

The Effect of the Weekend on the Risk of Sudden Infant Death Syndrome

P. S. Spiers, PhD, and W. G. Guntheroth, MD

ABSTRACT. *Objective.* The risk of sudden infant death syndrome (SIDS) is associated strongly with socioeconomic status. However, many infants who live in one socioeconomic environment, with its attendant level of risk of SIDS over the weekend, often are exposed to a different level of risk during the work week (because of day care for the infant). If the association between SIDS and socioeconomic status acts through the quality of supervision of the infant, then there could be an immediate change in the level of risk as the infant moves from home to outside care to home again. In this scenario, infants of economically disadvantaged parents would have a higher risk of SIDS over the weekend than they do during the week. On the other hand, infants of economically advantaged parents would be at lower risk over the weekend. Therefore, the relative risk of SIDS associated with the weekend (risk over the weekend vs risk during the work week) should be found to decrease as the number of years of maternal education (a surrogate for socioeconomic status) increases. Testing this prediction is the objective of the study.

Methodology. Instances of SIDS in the postneonatal period (28–364 days) among the cohort of all infants born in the United States between January 1989 and December 1991 were analyzed. The number 798.0, taken from the *International Classification of Diseases*, was used to identify 14 996 cases of SIDS.

Deaths among hospital patients were distinguished from all other deaths. The latter were divided into four categories: 1) death occurred in the emergency department; 2) the infant was dead on arrival at the emergency department; 3) death occurred at a residence; and 4) death occurred at some other place. Maternal education was divided into four categories: <12, 12, 13 to 15, and ≥ 16 years. The weekend ratio was defined as the ratio of SIDS cases on Saturday and Sunday (times 5) and Monday through Friday (times 2). The predicted trend in this ratio by maternal education was tested by applying a χ^2 test-for-trend.

Results. The overall weekend ratio was 1.00, indicating that the risk of SIDS was no higher over the weekend than it was Monday through Friday. However, for infants of mothers with <12 years of education, the ratio was 1.13. For infants of mothers with ≥ 16 years of education, it was 0.55. The trend in the ratio as maternal education increased (1.13, 0.99, 0.86, and 0.55) was highly significant ($\chi^2 = 74.2$; 1 degree of freedom). Each of the four ratios, with the exception of 0.99, was significantly different

from 1.00 ($z = 3.74, 2.45, \text{ and } 6.09$, respectively). The ratios for infants of mothers with 13 to 15 and ≥ 16 years of education also were significantly different from each other ($z = 4.57$).

For all causes of death combined (including the relatively small number of SIDS cases) among hospital inpatients, there was no significant trend in the weekend ratio as the level of maternal education increased. However, among deaths not attributable to SIDS or accidents occurring outside the hospital, there was a slight but significant declining trend ($\chi^2 = 8.4$; 1 degree of freedom). The risk of an accidental death was highest over the weekend for all four maternal education categories.

On an average working day, the risk of SIDS among offspring of mothers with <12 years of education was found to be 3.9 times greater than that among offspring of mothers with ≥ 16 years of education. At the weekend, the relative risk increased to 7.9.

A plot of the weekend ratio against single years of maternal education revealed a unimodal distribution with a peak at 11 years.

Conclusions. First, the results of the study are consistent with the level of risk of SIDS, changing promptly toward the risk level obtained in the baby's new environment. Variability in the observation of unusual respiratory events seems the most likely explanation. It is unlikely that confounding factors played a role in the results for tertiary-educated mothers. Alternative explanations, such as less attentive maternal supervision or less regularity in the baby's routine over the weekend, could explain logically the result for infants of mothers with <12 years of education. But for infants of mothers with ≥ 16 years of education the opposite would have to be proposed.

Second, the absence of an overall weekend ratio > 1.00 is comparable with the minority of previous reports. The overall ratio is > 1.00 when SIDS cases occurring in a hospital setting are excluded. This probably is explained by the fact that care providers over the weekend are less likely to seek outside help because of their restricted (perceived or real) access to medical care. *Pediatrics* 1999; 104(5). URL: <http://www.pediatrics.org/cgi/content/full/104/5/e58>; *child care, day care centers for children, death certificates, education, maternal behavior, sudden infant death.*

ABBREVIATION. SIDS, sudden infant death syndrome; RR, relative risk; df, degree of freedom.

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The postnatal environment seems to influence strongly the risk of sudden infant death syndrome (SIDS).^{1,2} Presumably, some aspect of the environment accounts for the risk of SIDS being higher during the weekend than it is throughout the week in most studies that have examined the is-

sue.³⁻¹⁰ The ratio of the number of studies that have found an elevated risk to the number that have not¹¹⁻¹³ is about three to one.

Chalnoky and Balogh¹⁴ believe that any variation in infant mortality by day of the week has to be attributable to human factors. Explanations offered to account for the weekend effect in the case of SIDS include 1) restricted access to medical care over the weekend;^{4,5,7,8} 2) less attentive maternal supervision than during the week;^{8,10} and 3) differences between the baby's routine during the week and over the weekend.^{5,8,9}

One of the strongest environmental influences on the risk of SIDS is associated with socioeconomic status; the higher the status the lower the risk.^{15,16} However, this is probably not a simple relationship, because for a significant fraction of infants, the environment changes on both an interday and an intraday basis. Many infants who live in one socioeconomic environment, with its attendant level of risk of SIDS, over the weekend often are placed in another environment (day care), which has a different level of risk for perhaps 8 hours per day during the work week.

If the relationship between socioeconomic status and risk of SIDS acts primarily through the quality of supervision of the infant, then there could be an immediate change in the level of risk as the infant moves from home to outside care to home again. According to this scenario, infants of economically disadvantaged parents would have a higher risk of SIDS over the weekend than they do during the week. In contrast, infants of economically advantaged parents would be at lower risk over the weekend.

In this paper, we examine the prediction that the relative risk (RR) of SIDS associated with the weekend Saturday and Sunday vs Monday through Friday) decreases as the number of years of education obtained by the mother increases. The design of the study is historical prospective.

METHODS

The details of infant deaths occurring in the postneonatal period (28-364 days) among the cohort of infants born in the United

States between January 1, 1989 and December 31, 1991 were taken from CD-ROM disks.¹⁷ These disks contain information drawn from both a child's birth certificate and death certificate (if deceased). The percentage of infant deaths not linked to an appropriate birth certificate was low (2.4%).

The instances of SIDS were coded under *International Classification of Diseases*, Number 798.0.¹⁸ The level of maternal education, a generally accepted surrogate of economic status, was examined initially using four categories (<12, 12, 13-15, and ≥16 years). Deaths among hospital inpatients were distinguished from all other deaths. The latter were divided into four categories: 1) death occurred in the emergency department; 2) the infant was dead on arrival at the emergency department; 3) death occurred at a residence; and 4) death occurred at some other place.

Deaths occurring on a Saturday or Sunday were combined, as were those occurring between Monday and Friday. The risk of SIDS over the weekend, relative to the risk on a typical working day, then was calculated by multiplying the ratio of these two numbers by 5/2. The predicted existence of a decreasing trend in this ratio, as the number of years of maternal education increased, was tested by a χ^2 test for trend.¹⁹

RESULTS

Among infants born in the United States between January 1, 1989 and December 31, 1991, there were nearly 15 000 (14 996) infant deaths in the postneonatal period ascribed to SIDS. The distribution of these infants by the educational levels of their mothers was 5771 (<12 years), 5287 (12 years), 1,963 (13-15 years), and 945 (≥16 years). The educational level of 1030 mothers was unknown.

In Table 1, the RR associated with the weekend is broken down by place of death and maternal education. Although there is no weekend effect overall (RR = 1.00), the declining trend in RR as maternal education increases is highly significant ($\chi^2 = 74.2$, 1 degree of freedom [df]). Comparing the proportions of SIDS cases (all locations combined) occurring over the weekend to the expected proportion of 0.286 (2/7) in the four educational categories, the approximate standardized normal deviate values (1 tail) are 3.74, 0.28, 2.45, and 6.09, respectively. Except for the value associated with maternal education equal to 12 years, all these values are significant at at least the 0.01 level. The difference between the proportions associated with maternal educational levels of 13 to 15 years and ≥16 years is significant at the 0.001 level ($z = 4.57$).

TABLE 1. The RR of SIDS Over the Weekend, Compared to That During the Week by Place of Death and Maternal Education, United States 1989-1991

Maternal Education (Years)	Place of Death						Total (7)
	Hospital (1)	ER (2)	DOA (3)	Residential (4)	Other (5)	UK (6)	
<12	1.07	1.07	1.21	1.12	1.55	1.13	1.13
12	0.74	0.93	1.07	1.10	0.92	0.97	0.99
13-15	0.80	0.80	0.94	1.04	0.57	0.50	0.86
≥16	0.71	0.43	0.57	0.95	0.37	0.21	0.55
Unknown	1.35	0.90	0.98	1.10	1.15	1.25	1.04
All	0.92	0.91	1.07	1.09	1.05	0.95	1.00

Number of deaths on Saturday and Sunday combined

Row 1: 80, 625, 435, 524, 95, 42, and 1801

Row 2: 63, 607, 328, 413, 51, 38, and 1500

Row 3: 35, 209, 108, 128, 17, 6, and 1503

Row 4: 15, 67, 36, 45, 6, 1, and 170

Row 5: 41, 106, 33, 103, 12, 7, and 302

Row 6: 234, 1614, 940, 1213, 181, 94, and 4276

ER indicates emergency room; DOA, dead on arrival.

TABLE 2. The RR of Death Over the Weekend by Cause of Death, Place of Death, and Maternal Education, United States 1989–1991

Maternal Education (Years)	Hospital All	Outside of Hospital*			Unknown All	Total All
		SIDS	Accidents	Other		
<12	0.91	1.14	1.14	1.11	1.13	1.05
12	0.89	1.01	1.15	0.94	1.64	0.96
13–15	0.85	0.88	1.23	0.94	0.88	0.89
≥16	0.92	0.54	1.48	0.92	0.63	0.82
Unknown	1.02	1.00	1.01	1.53	0.35	1.02
All	0.90	1.00	1.16	1.03	0.96	0.97

Number of deaths on Saturday and Sunday combined

Row 1: 1249, 1679, 242, 1013, 90, and 4273

Row 2: 1506, 1399, 197, 859, 95, and 4056

Row 3: 636, 462, 66, 305, 33, and 1502

Row 4: 443, 154, 29, 172, 17, and 815

Row 5: 306, 254, 29, 160, 23, and 772

Row 6: 4140, 3948, 563, 2509, 258, and 11418

* Includes dead on arrival, emergency room, residential, and other.

Among hospital inpatients succumbing to SIDS, the trend by level of maternal education is just short of significance on a one-tail test ($\chi^2 = 2.65$, 1 df). For infants who were not hospital inpatients at the time of death or who died at an unknown location (Table 1), the declining trend is significant for columns ii, iii, v, and vi (χ^2 values of 42.3, 15.7, 20.9, and 4.9, respectively, each with 1 df). In contrast, the trend in residential deaths does not even approach significance ($\chi^2 = 0.94$).

There is no trend across maternal education among deaths from all causes combined (including SIDS) occurring in hospital (Table 2). Among deaths outside the hospital that are not attributable to SIDS or accidents the declining trend is slight but statistically significant ($\chi^2 = 8.4$; 1 df). The risk of an accidental death in the postneonatal period is consistently greater at the weekend than during the week. This was as true for accidental deaths attributable to suffocation or inhalation of a foreign object as it was for accidental deaths attributable to other causes.

For infants of mothers with 12 years of education (ie, high school graduates) the absolute risk of succumbing to SIDS is essentially the same on a weekday as it is on a Saturday or Sunday (Table 3). Table 3 also shows the absolute rates for infants of mothers with <12, 12, and 13 to 15 years of education, each expressed as a ratio of the rate for infants of mothers with ≥16 years of education. From these results, one observes that on an average working day the risk of SIDS among the offspring of mothers with <12 years of education is 3.86 times that of the offspring of

mothers with ≥16 years of education. During the weekend, it is 7.90 times greater (Table 3).

In Fig 1, the weekend RR of SIDS is plotted against single years of maternal education. The distribution is unimodal, with a peak in the ratio occurring when the mother received 11 years of education.

DISCUSSION

As predicted, in the first level of analysis (represented by data in the Tables), the weekend effect for SIDS was found to decrease as the level of maternal education increased. This result is consistent with the occurrence of an immediate change in the risk of SIDS as the infant moves from one environment to another environment. Because the interval between exposure and symptoms in everyday infections is probably not <48 hours, the results could not plausibly have arisen as a consequence of changes in the rates of exposure to infection. The difference in the level of risk of SIDS between the weekend and the working week plausibly could be linked to such risk factors as parental smoking, bed sharing, or sleep deprivation in the case of poorly educated mothers but not well educated mothers. It is possible that the percentage of infants placed in the prone position was high for poorly educated mothers, low for college-educated mothers, and somewhere in the middle for day care outside the home. But the percentage differences would have to have been very large. This is unlikely because the years of the study (1989 through 1991) were before sleep position became an issue in the United States.

TABLE 3. Mortality Rate (per 10 000 per Day) and Risk of SIDS Relative to That in Infants of Mothers With ≥16 Years of Education, Over the Weekend and During the Working Week by Level of Maternal Education

Maternal Education (Years)	Rate per Day		RR	
	Saturday and Sunday	Monday Through Friday	Saturday and Sunday	Monday Through Friday
<12	3.32	2.93	7.90	3.86
12	1.71	1.72	4.07	2.26
13–15	1.07	1.25	2.55	1.64
≥16	0.42	0.76	1.00	1.00
All	1.74	1.75		

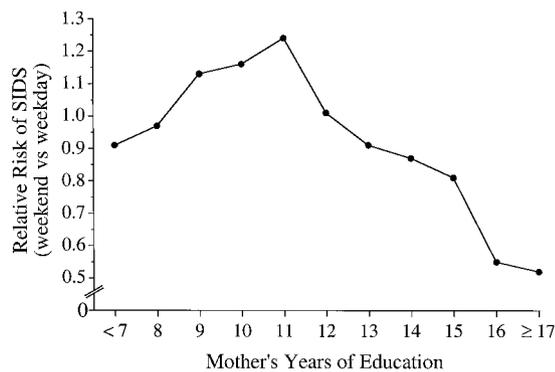


Fig 1. The RR of cases of SIDS over the weekend by level of maternal education

Over the weekend, infants whose mothers received 12 years of education had four times the risk of succumbing to SIDS than infants of mothers who were college-educated. If quality of supervision of the infant explains the variation in the weekend ratio with maternal education (perhaps because the poorly educated mother is given less relevant instruction), then an observable aspect of the infant's behavior that is considerably more likely to be noted by the more educated observer must exist. Unusual respiratory events seem to be the most likely indicator. Mandell²⁰ reported that 37% of mothers of SIDS victims who were nurses (and thus trained observers) observed periodic cyanosis, apnoeic episodes, or wheezing in their children in retrospect. Only 6% of mothers of SIDS victims who were not nurses reported such events.²⁰ (It is conceivable that sleeping in the prone position is a risk factor for SIDS partly because the caregiver's ability to monitor the baby's condition visually is restricted). The fact that SIDS victims suffer from an increased frequency of moderate hypoxic episodes not related to the terminal event is supported by autopsy findings of abnormalities in the brainstem²¹ and lung arteries²² and of elevated levels of fetal hemoglobin.²³

Although the time of death (if known) is entered routinely on every death certificate, unfortunately, it was not included in the data available for analysis. This represents a limitation of the study, because infants are not in alternative care settings 24 hours per day. Without being able to show results compatible with the risk of SIDS changing by the hour as the infant moves from one risk environment to another, what can be said about alternative explanations for the tendency for the weekend ratio to decline with increasing maternal education? For example, is it possible that it is attributable to variability in maternal supervision? But to which maternal educational category does one apply this explanation? The weekend effect in mothers with <12 years of education reasonably could be attributable to their being more attentive during the week than over the weekend, but it seems unreasonable to propose that the opposite is the case in college-educated mothers and that mothers with a high school education have a level of attentiveness that does not vary by the day of the week.

Over the working week, the average amount of

time spent in an alternative care setting by infants who are not totally cared for by their parents is probably ~30 hours (some parents work part time). When this is coupled with the fact that probably >40% of infants are not placed in an alternative care setting,²⁴ then the large difference between the weekend risk for SIDS and the weekday risk (0.42 vs 2.76; Table 3) among infants of tertiary-educated mothers is difficult to understand (at least in terms of the hypothesis proposed). One possible explanation is that the risk of SIDS is not at its highest during the night, nor even uniform over the 24 hours of a day, but significantly elevated during those hours when an infant normally is placed in alternative care. Bergman²⁵ and the authors of the Newcastle survey¹⁰ both reported that 90% of SIDS cases were found between 6 AM and 6 PM. Of 11 cases in which the interval between last seen alive and death was ≤2 hours, Hilton and Turner²⁶ reported 8 found between 6 AM and 6 PM. The crucial question of course is what would the percentages have been if they had been based on the time when death occurred?

A slight, but statistically significant, trend in the weekend ratio was observed among infants who died outside of the hospital from a cause of death not classified under SIDS or accidents. This might have been caused by the presence of misdiagnosed instances of SIDS. SIDS is a diagnosis of exclusion,²⁷ and there is some subjectivity (and probably some error) involved in what is interpreted as an explained death. This is coupled with the possible inadequacy of the very definition of SIDS. For example, respiratory infection frequently accompanies sudden death in infancy,^{28,29} and the assumption that SIDS cannot occur after this type of infection has developed to a more serious level seems somewhat arbitrary.

Overall, there was no weekend effect for SIDS. This was primarily a consequence of the low ratios among hospital inpatients and outpatients, offsetting the high ratios among deaths occurring elsewhere. A contribution to the no weekend effect also was made by a tendency among the offspring of parents who did not graduate high school with educational levels between <7 and 11 years for the ratio to increase rather than to decrease with increasing education (see Fig 1). Both observations deserve comment.

The lower weekend ratio among hospital deaths could have come about as a consequence of families being less inclined to call emergency services over the weekend. But the extent to which the ratio among hospital deaths offsets that among deaths occurring elsewhere clearly depends on the degree to which the former are included in the study. This could involve more than a simple choice on the part of the investigator. In some hospitals, cases of SIDS may be undiagnosed either because of a low in-house autopsy rate or because of a desire to reduce the possibility of litigation.

In the present study, 46.1% of all infants with SIDS died in hospital, as inpatients or outpatients. Emery⁴ reported a similar percentage (47.0) from Sheffield, England. In contrast, only 1 of 30 cases in the Newcastle survey died in hospital.¹⁰ Most studies concerned with the weekend effect in SIDS give no in-

formation on the site of death. One exception was the study conducted by Macfarlane and Gardner⁵ in which the authors restricted their cases to those infants dying outside of a hospital. In both the study by Macfarlane and Gardner⁵ and the Newcastle survey,¹⁰ there was a significant weekend effect. The present study's finding of a weekend effect >1.0 (1.08) among nonhospital deaths and <1.0 (0.96) among hospital deaths replicates the observations of Emery.⁴

In addition to the degree to which SIDS cases occurring in hospital are included, there is also an influence on the strength of a weekend effect in a community. This influence is the risk of SIDS associated with the alternative care setting and the extent to which use is made of alternative care. For example, in a community in which this risk is below the community's average and alternative care is used widely, one would expect the weekend effect to be quite high.

The unexpectedly low weekend ratio among infants of mothers with <11 years of education (evidenced by the change in direction of the trend in Fig 1) might be a consequence of these mothers being increasingly unable to afford day care outside of the home. According to a recent survey,²⁴ the three most important resources for caring for an infant outside of the home in the United States are 1) extended members of the family (48%), 2) independent providers (typically caring for 3–5 infants; 32%), and 3) center-based care (14%). The poorly educated mother is much more likely than is the better educated mother to use the first option over the other two.²⁴ Thus, the fraction of mothers with <11 years of education who place their infants in a Monday through Friday environment with an associated risk level for SIDS that is lower than that to which the infant is exposed normally is likely to be relatively small.

Because only a small percentage of infants receive center-based care,²⁴ any campaign to increase the caregiver's alertness should concentrate on the community at large. It probably would be more cost-effective if additional attempts to persuade caregivers to avoid placing infants in the prone position during sleep followed a similar strategy. Any attempt to reduce the incidence of SIDS by modification of the caregiver's behavior should emphasize simultaneously, for the benefit of caregivers of deceased infants, that they are not being blamed for an event that can occur in all walks of life.

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