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Death Scene Investigation and Autopsy Practices in Sudden Unexpected Infant Deaths

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Abstract

Objective—To describe and compare sudden unexpected infant death (SUID) investigations among states participating in the SUID Case Registry from 2010 through 2012.

Study design—We analyzed observational data from 770 SUID cases identified and entered into the National Child Death Review Case Reporting System. We examined data on autopsy and death scene investigation (DSI) components, including key information about the infant sleep environment. We calculated the percentage of components that were complete, incomplete, and missing/unknown.

Results—Most cases (98%) had a DSI. The DSI components most frequently reported as done were the narrative description of the circumstances (90%; range, 85%–99%), and witness interviews (88%, range, 85%–98%). Critical information about 10 infant sleep environment components was available for 85% of cases for all states combined. All 770 cases had an autopsy performed. The autopsy components most frequently reported as done were histology, microbiology, and other pathology (98%; range, 94%–100%) and toxicology (97%; range, 94%–100%).

Conclusions—This study serves as a baseline to understand the scope of infant death investigations in selected states. Standardized and comprehensive DSI and autopsy practices across jurisdictions and states may increase knowledge about SUID etiology and also lead to an improved understanding of the cause-specific SUID risk and protective factors. Additionally, these results demonstrate practices in the field showing what is feasible in these select states. We encourage pediatricians, forensic pathologists, and other medicolegal experts to use these findings

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to inform system changes and improvements in DSI and autopsy practices and SUID prevention efforts.

Death scene investigation (DSI) and autopsy findings provide essential information that may explain why some infants die suddenly and unexpectedly. There were 3434 reported sudden unexpected infant deaths (SUIDs) in the US in 2013, accounting for 14.6% of all infant deaths.^{1,2} Most SUIDs are unwitnessed, and autopsy findings alone are not usually enough to explain why these deaths occurred. A thorough DSI, including a detailed description of obstructions to the infant's airway and potential hazards in the sleep environment, can help the death certifier distinguish between sudden infant death syndrome (SIDS) and other causes of death, such as accidental suffocation.³

Despite the critical role of the DSI and autopsy in determining cause of death, the importance of standardized protocols did not receive national attention until the 1980s. In 1986, Bass et al⁴ demonstrated that a DSI could inform the cause-of-death determination in cases of SUID. In 1989, an expert panel formally recognized the importance of the DSI and autopsy when they defined SIDS as "the sudden death of an infant under 1 year of age which remains unexplained after a thorough case investigation, including performance of a complete autopsy, examination of the death scene, and review of the clinical history."³ In 1996, the Centers for Disease Control and Prevention (CDC) published guidelines and a reporting form, the Sudden Unexpected Infant Death Investigation Reporting Form (SUIDIRF), for the investigation of SUID.^{5,6} At the same time, several forensic pathologists from around the world developed an international SUID autopsy protocol.⁷ After the publication of the SUIDIRF and the international autopsy protocol (beginning around 1998), death certifiers reported fewer SIDS cases and attributed more cases to unknown causes and accidental suffocation.^{8,9} It is likely that improved case investigations influenced this shift in SIDS classification.⁹

Recognition of the importance of DSI and autopsy in the 1980s and protocol development in the 1990s did not result immediately in universal investigation practices. In 1992, although most SIDS cases (about 90%) had autopsies, the number of SIDS determinations that were made without a DSI was unknown. In addition, autopsy and DSI practices varied by jurisdiction and only 4 states had written protocols specific to SUID.¹⁰ By 2004, fewer than two-thirds of US medical examiner and coroner offices reported having a DSI (60.9%) or autopsy (63.9%) policy for SUID.¹¹ As a result of these findings, in 2006 the CDC revised the 1996 SUIDIRF, developed educational materials,^{5,6,12,13} and conducted training that subsequently reached >23 000 medicolegal professionals.¹⁴ In 2007, the National Association of Medical Examiners outlined the "bare minimum" of a complete SUID death investigation.¹⁵ Despite the numerous efforts to improve SUID investigation practice, we are unaware of any formal evaluation to assess the extent of variation in DSI and autopsy practices across states and jurisdictions. Although death certificates typically document if an autopsy was completed, they do not capture whether a DSI was performed or which components of the autopsy and DSI were completed. The SUID Case Registry is a cooperative agreement between the CDC and funded grantees to enhance existing child death review (CDR) programs' ability to conduct comprehensive population-based surveillance of SUID data, including information on DSI and autopsy practices. We describe

and compare the frequency of DSI and autopsy performance practices for SUID cases in 7 states participating in the CDC's SUID Case Registry.

Methods

We used data from the National Child Death Review Case Reporting System (NCDR-CRS), which captures information reported by CDR teams. Our retrospective review consisted of SUID cases reported by state and local CDR teams participating in the initial years of the SUID Case Registry. CDR and the SUID Case Registry programs and practices have been described elsewhere.^{16,17} Briefly, CDR teams in states participating in the SUID Case Registry gather and review information about SUID cases from multiple data sources, including death certificates, autopsy reports, coroner/medical examiner records, law enforcement reports, emergency medical services reports, photographs and reports from doll reenactments, child protective services records, hospital reports, medical records, death scene photos, and pathology reports. Multidisciplinary CDR teams summarize findings and recommendations from reviews and enter this information into the NCDR-CRS. Data then undergo quality assurance measures at the state level. Data use agreements with participating states allow us to use these data and ensure that the state's data remain confidential.

For this analysis, we selected SUID cases that occurred from 2010 through 2012 and were entered into the NCDR-CRS Version 2.2s (Figure; available at www.jpeds.com). Eligible cases were resident infant deaths (<365 days old) with any of the following causes reported on the death certificate: unknown, undetermined, SIDS, SUID, unintentional sleep-related asphyxia/suffocation/strangulation, unspecified suffocation, cardiac or respiratory arrest without other well-defined causes, or ill-defined causes with potentially contributing unsafe sleep factors, except if manner of death was reported as homicide. Case numbers varied across study years. Two states joined the SUID Case Registry in 2011 and therefore did not contribute any cases for 2010. Additionally, 2 states had not submitted the 2012 death year cohort at the time of this analysis. Our final sample included 770 cases (Figure).

We examined variables related to DSI, infant sleep environment, and autopsy available in the NCDR-CRS Version 2.2s. These variables are described in the NCDR-CRS data dictionary.¹⁸ Most study variables were derived from single questions in the NCDR-CRS. For the remaining study variables, we created composite variables by combining multiple questions (Table I).

Statistical Analyses

We calculated the percentage complete, incomplete, and missing/unknown for each DSI and autopsy component. For the sleep environment variables, we calculated the percentage of cases with documented information about each selected sleep environment component. Data about the infant sleep environment was reported for the 759 cases that occurred in a sleep environment. For all analyses, we examined each state and component individually and all states and components combined. Because we aimed to compare differences among states and not to identify lower performing states, we represent states with letters (A–G) and do not reveal the numbers of SUID cases or type of medicolegal system by state to maintain confidentiality per our data use agreements with the participating states.

Results

Based on the composite variable for DSI performed, 98% of cases had a DSI, ranging from 100% in states A, E, and G to 95% in state F (Table II). For all states combined, narrative description of the circumstances (90%) and witness interviews (88%) were reported most frequently. The SUIDIRF or jurisdictional equivalent (71%), scene photos (68%), any scene re-creation (45%), and scene re-creation with a doll (37%) were reported less frequently. The SUIDIRF or jurisdictional equivalent had the largest range when compared across states; ranging from 100% completion in state E to 24% completion in state A. Narrative description of circumstances had the narrowest range, from 99% completion in state A to 85% completion in state C. Variation in the percentages of DSI components reported as complete was observed depending on the state's type of medicolegal system.

Within each state, the consistency of reporting across DSI components varied. State E had the highest percentages of reported DSI components, ranging from 100% completion of the SUIDIRF or jurisdictional equivalent to 58% completion of a scene re-creation with a doll. State A had the lowest percentages and the most variation in reported DSI components, ranging from 99% completion of a narrative description of circumstances to 13% completion for scene re-creation with a doll. For all states and DSI components combined, the average missing/unknown was 15%, ranging from state A with 58% missing/unknown for SUIDIRF or jurisdictional equivalent to states E and G with 0% missing/unknown for SUIDIRF or jurisdictional equivalent. States B and C had the highest average missing/unknown for all DSI components combined (22%).

Sleep Environment

The majority of cases (98%) occurred in a sleep environment (Table III). Information about the infant sleep environment was available 85% of the time for all variables and states combined. Incident sleep place (98%), same surface with person(s) or animal(s) (96%), caregiver/supervisor fell asleep while feeding child (94%), new or different sleep environment than usual (92%), position found (86%), position placed (85%), and crib, bassinet, or port-a-crib in home (81%) were reported as available most frequently for all states combined. Usual sleep place (73%), airway when found (73%), and usual sleep position (63%) were reported as available least frequently for all states combined. Airway when found had the most variation, ranging from 95% availability in state G to 35% availability in state F. Incident sleep place, caregiver/supervisor fell asleep while feeding child, and same surface with person(s) or animal(s) had the least variation, ranging from 100% to 90%.

Within each state, the availability of information about the infant sleep environment varied. State G had the highest percentage of available information. State F had the lowest percentage of available data and the largest range between variables, from 91% for caregiver/supervisor fell asleep while feeding child to 35% for airway when found.

Autopsy

All cases (100%) had an autopsy performed as indicated by the composite variable (Table II). Among autopsy components, histology, microbiology and other pathology (98%), toxicology (97%), and radiographs (87%) were performed most frequently for all states combined. Metabolic testing (71%), blood chemistry (41%), and genetic testing (23%) were performed less frequently. Blood chemistry had the largest range when comparing states, from 100% completion in state E to 10% completion in state A. Toxicology, and microbiology, histology, and other pathology had the narrowest range, from 100% to 94%. We observed variation in the percentages of autopsy components reported as complete depending on the state's type of medicolegal system.

Within each state, the consistency in reporting varied across autopsy components. State E had the highest percentages of reported autopsy components; all components were reported 100% of the time with the exception of genetic testing (33%). State A had the lowest percentages of reported autopsy components, the highest average missing/unknown (35%), and the greatest range, from 99% completion of toxicology to 0% completion of genetic testing. For all states, 8% of the combined autopsy components were missing/unknown. Multiple states reported several autopsy components with 0% missing/unknown. Genetic testing in state A had the highest missing/unknown (73%).

Discussion

Implementation of thorough and consistent DSI and autopsy practices increases understanding of the circumstances surrounding SUID and improves accuracy in diagnosing the causes of SUID. Having reliable and accurate data about SUID cases improves the ability to monitor trends and develop effective prevention strategies, ultimately leading to a decrease in SUID. This report is a baseline study to understand the scope of infant death investigations in selected US states. We found that almost all SUID cases had an autopsy (100%) and DSI (98%) performed, but that the components of the investigation varied. The autopsy components conducted least often were blood chemistry (41%) and genetic testing (23%). However, these tests may only be conducted as needed and depending on the circumstances.¹⁵ The perceived usefulness of tests influence actual performance of testing, as highlighted in a recent study about infectious disease testing for SUID.¹⁹ The DSI components conducted least often include usual sleep place (73%) and usual sleep position (63%). Changes in sleep place and position are associated with an increased risk of SIDS,²⁰ making usual sleep place and position important variables to document. However, the variable new or different environment than usual was available for 92% of cases and may be used by death certifiers when usual sleep place and position are unavailable.

Although the performance of a DSI and an autopsy were nearly universal in our study, a marked improvement from earlier decades,¹⁰ we note that there were still some DSI components for which the percentage of performance is not optimal. Any scene re-creation (45%), especially one with a doll (37%), was available for fewer than one-half of cases and can be an integral part in understanding airway obstruction and the role of potential hazards in the sleep environment.^{6,15} Additionally, there was a lack of information about the infant's airway when found, available for 73% of cases, which is also important in understanding the

circumstance surrounding the death. This information may be unavailable because parents or emergency medical services personnel move the infant quickly without noting the infant's position.^{15,20}

Because the analysis of missing/unknown responses revealed high data quality (ie, few missing and unknown responses), observed variations in reporting performance of DSI and autopsy components between states likely reflect true practice. The data used in these analyses are compiled from various sources, and are not collected through primary data collection. As such, understanding the reasons for the variations in reporting and missing/unknown responses are outside of the scope of these data but could be attributed to a number of factors, for example, differing protocols for autopsies and DSIs, variation in the capacity of the CDR teams collecting and entering data, availability of resources for investigations, and differences in medicolegal systems. Study states represent county coroner systems, county medical examiner systems, regional offices overseen by a state medical examiner, combined county medical examiner and coroner systems, state medical examiner systems, and combined state and county medical examiner systems.²¹ Although slight variation was observed in the percentages of autopsy components reported depending on the type of medicolegal system, this study shows that documenting complete and comprehensive autopsies and DSIs is feasible across all types of systems.

A limitation is that our study only represents 7 states and may lack generalizability to the US as a whole. In addition, we relied on information reported by state and local CDR teams, and data have not been validated. However, it is likely that reported data were accurate because most reported information was based on abstracted and summarized data from several sources and discussions among multidisciplinary professionals who often had first-hand knowledge of the cases. Moreover, our ability to accurately evaluate the completeness of DSI and autopsy components was improved because we created composite variables considering responses to several related questions. Additionally, if there were reporting biases, we would anticipate that DSI and autopsy components were underreported, because it is more likely that a component was conducted and not documented as opposed to documented and not conducted.

Because SUID Case Registry grantees evaluate the gaps in case investigations, they work with CDR teams and medicolegal professionals to implement activities to improve DSI and autopsy consistency and comprehensiveness. For example, some grantees provide resources to medical examiner offices to investigate and review SUID cases. Other grantees facilitate trainings for medical examiners, coroners, and death investigators to emphasize what data are important to document at an infant death scene, how to complete the SUIDIRF or jurisdictional equivalent, and how to perform a scene re-creation using a doll. Grantees have also distributed DSI kits with dolls and cameras for documenting scene re-creations. These tools allow investigators to record the most important information from the death scene, including the infant's airway when found. Future studies using the SUID Case Registry data could monitor the impact of these activities on progress toward improving practices.

The importance of the DSI and autopsy in determining cause of death is well-established and much work has been done to improve case investigation practices. This study serves as a

baseline to understand the scope of infant death investigations in selected states. Standardized and comprehensive DSI and autopsy practices across jurisdictions and states may increase knowledge about SUID etiology and lead to improved understanding of cause-specific SUID risk and protective factors. Additionally, these data, representing a variety of medicolegal systems, demonstrate that documenting complete and comprehensive autopsies and DSIs is feasible across many systems. We encourage pediatricians, forensic pathologists, and other medicolegal experts who review these findings to use them to inform system changes and improvements in DSI and autopsy practices and SUID prevention efforts. To improve practices, the medicolegal community could work to ensure that comprehensive protocols are further developed, such that a gold standard becomes universally accepted and implemented. There is a need to identify DSI and autopsy practices that are most effective and have the strongest influence on explaining why SUID occurs.²² In determining feasibility, one must consider available resources (eg, budget, staffing, equipment, and training needs).²³ Future studies using the SUID Case Registry data can monitor resulting progress in improving standardized practices.

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Glossary

CDC	Centers for Disease Control and Prevention
CDR	Child death review
DSI	Death scene investigation
NCDR-CRS	National Child Death Review-Case Reporting System
SIDS	Sudden infant death syndrome
SUID	Sudden unexpected infant death
SUIDIRF	Sudden Unexpected Infant Death Investigation Reporting Form

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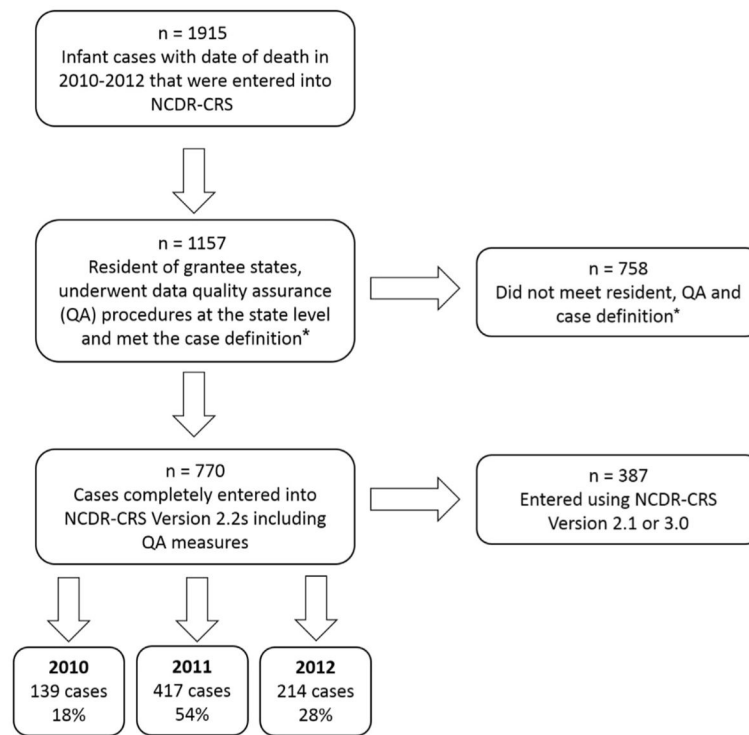


Figure. Description of the study population. * Cases that met the case definition were infant deaths (<365 days old) reported on the death certificate as cause unknown, undetermined, SIDS, SUID, unintentional sleep-related asphyxia/suffocation/strangulation, unspecified suffocation, cardiac or respiratory arrest without other well-defined causes, or ill-defined causes with potentially contributing unsafe sleep factors, except if manner of death was reported as homicide.

Table I

Variable descriptions

Study variables	Question in the NCDR-CRS	Valid responses
DSI		
Performed	DSI performed?	Yes
	Agencies that conducted a scene investigation?	Medical examiner, coroner, medical examiner investigator, coroner investigator, law enforcement, fire investigator, emergency medical services, child protective services, other, unknown
SUIDIRF or a jurisdictional equivalent	For infants, which of the following data sources were available at the review?	CDC's SUIDI reporting form, jurisdictional equivalent of the CDC SUIDI reporting form
	For infants, which of the following data sources were available at the review?	CDC's SUIDI reporting form, jurisdictional equivalent of the CDC SUIDI reporting form
Narrative description of circumstances	If a DSI was performed, which of the following DSI components were completed?	CDC's SUIDI reporting form or jurisdictional equivalent
	If a DSI was performed, which of the following DSI components were completed?	Narrative description of circumstances completed
Scene photos	If a DSI was performed, which of the following DSI components were completed?	Scene photos
Any scene re-creation	If a DSI was performed, which of the following DSI components were completed?	Scene re-creation with doll, scene recreation without doll
Scene re-creation with a doll	If a DSI was performed, which of the following DSI components were completed?	Scene re-creation with doll
Witness interviews	If a DSI was performed, which of the following DSI components were completed?	Witness interviews
Infant sleep environment		
Incident sleep place	Incident sleep place:	Crib, bassinette, adult bed, waterbed, playpen/ other play structure but no portable crib, couch, chair, floor, car seat, stroller, other
Position placed	Child put to sleep:	On back, on stomach, on side
Position found	Child found:	On back, on stomach, on side
Usual sleep place	Usual sleep place:	On back, on stomach, on side
Crib, bassinette, or port-a-crib in the home	Was there a crib, bassinette, or port-a-crib in the home for child?	Yes, no
New or different environment than usual	Child in a new or different environment than usual?	Yes, no
Airway when found	Child's airway was:	Unobstructed by person or object, fully obstructed by person or object, partially obstructed by person or object
Caregiver/supervisor fell asleep while feeding child	Caregiver/supervisor fell asleep while feeding child?	Yes, no
Same room as caregiver/supervisor at time of death	Child sleeping in the same room as caregiver/supervisor at time of death?	Yes, no
Same surface with person(s) or animal(s)	Child on same surface with person(s) or animal(s)?	Yes, no
Autopsy		
Autopsy performed	Autopsy performed?	Yes
	If investigation found evidence of abuse, from what source?	From autopsy
	For infants, which of the following data sources were available at the review?	Autopsy/pathology reports

Study variables	Question in the NCDR-CRS	Valid responses
	Toxicology screen?	Yes
	For infants, histology conducted?	Yes
	For infants, blood chemistry conducted?	Yes
	Radiographs taken?	Yes
	For infants, microbiology conducted?	Yes
	For infants, other pathology conducted?	Yes
Toxicology	Toxicology screen?	Yes
	If autopsy performed, were the following assessed in the autopsy?	Routine toxicology for ethanol, sedatives and/or stimulants, toxicology for suspected drugs if investigation suspects exposure
Microbiology, histology, and other pathology	If autopsy performed, were the following assessed in the autopsy?	Microbiology, microscopic examination of brain, heart, lung, airway, or liver
	For infants, microbiology conducted?	Yes
	For infants, histology conducted?	Yes
	For infants, other pathology conducted?	Yes
Blood chemistry	For infants, blood chemistry conducted?	Yes
Radiograph	Radiographs taken?	Yes
	If autopsy performed, were the following assessed in the autopsy?	Radiograph-single, radiograph-skeletal series, CT scan
Genetic testing	If autopsy performed, were the following assessed in the autopsy?	Genetic testing
Metabolic testing	If autopsy performed, were the following assessed in the autopsy?	Metabolic screening

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Percentage of cases with a DSI and autopsies performed and percent of DSI and autopsy components performed, stratified by state, 2010–2012

Table II

State	A	B	C	D	E	F	G	Total (N = 770)
DSI performed								
Yes	100	98	98	96	100	95	100	98
No	0	1	2	4	0	5	0	2
Missing/unknown	0	1	0	0	0	0	0	0
If DSI completed, components of the DSI performed								
State	A	B	C	D	E	F	G	Total (N = 753)
SUIDIRF or jurisdictional equivalent								
Yes	24	87	70	62	100	88	80	71
No	18	5	5	32	0	11	20	10
Missing/unknown	58	8	25	6	0	1	0	18
Narrative description of circumstances								
Yes	99	90	85	89	92	92	97	90
No	0	1	1	6	0	2	2	1
Missing/unknown	1	9	14	4	8	6	2	8
Scene photos								
Yes	70	62	66	62	92	63	95	68
No	7	8	7	34	0	26	3	11
Missing/unknown	23	30	27	4	8	11	2	21
Any scene re-creation								
Yes	20	33	65	49	83	20	73	45
No	71	34	9	49	8	65	25	35
Missing/unknown	9	34	27	2	8	14	2	21
Scene re-creation with a doll								
Yes	13	27	56	43	58	19	56	37
No	77	39	16	55	33	66	42	41
Missing/unknown	10	34	29	2	8	14	2	22
Witness interviews								

State	A	B	C	D	E	F	G	Total (N = 770)
Yes	97	85	85	92	92	85	98	88
No	1	1	3	6	0	6	0	2
Missing/unknown	2	14	12	2	8	9	2	9
All DSI components*								
Yes	62	71	74	71	9	70	89	72
No	19	10	5	25	2	22	10	12
Missing/unknown	19	19	21	4	6	8	2	15
State	A	B	C	D	E	F	G	Total (N = 770)
Autopsy performed								
Yes	100	100	100	100	100	100	100	100
No	0	0	0	0	0	0	0	0
Missing/unknown	0	0	0	0	0	0	0	0
If autopsy completed, components of the autopsy performed								
State	A	B	C	D	E	F	G	Total (N = 770)
Toxicology								
Yes	99	99	94	100	100	98	100	97
No	1	1	4	0	0	2	0	2
Missing/unknown	0	1	2	0	0	0	0	1
Microbiology, histology, and other pathology								
Yes	98	99	97	100	100	94	98	98
No	2	0	1	0	0	6	0	1
Missing/unknown	0	1	2	0	0	0	2	1
Blood chemistry								
Yes	10	37	42	86	100	17	95	41
No	35	60	45	8	0	81	2	46
Missing/unknown	56	4	13	6	0	3	3	14
Radiograph								
Yes	62	96	85	98	100	84	100	87
No	11	3	10	2	0	16	0	7

State	A	B	C	D	E	F	G	Total (N = 770)
Missing/unknown	27	1	6	0	0	1	0	6
Genetic testing								
Yes	0	68	6	12	33	3	32	23
No	27	27	88	88	67	94	64	63
Missing/unknown	73	6	6	0	0	3	3	14
Metabolic testing								
Yes	31	88	65	82	100	66	98	71
No	14	10	28	14	0	26	0	18
Missing/unknown	56	3	7	4	0	8	2	12
All autopsy components								
Yes	50	81	65	80	89	60	87	69
No	15	17	29	19	11	38	11	23
Missing/unknown	35	3	6	2	0	3	2	8

Note: Groups not equal to 100% are due to rounding. States are represented by letters to maintain confidentiality.

* Includes all variables in table except for scene re-creation with a doll because this variable is a subset of any scene re-creation.

Percentage of cases reporting information about sleep environment among deaths that occurred in the sleep environment, stratified by state, * 2010–2012

Table III

State	A	B	C	D	E	F	G	Total (N = 759)
Incident sleep place	100	100	98	100	100	90	98	98
Position placed	78	88	85	85	92	76	97	85
Position found	86	89	84	87	92	76	97	86
Usual sleep place	71	67	79	77	92	53	97	73
Usual sleep position	60	58	70	53	83	44	97	63
Crib, bassinette, or port-a-crib in the home	88	71	88	68	75	78	93	81
New or different environment than usual	99	91	93	98	100	75	97	92
Airway when found	78	79	72	85	58	35	95	73
Caregiver/supervisor fell asleep while feeding child	98	94	90	98	100	91	98	94
Same room as caregiver/supervisor at time of death	99	88	93	98	100	90	98	93
Same surface with person(s) or animal(s)	98	97	95	100	100	90	98	96
Total	87	84	86	86	90	72	97	85

Note: Groups not equal to 100% are due to rounding. States are represented by letters to maintain confidentiality.

* Cases that did not occur in a sleeping environment were excluded from this analysis (n = 11).