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RESEARCH ARTICLE

Sudden unexpected infant death risk profiles in the first month of life

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ABSTRACT

Background: Limited improvement in current SUID rates requires further identification of its characteristics, including age-specific risk patterns.

Objective: Compare SUID risk factors in the first week versus the remainder in the first month of life.

Design/methods: We compared maternal and infant data from New Jersey databases for SUID from 2000 to 2015 in infants $\geq$ 34 weeks GA in the two groups.

Results: In the period studied, 123 died in the first 27 days, 24 before seven. Deaths in the first week had a higher percentage of mothers with post-High School education (OR 3.50, CI: 1.38–8.87) and a primary Cesarean section delivery (OR 4.0, CI: 1.39–11.49), and a smaller percentage with inadequate prenatal care (OR 0.36, CI: 0.14, 0.94). A smaller percentage of first-week deaths had mothers who smoked during pregnancy or identified as Black, non-Hispanic, but these findings did not reach significance ($p < .08$ and $p < .09$, respectively).

Conclusions: SUID in the first week and the first month of life is rare. However, despite a limited sample size, data suggest that even within the first month of life, there are differences in risk patterns for SUID based on age at death. Age-specific profiles may lead to new hypotheses regarding causality and more refined risk-reduction guidelines and warrant further study.

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Gestational age (GA); sudden infant death syndrome (SIDS); sudden unexpected infant death (SUID); sudden unexpected postnatal collapse (SUPC)

Introduction

Limited improvement in Sudden Unexpected Infant Death (SUID) rates over the past two decades indicates the need to examine its characteristics further. One promising area of focus has been age-specific risk patterns, as evidenced by recent investigations into terminology, risk factors, and risk-reduction recommendations in the first week of life [1–8]. SUID, the death of an infant under one year of age occurring suddenly and unexpectedly, with no apparent cause before investigation, is comprised of Sudden Infant Death Syndrome (SIDS), Accidental Suffocation and Strangulation in Bed and Ill-defined and Unknown Causes, codified by ICD-10 as R95, R99, and W75, respectively. Since 1992, the American Academy of Pediatrics has provided and recurringly updated guidelines for the first year of life to reduce the risk of SIDS and other sleep-related infant deaths, the most recent in 2016 [9]. However, following an initial decline in SUID in the 1990s in response to adopting these practices, there has been little change in its rate [10]. Recent declines have been limited to preterm infants $<$ 34 weeks gestational age, a group at the highest risk for SUID [11] but constituting only 9% of these deaths [12]. In this population, SUID rates declined from 2.86 per 1000 live births in 1999 to 2.34 in 2018 [12,13]. In contrast, SUID rates for infants $\geq$ 34 weeks gestational age, who constitute 91% of these deaths, have remained static at 0.86 and 0.85, respectively [12,13]. These stagnating rates reflect the continued use of unsafe sleep practices [14,15], adverse antecedent social and health determinants such as preterm birth [11] that contribute to vulnerability, racial disparity in the presence of these adverse determinants [16], and the growing recognition that age subgroups may exhibit conditions and circumstances requiring more intense scrutiny [2,7,17–19].

SUID in the first week of life is rare. Bass noted that the average annual SUID deaths in the USA in the 1995 to 2014 period totaled 130 infants under seven days of age and 314, between 7 and 27 days [7]. However, investigations have identified specific risk profiles characterizing these early neonatal deaths [2,7,8,20], including in a subset occurring after a Sudden Unexpected Postnatal Collapse (SUPC) in

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apparently healthy late-preterm and term infants [2,6–8] and hypothesized as associated with early postpartum maternal practices, such as positioning [3,4]. These concerns have prompted a rise in risk-reducing guidelines from the AAP and the Association of Women's Health, Obstetric and Neonatal Nurses related to this early period and addressing safe practices in the management of skin-to-skin care as well as transition to a safe home environment [4,19,21,22].

Using population-based data in New Jersey, our goal in this study was to examine further the epidemiological and behavioral risk factors associated with early SUID in late-preterm and term infants, the period described as evidencing static SUID rates, focusing on distinguishing the profiles of infants whose deaths were classified as SUID in the first week, a period of growing attention [7], compared to cases succumbing during the remaining three weeks in the first month of life, a period also reflective of postpartum recovery, fatigue, the establishment of breastfeeding practices, and development of new household routines.

Method

We conducted a retrospective, cross-sectional study from 2000 to 2015 using de-identified public access data from the New Jersey State Health Assessment Data System for demographic information and the SIDS Center of New Jersey's de-identified SUID case database for cases with reported behavioral information. We defined a SUID case as an infant death $<$365 days of age with the following International Classification of Diseases -10th edition codes: R95 (Sudden Infant Death Syndrome), R99 (ill-defined and unknown cause), or W75 (accidental suffocation or strangulation in bed). In New Jersey, these deaths are routinely diagnosed by the medical examiner system based on the autopsy results, death scene investigations and review of the clinical history. We excluded infants below 34 weeks' gestational age to focus on the gestational ages, which have experienced a slight decline in SUID rates over time. Eliminating infants below 34 weeks of gestational age also helped minimize health issues related to preterm birth.

We recorded demographic characteristics of infants coded as a SUID death, comparing those dying $<$7 days of life with those dying 7–27 days of life. The methodology related to the SIDS Center of New Jersey database has been described previously [23]. Briefly, under a New Jersey Department of Health grant, the SIDS Center of New Jersey (SCNJ) receives epidemiological and behavioral data on New Jersey's SUID cases. The diagnosis of SUID was made by a regional or county medical examiner, based on autopsy findings, the clinical history, and the death-scene investigation, with the final coding reported by the New Jersey Center for Health Statistics. Rare exceptions were cases occurring in hospitals shortly after birth, for which the institution's pathologist or attending physician assessed causality and for whom behavioral data was unavailable. The institutional review board of Robert Wood Johnson Medical School, Rutgers University, approved this study as meeting the standards for exempt status.

Maternal information included age, race, ethnicity, marital status, educational attainment, smoking status in pregnancy, adequacy of prenatal care as defined by the Kotelchuck method [24], parity, and delivery mode [9,11,25–27]. Although data on income were not available [28], we used education as a proxy. Although delivery mode has not been associated with SUID [29], it has been described as a harbinger of risk factors such as fatigue, exposure to analgesia and anesthesia [8,20,30–33], and postpartum depression [34–38]. Infant demographic data included gestational age, gender, feeding (breast vs. formula), and sleep environment risk factors such as bed-sharing at last placement and position in which the infant was found [9,23,39].

For this univariate analysis, discrete data are presented as the number of cases and percentages. Differences were assessed by the Pearson X^2 test or Fisher's exact test, where the expected cell frequency is $<$5. Odds ratios and confidence intervals were calculated. Significance was achieved at a p-value of .05. Statistical analysis was completed with Statistica, version 13.3 (Tibco, Palo Alto, CA).

Results

In New Jersey, from 2000 to 2015, 889 deaths of infants born at $\geq$34 weeks of gestation were classified as SUID. One hundred twenty-three (13.8%) occurred in the first 27 days of life, of which 24 (2.7%) were before 7 days, and 99 (11.1%) were between 7 and 27 days. The mortality rate per 1000 live births was 0.015 and 0.060, respectively, for under 7 days and 7–27 days at death (compared to a rate of 0.5 for all gestational ages $\geq$34 weeks gestational age).

As noted in Table 1, infants dying during the first 6 days of life (Group I) were more likely to be classified as R99 (Ill-defined and Unknown Cause compared to deaths from 7 to 27 days (Group II) (58.3% vs. 33.3%, $p = .04$). Table 2 contains demographic data for infants

dying in each of the two time periods and their mothers on variables associated with risk prediction for SUID. Significant differences between the two groups were noted with respect to a higher percentage in Group 1 with post-High School education ($p = .006$), adequate prenatal care ($p = .032$), and delivery by primary Cesarean section ($p = .007$). The percentage of primary Cesarean sections limited to primiparous mothers in each Group also was higher in Group I. Specifically, of the ten of 24 women in Group I who were primiparous, 50% were delivered *via* Cesarean section compared to 16% of the 25 primiparous women in Group II ($p = .081$). While a lower proportion of mothers whose infants died in Group I were Black ($p = .089$), smoked in pregnancy ($p = .077$) or were multiparous ($p = .109$), risk factors commonly associated with SUID, these differences did not reach significance. Nutritional information was reported for only 10 of the 24 cases in Group I and 56 of 99 cases in Group II and showed that while breastfeeding was more common in the first Group (60% vs. 28.6.5%; $p = .072$), the difference did not reach significance. Bedsharing patterns were comparable for both groups.

Table 1. Distribution of ICD-10 codes for New Jersey births ≥34 weeks gestational age classified as SUID in the first week of life or later (2000–2015).

		Age at death	
		Group I <7 days N = 24 n (%)	Group II 7–27 days N = 99 n (%)
SUID code	R95	10 (41.7)	55 (56.6)
	R99	14 (58.3)	33 (33.3)*
	W75	0	11 (11.1)

R95: sudden infant death syndrome; R99: ill-defined and unknown causes; W75: accidental suffocation and strangulation in bed.
*R99 vs. other codes ($p = .041$).

Data were reported for 10 of the 24 cases in Group I and 71 of the 99 cases in Group II, with 50% vs. 56.3% found sharing, respectively. Information on sleep position at discovery was available for 11 of 24 cases in Group I and 68 of 99 in Group II. The higher percentage of the supine position in Group I did not reach significance (72.7% vs. 50%, $p = .20$).

Discussion

The analysis of New Jersey SUID cases from 2000 to 2015 demonstrated that deaths within the first week differ not only in comparison to deaths in the remainder of the first year of life, as previously established [7], but also in comparison to deaths in the remainder of the first month of life. Specifically, SUID cases in the first week of life, among infants ≥34 weeks gestational age, had a different risk pattern than deaths occurring from 7 to 27 days, one less likely to demonstrate risk factors associated with classic descriptions of SUID [9].

Deaths in the first week were to mothers who had significantly more education, a proxy for socioeconomic status, and adequate prenatal care. While lower proportions of smoking in pregnancy, a major risk factor for SUID [27], multiparity, and mothers self-identified as Black, were also found in the first week compared to deaths from 7 to 27 days of age, these differences did not reach significance. In addition, cases in the first week were more likely to have been delivered *via* primary Cesarean section. Although the mode of delivery has not been identified as a risk for SUID [29], primary Cesarean sections may be a proxy for other potential risks such as postpartum depression, fatigue, or use of analgesics. These factors may distract from awareness of the proximate infant's

Table 2. Maternal and infant demographics for New Jersey births ≥34 weeks gestational age classified as SUID in the first vs. second to fourth week of life (2000–2015).

		Age at death		
		Group I <7 days N = 24 n (%)	Group II 7–27 days N = 99 n (%)	OR (95% CI)
Maternal age	<25 year	8 (33.3)	51 (51.5)	0.47 (0.18–1.20)
Race/ethnicity	Black	5 (20.8)	39 (39.8)	0.40 (0.14–1.17)
	White	13 (54.2)	43 (43.9)	
	Hispanic	3 (12.5)	14 (14.1)	
	Other	3 (12.5)	2 (22.2)	
Marital status	Unmarried	13 (54.2)	58 (58.6)	0.83 (0.34–2.05)
Education	>High school	12 (50.0)	22 (22.2)	3.50 (1.38–8.87)
Parity	Primiparous	10 (41.7)	25 (25.3)	2.11 (0.83–5.36)
Tobacco use	Smoked in pregnancy	4 (16.6)	35 (35.4)	0.37 (0.12–1.15)
Prenatal care*	Inadequate	7 (29.2)	53 (53.5)	0.36 (0.14–0.94)
Delivery mode	Primary C-section	8 (33.3)	11 (11.1)	4.00 (1.39–11.49)
Prematurity	34–36 weeks GA	2 (8.3)	14 (14.1)	0.55 (0.12–2.61)
Gender	Male	11 (45.8)	55 (55.5)	0.68 (0.28–1.66)

safety and have been associated with or hypothesized as relevant to early deaths [8,20,30,34–38]. These findings underscore the importance of guidelines issued by the Association of Women's Health, Obstetric and Neonatal Nursing advising on managing maternal and infant interactions following a cesarean birth [21,22]. The lower frequency of traditional risk factors for SUID in first-week deaths was previously noted than deaths during the remaining 51 weeks of the first year of life [7]. These distinct observations within the first week, compared here to the remainder of the first month, further suggest that Sudden Unexpected Early Neonatal Deaths comprise a unique entity, despite factors common to the entirety of the first month of life, such as maternal recovery, heightened fatigue, adjustment to new family routines, and efforts to establish breastfeeding, and should be examined separately.

Adding to the unique properties of early deaths, it is of interest that the majority were classified as R99, ill-defined and unknown cause. In contrast, those in the remaining weeks of the first month were most likely to be classified as R95. This pattern is consistent with the distinction Lavista et al. found between deaths in the first week and those in the remainder of the first year [7]. Since SIDS is a death of a previously healthy infant for which no cause has been identified following an autopsy, death scene investigation, and review of the medical history [40], the greater use of an R99 code in the first week suggests an incomplete investigation or greater uncertainty as to whether all possible causes have been considered and ruled out.

Decades of stagnating SUID rates following an initial decline associated with the Back to Sleep public health campaign called for a more targeted examination of risk and vulnerability. Findings of variations in risk patterns over different ages in the first year of life support the need to improve our understanding of age-specific vulnerabilities, mechanisms, and interventions [2,7,17,18]. and have generated relevant policies [19,21,22]. The unique physiological processes associated with the postpartum period should encourage more research into intrinsic mechanisms related to these deaths [41,42]. While risk factors exist on a continuum throughout the first year of life, discrete examples of more age-specific risks include guidance by the AAP that rolling over following supine placement is acceptable once the infant has acquired skills for turning from prone to supine and back. Moreover, although deaths within a narrow range of time or population subgroups may constitute only a small portion of all SUID cases, the policies targeted to address these cases can improve outcomes.

Adverse social and health determinants such as preterm birth [11] contribute to vulnerability, and racial disparities in these adverse determinants [16] are associated with racial disparity in rates. There was a non-significant trend in our study toward fewer cases with maternal race self-identified as Black in deaths in the first week. However, our study did not have sufficient power to examine whether deaths in the first week demonstrated a comparable or diverse racial pattern for social and health determinants. Overall, we did find that fewer adverse social and health determinants were identified in SUID cases in the first week of life. Their diminished role underscores the importance of continuing to identify early intrinsic mechanisms.

Breastfeeding as a sentinel event combined with skin-to-skin contact in primiparous women in the first days of life has been cited as potentially elevating the risk of a sudden unexpected postnatal collapse (SUPC) [1,2,20,33]. These cases are rare but can result in death or severe disability [43]. SUPC is defined as an unexpected collapse in the first days of a term or near-term infant deemed well at birth [4]. There are definitional variations regarding age limits, from deaths within the first 24 h to those within the first week. Focusing on deaths in the first week, the time of occurrence has varied extensively, with approximately a third of the cases occurring during the first two hours of life [43].

Positioning-induced airway obstruction in the first hours or days of life, perhaps associated with skin-to-skin contact and breastfeeding, has also been hypothesized to be more likely in primiparous mothers unfamiliar with signs of an emerging challenge to the infant [1,2,20]. Other potential risks include reduced maternal awareness due to postpartum fatigue, postpartum depression, or analgesics after a Cesarean section delivery [7,8,30,36–38]. The American College of Obstetricians and Gynecologists recommends a stepwise approach to early postpartum pain that may, as needed, include opioids [31]. Finally, maternal distraction caused by television or cellphone has also been hypothesized [5].

However, skin-to-skin care benefits maternal-infant bonding and breastfeeding, even after cesarean sections [4,44]. Therefore, to assure that these goals are safely met without elevating the risk of airway obstruction, SUPC, or SUID in the first days of life, guidelines for safe management during skin-to-skin contact after delivery and during rooming-in have been developed by the American Academy of Pediatrics Committee on Fetus and Newborn and the Association of Women's Health, Obstetric and

Neonatal Nursing and promulgated in the neonatal, pediatric and nursing literature [4,19,21,22]. In addition, protocols have also been developed for safety management in the home [19,45]. A recent statewide survey of safe management of skin-to-skin care during hospitalization found gaps in education and supervision that would result in an elevated risk of adverse outcomes, thus underscoring the importance of increasing staff education and standardization of policies across hospitals [46].

Given our observations that a higher percentage of mothers of infants dying early delivered by primary section, additional investigation is warranted to determine the mechanism by which this mode of birth might elevate risk, from antecedent factors that lead to this mode of delivery to its impact on a wide range of factors ranging from aberrant microbiome development in the newborn [47] to compromised emotion or awareness in the mother. Mothers delivering their infants *via* an unplanned cesarean section are at higher risk of developing postpartum depression, associated with a three-fold risk of SIDS [37]. These findings underscore the need for hospitals to affirm that already existing policies by the AAP and AWHONN related to the management of postpartum maternal-infant contact be actively followed by staff and shared with families for continuity of safe care during and after discharge from the birthing hospital.

Limitations

Approximately 3.5% or 2021 of all SUID deaths in the US from 2000-to 2015 occurred during the first week of life. Using state-level data from New Jersey, only 61 cases occurred in the first week. The low number also reflects New Jersey's low rate of SUID relative to the US (i.e. 0.51 vs. 0.91 per 1000 live births, respectively, for 2018 [12]. Although data were unavailable on possible neonatal morbidities, excluding deaths $<$34 weeks' gestational age to achieve the study group, we also sought limited potential contributing factors associated with shorter gestation. Thus, the number of cases in the first week declined to 24. The small sample size may have resulted in type 2 errors for several of our variables, which could have impacted our results. Furthermore, with the retrospective methodology of our study, the validity of uniform application of diagnostic protocols could not be independently established.

Another limitation was that we could not perform logistic regressions to control potential confounding factors due to small numbers and a lack of within-subject data. Thus, findings reflect univariate analyses and offer descriptive data from which future hypotheses may be developed.

Behavioral data reported to the SCNJ on safe sleep practices at the last placement of the infant and discovery are less complete in the gestational age group studied, compared to older SUID cases, further reducing the sample size and limiting the generalizability of the findings.

However, despite the limited number of SUID deaths in the first week of life from 2000 to 2015, our findings supported the national study by Lavista Ferres et al. [7] concerning the unique risk profile associated with deaths in the first week compared to the remainder of the first month in our study and the rest of the first year in theirs.

The specific location of death in the first week of life could not be determined in the databases. However, based on descriptive information available in the SCNJ database for 12 of the 13 deaths in the first week, nine appear to have occurred before discharge and three at home. Therefore, the evidence on location from this limited sample suggests that both home and hospital are sites of death in the first week, affirming the importance of following safe sleep protocols, including safe positioning in skin-to-skin care, should those factors have played a role in these deaths, and the importance of sharing this information with families in advance of discharge, as is recommended by the AAP and the SCNJ.

Conclusion

SUID during the first week of life may be a different phenomenon from SUID in the remaining weeks of the first month, as suggested by different demographic characteristics, risk factors, and choice of diagnostic code within the spectrum of SUID. This entity should be more explicitly examined to improve opportunities for accurate assessment of pathogenetic mechanisms.

Author contributions

Thomas Hegyi conceptualized, and designed the study, contributed to the analysis, drafted the initial manuscript, and approved the final manuscript as submitted. Barbara M. Ostfeld contributed to the conception, design, provided content and suggestions for analyses, contributed to the manuscript, and approved the final manuscript.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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