Neonatal Mortality by the Day of the Week In the 1974–75 Arkansas Live Birth Cohort

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Abstract: This study is an analysis of daily variations in neonatal mortality among 66,049 live births in the 1974–75 Arkansas live birth cohort. Weekends and holidays in general, and Sundays in particular, were found to have the fewest number of deliveries. Variations in deliveries by the day of the week were attributed to obstetric practices. Births weighing less than 2500 gms. were over-represented among weekend deliveries as were infants experiencing a birth-related injury. Neonatal mortality was found to be higher among weekend deliveries with a Sunday rate that was 27 per cent above the weekly average. Separate analysis by race and birth weight revealed the weekend peak to be more pronounced among non-whites. Analysis of daily variations by cause of death showed that Sundays exceeded the overall average for seven of the eight cause of death categories examined. (*Am J Public Health* 1981; 71:601–605.)

Introduction

Daily variations in mortality are well established for selected causes of death.[1, 2] Studies of daily variations in mortality have typically done so from one of two perspectives. The first perspective attempts to establish a relationship between daily variations in mortality and episodic events such as extremes in temperature,[3–5] air pollution, or solar activity;[6] the second seeks to establish a relationship between mortality and specific days of the week. Fluctuations in mortality relative to differential social behavior that occurs as part of the weekly cycle are best exemplified by the weekend peaks in homicides,[1, 2] motor vehicle accidents,[1, 2] or the tendency for coronary heart disease to peak on Mondays.[1]

Among the newborn it is possible to examine daily mortality patterns in terms of an additional criterion: mortality can be calculated by the day of birth as well as the day of death. In a recent analysis of births in England and Wales for the period 1970–76 MacFarlane found that perinatal mortality was significantly higher among weekend deliveries than was true for the remainder of the week.[7] It was also observed that fewer deliveries occurred on either the weekend or major holidays than on other days. MacFarlane noted that the relative lack of weekend deliveries increased during the time period, a tendency she attributed to changing obstetric practices.

Although MacFarland found substantial differences in perinatal mortality by the day of week, the results were based upon crude rates obtained by relating perinatal deaths on a given day of birth to deliveries made on that day. The present study employs a more appropriate data base for an analysis of daily mortality among newborn. By matching the mortality experience of the 1974–75 Arkansas live birth cohort it is possible to explore the relationship between the day of birth and mortality in a more valid and detailed fashion.

Data and Methods

The data used in this study are based upon information contained on the certificate of birth and infant death filed with the Arkansas Department of Health. The data consist of all resident births that were delivered in the State during the two-year period. By matching the infant death record with the corresponding birth record it is possible to analyze mortality in terms of the detailed characteristics on either the birth or death record.

Out of a total of 967 infant deaths occurring to the 66,056 births during the two years studied, only seven death records could not be matched with the appropriate birth record and these have been excluded from analysis. The proportion of records successfully matched in this study is substantially higher than was true of a study using matched records conducted by the National Center for Health Statistics[8] or by researchers in Louisiana.[9] Because of the lack of reliable vital statistics data for late fetal deaths the present study will analyze neonatal mortality (death during the first 27 days following birth) in lieu of perinatal mortality.

Results

A pattern in obstetric care is clearly evident from Table 1 when the number of deliveries for each day of week are examined. Tuesday through Friday have the highest daily per cent of deliveries with the peak occurring on Tuesday.

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TABLE 1—Number of Births by Day of Week, 1974–75 Arkansas Live Birth Cohort

Births by Race of Mother	Day of Birth							
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total
Total[a]	9,389	10,165	8,929	9,749	9,876	8,615	8,426	66,049
(%)	14.2	15.4	14.9	14.8	15.0	13.0	12.8	100.0
White[b]	7,110	7,832	7,609	7,478	7,550	6,461	6,199	50,239
(%)	14.2	15.6	15.1	14.9	15.0	12.9	12.3	100.0
Nonwhite[c]	2,279	2,333	2,220	2,271	2,326	2,154	2,227	15,810
(%)	14.4	14.8	14.0	14.4	14.7	13.6	14.1	100.0

[a] $X^2_{(6)} = 294.2$, $P < .001$
[b] $X^2_{(6)} = 323.1$, $P < .0001$
[c] $X^2_{(6)} = 10.7$, $P = 0.10$

The weekend in general, and Sunday in particular, have the lowest per cent of deliveries. The 8,426 births occurring on Sunday is 10 per cent lower than would be expected if deliveries were evenly distributed throughout the week. When race of the mother is examined it appears that nonwhite women are less likely to show a low rate of weekend deliveries than Whites.

Table 2 displays the distribution of deliveries registered on major holidays (overall average 148.6) compared to the average number of deliveries during the month of the holiday

TABLE 2—Observed and Average Daily Births for Major Holidays, 1974–1975 Arkansas Live Birth Cohort

Holiday	Observed Deliveries (1)	Average daily Deliveries* (2)	Difference (1–2)	X^2
New Year's Day				
White	106	137.5	−31.5	7.22[b]
Nonwhite	46	47.5	−1.5	0.05
Total	152	185.0	−33.0	5.89[b]
Easter				
White	106	102.7	+3.3	0.11
Nonwhite	38	38.7	−0.7	0.01
Total	144	141.4	+2.6	0.05
Memorial Day				
White	99	121.4	−22.4	4.13[a]
Nonwhite	31	31.7	−0.7	0.02
Total	130	153.1	−23.1	3.48
Independence Day				
White	125	148.3	−23.3	3.66
Nonwhite	38	44.7	−6.7	1.00
Total	163	193.0	−30.0	4.66[a]
Labor Day				
White	106	160.0	−54.0	18.22[d]
Nonwhite	41	44.8	−3.8	0.32
Total	147	204.8	−57.8	22.73[d]
Thanksgiving				
White	116	146.3	−30.3	6.28[b]
Nonwhite	36	48.3	−12.3	3.13
Total	152	194.6	−42.6	9.33[c]
Christmas				
White	112	146.3	−34.3	8.04[c]
Nonwhite	40	43.0	−3.0	0.21
Total	152	189.3	−37.3	7.35[c]
Total				
White	110.0	137.5	−27.5	5.50[b]
Nonwhite	38.6	42.7	−4.1	0.39
Total	148.6	180.2	−31.6	5.54[b]

*Average daily births are based upon the number of births occurring on the same day of the week in the month of the holiday.
[a] $p < .05$
[b] $p < .02$
[c] $p < .01$
[d] $p < .001$

TABLE 3—Selected Obstetric Indicators by Day of Week, 1974–75 Arkansas Live Birth Cohort

	Day of Birth							
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total
% Deliveries	14.2	15.4	14.9	14.8	15.0	13.0	12.8	100.0
Obstetric Indicator								
% Under 2,501 grams[a]	7.4	7.2	6.8	6.6	7.4	7.1	8.3	7.5
Reported by Birth[b]								
Injury (5)	2.9	3.0	2.6	3.0	2.5	3.1	4.6	3.1
Reported Pregnancy[c]								
Complications (%)	6.2	6.3	6.5	5.8	6.9	6.0	5.3	6.2
Reported Malformation (per 1,000 deliveries)[d]	9.7	8.8	11.7	8.3	10.2	11.5	9.6	9.9
Deliveries with Malformation Information Missing	123	139	126	121	161	111	118	894
Deliveries with Pregnancy Complication Information Missing	155	163	186	220	177	181	172	1,254

[a] $X^2_{(6)} = 29.7$, $P < .001$
[b] $X^2_{(6)} = 85.0$, $P < .001$
[c] $X^2_{(6)} = 25.0$, $P = .001$
[d] $X^2_{(6)} = 104.5$, $P = .001$

(overall average 180.2). Only two holidays do not reflect a significant difference in the number of deliveries, and one of them (Easter) is a traditional Sunday holiday. Since Sundays have the lowest number of births, little additional reduction is possible. The other holiday without a significant dip in deliveries is Memorial Day. The largest deficit occurs inappropriately on Labor Day where the observed number of deliveries of 106 is nearly 51 per cent lower than expected. Once more, when race of mother is considered, the differences stand out in sharp relief. Among White women, five of the seven holidays are associated with a significant reduction in obstetric activity, while among nonwhites, the differences with the exception of Thanksgiving are trivial. Even for Thanksgiving, however, the difference fails to reach conventional levels of significance.

Daily variation in other items available from the birth certificate are displayed in Table 3. The proportion of infants weighing less than 2500 grams, unlike that for total deliveries, is highest on Sundays. The incidence of birth injuries is elevated among Sunday deliveries, but the per cent of pregnancy complications is lower. The correlation coefficient between the per cent of births delivered by day and the incidence of birth injuries is -0.73 ($F_{1,5} = 5.62$, $p = .07$). The same correlation for pregnancy complications is $+0.70$ ($F_{1,5} = 4.08$, $p = .09$). As is evident, congenital malformations display greater variability than either reported birth injuries or pregnancy complications. Although the chi-square statistic is larger for this item, the correlation coefficient is substantially lower than for the other two items ($r = -0.30$) as a consequence of the nonlinear nature of the association. Given the underlying genetic nature of this indicator, specific daily variations would not be expected.

Neonatal and postneonatal mortality rates by race and day of the week are shown in Table 4. The neonatal mortality rate for Sunday (13.3) is nearly 3 per 1000 higher than the overall rate. Monday and Tuesday have the lowest rates while Wednesday through Saturday have rates in the range of 10.3 to 10.7. The weekend rise in mortality among nonwhites is more pronounced with the Sunday rate of 18.9 that is statistically significant at .005.

Table 5 presents neonatal mortality rates by birthweight and race. As can be seen, Sunday stands out as the day of the week having the highest percentage of births weighing less than 2500 grams for both whites and nonwhites. The chi-

TABLE 4—Neonatal and Postneonatal Mortality by Day of Birth: 1974–75 Arkansas Live Birth Cohort

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total	X^2 (df6)
Neonatal									
Total	9.3	9.7	10.3	10.5	10.5	10.7	13.3	10.5	8.46
White	8.9	9.2	9.9	9.5	9.1	10.1	11.1	9.6	2.41
Nonwhite	10.5	11.6	11.7	13.2	14.2	12.1	18.9	13.1	7.16
Postneonatal									
Total	4.3	3.8	4.2	3.7	3.7	4.3	4.6	4.1	1.71
White	3.1	3.1	4.1	2.4	3.4	3.4	3.9	3.3	4.22
Nonwhite	7.9	6.4	4.5	7.9	4.7	7.0	6.3	6.5	4.02

TABLE 5—Neonatal Mortality by Day of Week, Birth Weight, and Race, Arkansas 1974–1975 Live Birth Cohort

Race	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total
	Under 2500 grams							
White								
Neonatal Mortality	97.7	91.9	106.2	122.2	99.6	99.7	118.8	109.8
No. Births	440	468	452	401	462	391	421	3,035
% < 2500 g.	6.2	6.0	5.9	5.4	6.1	6.0	6.8	6.4
Nonwhite								
Neonatal Mortality	66.5	70.1	83.3	86.4	88.6	81.1	100.0	82.2
No. Births	261	271	216	243	271	222	280	1,764
% < 2500 g.	11.4	11.6	9.7	10.7	11.6	10.3	12.6	11.2
	2500 grams and Over							
White								
Neonatal Mortality	2.7	3.8	3.4	2.7	3.1	3.5	2.9	3.2
No. Births	6,670	7,364	7,157	7,077	7,088	6,070	5,778	47,204
Nonwhite								
Neonatal Mortality	3.5	3.9	4.0	4.4	4.4	4.1	7.2	4.5
No. Births	2,018	2,062	2,004	2,028	2,055	1,932	1,947	14,046

square for the percentage of births by day weighing over 2500 grams vs those weighing less than 2500 grams for White is 12.77 (df6) and 12.44 (df6) for nonwhites; both approach significance at the .05 level. Sunday remains the peak day of nonwhite mortality for deliveries of low birthweight with the observed rate of 100.0 exceeding the average for the week by 22 per cent. Among White neonates weighing less than 2500 grams the mortality peaks on Wednesday and is 11 per cent higher than the total but is not statistically significant. When White infants weighing 2500 grams or more are considered, the weekend mortality is greatly diminished and, in fact, the Sunday rate is *lower* than the average for the week. Among nonwhites, however, the Sunday rate of 7.2 is 60 per cent higher than the total and is statistically significant (.027).

Neonatal mortality from selected causes of death are displayed in Table 6. In spite of the greater variability in these rates as a consequence of the reduced number of deaths, Sunday remains the day with higher than average mortality for seven of the eight causes presented.

Discussion

Since there is no known biological reason that can account for the daily variations in both the distribution of births and neonatal deaths it would appear that both are a consequence of other factors. One explanation for the daily variability observed is that medical professionals manage pregnancy to avoid the necessity of a delivery on a weekend or holiday. The observed variability of births by day of week and holidays is consistent with this interpretation. That the observed dip in births on weekends and holidays is greater among Whites suggests a greater likelihood of obstetric management than among nonwhites. Additional support for the argument that the daily patterns in deliveries is a consequence of a reduced likelihood of obstetric management on weekends and holidays follows from the relationships between the incidence of birth injuries and pregnancy complications as well as the distribution of births by day of week and holidays. The incidence of birth injuries should vary inversely with the extent of obstetric intervention while the incidence of pregnancy complications should vary directly. The rationale for the latter is based on the assumption that the major pregnancy complication mentioned on the birth certificate is the need for a cesarean section: the need for or choice of delivery by cesarean section is likely to be manifest prior to the commencement of labor. The statistically significant variability in the per cent of congenital malformations by day remains unexplained.

Although diminished in magnitude, variations in mortality can also be attributed to differences in obstetric intervention. The existence of elevated Sunday mortality among nonwhite neonates and an absence of similar variability among White newborns and postneonates of both groups suggests that these variations are also socially induced. If it is assumed that neonatal mortality varies inversely with the level and quality of obstetric care, the elevated mortality would be a consequence of less adequate staffing and/or practice on weekends and holidays. To the extent that neonatal mortality varies inversely with obstetric management, then the reduced number of weekend deliveries and elevated mortality are consistent with this hypothesis. Additional support for this line of reasoning follows from the finding that neither White nor nonwhite postneonates displayed higher weekend or Sunday mortality rates: as the interval between delivery and time of death increases, the likelihood of environmental factors affecting mortality increases.

An additional factor that could also produce the elevated weekend and Sunday neonatal mortality is that these deliveries are more likely to be emergencies as a consequence of the greater capability of staff to avoid emergencies

TABLE 6—Neonatal Mortality per 100,000 Live Births for Selected Causes by Day of Week, 1974–75 Arkansas Live Birth Cohort

	Day of Birth								
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total	p[a]
Total Deliveries	9,389	10,165	9,829	9,612	9,737	8,487	8,278	66,050	
Cause of Death[b]									
Septicemia (038)	42.6	49.2	20.4	0.0	20.5	23.6	72.5	31.8	.019
Pneumonia (480–486)	31.9	9.8	30.5	10.4	10.3	0.0	24.2	16.6	.294
Congenital Anomalies (740–759)	106.5	127.9	142.4	208.1	184.9	141.4	169.1	152.9	.352
Hyaline Membrane Disease (776.1)	138.5	127.9	101.7	187.3	123.2	117.8	181.2	137.8	.145
Respiratory Distress Syndrome (776.2)	74.6	98.4	61.0	72.8	82.2	117.8	96.6	84.8	.356
Asphyxia of Newborn, Unspecified (776.9)	53.2	68.9	101.7	72.8	92.3	94.3	60.4	77.2	.291
Immaturity Unqualified (777)	127.8	68.9	152.6	124.8	92.4	141.4	229.5	130.2	.006
Symptoms and Ill Defined Conditions (780–796)	42.6	68.9	20.4	52.0	71.9	85.2	60.4	56.0	.432
All Other Causes	308.9	354.2	396.8	322.5	369.7	353.7	434.9	358.8	.123
All Causes	926.6	973.9	1,027.6	1,050.8	1,047.6	1,072.2	1,328.8	1,046.2	

[a]Probability: Sunday vs Weekly Average
[b]ICD Codes: Eighth Revision International Classification of Disease, Adapted, 1965.

among deliveries that occurred during the week. Weekend deliveries therefore would be of higher obstetric risk and would be more likely to be emergencies, thus increasing risk of death. One indicator of the emergency nature of Sunday deliveries was the peak in the per cent of births weighing less than 2500 grams on that day. Unfortunately it is not possible to identify which of the two factors—variations in staffing or an increased proportion of emergencies—produced the observed mortality patterns.

It needs to be emphasized that many of the inferences described are based upon indirect evidence and a small number of observations. In addition, it should be kept in mind that Arkansas is a rural state and many of the hospitals are small and have a limited staff. Variations in staffing between weekends and holidays and the remainder of the week may be more pronounced than might be the case in a state characterized by a larger urban population. Ideally, additional studies are needed that utilize a larger number of cases and examine mortality by mode of delivery. In addition, more detailed analysis based upon more precise times of birth and death (rather than day of week and 28-day deaths), analyses made in the context of the size and composition of in-house and on-call staff, would be of value in explaining the reasons for the observed variations in the distribution of births and deaths by day of birth.

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