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National and State Trends in Sudden Unexpected Infant Death: 1990–2015

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Abstract

BACKGROUND: Sharp declines in sudden unexpected infant death (SUID) in the 1990s and a diagnostic shift from sudden infant death syndrome (SIDS) to unknown cause and accidental suffocation and strangulation in bed (ASSB) in 1999–2001 have been documented. We examined trends in SUID and SIDS, unknown cause, and ASSB from 1990 to 2015 and compared state-specific SUID rates to identify significant trends that may be used to inform SUID prevention efforts.

METHODS: We used data from US mortality files to evaluate national and state-specific SUID rates (deaths per 100 000 live births) for 1990–2015. SUID included infants with an underlying cause of death, SIDS, unknown cause, or ASSB. To examine overall US rates for SUID and SUID subtypes, we calculated the percent change by fitting Poisson regression models. We report state differences in SUID and compared state-specific rates from 2000–2002 to 2013–2015 by calculating the percent change.

RESULTS: SUID rates declined from 154.6 per 100 000 live births in 1990 to 92.4 in 2015, declining 44.6% from 1990 to 1998 and 7% from 1999 to 2015. From 1999 to 2015, SIDS rates decreased 35.8%, ASSB rates increased 183.8%, and there was no significant change in unknown cause rates. SUID trends among states varied widely from 41.5 to 184.3 in 2000–2002 and from 33.2 to 202.2 in 2013–2015.

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CONCLUSIONS: Reductions in SUID rates since 1999 have been minimal, and wide variations in state-specific rates remain. States with significant declines in SUID rates might have SUID risk-reduction programs that could serve as models for other states.

Sharp declines in the rates of sudden infant death syndrome (SIDS) in the 1990s have been associated with national efforts to promote infant safe sleep, mainly through the Back-to-Sleep campaign.[1] The decline in SIDS rates since the late 1990s has been, in part, attributed to a diagnostic shift that was identified from 1999 through 2001; some death certifiers are classifying fewer deaths due to SIDS and more deaths due to other ill-defined and unspecified causes of mortality (unknown cause), or accidental suffocation and strangulation in bed (ASSB).[2–4] Given this diagnostic shift, grouping SIDS deaths with deaths classified as due to unknown cause or ASSB on US death certificates as sudden unexpected infant deaths (SUIDs) is a strategy for consistently monitoring SUID trends.[2,5]

Despite declines in rates, SUID remains an important cause of infant mortality, accounting for ~3500 US infant deaths annually,[6] and it remains a focus of national and local prevention efforts. The American Academy of Pediatrics recommends the following to reduce the risk of SUID: a supine sleep position, room sharing without surface sharing, creating a sleep environment free of objects that can obstruct an infant’s airway, and avoiding pre- and postnatal exposure to tobacco smoke.[7] A thorough examination of US and state-specific SUID trends is needed to further characterize diagnostic shifts, understand state differences, and provide insight into the potential impacts of and opportunities for prevention efforts.

Knowledge of recent national and state trends of SUID can help measure progress toward the Healthy People 2020 (HP2020) goal of reducing SUID deaths to 84 per 100 000 live births.[8] Understanding how state-level data compare with this goal may help programs make critical decisions about resource allocation for prevention activities.

States with declining SUID rates may have implemented successful programs that can be adapted in states with higher or stagnating SUID rates. In this study, we examine US rates of SUID and SUID subtypes (including SIDS, unknown cause, and ASSB) and state-specific SUID rates to identify significant trends that can be used to inform future SUID risk-reduction strategies.

METHODS

We used data from the US compressed mortality file to evaluate national and state-specific SUID rates for 1990 through 2015.[6,9] We calculated rates per 100 000 live births for overall SUID and each SUID subtype. In this analysis, SUID was defined as an infant (<365 days old) with an *International Classification of Diseases, Ninth Revision* (ICD-9) or *International Classification of Diseases, 10th Revision* (ICD-10) code for SIDS, unknown cause, or ASSB.[10,11] Underlying cause-of-death ICD-9 codes 798.0 (SIDS), 799.9 (unknown cause), and E913.0 (ASSB) were used for deaths occurring from 1990 through 1998; and ICD-10 codes R95 (SIDS), R99 (unknown cause), and W75 (ASSB) were used for deaths occurring from 1999 through 2015.[2] Examining SUID rates overall and by subtype allowed us to examine if the diagnostic shift has continued in later years.[2,3]

To examine trends in US rates for SUID overall and by subtype (SIDS, unknown cause, and ASSB), we used SAS version 9.3 for Windows (SAS Institute, Inc, Cary, NC) to calculate the percent change (PC = $[(e^{\beta})^{\text{years}} - 1] \times 100\%$), and we calculated the 95% confidence intervals by fitting a Poisson regression model in SAS to the annual rate data with a linear effect for year (on the logarithmic scale).[12,13] To assess overall trends, we calculated the PC for 1990 through 2015, and to examine the diagnostic shift among SUID subtypes, we calculated the PC for 1990 through 1998 (before the shift was identified) and for 1999 through 2015. P values <.05 were considered significant.

To investigate state differences in SUID, we compared state-specific SUID rates from 2000–2002 to 2013–2015. These periods were selected to investigate more recent trends since the turn of the century. Because states were likely differentially affected by the diagnostic shift, we examined SUID rates, combining SIDS, unknown cause, and ASSB, to allow for more comparable rates across all 50 states and the District of Columbia. For simplicity, we refer to the District of Columbia as a state. Using 3-year time segments allowed for more stable estimation of SUID rates in states with a lower SUID incidence. We calculated the PC ($[(\text{Rate}_1 - \text{Rate}_0) / \text{Rate}_0] \times 100\%$) and z scores using Poisson rates ($\ln[\text{Rate}_0 / \text{Rate}_1] / \sqrt{[1 / \text{deaths}_o + 1 / \text{deaths}_1)}$ to assess the statistical significance ($P < .05$) of the PC between 2000–2002 and 2013–2015. To visualize the changes in state-specific rates from 2000–2002 to 2013–2015, heat maps were created in ArcGIS 10.4.1. Heat map data are presented in quintiles, which were created by dividing the range of SUID rates over both periods into 5 equal intervals.

RESULTS

During the study period (1990–2015), SUID rates per 100 000 live births declined from 154.6 in 1990 to 92.4 in 2015. Among SUID subtypes, the SIDS rate was highest, followed by unknown cause and ASSB rates (Fig 1). In 1990, SIDS accounted for most SUIDs and occurred at a rate of 130.3 deaths per 100 000 live births. At that time, the SIDS rate was almost 40 times higher than the ASSB rate (3.4 per 100 000) and 6 times higher than the unknown cause rate (20.9 per 100 000). Over the study period, the gap between SIDS rates and the rates of the other SUID subtypes narrowed. In 2015, the SIDS rate was <2 times higher than either ASSB or unknown cause (39.3 vs 23.0 and 30.0 deaths per 100 000 live births, respectively).

In Table 1, we describe the overall PC for SUID and SUID subtypes over the study period and for the years of 1990–1998 and 1999–2015. From 1990 through 2015, there was a PC of −40.5% for SUID, −70.9% for SIDS, 45.1% for unknown cause, and 671.0% for ASSB (Table 1). From 1990 through 1998, the PC was −44.6% for SUID, −50.9% for SIDS, −14.1% for unknown cause, and 30.2% for ASSB (Table 1). From 1999 through 2015, the PC was −7.2% for SUID, −35.8% for SIDS, and 183.8% for ASSB, with no significant change in unknown cause (Table 1).

In analyses of state-specific SUID trends, several patterns emerged (Table 2). All states, but Louisiana and Alabama, had a reduction in SUID when 1990–1992 was compared with 2013–2015. In 2013–2015, 18 states met or exceeded the HP2020 SUID goal of 84 deaths per 100 000 live births, compared with 16 states in 2000–2002 and 1 state in 1990–1992. California, Colorado, the District of Columbia, Florida, Kansas, Missouri, New York, Oregon, Washington, and Wisconsin had significant percentage declines in SUID rates when 2000–2002 was compared with 2013–2015. The greatest declines occurred in the District of Columbia (−44.5%), Colorado (−40.8%), and Wisconsin (−37.8%). The SUID rate in the District of Columbia declined from 184.3 in 2000–2002 to 102.2 in 2013–2015, a difference of −82.1 per 100 000 live births. Of the states that declined between 2000–2002 and 2013–2015, the SUID rates in Colorado, Oregon, Washington, and Wisconsin were above the HP2020 goal in 2000–2002 and dropped below it in 2013–2015. The SUID rate in California exceeded the HP2020 goal in 2000–2002 and 2013–2015.

In contrast, Alaska, Arkansas, Alabama, Kentucky, and Louisiana had the highest SUID rates in 2013–2015, coupled with large significant percentage increases when comparing 2000–2002 with 2013–2015. In addition, these states had >150 SUIDs per 100 000 live births, nearly twice the HP2020 goal. Of these states, Alaska had the largest rate increase of 55 per 100 000 live births from 2000–2002 to 2013–2015 (147.1 vs 202.2).

The variability of state-specific SUID rates from 2000–2002 to 2013–2015 are depicted in heat maps in which quintiles, 5 equal intervals representing the range of SUID rates over both periods, are compared (Fig 2). In 2000–2002, 6 states (AZ, CT, ME, MA, RI, and UT) were in the lowest quintile (33.3–67.1 per 100 000 live births) and only the District of Columbia was in the highest quintile (168.5–202.2 per 100 000 live births). In 2013–2015, 10 states (CA, CO, CT, MA, MN, NJ, NY, RI, UT, and VT) were in the lowest quintile and 4 states (AK, AR, AL, and MS) were in the highest quintile.

DISCUSSION

Despite refinements to the American Academy of Pediatrics safe sleep guidelines[14–16] and an expansion of the national Back-to-Sleep campaign in 2012 to emphasize safe sleep environments in addition to sleep position in the Safe-to-Sleep campaign,[17] SUID rates only decreased 7.2% from 1999 through 2015, as compared with 44% from 1990 through 1998. From 1990 through 1998, the decline in SUID was driven mostly by a decrease in SIDS rates. However, from 1999 through 2015, the decline in SUID was less dramatic. SIDS rates continued to decrease, but classification by subtype changed, with a significant increase in the ASSB rate (183.8%) and no significant change in the unknown cause rate. When the diagnostic shift was first identified, the shift was occurring from SIDS to ASSB and unknown cause.[2,3] On the basis of our data, we suggest that, more recently, SUIDs are still being classified less often as SIDS and more often as ASSB alone. This diagnostic shift may have resulted from a variability in cause-of-death determination practices[4] and an increase in the use of standard infant death investigation protocols.[18–21]

Trends in SUID rates mirror trends observed in the prevalence of some unsafe sleep factors since the 1990s. For example, soft bedding use in infant sleep environments decreased 85.9% from 1993 through 1995 and decreased only 54.7% from 2008 through 2010.[22] And, after an increase in supine sleep placement from 1992 to 1996,[1] there was no significant change from 2001 through 2010.[23,24] Conversely, the percentage of infants sharing a sleep surface significantly increased from 6.5% in 1993 to 13.5% in 2010.[25] Given this increase, one would expect an increase in SUID rates.

Further analyses are needed to fully understand the contribution of the diagnostic shift and unsafe sleep environments on ASSB and SUID rates.

The reasons some states experienced success in significantly decreasing SUID rates and others did not are likely multifaceted. There are a wide range of state strategies being used to reduce SUID, including but not limited to policies in facilities and clinics, Safe-to-Sleep campaigns, Special Supplemental Nutrition Program for Women, Infants, and Children messaging, home-visiting programs, and quality improvement collaboratives at birthing hospitals.[26] The role of these SUID risk-reduction programs, demographic changes, tobacco use, and emerging issues such as increasing opioid use deserve further investigation. The District of Columbia had the largest significant percent decrease and absolute SUID rate decline over the study period. In 2000–2002, the District of Columbia had the highest state-specific SUID rate (184.3 deaths per 100 000 live births), approximately twice that of the United States as a whole (94.5 deaths per 100 000 live births). However, in 2013–2015, the District of Columbia SUID rate dropped to 102.2 deaths per 100 000 live births.

Between 2000 and 2015 the racial and ethnic makeup of the District of Columbia changed considerably.[27,28] Births to Asian/Pacific Islander, Hispanic, and non-Hispanic white mothers increased from 32.8% of total births in 2000 to 49.4% in 2015. In contrast, births to non-Hispanic black mothers declined from 66.6% in 2000 to 50.1% in 2015.[27,28] In the United States, non-Hispanic blacks have nearly double the rates of SUID as Asian/Pacific Islander, Hispanics, and non-Hispanic whites.[29] This change in racial and ethnic composition likely contributed to the decrease in SUID in the District of Columbia over the study period. In addition, activities in the District of Columbia aimed at increasing prenatal care and child immunizations, preventing child injuries, and reducing alcohol use during pregnancy that were targeted toward the African American population may have contributed to the improved SUID rates.[30]

Beginning in 2012, several states participated in the Maternal and Child Health Bureau at the Health Resources and Services Administration initiative to reduce infant mortality by improving safe sleep practices. This initiative, known as the Collaborative Improvement and Innovation Network, engaged states from Region 4 (AL, FL, GA, KY, MS, NC, SC, and TN) and Region 6 (AR, LA, NM, OK, and TX).[31] In examining SUID rates from our analysis, it appears that among those states participating in Collaborative Improvement and Innovation Network since 2012, only Florida had a significant decrease (−10.1%) in SUID rates when 2000–2002 was compared with 2013–2015. Analyzing national and state-specific SUID trends, as in this article, can not only be used to identify states that have been successful in reducing the SUID rate but can also be used to evaluate the impact of state and national initiatives when allocating future resources.

Our study is limited by its use of death certificate data, which lacks information about risk and preventive factors present at the time of death. This prevented us from being able to group cases with similar circumstances at death; without this information, it is difficult to determine the contribution of variation in how cause of death is assigned by different death certifiers. To mediate the effect of this issue, we report aggregated SUID data in addition to the SUID subtype data. An additional limitation is that death certificates are often filed with a "pending" cause of death until the death investigation is complete, and the official cause of death is consequently assigned. If the death certificate is not amended in a timely manner, these deaths are coded at the national level as due to unknown cause. This classification practice results in a higher prevalence of deaths due to unknown cause in the national mortality files when compared with state files that may be more accurate. This was the case in California in 2000 and 2001, Georgia in 2008 and 2009, and New Jersey in 2009, resulting in an artificially low rate of SIDS and an inflated rate of unknown-cause deaths.[2] Because we grouped SUID subtypes, this did not impact our interpretation of state-specific SUID findings but may have affected our interpretation of the diagnostic shift at the national level. Conversely, the use of vital statistics data was an asset to our study because we were able to examine 25 years of state- and national-level data. Another strength of this study is our inclusion of state and national trends, because most studies have looked at national or regional SIDS or SUID trends[32,33]

CONCLUSIONS

The lack of a substantial reduction in US SUID rates since 1999 is an opportunity for programs to re-evaluate their strategies to promote safe sleep and reduce SIDS risk factors. Although some states have experienced notable declines, wide variations in SUID rates by state still exist. States that have been successful in significantly reducing their SUID rates might serve as models for other states in terms of SUID risk reduction. Increased understanding about the factors that have influenced these state-specific trends is needed to leverage successful interventions for adaptation by other states. Influencing factors may include state-level policies and regulations, as well as creative and innovative approaches for encouraging safe sleep practices.

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ABBREVIATIONS

ASSB	accidental suffocation and strangulation in bed
HP2020	Healthy People 2020
ICD-9	*International Classification of Diseases*, *Ninth Revision*
ICD-10	*International Classification of Diseases*, *10th Revision*
PC	percent change
SIDS	sudden infant death syndrome
SUID	sudden unexpected infant death

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WHAT'D KNOWN ON THIS SUBJECT:

Sharp declines in sudden unexpected infant death (SUID) during the 1990s and a diagnostic shift beginning ~1999 have been documented. However, trends in SUID rates after 1999 and state-specific SUID rates have not been fully explored and may be used to inform prevention efforts.

WHAT THIS STUDY ADDS :

There has been little change in overall SUID rates since 1999, but there is evidence of a continuing diagnostic shift between SUID subtypes. State SUID trends varied greatly.

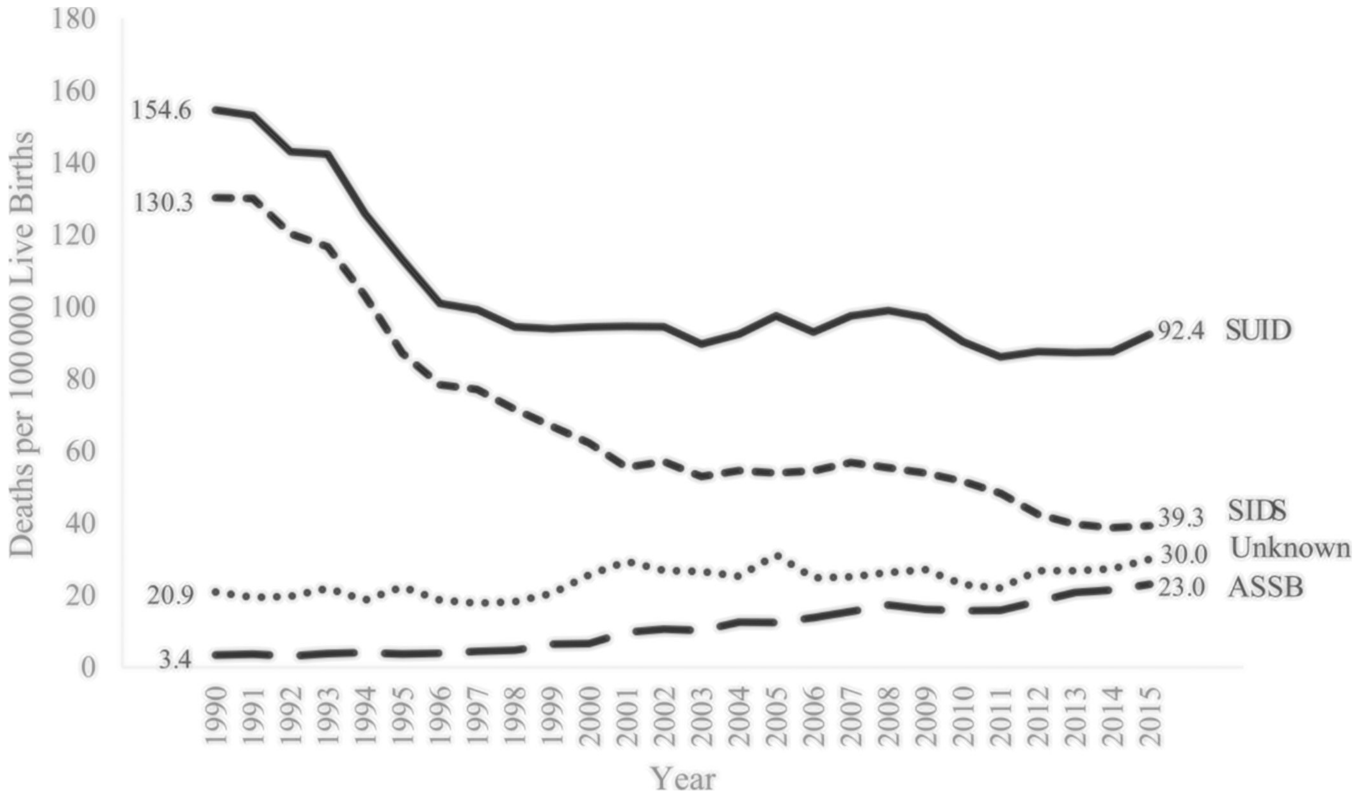

FIGURE 1.

Trends in SUID and SUID subtype rates per 100 000 live births, United States, 1990–2015. The ICD-9 and ICD-10 codes for SUID and SUID subtypes are as follows: SUID (ICD-9: 798.0, 799.9, and E913.0 or ICD-10: R95, R99, and W75), SIDS (ICD-9: 798.0 or ICD-10: R95), unknown, other ill-defined and unspecified causes of mortality (ICD-9: 799.9 or ICD-10: R99), and ASSB (ICD-9: E913.0 or ICD-10: W75).

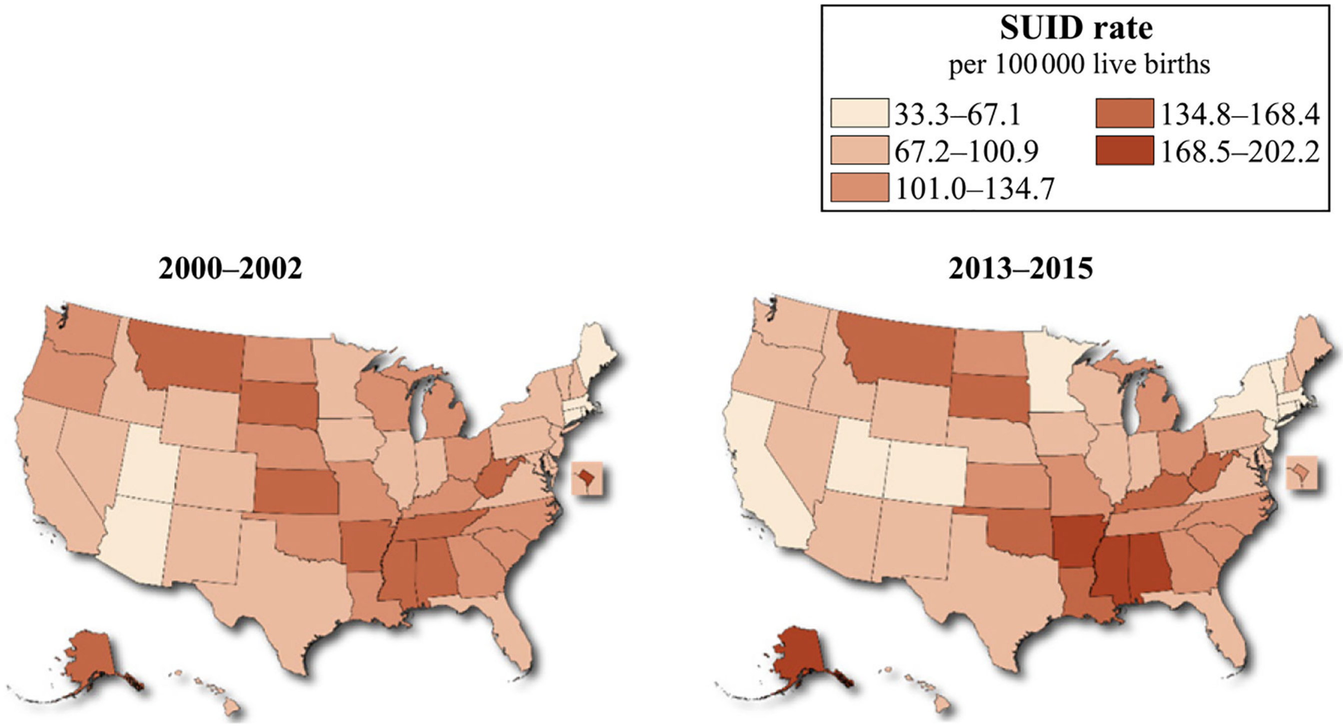

FIGURE 2.
SUID rates per 100 000 live births, United States, 2000–2002 and 2013–2015. SUID is defined as infant deaths that were assigned (ICD-10) codes for SIDS (R95), other ill-defined and unspecified causes of mortality (R99), and ASSB (W75). Map classes are equal quintiles across both periods.

TABLE 1

PC in SUID Rates, United States, 1990–2015

PC (95% confidence interval)	SUID	SIDS	Unknown	ASSB
1990–2015	−40.5[a] (−42 to −39)	−70.9[a] (−72 to −70)	45.1[a] (39 to 51)	671.0[a] (619 to 725)
1990–1998	−44.6[a] (−46 to −43)	−50.9[a] (−52 to −49)	−14.1[a] (−20 to −8)	30.2[a] (11 to 53)
1999–2015	−7.2[a] (−10 to −5)	−35.8[a] (−38 to −34)	4.6 (0 to 10)	183.8[a] (166 to 204)

The ICD-9 and ICD-10 codes for SUID and SUID subtypes are as follows: SUID (ICD-9: 798.0, 799.9, and E913.0 or ICD-10: R95, R99, and W75), SIDS (ICD-9: 798.0 or ICD-10: R95), unknown, other ill-defined and unspecified causes of mortality (ICD-9: 799.9 or ICD-10: R99), and ASSB (ICD-9: E913.0 or ICD-10: W75).

[a] Indicates significant (<.05) *P* value.

TABLE 2

SUID Rates per 100 000 Live Births, Rate Difference and PC by State, United States, 1990–2015

State	1990–1992	2000–2002	2013–2015	Rate Difference From 2000–2002 to 2013–2015	PC Comparing 2000–2002 to 2013–2015
Alabama	175.0	137.4	180.5	43.2	31.4*
Alaska	257.7	147.1	202.2	55.1	37.5*
Arizona	157.3	59.5	80.3	20.8	34.9*
Arkansas	220.1	152.4	188.3	36.0	23.6*
California	127.7	72.6	48.4	−24.2	−33.3*
Colorado	213.1	97.6	57.7	−39.8	−40.8*
Connecticut	108.0	63.4	60.1	−3.3	−5.2
Delaware	130.5	76.0	91.0	15.0	19.7
District of Columbia	318.0	184.3	102.2	−82.1	−44.5*
Florida	128.0	97.6	87.8	−9.9	−10.1*
Georgia	161.0	110.9	116.3	5.4	4.9
Hawaii	132.7	86.4	67.9	−18.5	−21.4
Idaho	213.4	80.6	88.1	7.5	9.3
Illinois	177.0	95.9	88.3	−7.6	−7.9
Indiana	158.6	89.9	98.3	8.4	9.4
Iowa	168.6	97.8	81.2	−16.7	−17.0
Kansas	154.1	135.7	110.1	−25.6	−18.9*
Kentucky	167.4	132.8	155.5	22.7	17.1*
Louisiana	145.5	122.1	156.5	34.3	28.1*
Maine	99.7	58.6	89.3	30.6	52.2
Maryland	159.8	82.0	88.4	6.4	7.8
Massachusetts	89.5	41.5	55.8	14.3	34.4*
Michigan	174.8	101.4	104.3	3.0	2.9
Minnesota	151.0	72.3	63.7	−8.7	−12.0
Mississippi	193.9	155.6	175.4	19.7	12.7
Missouri	196.8	120.2	101.5	−18.7	−15.6*

State	1990–1992	2000–2002	2013–2015	Rate Difference From 2000–2002 to 2013–2015	PC Comparing 2000–2002 to 2013–2015
Montana	254.3	151.6	136.4	−15.2	−10.0
Nebraska	178.3	102.9	86.7	−16.2	−15.7
Nevada	233.3	84.4	73.7	−10.7	−12.7
New Hampshire	118.2	70.9	88.9	17.9	25.3
New Jersey	113.6	68.8	61.2	−7.6	−11.0
New Mexico	175.6	77.9	76.7	−1.2	−1.6
New York	116.6	69.1	53.7	−15.4	−22.3[*]
North Carolina	158.0	105.7	110.3	4.6	4.4
North Dakota	152.1	130.1	114.2	−15.9	−12.2
Ohio	178.8	113.2	102.0	−11.2	−9.9
Oklahoma	209.1	133.7	152.0	18.3	13.7
Oregon	233.1	104.9	82.9	−22.0	−21.0[*]
Pennsylvania	129.4	92.5	87.2	−5.2	−5.7
Rhode Island	78.8	47.2[a]	64.4	17.1	36.3
South Carolina	156.6	111.2	114.2	3.0	2.7
South Dakota	248.8	164.9	157.3	−7.6	−4.6
Tennessee	179.8	137.2	128.7	−8.5	−6.2
Texas	118.4	97.3	92.6	−4.6	−4.7
Utah	178.1	56.7	66.1	9.3	16.4
Vermont	137.6	67.5[a]	33.3[a]	−34.2	−50.7
Virginia	133.4	98.5	90.4	−8.1	−8.2
Washington	214.3	104.7	75.3	−29.4	−28.1[*]
West Virginia	165.0	151.6	159.2	7.6	5.0
Wisconsin	154.9	109.7	68.2	−41.5	−37.8[*]
Wyoming	303.8	100.4[a]	86.6	−13.9	−13.8
United States	150.3	94.5	89.2	−5.4	−5.7[*]

SUID is defined as infant deaths that were assigned ICD-9 and ICD-10 codes for SIDS (798.0 or R95), other ill-defined and unspecified causes of mortality (799.9 or R99), and ASSB (E913.0 or W75).

[a]The figure does not meet the standards of reliability or precision; it is based on fewer than 20 deaths in the numerator.

[*]*P* value < .05.