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Explaining Sudden Unexpected Infant Deaths, 2011–2017

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Abstract

BACKGROUND: Sudden unexpected infant death (SUID) represents a broad group of explained and unexplained infant deaths (<1 year old). Explaining why SUID occurs is critical to understanding etiology and prevention. Death certificate data cannot differentiate explained from unexplained SUID cases nor describe the surrounding circumstances. We report SUID rates by explained and unexplained categories and describe demographics and history of recent injury or illness using the Centers for Disease Control and Prevention SUID Case Registry.

METHODS: The registry is a population-based surveillance system built on Child Death Review programs. Data are derived from multiple sources, including death certificates, scene investigations, and autopsy reports. Cases included SUIDs reported by states or jurisdictions participating in the registry during 2011–2017. Cases were classified into explained and unexplained categories by using the registry's classification system. Frequencies, percentages, and mortality rates per 100 000 live births were calculated.

RESULTS: Of the 4929 SUID cases, 82% were categorized as unexplained. Among all cases, 73% had complete case information. Most SUIDs (72%) occurred in an unsafe sleep environment. The SUID mortality rate was 97.3 per 100 000 live births. Among explained and possible suffocation deaths, ~75% resulted from airway obstruction attributed to soft bedding.

CONCLUSIONS: Unsafe sleep factors were common in explained and unexplained SUID cases, but deaths could only be classified as explained suffocation for ~20% of cases. Further analysis of

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unexplained deaths, including continued improvements to death scene investigation and documentation, may generate hypotheses for physiologic and genetic research, advance our understanding of gaps in SUID investigation, and enhance our understanding of infants at highest risk.

Sudden unexpected infant death (SUID) represents a broad group of explained and unexplained infant deaths. Subgroups include explained accidental suffocation (airway obstruction from overlay, soft bedding, or wedging or entrapment) and unexplained causes (sudden infant death syndrome [SIDS], unknown or undetermined causes). Despite some of these deaths being preventable (ie, explained accidental suffocation), marked decreases in SUID rates have not occurred since the 1990s.^{1,2} SIDS and unintentional injuries (72% accidental suffocation) are among the leading causes of overall infant mortality and postneonatal mortality in the United States.^{1,3}

Lack of uniformity in defining and classifying SUID is a long-standing limitation of surveillance. Rates of SUID and SUID subtypes are frequently calculated by using death certificate data. Cause-of-death determination is subject to death certifier preferences, training and experience, and state and local guidance.^{4,5} Inconsistent reporting practices have resulted in a diagnostic shift among SUID subtypes^{5–8} and adversely affects reliable monitoring of SUID and SUID subtypes which impacts understanding of the magnitude of and causes underlying SUID.

Identifying at-risk populations, developing prevention and education strategies, and research all depend on accurate and consistent monitoring of SUID and SUID subtypes.⁹ To supplement death certificate data and better understand SUID trends and characteristics, the Centers for Disease Control and Prevention (CDC) created the SUID Case Registry in 2009 (henceforth the registry).¹⁰

Although several classification systems have been developed to address inconsistencies in classifying SUID and SUID subtypes, none have been widely implemented or adopted.^{11–19} The CDC SUID Case Registry classification system and algorithm use standardized definitions and criteria to categorize registry cases, more effectively describe SUID subtypes, and reliably monitor trends.²⁰ It is important to note that the classification system and resulting categories and mechanisms are intended for epidemiological purposes and do not replace the official cause and manner of death. In this analysis, we apply the classification system to >12 000 registry cases during 2011–2017 and report overall and category-specific SUID rates.²¹ We describe explained and unexplained SUID categories by demographics and history of recent injury or illness and report the frequency of deaths due to suffocation by the mechanism to which the external airway obstruction is attributed. Understanding trends and explaining why SUIDs occur is critical to understanding etiology and preventing future deaths.

METHODS

The study population consisted of infant (<1 year) deaths occurring during 2011–2017 and reported to the registry. The registry is a population-based surveillance system built on existing Child Death Review (CDR) programs.^{9,22,23} The registry includes 18 states and

jurisdictions and represents 30% of all US SUID cases. Registry cases are comparable to US SUID cases in terms of age at death, gestational age, sex, and Medicaid coverage. However, compared with US SUIDs, the registry is composed of more non-Hispanic Black (37% vs 30%) and fewer non-Hispanic white (42% vs 47%) infants.²⁴ In the registry and US SUID population, the proportion of non-Hispanic Black and American Indian or Alaskan native infants is approximately twice that of the US birth population proportions (16% and 1%).²⁵

Multidisciplinary CDR teams compile information on infant deaths from multiple sources (eg, death certificates, autopsy, and law enforcement reports, and child protective services and medical records). Registry awardees receive CDC funds and technical assistance to increase staffing, support CDR activities, and ensure comprehensive review of all resident SUID cases. Case information is entered into the National Fatality Review Case Reporting System (NFR-CRS). Each awardee granted permission for inclusion of aggregate, deidentified data in our analysis.

Case identification was broad and not limited to underlying cause-of-death classification. Infections and exposure to environmental hazards (eg, unsafe sleep environment, poisoning) were considered. SUID cases were those with any of the following causes reported on the death certificate: unknown; undetermined; SIDS; SUID; unintentional sleep-related asphyxia, suffocation, or strangulation; unspecified suffocation; cardiac or respiratory arrest without other well-defined causes; or unspecified causes with potentially contributing unsafe sleep factors. Cases were residents of one of the states or jurisdictions participating in the registry: Alaska; Arizona; San Francisco, California; Colorado; Delaware; Georgia; Kentucky; Louisiana; Michigan; Minnesota; New Hampshire; New Jersey; New Mexico; Nevada; Pennsylvania; Tennessee; the Tidewater region of Virginia; and Wisconsin. Because the study spanned multiple funding cycles, the number of awardees varied across years.

All cases were classified by trained CDC registry staff using the registry classification system and algorithm.²⁰ Since first published, the algorithm has been updated to improve clarity and promote more consistent classification (Fig 1). For this study, SUID cases were grouped into mutually exclusive categories: unexplained, no autopsy or death scene investigation (DSI); unexplained, incomplete case information; unexplained, no unsafe sleep factors; unexplained, unsafe sleep factors; unexplained, possible suffocation with unsafe sleep factors; or explained, suffocation with unsafe sleep factors.

A DSI was defined as any agency obtaining information about the circumstances of the death, including a detailed description of any obstructions to the infant's airway and potential hazards in the sleep environment. Cases assigned to the unexplained, no autopsy or DSI and unexplained, incomplete case information categories were combined into one category: unexplained, incomplete information. A safe sleep environment was defined as one where (1) the infant was found supine on a firm sleep surface, including a crib or bassinet mattress, portable crib, or pack-and-play, and (2) the sleep surface was free of soft objects, loose bedding, bumper pads, or any objects that could increase the risk for suffocation. We derived these criteria from the 2016 American Academy of Pediatrics recommendations for a safe infant sleeping environment.²⁶ Cases classified as either unexplained, possible suffocation or explained, suffocation were also assigned a mechanism to which the airway

obstruction was attributed (soft bedding, overlay, wedging, and other) (Figs 1 and 2).²⁰ Cases could be assigned >1 mechanism, for example, an infant whose nose and mouth were obstructed by soft bedding (soft bedding) and had their neck or chest compressed by a person (overlay) (Fig 2).

We calculated frequencies and percentages for each category and mechanism. Demographics and clinical history were derived from the NFR-CRS, including infant race and/or ethnicity, age, sex, insurance coverage at birth, and history of injury in the 72 hours before death. Additionally, a composite indicator of illness 72 hours before death was created from a positive response to having fever, lethargy, vomiting, diarrhea, trouble breathing, apnea, cyanosis, or seizures. Individual illness symptoms were explored before grouping; cells sizes were small, and no single symptom was more prevalent. Category-specific mortality rates per 100 000 live births were calculated by using birth certificate data from the states or jurisdictions represented in each analysis year.²⁵ Analysis of variance (continuous) and multinomial logistic regression (categorical) were used to test statistical differences across SUID categories. Distribution of mechanisms among explained, suffocation and unexplained, possible suffocation cases was tested by using the χ^2 test. The distribution of categories across death-year cohorts was also examined for all cases and for the 6 states participating in all study years. Analyses were conducted by using SAS for Windows version 9.3 (SAS Institute, Inc, Cary, NC). A *P* value of <.05 was considered statistically significant.

RESULTS

Of the 4929 SUIDs identified from 2011 to 2017, 18% were categorized as explained, suffocation; 13% as unexplained, possible suffocation; 41% as unexplained, unsafe sleep factors; 1% as unexplained, no unsafe sleep factors; and 27% as unexplained, incomplete information (Table 1). Overall, 82% of SUIDs were unexplained. The overall SUID rate was 97.3 per 100 000 live births in the represented states and jurisdictions. The category-specific mortality rates per 100 000 live births were as follows: explained, suffocation: 17.7; unexplained, possible suffocation: 12.8; unexplained, unsafe sleep factors: 39.9; unexplained, no unsafe sleep factors: 1.1; and unexplained, incomplete information: 25.7. The mortality rate of unexplained SUID was 79.6 per 100 000 live births.

Among all SUID cases, 78% involved infants 4 months old, 25% involved infants who were born preterm (<37 weeks' gestation), and 58% involved infants who were male (Table 1). Most infants were non-Hispanic white (42%) or non-Hispanic Black (37%); 68% were insured by Medicaid. Overall, 16% of infants had a reported recent illness before death, and 2% had a recent injury before death.

There were significant differences in distribution between categories for age at death, gestational age at birth, recent illness, and recent injury (Table 1). The mean age at death (in months) for SUIDs classified as unexplained, possible suffocation (4 months) was significantly higher than the mean age at death for SUIDs classified as unexplained, unsafe sleep factors (3 months); unexplained, incomplete information (3 months); and unexplained, no unsafe sleep factors (3 months). The mean gestational age at birth (in weeks) for SUIDs classified as explained, suffocation (38 weeks) was higher than that for those classified as

unexplained, incomplete information (37 weeks). No significant differences between categories for infant sex, race and/or ethnicity, or Medicaid insurance coverage at birth (Table 1) were observed. The percentage of deaths at 4 months old ranged from 71% for unexplained, possible suffocation to 81% for unexplained, unsafe sleep factors. The percentage of deaths for infants born preterm ranged from 19% for explained, suffocation to 28% for unexplained, incomplete information. The percentage of deaths for infants with a reported recent injury ranged from 1% for explained, suffocation and unexplained, unsafe sleep factors to >3% for unexplained, no unsafe sleep factors.

Among cases categorized as unexplained, incomplete information, 4% did not have an autopsy and 12% did not have a DSI reported in the NFR-CRS. Among unexplained, incomplete information cases with documented autopsies and DSIs, the following were not reported: 13% toxicology testing, 52% imaging (eg, radiograph, ultrasound), 13% pathology, 38% found body position, and 9% found body location (eg, crib, adult bed).

For the 1548 cases classified as explained, suffocation or unexplained, possible suffocation, 74% were attributed to soft bedding, 20% to overlay, 7% to wedging, and 5% to other (Table 2). Examples of “other” included airway obstruction by a plastic bag and suffocation in a pile of clothing on the floor after falling from an adult bed. There were 99 suffocation cases with multiple mechanisms: 8% of explained, suffocation and 4% of unexplained, possible suffocation cases.

From 2011 to 2017, 31% of cases (range 26%–36%) were classified as either explained, suffocation or unexplained, possible suffocation; 41% (range 37%–46%) were classified as unexplained, unsafe sleep factors; and 26% (range 21%–36%) were classified as unexplained, incomplete information. Only 1% to 2% of cases were classified as unexplained, no unsafe sleep factors. Fluctuations in the proportions of cases assigned to each category over the study period were observed and remained when analysis was restricted to cases from the 6 consistent registry state participants (CO, MI, MN, NH, NJ, and NM) over the study period (Table 3).

DISCUSSION

Although 72% of SUIDs occur in unsafe sleep circumstances, only 18% were categorized as explained, suffocation. Another 13% were classified as unexplained, possible suffocation. Of the cases categorized as explained, suffocation and unexplained, possible suffocation, 74% of airway obstructions were attributable to soft bedding. Application of the registry classification system to 4929 registry cases from 2011 to 2017 allowed for calculation of the overall SUID and category-specific mortality rates. On the basis of US death certificate records files, the mortality rate for accidental suffocation and strangulation in bed within registry states and jurisdictions for 2011–2017 was 27.3 per 100 000 live births.¹ In contrast, the registry mortality rate for cases classified as explained, suffocation, the SUID classification category most directly comparable to accidental suffocation and strangulation in bed, was 17.7 per 100 000 live births. The difference in the rates reported in the registry and from death certificate surveillance is not surprising given the differing reporting and classification practices between the 2 surveillance systems. The registry’s classification

system requires specified criteria with strong evidence of an airway obstruction for classification as explained, suffocation. Death certifiers, during the study period, varied in the types of evidence used to determine suffocation deaths.⁵

More explicit criteria for evidence needed to certify suffocation as a cause of death has been proposed recently by 2 groups: the Third International Congress on Sudden Infant and Child Death (Radcliffe Congress), representing international SIDS and SUID experts,²⁷ and the National Association of Medical Examiners' Panel on Sudden Unexpected Death in Pediatrics (NAME Panel), representing US medical examiners and other experts.²⁸ Both proposed schemes have definitions and criteria for accidental suffocation comparable to the registry category of "explained, suffocation." Also, the proposed unexplained categories, as a group, align with the registry's unexplained categories.

In addition, both groups proposed standard definitions to address known inconsistencies in cause-of-death reporting practices.⁵ The Radcliffe Congress proposed criteria and classification for the World Health Organization's *International Classification of Diseases, 11th Revision*, and the NAME Panel proposed standards for reporting cause for US death certification. If one or both approaches to defining and certifying SUID were to be widely adopted, causes of death will be more consistently reported and state- and jurisdiction-specific mortality rates based on death certificate surveillance may more closely align with registry rates.

A new finding of our study is the variability in age at death by SUID category. Most SUID studies suggest a peak between 2 and 4 months.^{6,29-31} Our categorization revealed that the mean age at death for SUIDs classified as unexplained, possible suffocation was 4 months, older than that for most of the other SUID subgroups. Because SUID subcategories likely represent different etiologies, variations in age at death by category can help generate new hypotheses to help understand etiology.

Unique to the registry classification system is the ability to differentiate the mechanism(s) accidental airway obstruction is attributed to (ie, soft bedding, overlay, or wedging). Neither vital records, the Radcliffe Congress, nor the NAME Panel classifications include this differentiation, which is important for understanding the circumstances leading to death and developing effective prevention strategies.

The registry classification system was designed to identify gaps in SUID case investigation. Approximately one-quarter of cases in this analysis were categorized as unexplained, incomplete information, primarily because of a lack of documentation of autopsy imaging. Imaging, such as radiographs, is critical to identify and rule out physical abuse cases.³² To further reduce the proportion of cases classified as unexplained, incomplete information, the CDC continues to provide extensive, tailored feedback and technical assistance to registry awardees and encourages awardees to partner with death investigators to improve SUID investigations in their jurisdictions. The CDC provides ad hoc and quarterly case categorization and data quality feedback to registry states and jurisdictions and emphasizes identification of strategies to improve DSI and autopsy practices and reporting.

The smallest SUID category was unexplained, no unsafe sleep factors, accounting for only 1% of cases. This unique category includes infants who died while sleeping with no unsafe sleep factors and those who were awake with a witness who observed the infant becoming unresponsive. These deaths are likely due to natural causes and support more in-depth investigation into the contribution of biological or genetic factors, for example, brainstem abnormalities or neurologic or cardiac conditions with or without abnormal genetic variants.^{33–35} These factors should also be explored for other unexplained SUID categories.

Cases classified as unexplained, unsafe sleep factors were the largest (40%) of all categories. In future analyses, it will be important to examine such cases to fully describe the circumstances at death and potential risk factors, investigate the similarities and differences between this and other categories, and determine the role of intrinsic (eg, cardiac channelopathies, preterm birth, genetic abnormalities) and/or extrinsic (eg, prone sleep, soft bedding, injuries) factors as causal or risk factors.²⁸ An estimated 1% to 10% of SUIDs may be homicides.³⁶

There are several key implications for pediatric health care professionals. More than 70% of cases were found in an unsafe sleeping environment per American Academy of Pediatrics safe sleep guidelines. Understanding the reasons for nonadherence to the guidelines (eg, lack of knowledge, financial barriers, social norms, cultural factors) and identifying methods of addressing them is critical to reducing the risk of these deaths. In addition, the 18% of cases with a reported recent illness and/or injury may have had recent contact with a health provider, potentially representing an additional opportunity for receipt of safe sleep messaging. Recent health care encounters were not formally assessed, however. Finally, continued improvements to DSI and autopsy and to their documentation are critical to understanding the sleep environment's role in infant deaths. Such improvements could be achieved by addressing training and resource needs of the medicolegal death investigation community.³⁷

This study has some limitations. Case classification depends on the accuracy and completeness of the information collected; medicolegal systems and investigation practices vary across the 18 states and jurisdictions participating in the registry. SUID investigation in this and other observational studies is complicated by the fact that most SUIDs are unwitnessed events. Therefore, accounts of death circumstances generally describe when the infant was found. Furthermore, evidence can be compromised during infant resuscitation attempts or transportation to the hospital.

An additional limitation is not capturing some medicolegal information in the NFR-CRS, resulting in a large proportion of cases classified as unexplained, incomplete case information. One criterion for awardee selection is a documented collaboration and data-sharing support from medical examiner and coroner offices, which may lead to improved data completeness with continued registry participation. Furthermore, receipt of technical assistance and resulting improvements in data quality limit the generalizability of our results beyond registry participants. In addition to the 18 registry states and jurisdictions, at least 15 nonregistry states and jurisdictions have applied the classification system to >500 additional SUID cases (National Center for Fatality Review and Prevention, personal communication,

July 17, 2019). Future analyses that include these data may increase generalizability and study power to detect differences.

SUID investigations and, hence, information reported to the registry, sometimes lack detailed information about the circumstances surrounding the death. Scene investigation guidelines, such as the CDC's SUID Investigation Reporting Form,³⁸ help investigators facilitate the collection of data about the sleep environment and related circumstances, including caregiver behaviors and characteristics to inform cause-of-death determination. Collection of this information has improved³⁹ but remains challenging because deaths are often unwitnessed events and the scene is often disrupted because of resuscitation efforts and transport.⁴⁰ However, compared with death certificate surveillance, the registry data can better describe items in the infant environment that caused or may have contributed to the infant's death, making it possible to thoroughly describe factors contributing to these deaths.

Other limitations are that state and jurisdiction participation in the registry varied over the study years, limiting the ability to examine trends. Furthermore, the small numbers of cases classified as unexplained, no unsafe sleep factors precluded stratification by state and/or jurisdiction.

CONCLUSIONS

We applied the SUID Case Registry classification system to almost 5000 SUID cases from 7 years of data. Unsafe sleep circumstances were common among SUID cases, but data could only explain why the death occurred in ~1 in 5 cases (ie, those assigned to “explained, suffocation”). Further analysis of unexplained SUID categories in the registry, augmented by continued improvements to death investigation and documentation, can generate hypotheses for physiologic or genetic research and advance our understanding of gaps in SUID investigation and groups at highest risk. This is critical to further developing safe sleep guidelines and educational efforts to eliminate SUID throughout the United States.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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ABBREVIATIONS

| | |
|-------------------|---|
| CDC | Centers for Disease Control and Prevention |
| CDR | Child Death Review |
| DSI | death scene investigation |
| NAME Panel | National Association of Medical Examiners' Panel on Sudden Unexpected Death in Pediatrics |
| NFR-CRS | National Fatality Review Case Reporting System |
| SIDS | sudden infant death syndrome |
| SUID | sudden unexpected infant death |

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WHAT'S KNOWN ON THIS SUBJECT:

Sudden unexpected infant deaths (SUIDs) are a common cause of infant mortality. The Centers for Disease Control and Prevention SUID Case Registry can differentiate explained from unexplained SUID cases. By supplementing death certificate surveillance, the registry can consistently describe SUID types and their circumstances of death.

WHAT THIS STUDY ADDS:

Although 72% of SUIDs occurred in unsafe sleep circumstances, only 18% of SUIDs could be explained as a suffocation death. Of the explained and possible suffocation deaths, 75% of airway obstruction deaths were attributable to soft bedding.

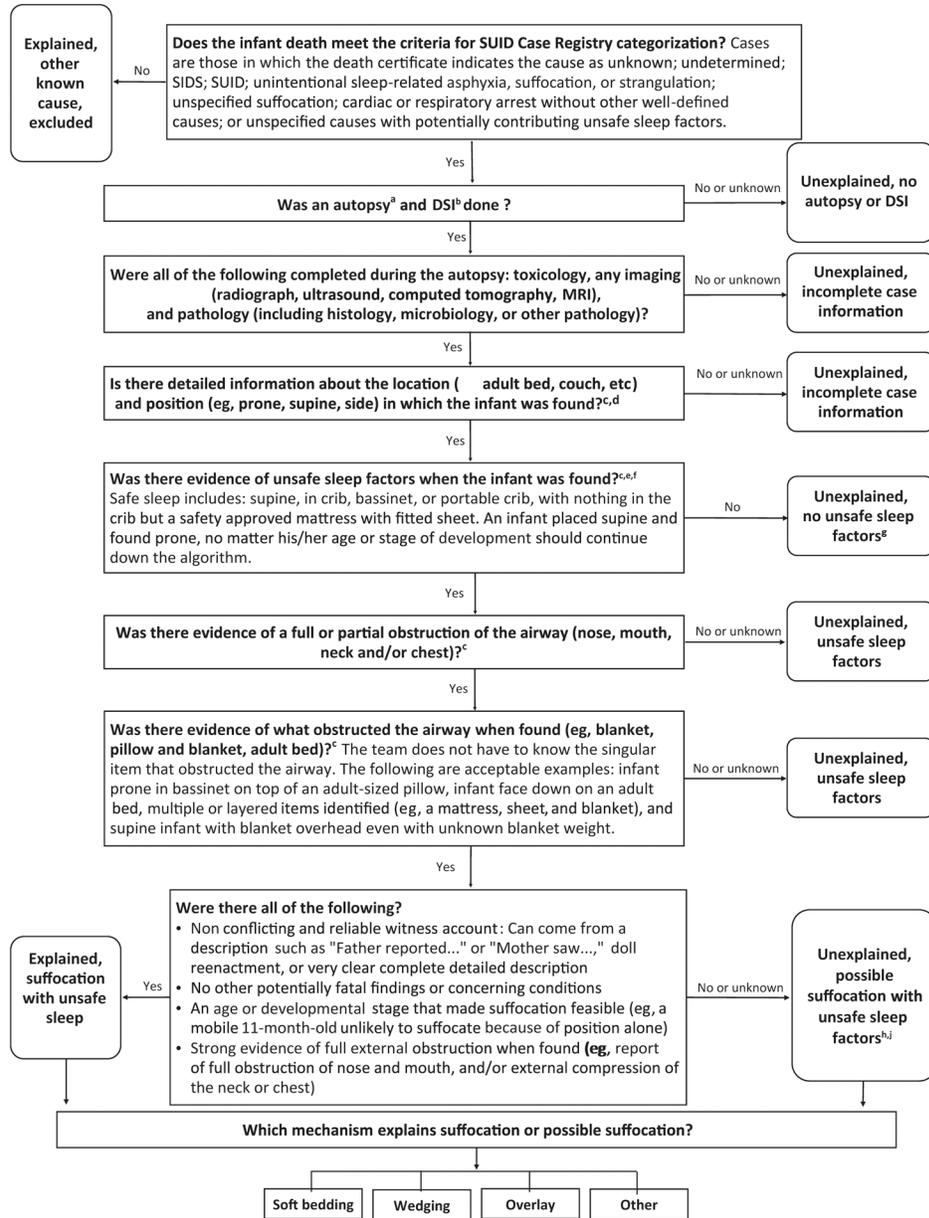


FIGURE 1. SUID categorization guide. ^a An autopsy must include an internal examination. ^b Death investigation = any agency obtaining information about the circumstances of the death; this does not need to include a visit to the scene or need to have complete information. ^c When there is conflict, use the expertise of your multidisciplinary team and all of the evidence to figure out what really happened. If there is enough evidence for the team to resolve the conflict, then document the team’s decision in the narrative and continue down the algorithm. If the evidence does not reveal a clear resolution, then document the sustaining conflict and treat it as an unknown. Refrain from making assumptions and err on the side of an unknown. ^d Consideration of lividity may be useful in verifying position, but lack of information on lividity does not make the case incomplete. Lividity that indicates supine

positioning could be from flipping the infant after death and should be considered cautiously.^e Answer no if the infant was not sleeping.^f Infant was put in a car seat (1) to sleep (should continue down the algorithm); (2) to travel, not sleep, with soft objects or loose bedding (should continue down the algorithm); or (3) to travel, not sleep, with no soft objects or loose bedding (should be categorized as “unexplained, no unsafe sleep factors”).^g Includes infants who were witnessed going unresponsive.^h Needs to be assigned at least 1 mechanism using the following definitions (the following are examples, not a comprehensive list): (1) soft bedding: when an infant’s airway is obstructed by a blanket, sheet, pillow, couch or recliner cushions, or other soft objects of loose bedding that are part of the immediate sleep environment: (a) nose and/or mouth obstructed at the intersection of soft bedding (eg, where a pillow and mattress meet, where the back and seat of a couch meet); (2) wedging: when an infant’s airway is obstructed as a result of being stuck or trapped between inanimate objects: (a) wedged with face clear (eg, in gap, face above mattress), chest or neck obstruction only; (3) overlay: when a person rolls on top of or against an infant, obstructing the infant’s airway: (a) overlay with face clear (obstructed chest or neck only), (b) face into person with or without chest or neck obstruction, and (c) infant pinned between person and couch, facing person (Surface sharing only is not enough evidence for overlay. An overlay needs to be witnessed, eg, someone waking up on top of an infant or someone seeing someone else on top of an infant.); (4) other: when an infant’s airway is obstructed by something in the sleep environment other than soft bedding, overlay, or wedging, such as a plastic bag (“other” should not be selected for unsafe sleep factors, such as prone positioning or impaired caregivers); and (5) multiple mechanisms: (a) wedging and soft bedding: (i) wedged with face into soft bedding (mattress, pillow, blankets), nose and mouth obstructed, and (ii) wrapped or entangled in blankets and wedged; (b) overlay and soft bedding: (i) overlay with nose and/or mouth obstructed by soft bedding (mattress, pillow, blankets) and (ii) infant pinned between person and couch and facing couch.ⁱ Examples include the following: (1) a 1-month-old infant found face down in a pillow with her nose and mouth fully obstructed, (2) a 2-month-old infant found with her head and face wedged between the cushions at the back of the sofa, and (3) a 4-month-old infant found lifeless in a twin bed with his head and body underneath his mother.^j Includes infants whose airways were obstructed by a Consumer Product Safety Commission–approved mattress used as recommended in a crib, portable crib, or bassinet.

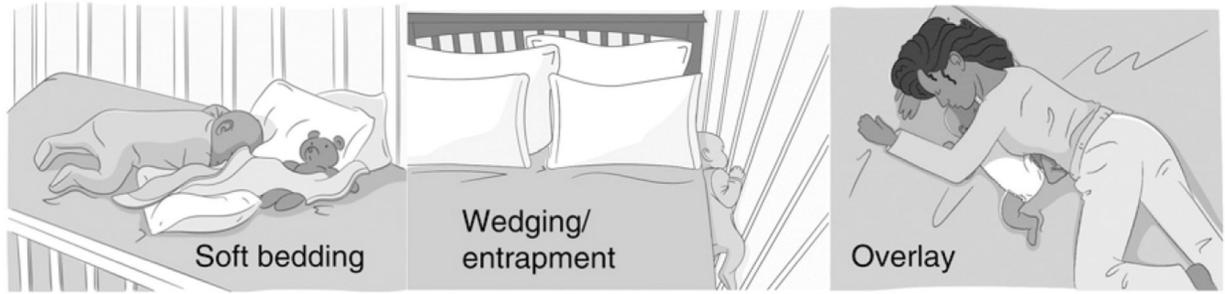


FIGURE 2. Mechanisms of explained or possible suffocation occurring in an unsafe sleep environment specified in the CDC SUID Case Registry classification system.

TABLE 1
Demographic Characteristics of SUIDs by Assigned SUID Category, 2011–2017

| Characteristic | Total | SUID Case Registry Categories | | | | | Unexplained, No Unsafe Sleep Factors | Unexplained, Incomplete Information ^a |
|---|------------|--|---|-----------------------------------|--------------------------------------|--|--------------------------------------|--|
| | | Explained, Suffocation With Unsafe Sleep Factors | Unexplained, Possible Suffocation With Unsafe Sleep Factors | Unexplained, Unsafe Sleep Factors | Unexplained, No Unsafe Sleep Factors | Unexplained, Incomplete Information ^a | | |
| Total, <i>n</i> (%) | 4929 (100) | 899 (18) | 649 (13) | 2022 (41) | 55 (1) | 1304 (27) | | |
| Mortality rate, per 100 000 live births | 97.3 | 17.7 | 12.8 | 39.9 | 1.1 | 25.7 | | |
| Age, mo, % ^b | | | | | | | | |
| 0 | 12 | 10 | 7 | 13 | 23 | 13 | | |
| 1 | 19 | 18 | 16 | 20 | 20 | 20 | | |
| 2 | 20 | 19 | 19 | 20 | 13 | 20 | | |
| 3 | 16 | 15 | 15 | 17 | 18 | 17 | | |
| 4 | 11 | 12 | 14 | 11 | — | 9 | | |
| 5 | 8 | 8 | 10 | 7 | — | 7 | | |
| 6 | 5 | 7 | 7 | 4 | — | 4 | | |
| 7 | 3 | 4 | 3 | 3 | — | 3 | | |
| 8 | 3 | 4 | 4 | 2 | — | 2 | | |
| 9 | 2 | 1 | 3 | 1 | — | 2 | | |
| 10 | 1 | 1 | 1 | 1 | — | 1 | | |
| 11 | 1 | 1 | 1 | 1 | 0 | 0 | | |
| Gestational age at birth, completed weeks, % ^b | | | | | | | | |
| <32 | 7 | 4 | 8 | 6 | 7 | 9 | | |
| 32–34 | 3 | 2 | 3 | 3 | 7 | 4 | | |
| 34–<37 | 15 | 13 | 13 | 16 | 11 | 14 | | |
| 37 | 75 | 81 | 76 | 75 | 75 | 72 | | |
| Sex, % | | | | | | | | |
| Male | 58 | 58 | 57 | 58 | 53 | 57 | | |
| Female | 42 | 42 | 43 | 42 | 47 | 43 | | |
| Missing or unknown (<i>n</i> = 1) | — | — | — | — | — | — | | |
| Race and/or ethnicity, % | | | | | | | | |

| Characteristic | Total | SUID Case Registry Categories | | | | |
|--|-------|--|---|-----------------------------------|--------------------------------------|--|
| | | Explained, Suffocation With Unsafe Sleep Factors | Unexplained, Possible Suffocation With Unsafe Sleep Factors | Unexplained, Unsafe Sleep Factors | Unexplained, No Unsafe Sleep Factors | Unexplained, Incomplete Information ^a |
| Non-Hispanic white | 42 | 41 | 44 | 42 | 33 | 42 |
| Non-Hispanic Black | 37 | 37 | 35 | 37 | 36 | 36 |
| Hispanic | 13 | 15 | 12 | 12 | 24 | 13 |
| Other ^c or multiple | 9 | 8 | 9 | 9 | — | 9 |
| Insured by Medicaid at birth, % | | | | | | |
| Yes | 68 | 68 | 68 | 68 | 56 | 68 |
| No | 32 | 32 | 32 | 32 | 44 | 32 |
| Illness ^d in last 72 h before death, % ^b | | | | | | |
| Yes | 16 | 13 | 16 | 17 | 24 | 14 |
| No | 84 | 87 | 84 | 83 | 76 | 86 |
| Injury ^e in last 72 h before death, % | | | | | | |
| Yes | 2 | 1 | 2 | 1 | — | 2 |
| No | 98 | 99 | 98 | 99 | 96 | 98 |

—, nonzero values less than the National Center for Fatality Review and Prevention's data suppression threshold ($n < 6$).

^a,"Unexplained, incomplete information" includes cases categorized as unexplained, incomplete case information or unexplained, no autopsy or DSI per the SUID Case Registry classification system.

^bDistribution across SUID Case Registry categories was significantly ($P < .05$) different.

^cOther race includes Asian American, Pacific Islander, native Hawaiian, American Indian, and Alaskan native.

^dCaregiver report or medical record documentation of infant having experienced any of the following in the 72 h before death: fever, lethargy, vomiting, diarrhea, trouble breathing, apnea, cyanosis, or seizures.

^eCaregiver report or medical record documentation indicating child was injured either unintentionally, such as a motor vehicle crash or fall, or intentionally, such as abuse or neglect.

TABLE 2

Assigned Mechanisms of Suffocation for SUIDs Classified as “Explained, Suffocation With Unsafe Sleep Factors” or “Unexplained, Possible Suffocation With Unsafe Sleep Factors,” 2011–2017

| SUID Category | No. Cases by Mechanism ^a | | | >1 Mechanism, <i>n</i> | |
|---|-------------------------------------|-----------------------|-----------------------|------------------------|----------------------------------|
| | Soft Bedding, <i>n</i> (%) | Overlay, <i>n</i> (%) | Wedging, <i>n</i> (%) | | Other, ^b <i>n</i> (%) |
| Explained, suffocation with unsafe sleep factors | 656 (75) | 198 (22) | 85 (9) | 31 (3) | 72 |
| Unexplained, possible suffocation with unsafe sleep factors | 486 (73) | 105 (16) | 22 (3) | 49 (8) | 27 |
| Total | 1142 (74) | 303 (20) | 107 (7) | 80 (5) | 99 |

^aCases could be assigned >1 mechanism; thus, mechanisms sum to >100%.

^bExamples include infants found with a plastic bag obstructing the airway, strangulation by a nasal cannula, and suffocation in clothing piles on the floor after falling from an adult bed.

TABLE 3

Distribution of SUID Categories by Year, 2011–2017

| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Mean |
|--|------|------|------|------|------|------|------|------|
| Overall, % | | | | | | | | |
| Explained, suffocation with unsafe sleep factors | 9 | 16 | 16 | 15 | 20 | 20 | 23 | 18 |
| Unexplained, possible suffocation with unsafe sleep factors | 20 | 15 | 10 | 12 | 13 | 12 | 13 | 13 |
| Unexplained, unsafe sleep factors | 43 | 46 | 37 | 41 | 39 | 41 | 42 | 41 |
| Unexplained, no unsafe sleep factors | 1 | <1 | 1 | 1 | 1 | 2 | 1 | 1 |
| Unexplained, incomplete information ^a | 27 | 24 | 36 | 31 | 27 | 25 | 21 | 26 |
| Among cases from 6 states ^b participating in all study years, % | | | | | | | | |
| Explained, suffocation with unsafe sleep factors | 8 | 16 | 19 | 15 | 21 | 22 | 19 | 17 |
| Unexplained, possible suffocation with unsafe sleep factors | 21 | 15 | 11 | 11 | 14 | 14 | 13 | 14 |
| Unexplained, unsafe sleep factors | 37 | 46 | 39 | 48 | 39 | 36 | 42 | 41 |
| Unexplained, no unsafe sleep factors | 1 | 0 | 1 | 1 | 1 | 2 | 1 | 1 |
| Unexplained, incomplete information ^a | 33 | 24 | 30 | 25 | 25 | 27 | 25 | 27 |

State participation by year: Colorado, Michigan, Minnesota, New Hampshire, New Jersey, and New Mexico: 2011–2017; Arizona, Louisiana, and Wisconsin: 2013–2017; California (San Francisco), Delaware, Tennessee, and Virginia (Tidewater region): 2014–2017; Alaska, Kentucky, and Nevada: 2016 and 2017; Georgia: 2011, 2015, and 2016; and Pennsylvania: 2016.

^a“Unexplained, incomplete information” includes cases categorized as unexplained, incomplete case information or unexplained, no autopsy or DSI per the SUID Case Registry classification system.

^bColorado, Michigan, Minnesota, New Hampshire, New Jersey, and New Mexico.