Age at Death, Season, and Day of Death as Indicators of the Effect of the Back to Sleep Program on Sudden Infant Death Syndrome in the United States, 1992-1999

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Background: In June 1992, the American Academy of Pediatrics Task Force on Infant Positioning and Sudden Infant Death Syndrome (SIDS) made its first recommendation concerning placing infants in a supine position. Since the publication of this recommendation, SIDS rates in the United States have declined 44%. Before this recommendation, SIDS had a marked seasonal pattern and was noted to occur more frequently on weekends.

Objective: The objective of this study was to determine if significant changes in SIDS rates have occurred in age at death (0-27 days vs 1-6 months vs 7-11 months), season of death, and weekday of death since the implementation of the recommendations for supine positioning of infants for sleep.

Design: United States natality and mortality data were used for the years 1992 through 1994. United States linked infant birth and death certificate files were used for the years 1995 through 1999. Season of death was calculated from month of death and was ordered for analysis from winter to fall to spring to summer; day of death was ordered from Monday to Sunday and additionally analyzed as weekend (Saturday and Sunday) vs weekday (Monday through Friday).

Results: During the 8 years, 28,548 deaths were attributed to SIDS among residents of the United States. The average annual decrease in the SIDS rate for neonates aged 0 to 27 days was 6.6%; for infants aged 1 to 6 months, 9.0%; and for infants aged 7 to 11 months, 6.1%. The average decline in seasonal rates from winter to summer was 11.2% per season. A significant interaction between year of death and season indicated a diminishing rate of seasonal variation. The odds ratio for weekend vs weekday SIDS deaths was 0.98 (95% confidence interval, 0.96-1.01). There was no significant interaction between year of death and weekday of death, which indicates no change in the relationship since the implementation of the supine sleeping recommendations.

Conclusions: These data provide insights into the effect of the supine sleep recommendations on SIDS. The reduction in seasonal variation of SIDS suggests advantages conferred by supine sleeping in colder seasons.


Sudden Infant Death Syndrome (SIDS) remains a major contributor to infant mortality in the United States. In 1999, approximately 26,48 infant deaths were attributed to SIDS, making it the third leading cause of death during infancy. Since the initial recommendation by the American Academy of Pediatrics Task Force on Infant Positioning and SIDS in June 1992 to place infants to sleep in a supine position, there has been a 44% decline in the SIDS rate from 1.20 per 1000 live births to 0.67. This decline in SIDS rate is assumed to be associated with the decline in prevalence of prone positioning from approximately 70% in 1992 to 20% in 1998.

Before the implementation of the “Back to Sleep” campaigns, several characteristics of SIDS deaths had been described. Most SIDS deaths occurred in infants aged 2 to 3 months. SIDS deaths occurred more frequently during the winter, and there had been some reports of a higher prevalence of SIDS deaths on the weekend.

Beal et al reported a diminished seasonal variation of SIDS and a shift in the peak age at death for SIDS to 4 to 8 weeks in Australia after the implementation of a program to decrease prone sleeping. Adams et al reported a nonsignificant decline in seasonal variation of SIDS deaths and an increase in the proportion of late (infant age >6 months) SIDS deaths in

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California for the years 1990 through 1995. To our knowledge, whether the move away from prone positioning of infants for sleep has affected the age at death, seasonal distribution, and day of SIDS deaths in the entire United States has not been described.

Documentation of such changes may provide insights into the mechanisms of SIDS. For example, changes in the SIDS rates at certain ages at death might provide information on the effectiveness of supine positioning at various stages of development in the first year of life. Modifications of the seasonal variation of SIDS could point to mechanisms more related to environment than to infectious disease mechanisms that have been sought as a cause of seasonal variation in SIDS. Changes in the day of week of death from SIDS as a result of the Back to Sleep campaign could point to an interaction between compliance with infant positioning recommendations and modification of social behavior that might put an infant at higher risk for SIDS, particularly on the weekend.

The objective of this analysis was to determine if any significant changes had occurred in the United States in the age at death from SIDS, the season of SIDS deaths, and the day of the week of SIDS deaths from 1992 through 1999. For comparison, all other causes of mortality occurring in the postneonatal period during these years is presented.

**METHODS**

Data were obtained from US natality and mortality files for the years 1992 through 1994, because linked infant birth and death certificate files were not available for those years. For 1995 through 1999, linked infant birth and death certificate files were used. File characteristics and methods of data linkage have been reported elsewhere. Resident birth and infant death data were obtained from these files, along with the age, month, and day of death. *International Classification of Diseases, Ninth Revision (ICD-9)* code number 798.0 was used to identify SIDS deaths. All other codes were categorized as “other” causes. Age at death was categorized as 0 to 27 days, 1 to 6 months, or 7 to 11 months. Season of death was classified and ordered as follows: December, January, February (winter); September, October, November (fall); March, April, May (spring); and June, July, August (summer). Day of death was ordered as follows: Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, and Sunday. The weekend was considered Saturday and Sunday and was compared with the combined weekdays of Monday through Friday. Monthly, seasonal, weekday, and weekend rates were calculated by using a denominator of live births that consisted of the total number of annual live births for the year of death divided evenly across months, seasons, weekdays, or weekend. Seasonal and weekday rates are postneonatal case rates.

All analyses were performed by using Proc Genmod (SAS, Cary, NC). Average annual changes in rates across time were obtained by means of Poisson regression to estimate the regression coefficient and then exponentiating the coefficient, subtracting 1, and multiplying by 100 to express the result as the percent average annual change in rate. Odds ratios and 95% confidence intervals (CIs) were obtained by using logistic regression. A $\chi^2$ test for general association was used to measure differences in the distribution of age at death for the years 1992 and 1999. Tests for interaction between variables were determined by means of logistic regression, with the variables entered as nominal values. Statistical significance was arbitrarily considered $P < .05$.

**RESULTS**

During the 8 years from 1992 through 1999, 31,566,623 births to residents of the United States were available for analysis (Table 1). There were 28,548 infant deaths attributed to SIDS and 213,284 attributed to other causes. Although 94% of SIDS deaths occurred in the postneonatal period (infant age > 28 days), only 27% of other causes did so.

The SIDS rates in the neonatal period had an average annual decline of 6.6% ($P < .001$), although for the last 3 years of the period there was no change in rates ($P = .37$) (Table 2). The average annual decline in rates for other causes was 1.9% ($P < .001$) (Table 2). For the age range 1 to 6 months, SIDS rates declined annually at a rate of 9.0%, and other cause rates declined 2.6% annually. For the age range 7 to 11 months, SIDS rates decreased 6.1% annually from 1992 to 1999, but there was no change in rate for the last 3 years ($P = .98$). Rates for other causes decreased significantly 3.0% (95% CI, −3.7 to −2.2) per year.

To determine if these declines in SIDS rates for these large categories of age at death resulted in any significant shift in the monthly distribution of age at death for SIDS, we compared the monthly distribution of age at
death for SIDS for the years 1992 and 1999 (Figure). The $\chi^2$ value for the 2 years was significant ($P = .008$). An increase in the proportion of deaths occurring in the neonatal period (from 6.1% in 1992 to 7.7% in 1999) and a decrease in the proportion occurring in the second month (from 27.3% in 1992 to 24.6% in 1999) accounted for 29% of the $\chi^2$ value. The proportion of deaths occurring in infants aged 7 to 11 months increased from 4.5% of deaths to 5.8%.

When season of death from SIDS was analyzed in the fashion of winter to fall to spring to summer, there was an average seasonal decline in rates of 11.2% across all years (Table 3). There was, however, an interaction between season and year of death that revealed a statistically significant shift in the distribution of the age at death. The $P$ value for a $\chi^2$ test of general association between the 2 years was <.01, which indicates a statistically significant shift in the distribution of the age at death.

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Other causes of postneonatal mortality demonstrated a significant average daily decrease in rate from Monday to Sunday of −0.4%. The interaction between day of death and year of death for other causes ($P = .02$) indicated a significant variation in rates according to day of the week between 1992 and 1999. Odds ratios for average weekend rates, as compared with average weekday rates, were calculated by using logistic regression. For SIDS mortality, the odds ratio for weekend vs weekday rates was 0.98 (95% CI, 0.96-1.01). The odds ratio for weekend vs weekday mor-
tality rates for other postneonatal causes demonstrated a slightly reduced risk of mortality on the weekends, with an odds ratio of 0.96 (95% CI, 0.94-0.97).

Because other investigators observed a decreasing risk of weekend death from SIDS when the deaths were considered according to level of maternal education, from the lowest level of education to the highest, we attempted to re-create their observation. Using the linked vital statistics data for 1997, 1998, and 1999 and odds ratios generated by means of logistic regression, we observed a risk of weekend death from SIDS among women with less than 12 years of education, 12 years of education, and 13 to 15 years of education, as compared with women with 16 or more years of education, of 2.83 (95% CI, 1.89-4.24), 2.71 (95% CI, 1.81-4.07), and 2.30 (95% CI, 1.52-3.49), respectively.

**COMMENT**

Sudden infant death syndrome has been reported to occur most frequently in infants aged 2 to 3 months. Hypotheses for the high prevalence of deaths in this age range have included a concern for a developmental vulnerability of infants in their arousal mechanisms at this age and a concern about infants’ lack of motor skills to remove themselves from a potentially asphyxiating position. With the advent of the supine sleeping recommendations, the overall SIDS rate declined 44% from 1992 to 1999. Because most SIDS deaths occur in infants aged 1 to 6 months, most of the rate decline is assumed to occur in this age range.

In this study, we document that the most dramatic decrease in SIDS rate is in the age range of 1 to 6 months. Rates are also lower in the neonatal period, but the decline in rate was not as dramatic as that in infants aged 1 to 6 months and remained unchanged during the last 3 years of the period. Rates among infants aged 7 to 11 months, though decreasing significantly across the entire period, also did not change during the last 3 years examined. Adams et al reported a significant increase in late SIDS deaths in California for the period from 1990 through 1995.

These observations suggest several possible explanations. First, the older infants may be dying of causes other than SIDS. Suffocation, asphyxiation, and accidental strangulation are potential other causes that could be misclassified as SIDS. However, younger infants are reported in greater numbers with these diagnoses than are infants 7 months or older.

Second, supine positioning may confer no advantage in infants older than 6 months. Studies of levels of arousal in infants younger than 6 months suggest that infants sleep more lightly, and arousal thresholds are lower among infants placed in a supine position. Whether these facts apply to infants older than 6 months is uncertain. In addition, although infants may be placed in a
supine position to sleep, by the age of 6 months, they are able to assume their own sleeping position by rolling over.39 Thus, these older infants may assume a prone position and be at higher risk, effectively losing any protective effect of supine positioning. Some authors have argued that infants accustomed to sleeping in a supine position, when either purposefully or inadvertently positioned, may be at even higher risk for SIDS.40 No information is available on the infant death certificate concerning the position in which the infant was found at the time of death, so there is no way to establish whether there was a higher prevalence of prone positioning among the older infants dying of SIDS. The current recommendations for infant positioning apply to neonates and infants from birth to 11 months.34

Seasonal variation of SIDS with higher rates observed in the colder months has been reported by a number of investigators.36–38 Both Beal et al36 and Adams et al,37 however, noted a trend for the seasonal variation in SIDS to diminish after implementation of supine sleeping recommendations. Reasons for the higher prevalence of SIDS in the winter months include concern for a greater risk for infection that might predispose an infant to SIDS, a greater risk for overheating, and a greater risk for overbundling and consequent suffocation.

Although the winter months are associated with a higher prevalence of viral infections, Hoffman et al39 failed to observe a higher prevalence of such infections just before death among cases of SIDS, as compared with deaths in matched control cases. Helweg-Larsen et al,42 using data from the Nordic Epidemiological SIDS study (1991-1995), however, reported a higher prevalence of reports of infectious disease symptoms during the last week among cases of SIDS, as compared with control cases. They also noted that the risk of SIDS appeared higher among infants who were placed in a prone position to sleep and had symptoms before death.

Overheating as a function of overdressing or covering infants has also been suggested as a potential cause for SIDS in the winter. It is difficult to know whether overheating of an infant during the winter is more likely to occur in colder or warmer climates. Regional prevalences of SIDS in the United States do not suggest that the colder areas of the United States predispose infants to SIDS. The northeastern United States has the lowest SIDS rate independent of race and birth weight.8 Thus, an area with cool temperatures and a great likelihood for overheating and overheating has the lowest SIDS rates. An alternative hypothesis for the decline in seasonal variation may be the decreased likelihood of entrapment with covers or items in a bed or bassinet, which has been an area of emphasis in the Back to Sleep program implemented in 1991. Douglas et al,44 however, noted that although the seasonal pattern of SIDS has diminished, it still persists. Using Australian and Brit-

Table 4. Postneonatal Mortality Rates for SIDS and Other Causes of Death per 1000 Live Births According to Day of Week and Year

<table>
<thead>
<tr>
<th>Year</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
<th>Sunday</th>
<th>Average Change Across Days of the Week, %</th>
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<tr>
<td>SIDS</td>
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<td></td>
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<tr>
<td>1992</td>
<td>1.96</td>
<td>2.11</td>
<td>2.04</td>
<td>2.07</td>
<td>2.15</td>
<td>1.95</td>
<td>1.83</td>
<td>−1.1</td>
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<tr>
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<td>1.90</td>
<td>2.00</td>
<td>2.06</td>
<td>2.03</td>
<td>2.12</td>
<td>1.84</td>
<td>1.88</td>
<td>−0.5</td>
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<tr>
<td>1994</td>
<td>1.93</td>
<td>1.99</td>
<td>1.93</td>
<td>1.93</td>
<td>1.97</td>
<td>1.98</td>
<td>1.90</td>
<td>−0.7</td>
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<tr>
<td>1995</td>
<td>1.83</td>
<td>1.84</td>
<td>1.77</td>
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<td>1.92</td>
<td>1.81</td>
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<td>1996</td>
<td>1.74</td>
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<td>1.85</td>
<td>1.77</td>
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<td>1.68</td>
<td>1.78</td>
<td>1.62</td>
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<td>1.75</td>
<td>1.71</td>
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<td>1999</td>
<td>1.56</td>
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<tr>
<td>1992</td>
<td>−2.9</td>
<td>−3.2</td>
<td>−3.3</td>
<td>−2.3</td>
<td>−3.4</td>
<td>−1.7</td>
<td>−1.9</td>
<td>NA</td>
</tr>
<tr>
<td>1993</td>
<td>−3.8</td>
<td>−2.0</td>
<td>−4.1</td>
<td>−2.3</td>
<td>−4.2</td>
<td>−3.2</td>
<td>−2.6</td>
<td>−0.8</td>
</tr>
<tr>
<td>1994</td>
<td>−4.1</td>
<td>−2.3</td>
<td>−4.2</td>
<td>−2.4</td>
<td>−3.2</td>
<td>−2.7</td>
<td>−2.8</td>
<td>−0.9</td>
</tr>
</tbody>
</table>

Abbreviations: NA, not applicable; SIDS, sudden infant death syndrome.

*Weekdays were Monday through Friday, and weekends were Saturday and Sunday.
†For SIDS and other causes of death, respectively, the average annual change across all days of the week was −8.9% (95% confidence interval [CI], −9.3% to −8.4%) and −2.7% (95% CI, −3.0% to −2.3%), and the average daily change across all years was −0.6% (95% CI, −1.2% to 0.1%) and −0.4% (95% CI, −0.86% to −0.04%); changes were determined by means of Poisson regression. For SIDS (P = .45) and other causes of death (P = .02), the interaction between year and day of week was determined by means of logistic regression. For SIDS and other causes of death, respectively, the odds ratio for weekend vs weekday was 0.98 (95% CI, 0.96 to 1.01) and 0.96 (95% CI, 0.94 to 0.97), as determined by means of logistic regression, with the SIDS death rate as the dependent variable and weekend/weekday as a binary independent variable.
§Indicates P < .05.
Sudden infant death syndrome remains a major contributor to infant mortality in the United States. Recommendations for supine sleeping to reduce the risk for SIDS have been in effect since 1992. Although SIDS rates have been documented as declining since the recommendations were implemented, changes in characteristics of SIDS deaths as a result of the recommendations have not been reported for the United States as a whole. This article reviews changes in the age, season, and day of death of SIDS in the United States for the years 1992 through 1999. The changes reported in this analysis may add to the understanding of how supine positioning is associated with the observed decrease in SIDS rates.

Results of older SIDS studies tend to show a greater risk for SIDS on the weekend than does a more recent study reported by Spiers and Guntheroth. The 1974 through 1976 Newcastle survey reported that 16% (55%) of 29 sudden unexpected deaths occurred on a weekend or bank holiday. Murphy et al reported a higher prevalence of weekend SIDS deaths in England and Wales from 1979 through 1983. They reported an observed-expected ratio of 1.09 for weekend SIDS among infants aged 3 to 12 months, as compared with an average ratio of 0.96 for Monday through Friday. Mitchell and Stewart reported similar findings in New Zealand during the period from 1979 through 1984 across all ages of infants dying of SIDS. The observed-expected ratio for Sunday SIDS deaths was 1.22, as compared with an average ratio of 0.93 for the weekdays. Kaada and Sivertsen reported Norwegian data for the period from 1967 through 1985 and observed a 35% greater number of SIDS deaths on weekends and holidays among infants aged 3 to 12 months.

Our analysis parallels Spiers and Guntheroth’s observation of no increased risk of SIDS on the weekends. These authors, however, reported a significant decreasing risk of weekend death according to level of maternal education, from the lowest level of education to the highest. We observed a similar decrease in risk of weekend SIDS according to level of maternal education. Thus, although there is no increased risk of weekend death overall among SIDS cases, the risk may vary according to certain maternal or infant characteristics, all of which have not been delineated. Because these characteristics vary within a population, the weekend risk may vary, which may explain the varying results reported in the literature relative to the risk of SIDS on weekends.

Our analysis has a number of limitations. As with all vital statistics data, the validity of the data cannot be guaranteed. In particular, the certainty of SIDS diagnosis may be limited. Since 1995, no autopsy data have been issued with the public-use files to help confirm the diagnosis. In addition, there is no information about whether death scenes were investigated as part of the process in labeling a death as SIDS. These criteria have been recommended in labeling an unexpected infant death as SIDS.

Despite these limitations, vital statistics data provide an opportunity to give a national perspective for trends in SIDS mortality across time. Reporting the change in SIDS mortality across time was the major focus of this analysis. The move to ICD-10 coding of the underlying cause of death in 1999, however, may have had some effect on accurately tracking changes in SIDS rates. According to ICD-10 coding rules, an unexpected infant death may be coded as SIDS even when other conditions are listed on the death certificate. The comparability ratio between the ICD-10 and ICD-9 coding for SIDS in the 1999 data was 1.04, which implies a 4% greater likelihood for a death to be coded as SIDS with ICD-10 rules, as compared with ICD-9 rules. Nevertheless, SIDS rates decreased between 1998 and 1999. The question is whether they should be reported as 4% lower in 1999, considering that ICD-10 rules were used to define SIDS for that year. Another concern in this analysis is the possibility of change in the classification of SIDS deaths during this period. As of 1996, however, there had been no substantial shift in diagnostic classification of SIDS, although an increasing number of suffocation-related deaths as a percentage of the overall postneonatal mortality was noted.

In summary, this analysis has demonstrated a major decline in SIDS rates among infants aged 1 to 6 months. Seasonal variation in SIDS has declined since the implementation of supine sleeping recommendations. The mechanism for this decline remains unclear but may relate to changes in the sleeping environment or position that had previously put infants at greater risk during the winter months. Finally, although no overall change has occurred in the occurrence of SIDS on weekends, as compared with that on weekdays, the higher prevalence of weekend deaths in certain subpopulations deserves further exploration to determine why these subpopulations may be at greater risk of a SIDS death occurring on the weekend.

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