency CS and instrumental births as well. No other adverse neonatal outcomes differed significantly between the two groups. The link between planned mode of birth and neonatal outcomes remains unclear due to limited research and inconsistent CS classification across countries [19]. This highlights the relevance of our study in addressing these unexplored areas, particularly given the rising rates of emergency CS [1, 3, 4].

Caesarean section rates are increasing worldwide [1]. A recent systemic review and meta-analysis of 44 European studies showed large variations in CS rates [3]. Although rates were lowest in Northern Europe (16.9%), Southern Europe reported rates as high as (43.6%), of all births. Given this increasing trend, it is essential that both patients and healthcare professionals have a clear understanding of the implications of operative birth and its effects on the neonate.

Previous studies investigating the association between mode of birth and adverse neonatal outcomes such as respiratory distress have had conflicting results in the literature [20–23]. A study including both planned and emergency CS showed no significant difference in the requirement of CPAP at term between the two modes of birth, nor compared to vaginal birth [22]. Another retrospective cohort study comparing neonatal outcomes among 672 women with a planned CS or an intended vaginal birth after prior CS showed that there were a significantly higher number of neonates requiring CPAP, as well as other forms of respirational support, in the planned CS group [23]. Similarly, we found in this current large cohort that the odds of CPAP requirement were two-fold higher in the planned CS as compared to the planned vaginal group. These results suggest that neonates born by planned CS have a higher need for respiratory resuscitation compared to those born vaginally. A theory is that the neonates born vaginally are exposed to hormonal and physiological stress-related changes that occur during labour, making them more 'vigorous' at birth [24]. It is important to illuminate that planned CS are performed before the onset of labour. Gestational age also plays a role in the risk of developing respiratory morbidity and seizures, as the relative risk of respiratory morbidity among neonates born by planned CS increases with decreasing gestational age [20, 25].

The odds of presenting with a UApH < 7.05 were lower in the planned CS compared to planned vaginal birth. This result is in line with what has been mentioned in earlier studies [26–28]. Low pH in the umbilical artery is a proxy for neonatal acidemia and a recently published study of long-term outcomes of acidemic neonates found that a UApH < 7.05 was associated with an increased risk of death, cerebral palsy and epilepsy [29]. These results contrast with those of Bodner et al. [30], who investigated if there was a difference in UApH < 7.10, and found none.

Our findings are consistent with the broader literature comparing neonatal outcomes by intended mode of birth, where planned CS have been associated with distinct physiological differences related to the stress of birth, with labour-associated stress shown to influence neonatal adaptation and respiratory transition relative to births without labour exposure (e.g., 'the good stress of being born' concept). These discussions highlight the need to interpret birth mode associations with adverse outcomes in light of underlying biological mechanisms rather than surgical birth per se [31].

In our sub-analyses, we found that the odds of seizures were three-fold higher in neonates born by planned CS as compared to those born non-instrumental vaginally. These results are in contrast to those of Maharlouei et al. [12], and Kolås et al. [11], who found no differences between neonates born by planned CS compared to vaginal birth. Similar to previous research, we found no differences in Apgar score < 7 at 5 min between neonates born by planned CS compared to planned vaginal birth [11, 26, 27].

The large study sample from several maternity units in the South of Sweden was a major strength of the current study. This enabled the inclusion of uncommon neonatal outcomes such as seizures, acidosis, and suspected CNS disease. Moreover, this study makes a positive contribution to the field of research, allowing further understanding of the development of adverse neonatal outcomes and generalisation to the general population. In addition, the quality of the Swedish health register from which the data was collected, and the thorough methodology of cleansing of the data, validation of pH values, and further step-wise regression analysis, as well as controlling for confounding, ensured rigorous results. A limitation was that our extracted register data did not contain any information regarding the indication for planned CS. Planned CS may include

high-risk neonates where contraindications existed for vaginal birth. The large study sample and population-level data may likely minimise any potential biases. Additionally, there may be more frequent monitoring of neonates born via planned CS, which may lead to higher detection of complications in this group. On the other hand, as our results highlight, there is a particular need for extra vigilance and surveillance of neonates born by planned CS.

Our findings indicate that the risk of adverse neonatal outcomes, such as the need for CPAP and the development of seizures, increases with planned CS. This must be considered in clinical guidelines and recommendations for healthcare professionals and expectant mothers, particularly in regions where planned CS are preferred and widely practiced. Previous research aligns with our results, showing increased odds of neonatal seizures and CPAP treatment.

5 | Conclusions

In this large, population-based cohort study of term, singleton births, planned CS was associated with a higher odds of requiring respiratory support after birth, whereas the risk of neonatal acidemia was lower compared with planned vaginal birth. No significant differences were observed between the groups for other major adverse neonatal outcomes. Sub-analyses further demonstrated that, when compared specifically with non-instrumental vaginal births, planned CS was associated with increased odds of both CPAP treatment and neonatal seizures and acidemia was no longer significant. These findings highlight the importance of distinguishing neonatal outcomes by intended rather than actual mode of birth, as this more accurately reflects clinical decision-making pathways.

Given the rising global rates of CS, the results underscore the need for careful counselling and risk assessment when planning mode of birth. Although planned CS may mitigate the risk of neonatal acidemia, it appears to confer an increased risk of respiratory morbidity and, in some contexts, neurologic complications. Clinicians should remain vigilant in the immediate neonatal period, particularly for infants born via planned CS. Further research is warranted to explore underlying mechanisms, refine risk stratification, and inform guidelines to optimise neonatal outcomes.

Author Contributions

Mehreen Zaigham: conceptualization, methodology, software, data curation, investigation, validation, formal analysis, supervision, funding acquisition, visualization, project administration, resources, writing – original draft, writing – review and editing.

Acknowledgements

The authors have nothing to report.

Funding

The study was financed by grants from the Swedish state under the agreement between the Swedish government and the county councils, the ALF-agreement (MZ 2024-YF0033).

Ethics Statement

The study was approved by the Swedish Ethical Review Authority, Dnrs 2009/222, 2023–00434-02 and 2025–00585-01. The database used for this study contained anonymized data with no personal identification numbers.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

1. A. P. Betran, J. Ye, A. B. Moller, J. P. Souza, and J. Zhang, "Trends and Projections of Caesarean Section Rates: Global and Regional Estimates," *BMJ Global Health* 6, no. 6 (2021): e005671.

2. X. J. Yang and S. S. Sun, "Comparison of Maternal and Fetal Complications in Elective and Emergency Cesarean Section: A Systematic Review and Meta-Analysis," *Archives of Gynecology and Obstetrics* 296, no. 3 (2017): 503–512.

3. V. El Radaf, L. N. Campos, C. Savona-Ventura, T. Mahmood, and M. Zaigham, "Robson Ten Group Classification System for Caesarean Sections Across Europe: A Systematic Review and Meta-Analysis," *European Journal of Obstetrics, Gynecology, and Reproductive Biology* 305 (2025): 178–198.

4. P. da Silva Charvalho, M. Hansson Bittár, and Y. Vladic Stjernholm, "Indications for Increase in Caesarean Delivery," *Reproductive Health* 16, no. 1 (2019): 72.

5. Socialstyrelsen, "Kejsarsnitt i Sverige 2008–2017. Kriterier Som Styr Förlossningssätt, Samt Kartläggning Av Komplikationer," (2019), https://www.socialstyrelsen.se/globalassets/sharepoint-dokument/artikelkatalog/ovrigt/2019-12-6529.pdf.

6. Socialstyrelsen, "Statistik om Graviditeter, Förlossningar Och Nyfödda Barn 2022," Socialstyrelsen, 2023, https://www.socialstyrelsen.se/statistik-och-data/statistik/alla-statistikamnen/graviditeter-forlossningar-och-nyfodda/.

7. P. Velebil, C. Savona-Ventura, M. Zaigham, T. Mahmood, J. Wladimiroff, and F. Louwen, "How to Influence Rising Caesarean Section Rates in Europe? An Invited Scientific Review by European Board and College of Obstetrics and Gynaecology (EBCOG)," *European Journal of Obstetrics, Gynecology, and Reproductive Biology* 311 (2025): 113979.

8. F. A. Wilmink, C. W. Hukkelhoven, S. Lunshof, B. W. Mol, J. A. van der Post, and D. N. Papatsonis, "Neonatal Outcome Following Elective Cesarean Section Beyond 37 Weeks of Gestation: A 7-Year Retrospective Analysis of a National Registry," *American Journal of Obstetrics and Gynecology* 202, no. 3 (2010): 250.e1–250.e2508.

9. R. Soren, N. Maitra, P. K. Patel, and T. Sheth, "Elective Versus Emergency Caesarean Section: Maternal Complications and Neonatal Outcomes," *IOSR Journal of Nursing and Health Science* 5, no. 5 (2016): 2320.

10. G. Ajne, M. Blomberg, and Y. Carlsson, *Obstetrik*, Tredje upplagan ed. (Studentlitteratur, 2021).

11. T. Kolås, O. D. Saugstad, A. K. Daltveit, S. T. Nilsen, and P. Øian, "Planned Cesarean Versus Planned Vaginal Delivery at Term: Comparison of Newborn Infant Outcomes," *American Journal of Obstetrics and Gynecology* 195, no. 6 (2006): 1538–1543.

12. N. Maharlouei, P. Mansouri, M. Zahmatkeshan, and K. B. Lankarani, "Low-Risk Planned Caesarean Versus Planned Vaginal Delivery at Term: Early and Late Infantile Outcomes," *Eastern Mediterranean Health Journal* 25, no. 7 (2019): 503–513.

13. P. Mokarami, N. Wiberg, K. Källén, and P. Olofsson, "Arterio-Venous Blood Gas Δvalues for Validation of Umbilical Cord Blood Samples at Birth Are Not Only Biased by Sample Mix Ups but Also Affected by Clinical Factors," *Acta Obstetricia et Gynecologica Scandinavica* 98, no. 2 (2019): 167–175.

14. C. R. White, D. A. Doherty, R. Kohan, J. P. Newnham, and C. E. Pennell, "Evaluation of Selection Criteria for Validating Paired Umbilical Cord Blood Gas Samples: An Observational Study," *BJOG : An International Journal of Obstetrics and Gynaecology* 119, no. 7 (2012): 857–865.

15. Executive Summary: Neonatal Encephalopathy and Neurologic Outcome, Second Edition, "Report of the American College of Obstetricians and Gynecologists' Task Force on Neonatal Encephalopathy," *Obstetrics and Gynecology* 123, no. 4 (2014): 896–901.

16. M. Zaigham, K. Källén, and P. Olofsson, "Gestational Age-Related Reference Values for Apgar Score and Umbilical Cord Arterial and Venous pH in Preterm and Term Newborns," *Acta Obstetricia et Gynecologica Scandinavica* 98, no. 12 (2019): 1618–1623.

17. M. Zaigham "Informative Fetal Blood: Umbilical Cord Blood Analytes to Predict Neonatal Problems and Diseases Occurring LAter in Life," Lund University, 2019, https://portal.research.lu.se/sv/publications/informative-fetal-blood-umbilical-cord-blood-analytes-to-predict-.

18. O. Andersson and M. Zaigham, "Cord Clamping – 'Hold on a Minute' Is Not Enough, and Sample Your Blood Gases While Waiting," *Seminars in Perinatology* 47, no. 4 (2023): 151739.

19. M. Zaigham, J. Varallo, S. Thangaratinam, W. Nicholson, and G. H A Visser, "Global Disparities in Caesarean Section Rates: Why Indication-Based Metrics Are Needed," *PLOS Global Public Health* 4, no. 2 (2024): e0002877.

20. A. K. Hansen, K. Wisborg, N. Uldbjerg, and T. B. Henriksen, "Risk of Respiratory Morbidity in Term Infants Delivered by Elective Caesarean Section: Cohort Study," *BMJ* 336, no. 7635 (2008): 85–87.

21. Y. Li, C. Zhang, and D. Zhang, "Kejsarsnitt Och Risken för Neonatal Respiratory Distress Syndrome: En Metaanalys," *Archives of Gynecology and Obstetrics* 300, no. 3 (2019): 503–517.

22. T. Benterud, L. Sandvik, and R. Lindemann, "Cesarean Section Is Associated With More Frequent Pneumothorax and Respiratory Problems in the Neonate," *Acta Obstetricia et Gynecologica Scandinavica* 88, no. 3 (2009): 359–361.

23. B. D. Kamath, J. K. Todd, J. E. Glazner, D. Lezotte, and A. M. Lynch, "Neonatal Outcomes After Elective Cesarean Delivery," *Obstetrics and Gynecology* 113, no. 6 (2009): 1231–1238.

24. G. Faxelius, K. Hägnevik, H. Lagercrantz, B. Lundell, and L. Irestedt, "Catecholamine Surge and Lung Function After Delivery," *Archives of Disease in Childhood* 58, no. 4 (1983): 262–266.

25. N. Razaz, J. Bolk, H. Graham, et al., "Severe Neonatal Morbidity Across Gestational Age: Monitoring Infants at High Risk of Mortality," *Acta Paediatrica* 114, no. 8 (2025): 1847–1856.

26. B. S. Richardson, M. J. Czikk, O. daSilva, and R. Natale, "The Impact of Labor at Term on Measures of Neonatal Outcome," *American Journal of Obstetrics and Gynecology* 192, no. 1 (2005): 219–226.

27. V. Adewale, D. Varotsis, N. Iyer, et al., "Planned Cesarean Delivery vs Planned Vaginal Delivery: A Systematic Review and Meta-Analysis of Randomized Controlled Trials," *American Journal of Obstetrics & Gynecology MFM* 5, no. 12 (2023): 101186.

28. N. Eshraghi, H. Karandish, A. Mazouri, A. Abdi, M. Kashaki, and A. Bordbar, "Comparative Analysis of Neonatal Umbilical Cord Blood Gases Across Various Delivery Modes at a Referral Center," *Archives of Gynecology and Obstetrics* 310, no. 2 (2024): 705–709.

29. M. Zaigham, K. Källén, T. M. Sundberg, and P. Olofsson, "Long-Term Outcomes After Neonatal Acidemia," *American Journal of Obstetrics and Gynecology* 233, no. 3 (2025): 195.e1–195.e11.

30. K. Bodner, F. Wierrani, W. Grünberger, and B. Bodner-Adler, "Influence of the Mode of Delivery on Maternal and Neonatal Outcomes: A Comparison Between Elective Cesarean Section and Planned Vaginal Delivery in a Low-Risk Obstetric Population," *Archives of Gynecology and Obstetrics* 283, no. 6 (2011): 1193–1198.

31. H. Lagercrantz, "The Good Stress of Being Born," *Acta Paediatrica* 105 (2016): 1413–1416.

Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Table S1:** Differences in demographic characteristics between mothers giving birth by planned caesarean section (CS) and non-instrumental vaginal birth. **Table S2:** Logistic regression comparing adverse outcomes of neonates born by planned caesarean sections vs. non-instrumental vaginal birth using odds ratios (OR) and 95% confidence intervals (CIs). **Table S3:** Background characteristics compared between the two study groups, vaginal birth and emergency caesarean section, analysed using the Chi-2-test. **Table S4:** Logistic regression analysis assessing relationship between mode of birth and adverse neonatal outcomes, with results presented as odds ratio (OR), 95% confidence intervals (CI) and *p*-values before and after adjustments.