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Sudden Unexpected Postnatal Collapse in the Netherlands: A National Registry Study

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Keywords
Sudden unexpected postnatal collapse · Home birth · Hospital birth · Outcome

Abstract
Introduction: Sudden unexpected postnatal collapse (SUPC) is a rare and potentially life-threatening event with variable reported incidences, mostly derived from in-hospital data. This study investigated the incidence, aetiology, and circumstances of SUPC in the Netherlands and assessed differences between in-hospital and home settings. ***Methods:*** Data concerning SUPC cases were obtained through a web-based registry managed by the Dutch Paediatric Surveillance Unit from April 2019 to April 2022. SUPC was defined as a collapse within 24 h of birth requiring resuscitation with at least positive pressure ventilation in infants born at ≥35 weeks of gestation and with a 5-min Apgar score ≥8. ***Results:*** Of 94 registered SUPC cases, 60 met inclusion criteria: 52 cases occurred in hospital and 8 at home. The annual incidence ranged between 7 and 17 per 100,000 live births, with an average of 11 per 100,000. Median time to collapse was 64 min, with over two-thirds occurring within 2 h of birth. Collapses occurring at home occurred significantly later than those in hospital (165 min vs. 60 min; $p < 0.05$) and were associated with substantially higher mortality rates (37.5% vs. 6%; $p < 0.05$). Approximately half of all SUPC cases involved possible or definite airway obstruction, which – compared with other aetiologies – was more often related to preventable factors like reduced maternal vigilance and covering of the infant's nose and mouth. ***Conclusions:*** SUPC occurs in hospitals and at home, with later onset and higher mortality outside the hospital. Greater awareness and prevention are needed in both settings.

Introduction

Sudden unexpected postnatal collapse (SUPC) in apparently healthy newborns is a rare but life-threatening event. Reported incidences vary widely

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(1.9–133 per 100,000 live births), reflecting differences in definitions and study designs [1, 2]. SUPC may result from an hitherto unrecognized underlying condition or accidental postural asphyxia [3–9]. Both skin-to-skin contact (SSC) and breastfeeding have been associated with SUPC, which most often occurs within the first hours after birth [4, 5, 7, 10, 11]. Safe SSC and vigilant monitoring of mother-infant dyads during SSC or initial breastfeeding are crucial to prevent airway obstruction and to enable early recognition of infants at risk [3–9, 12, 13].

In the Netherlands, a significant proportion of newborns receive postnatal care at home, either following a planned home birth, accounting for approximately 14% of low-risk pregnancies, or after early hospital discharge [Perined | Kerncijfers 2021]. Most data on SUPC originate from hospital-based studies, while data on events occurring at home during the first postnatal days remain limited [1–9, 14]. To develop effective preventive strategies, it is essential to establish incidence, aetiology, and contextual factors of SUPC in both settings. This study investigates incidence, causes, and circumstances of SUPC occurring in-hospital and at home and compares these across settings.

Methods

SUPC was defined as collapse within 24 h of birth requiring resuscitation with at least positive pressure ventilation in infants born at ≥35 weeks of gestation and with a 5-min Apgar score of ≥8. Data on SUPC cases were collected through a web-based registry maintained by the Dutch Paediatric Surveillance Unit (Nederlands Signalerings Centrum Kindergeneeskunde [NSCK]) from April 2019 to April 2022. To evaluate the database, paediatricians were allowed to retrospectively register SUPC cases that occurred between November 2018 and March 2019. During the 3-year prospective study period, regular emails were sent to all 70 Dutch paediatric departments to report SUPC cases.

Upon notification, paediatricians completed an online questionnaire containing a limited number of items to encourage compliance (online suppl. File S1; for all online suppl. material, see https://doi.org/10.1159/000551725). Data collection included maternal and infant characteristics, timing and circumstances of SUPC, presumed cause, resuscitation methods, and known or anticipated outcome at discharge. Missing data were addressed by contacting respondents via email and telephone on at least two occasions.

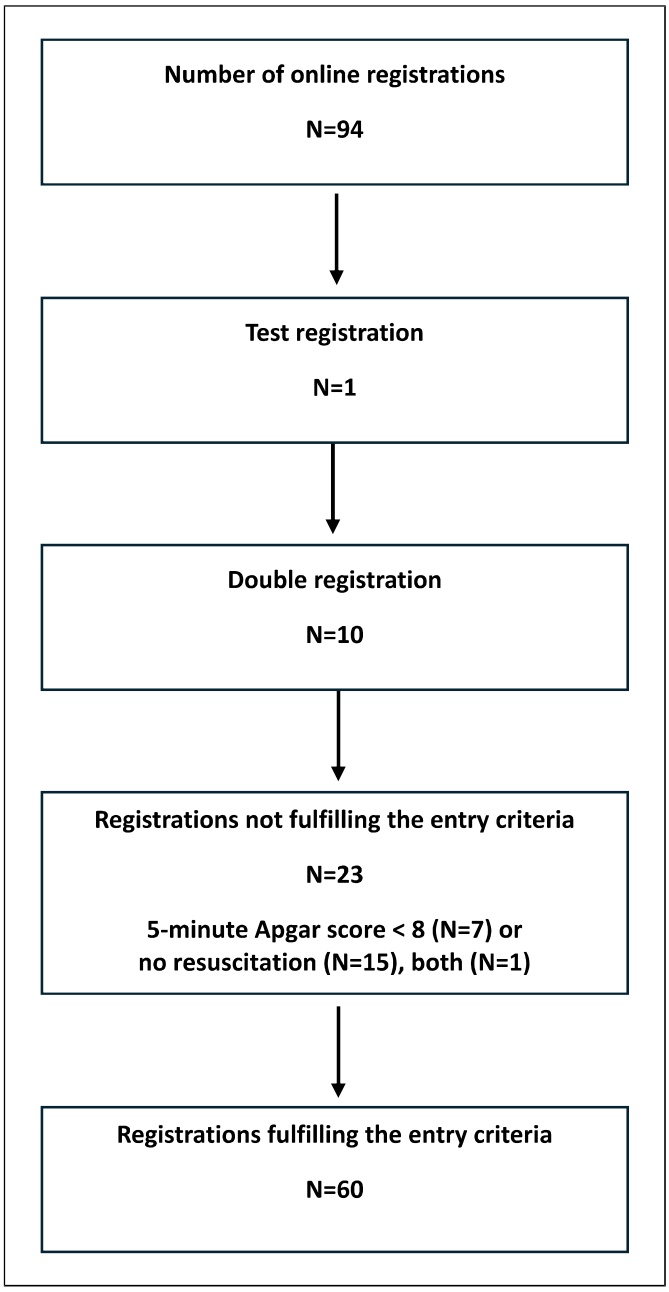

Fig. 1. Flowchart of registered SUPC cases.

In resuscitation, neonatal life support referred to airway management, insufflation breaths, continuous positive airway pressure, and positive pressure ventilation, with or without chest compressions. Neonatal advanced life support involved intubation and ventilation (with or without chest compressions) and eventually intravenous medication and/or fluids.

Airway obstruction was classified as the cause of SUPC if it was directly observed by caregivers and/or

Table 1. Characteristics of the NSCK and the 2021 Perined national birth cohort

	NSCK cohort, $N = 60$	Perined Dutch national birth cohort 2021, $N = 171.832$
Maternal age, years	32.1 (4.5)	31.2 (4.8)
Ethnicity, *n* (%)		
Caucasian	46 (77)	125.717 (73)
Non-Caucasian	14 (23)	46.115 (27)
Parity, *n* (%)		
Primiparous	31 (52)	75.548 (44)
Multiparous	29 (48)	95.001 (56)
Place of birth, *n* (%)		
Hospital	53 (88)	14.7776 (86)
Home	7 (12)	24.056 (14)
Induction of labour, *n* (%)	12 (20)	46.683 (27)
EDA, *n* (%)	10 (17)	40.277 (24)
Medication[1], *n* (%)		
During pregnancy: SSRI	4 (7)	NA
During delivery: opioids	13 (22)	19.955 (11)*
Meconium-stained amniotic fluid, *n* (%)	12 (20)	16.155 (10)*
Mode of delivery, *n* (%)		
Spontaneous vaginal delivery	47 (78)	126.661 (74)
Instrumental delivery	7 (12)	16.600 (10)
Caesarean section	6 (10)	26.393 (16)

Data are presented as numbers (percentages), except for maternal age, which is presented as mean (SD). EDA, epidural analgesia; NA, not available. *$p < 0.05$. [1]The table only lists medication that is registered in the Perined registration (Perined | Kerncijfers 2021).

parents or based on descriptions of the circumstances surrounding SUPC including covering of the mouth and nose or hyperextension or hyperflexion of the neck. Probable airway obstruction was assigned when reported by the attending paediatrician as the most likely cause, even if not directly observed. Baseline characteristics of the NSCK cohort data were compared with those from the 2021 Perined national birth register (Perined | Kerncijfers 2021) that contains digitally submitted perinatal data on all pregnancies and outcomes from 24 weeks of gestation onwards.

Statistics

We compared categorical baseline characteristics of the NSCK cohort with the 2021 Perined birth cohort using one-sample exact binomial tests, treating Perined proportions as fixed references. Comparisons between groups based on place of SUPC occurrence or aetiology were performed using independent samples *t* tests for normally distributed variables and the Mann-Whitney U test for non-normally distributed variables. Associations between categorical variables were tested using chi-square test or Fisher's exact test when expected cell counts were below 5. Analyses were based on available cases only and performed using IBM SPSS Statistics, version 22 (IBM Corp., Armonk, NY, USA). A two-sided *p* value of <0.05 was considered statistically significant. This manuscript was reported in accordance with the STROBE statement (online suppl. File S2).

Results

During the study period paediatricians registered 94 cases. After excluding a test case as well as duplicate registrations and cases not meeting the case definition, 60 SUPC cases were eligible for analysis (Fig. 1).

Table 1 presents the demographic, maternal, and birth characteristics of the NSCK cohort in comparison with the 2021 Perined birth NSCK cohort had higher rates of meconium-stained amniotic fluid (12/60 [20%] vs. 16,155/171,832 [10%]; $p = 0.012$) and opioid use during

Table 2. Characteristics of SUPC at home and in-hospital

	Collapse at home, $N = 8$	Collapse in hospital, $N = 52$	Total, $N = 60$
Age at collapse, minutes			
Mean (SD)	364 (475)	187 (294)*	211 (324)
Median [IQR]	165 [76–585]	60 [30–239]*	64 [30–257]
Circumstances of collapse			
Maternal age, years			
Mean (SD)	30.1 (3.4)	32.3 (4.6)	32.1 (4.5)
Primiparous mother	5 (63%)	26 (50%)	31(52%)
Newborn infant in care of the parents	6/7 (86%)	46/50 (92%)	52/57 (91%)
Unattended parent(s)	3/6 (50%)	28/42 (67%)	31/48 (65%)
First to recognize collapse			
Parents	4/8 (50%)	15/51 (29%)	19/59 (32%)
Healthcare worker	4/8 (50%)	36/51 (71%)	40/59 (68%)
Decreased maternal attention[1]	3/8 (37.5%)	8/45 (18%)	11/53 (21%)
Position of the baby in SSC			
Prone	3/7 (43%)	15/44 (34%)	18/51 (35%)
Side	3/7 (43%)	17/44(39%)	20/51 (39%)
Infant fully covered with sheet or blanket	1/6 (17%)	8/46 (17%)	9/52 (17%)
Mouth and nose covered	2/7 (29%)	10/48 (21%)	12/55 (21%)
Inadequate lighting conditions	2/6 (33%)	10/43 (23%)	12/49 (24%)
Infant's condition			
pH of first blood gas on admission, mean (SD)	6.97 (0.22)	7.09 (0.21)	7.07 (0.21)
Advanced resuscitation	4/8 (50%)	12/52 (23%)	16/60 (27%)
Cause of collapse			
Infants with (probable) upper airway obstruction	3/6 (50%)	25/49 (51%)	28/55 (51%)
Apparent upper airway obstruction	2	13	15
Probable upper airway obstruction	1	12	13
Underlying condition	3/6 (50%)	24/49 (49%)	27/55 (49%)
Pulmonary hypertension	2	4	6
Delayed transition	0	4	4
Pulmonary conditions (pneumothorax, pulmonary haemorrhage)	0	2	2
Early-onset neonatal infection	1	5	6
Congenital anomalies: oesophageal atresia	0	2	2
Feeding-related incident/aspiration	0	3	3
Seizures	0	3	3
Maternal medication (opioids)	0	1	1
Unknown	2/8 (25%)	3/52 (6%)*	5/60 (8%)
Outcome			
Total mortality	3/8 (37.5%)	3/52 (6%)*	6/60 (10%)
Uncertain or poor predicted neurological outcome	1/4 (25%)	7/45 (16%)	8/49 (16%)

Data are presented as numbers (percentages), unless otherwise specified. When information on a specific item was missing, the denominator was reduced accordingly. *$p < 0.05$. [1]Medical procedure or complication, use of mobile device, sleepiness, or drowsiness.

delivery (13/60 [22%] vs. 19,955/171,832 [12%]; $p = 0.025$). All other baseline characteristics were broadly comparable.

During the study period, 548,235 liveborn infants with a gestational age of ≥35 weeks were born in the Netherlands. The estimated population of SUPC within

24 h of birth was 11 per 100,000 live births. Over the study period, the incidence increased from 7 per 100,000 live births in 2019 to 17 per 100,000 live births in 2021.

Table 2 presents data on the 60 SUPC cases. Eight infants (13%) collapsed at home, seven of whom had been born at home and one following early hospital discharge. Fifty-two cases (87%) occurred in hospital, most commonly in the delivery room (83%). There was no significant difference in the incidence of SUPC between home and hospital birth with rates of 9.1 per 100,000 and 11.2 per 100,000 live births, respectively ($p = 0.71$).

Median [IQR] time of collapse was 64 [30–257] minutes (range 10 min to 23 hr 40 min), with home cases tending to occur later; median [IQR] time of collapse in hospital was 60 [30–239] minutes and 165 [76–585] minutes at home ($p = 0.023$). Two-thirds of SUPC cases occurred within 2 h of birth.

The great majority of infants (91%) were in parental care at the time of the collapse. Fifty-one infants (85%) were in SSC; 75% (38/51) were in prone or side position, and 21% (12/55) had their mouth and nose fully covered by a blanket or sheet. In 65% of cases, parents were unattended by healthcare professionals. One-third of incidents was first recognized by parents, whereas the remaining two-third was recognized by healthcare professionals.

Data on the condition of the infant were reflected by the need for resuscitation and presence of acidosis. Advanced neonatal resuscitation was required in 50% (4/8) cases at home and 23% (12/52) of hospital cases (NS). Blood gas pH was available for 46 infants, with a mean (SD) of 7.07 (0.21), and not statistically different between home and hospital cases.

Percentages of newborns with an underlying condition or (probable) upper airway obstruction were similar in the hospital setting and at home. Overall, 27 infants (45%) were reported as having an underlying condition, 28 infants (47%) were reported as having a probable or apparent upper airway obstruction, and in five infants (8%), the cause of collapse remained unknown.

Six infants (10%) died; autopsy was performed in three infants. SUPC-related mortality at home was relatively higher than for in-hospital cases (37.5% vs. 6%; $p = 0.027$). Uncertain or poor long-term neurological outcome was reported for eight out of 49 surviving SUPC cases; one at home and seven in-hospital. Compared with other aetiologies, SUPC cases with possible or definite airway obstruction were more often associated with preventable factors such as reduced maternal vigilance, covering of the infant's nose and mouth, and inadequate lighting conditions, the latter not reaching statistical significance.

Table 3 compares characteristics of SUPC cases by cause of collapse. Factors such as maternal age ≥35 years ($p = 0.0023$), reduced maternal attention ($p = 0.041$), and covering of the newborn's mouth and nose ($p < 0.001$) were significantly more prevalent in cases (probable) upper airway obstruction than in SUPC due to underlying medical conditions. Use of mobile devices was observed exclusively among cases classified as (probable) upper airway obstruction.

Discussion

This study assessed the incidence, causes and circumstances of SUPC by comparing events within the first postnatal day in hospital and home settings. During the study period the annual incidence increased from 7 to 17 per 100,000 live births, with a national average of 11 per 100,000, possibly reflecting increased awareness and reporting [15]. These findings fall within the range of previously reported incidences, ranging from 1.9 to 133 per 100,00 live births [1, 2]. Given its rarity, population-based studies provide more reliable estimates than single-centre reports. Nevertheless, inconsistent terminology and the absence of a standardized definition cause substantial heterogeneity in eligibility criteria, including gestational age, Apgar score, timing of collapse, required resuscitation, and outcome measures. In addition, some studies include only fatal cases, further complicating direct comparisons. When considering regional or national studies that are not limited to fatalities, reported incidences range from 2.6 to 38 per 100,000 live births [1–8]. Based on inclusion criteria, only the study by Pejovic and Herlenius is comparable, although based on regional hospital data [5].

Two-thirds of SUPC cases occurred within the first 2 h after birth consistent with prior reports showing approximately one-third of cases occurring within the first 2 h, with remaining cases occurring predominantly within 72 h [4–7]. Overall, 87% of cases occurred in hospital and 13% in home setting with a median [IQR] time of collapse of 64 [30–257] minutes, home events occurring about 100 min later. Given that SUPC occurs in apparently healthy infants and SUPC incidence was similar in hospital and home births, the earlier timing in hospital is unlikely to reflect a higher risk hospital population. Differences in care organization may contribute to the relatively later occurrence of SUPC in the home setting. In hospitals, continuous supervision

Table 3. SUPC characteristics according to the cause of SUPC

	(Probable) airway obstruction, *N* = 28	Other cause, *N* = 27	Unknown, *N* = 5
Age at collapse, min			
Median [IQR]	74 [49–227]	60 [19–270]	74 [48–458]
Circumstances of collapse, *n* (%)			
Maternal age, mean (SD)	33 (5.4)	30.9 (3.0)	33 (4.8)
Maternal age ≥35 years	11 (39%)*	1 (4%)	3 (60%)
Primiparous mother, *n* (%)	16 (57)	13 (48)	2 (40)
Collapse, *n* (%)			
At home	3 (11)	3 (11)	2 (40)
In hospital	25 (89)	24 (89)	3 (60)
Newborn infant in care of parents	26/27 (96%)	21/25 (84%)	5/5 (100%)
Unattended parent(s)	17/25 (68%)	11/19 (58%)	3/4 (75%)
First to recognize collapse			
Parents	8/28 (29%)	9/26 (35%)	2/5 (40%)
Healthcare worker	20/28 (71%)	17/26 (65%)	3/5 (60%)
Decreased maternal attention	8/25 (32%)*	2/24 (8%)	1/4 (25%)
Medical procedure/complication	2/25	1/24	0/4
Mobile device	5/25	0/24	0/4
Sleepy/drowsiness	1/25	1/24	1/4 (25%)
Position of the newborn infant in SSC			
Prone	10/26 (38%)	6/21 (29%)	2/4 (50%)
Side position	11/26 (42%)	8/21 (38%)	1/4 (25%)
Infant fully covered with sheet or blanket	4/25 (17%)	5/22 (22%)	0/5
Mouth and nose covered	12/25 (48%)*	0/25	0/5
Inadequate lighting conditions	8/23 (35%)	2/21 (10%)	2/5 (40%)
Infant's condition			
pH of first blood gas, mean (SD)	7.06 (0.21)	7.08 (0.23)	7.15 (0.18)
Advanced resuscitation	6/28 (21%)	8/27 (30%)	2/5 (40%)
Outcome			
Mortality	2/28 (7%)	3/27 (11%)	1/5 (20%)
Uncertain or poor predicted neurological outcome	6/23 (26%)	2/23 (9%)	0/4

Data are presented as numbers (percentages), unless otherwise specified. When information on a specific item was missing, the denominator was reduced accordingly. *$p < 0.05$.

during the first 2 h after birth is often limited due to staff shortages and high workload [16]. At home, a primary care midwife provides continuous support during labour, childbirth, and the first 2 h postpartum. Although a maternity care assistant may stay longer, parents are more likely to be left unsupervised thereafter.

At home, slightly more incidents occurred in primiparous mothers (63%) who may be inexperienced with safe positioning in SSC and may be unaware of the risk of SUPC. SUPC at home tended to be more serious and had a higher mortality when compared to in-hospital events. This may reflect the prompt availability of more experienced clinical staff in hospitals when resuscitation is needed.

The percentage of cases with (probable) upper airway obstruction was similar for cases at home and in-hospital. Most events (91%) occurred, while infants were in parental care, often during SSC. One-third of collapses were first recognized by parents, whereas two-thirds were recognized by healthcare workers. We noticed that documentation of circumstances and risk factors, as reported in the literature, was often incomplete, as was

information about counselling on safe SSC; only 2 out of 16 parents received any SSC guidance [6, 8].

Underlying conditions caused 45% of collapses, while 47% were due to reported (probable) upper airway obstruction. Overall mortality was 10% which is in line with the reported 11% mortality in SUPC at the first day of life [17]. Eight of 49 (16%) surviving infants were documented as having an uncertain or predicted poor neurological outcome. The slightly better outcome compared to previous reports may be attributable to differences in SUPC definitions [8]. Our study allowed inclusion of infants who did not require full resuscitation.

In cases of (probable) upper airway obstruction, reduced maternal awareness - whether due to medical procedures, complications, drowsiness, or mobile device use - was more frequent, occurring in 32% of such cases compared to 8% of SUPC cases with an underlying condition. Notably, mobile device use was reported exclusively in the (probable) upper airway obstruction group. Distraction from device use may increase the risk of overlooking early signs of neonatal distress. Additional identified risk factors in cases of (probable) upper airway obstruction included maternal age ≥35 years and covering of the newborn's mouth and nose.

Limitations and Strengths

Several limitations should be considered. Firstly, SUPC incidence may be underestimated due to ascertainment bias, as complete case capture could not be verified. Although common in registration studies, the NSCK response rate has been reported previously between 80 and 90% [18, 19]. Based on these considerations, estimated 1–2 cases per 100,000 may have been missed. However, given the severity of SUPC, it is likely that all cases were referred to a paediatrician. Additionally, through the Postmortem Evaluation of Sudden Unexplained Death in Youth (PESUDY) procedure, paediatricians are notified of neonatal deaths occurring at home [20].

Secondly, data collection took place during a period impacted by the COVID-19 pandemic. Pandemic-related changes in maternity care, staffing, postpartum supervision, or case recognition may have contributed to the higher SUPC incidence observed in 2021. Yet, this remains speculative, as no clear changes in perinatal outcomes were observed following the COVID-19 mitigation measures [21].

Thirdly, detailed description of the circumstances surrounding SUPC were often lacking, and data on maternal smoking, drug use, and body mass index were not available, precluding assessment of their role as potentially relevant risk factors [1, 6, 8]. Multidisciplinary perinatal audits planned by Perined for 2024–2026 are expected to gain more insight in SUPC circumstances, risk factors, causes, and modifiable healthcare factors [Perined | Auditthema's 2024–2026]. These audits will likely enhance awareness, education, and support healthcare professionals in implementing preventive measures [22].

Our study closely mirrors a national birth cohort, provides national, population-based data on SUPC and offers valuable insight into events occurring both in hospital and at home, particularly relevant given that the care of low-risk pregnancies is primarily midwife-led. Although statistically significant differences were observed in meconium-stained amniotic fluid and opioid use during delivery, all infants in the NSCK cohort had Apgar scores ≥8, indicating a good clinical condition at birth. These findings suggest that the observed intrapartum differences may have limited clinical relevance and are unlikely to meaningfully affect the comparability of the NSCK cohort with the broader Perined population. To date, only one population-based study has reported SUPC incidence within the first week in home and hospital settings, with 86% occurring in hospital, comparable to the 90% in our cohort. However, that study included only infants born at ≥37 weeks and provided no detailed information on timing or contextual factors for home events [14].

Our findings prompted the development of a national multidisciplinary guideline on SUPC prevention, applicable in both home and in hospital setting. This guideline includes recommendations for safe SSC and emphasizes the importance of careful, unobtrusive observation of the mother-infant dyad. A key element is parental empowerment through comprehensive knowledge, practical skills, and ongoing support. Parents should receive antenatal and postnatal information on early SSC and breastfeeding, safe positioning of the newborn infant, and the need for close observation and regular monitoring. They should be guided on how to attentively observe their newborn infant without distraction and be encouraged to seek help if signs of distress or unresponsiveness are observed.

Conclusion

In the Netherlands, approximately 19 newborn infants annually experienced SUPC with, about half of cases due to potentially preventable upper airway obstruction. Incidence did not differ between hospital and home settings, though home events were often more severe. We recommend increased professional

awareness, structured observation during the first hours of post-partum – particularly during SSC – and standardized parent education.

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Statement of Ethics

The registry was considered to be outside the scope of the Dutch Medical Research Involving Human Subjects Act. All data were anonymized. The study was approved by the Medical Research Ethics Committee of University Medical Centre Groningen and registered under No. M24.329480. As this registry-based study uses fully anonymized data that cannot be traced to individuals, informed consent was not required.

Conflict of Interest Statement

The authors declare that they have no conflicts of interest.

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Author Contributions

K.A.B., B.S., R.P.M., and C.V.H. initiated and designed the study. C.V.H. and K.A.B. participated in data collection, analysed the data, wrote the first draft, and submitted the final version for publication. K.A.B., A.N.R., I.K.M.R., B.A.S., R.P.M., E.M.W.K., and C.V.H. participated in data interpretation and contributed to drafting and revising the manuscript. C.V.H. supervised the study.

Data Availability Statement

All data generated or analysed during this study are included in this article and its online suppleementary material. Further enquiries can be directed to the corresponding author.

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