The Relationship Between Neonatal Mortality and Hospital Level

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Background. The relative safety of the small obstetrics unit compared with that of the larger or more technologically sophisticated units remains controversial. The purpose of this study was to examine the relationship between neonatal mortality and the level of perinatal services present in the hospital of birth.
Methods. Logistic regression was used to model neonatal mortality as a function of race, weight, and hospital level. Hospitals were classified into five categories using the volume of deliveries and the level of perinatal services available.
Results. Both black and white infants born at Level I-A hospitals who weighed less than 2250 (5 lb) fared worse than those born at Level III hospitals. There were no other statistically significant differences between the remaining hospital levels at any weight, although there was a trend toward improved mortality for white babies weighing less than 1500 g (3 lb, 5 oz) born at Level III centers. Level II-B hospitals, which also had neonatal intensive care available, did not demonstrate this trend.
Results. The results of this study support the safety of facilities with lower levels of care for delivery of normal birthweight infants and the need for continued centralized delivery of higher levels of care for high-risk patients.
Key words. Infant mortality; intensive care, neonatal; pregnancy outcome; delivery of health care.
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The level of care necessary to ensure safe delivery of infants at varying degrees of risk remains a difficult question. The answer is of critical importance to both consumers of health care and those attempting rational health care planning. Prominent in the controversy is the question of the relative safety of small obstetrics units compared with larger or more technologically sophisticated units.

Much of the debate regarding the small obstetrics units arose from efforts at perinatal regionalization that began in the 1970s. Although controlled evaluation has been very difficult, available evidence strongly suggests that the implementation of regionalization led to subsequent declines in neonatal mortality.[1] The improvement in neonatal mortality rates can probably be attributed to the centralization of high-risk obstetric and newborn care.[1]

Attempts have been made to classify hospitals by the level of perinatal care provided. Classification schemes have been inconsistent, but the majority have three levels based on obstetric volume and technologic sophistication, particularly the presence of a neonatal intensive care unit. Studies from New Zealand,[2] Finland,[3] Canada,[4] Australia,[5] and the United States[6-8] have demonstrated improved outcome for low birthweight infants who are born at hospitals with higher levels of care. The definition of low birthweight, however, varied among the studies. The success of centralized care for the high-risk newborn has led many to question the safety of obstetric care provided by the small obstetrics unit. Several studies have addressed this issue. Studies in New Zealand,[2] Finland,[3] and Canada[4] have suggested *improved* outcome for normal birthweight infants born at *lower* level centers. Data from the United States are not as clear. Hein,[9] in a seminal article in 1983, showed the importance of the small rural obstetrics unit in the state of Iowa, and noted that after regionalization, Level I-A hospitals (less than 500 deliveries, no pediatricians or obstetricians) had the lowest neonatal mortality rate. This finding could be attributed to the transport of women at high risk for premature delivery to hospitals with higher levels of care. This conjecture cannot be confirmed, however, as infant birthweight was not included in his analysis. Only three

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studies in the United States have attempted to compare neonatal mortality across all birthweights by hospital level of care. Cunningham,[6] using only obstetric volume for classification, found that units delivering 500 to 999 infants per year had the lowest mortality among full-term infants. Paneth and colleagues,[7] using the intensity of services available in New York City hospitals as his basis for comparison, found no benefit for delivery of full-term infants at Level III hospitals. Mayfield et al,[8] using obstetric volume and the level of nursery care available as classification criteria, found no association of hospital level of care or volume of deliveries with neonatal mortality in normal birthweight infants.

The purpose of this study was to examine the relationship between neonatal mortality and hospital level of care among infants of various birthweights. Hospitals were classified according to available services and number of deliveries.

Methods

The sample studied included all singleton live births in Missouri hospitals from January 1980 through December 1984. Birth certificates were matched with death certificates to determine the number of neonatal deaths. Race and birthweight were included in the analysis to control for case mix.

In 1985 the Missouri Department of Health collaborated with the National Institute of Child Health and Human Development (NICHHD) in a multistate and multinational project to produce a perinatal data set that included level of perinatal care. In 1985 a questionnaire was sent by the Department of Health to all hospitals delivering more than 500 babies per year to collect the data necessary for the classification. The classification criteria were established by NICHHD. The authors of this study believed that the criteria established for Level I would result in the inclusion of hospitals that might have been categorized as Level II in previous studies; therefore, Level I was subdivided into Level I-A and Level I-B. Level I-A hospitals were almost exclusively low-volume rural hospitals. In addition, criteria for Level III hospitals were sufficiently rigid to exclude some hospitals with neonatal intensive care available. Since this had previously been a major criteria for a Level III hospital, Level II hospitals were subdivided into those with neonatal intensive care and those without. The resultant classification scheme is shown in Table 1.

The relationship of neonatal mortality to hospital level was examined with birthweight and race as control variables. Logistic regression was used to smooth rates that would otherwise be unreliable in small subgroup analysis secondary to random error.

Table 1. Criteria for Hospital Perinatal Care Level Assignment*

Level I-A
- <500 births per year *or* missed ≥2 Level II-A criteria

Level I-B, II-A, II-B and III
- ≥500 births per year *and*...

Level I-B
- Missed only 1 Level II-A criteria

Level II-A must meet all the following criteria
1. Director of obstetrics is ABOG certified or staff includes ≥2 board certified obstetricians
2. Director of pediatrics is ABP certified or staff includes ≥2 board certified pediatricians
3. Anesthesiologist or nurse anesthetist is available 24 hours per day or staff includes ≥2 board certified anesthesiologists
4. Nurse-to-patient ratio for newborn intermediate care is 1:3-4
5. Laboratory technicians are in-house 24 hours per day
6. Ultrasound is available in-house

Level II-B
- Met all Level II-A criteria but not all Level III criteria *and* had a neonatal intensive care unit (self-designated)

Level III must meet all the following criteria
- Neonatal intensive care unit (self-designated) in same building or connected in same medical center
- Diagnose and treat severe respiratory distress syndrome requiring mechanical ventilation
- But can miss one or two:
  1. Director of obstetrics is ABOG certified with post-residency training and experience in maternal fetal medicine
  2. Director of neonatology is ABP certified with post-residency training and experience in neonatology
  3. Have on staff board certified anesthesiologist(s) with post-residency training and experience in obstetric, neonatal, and pediatric anesthesia
  4. Subspecialists on staff:
     - Obstetric ultrasonographer
     - Physician performing amniocentesis
     - Obstetric endocrinology/fertility expert
     - Pediatric neurologist
     - Pediatric hematologist
     - Pediatric cardiologist
     - Pediatric geneticist
  5. Nurse-to-patient ratio for newborn intensive care is 1:1-2
  6. Diagnose and treat symptomatic congenital heart disease and persistent fetal circulation
  7. Organized program to accept and direct transport of high risk mothers and infants
  8. Adult intensive care unit
  9. CT scanner in-house

**The classification criteria for hospital perinatal care levels (Levels I to III) were established by the National Institute of Child Health and Human Development, 1985. ABOG denotes American Board of Obstetricians and Gynecologists; ABP, American Board of Pediatrics*

Neonatal mortality was modeled as a function of weight (W), race (R), and hospital level (H) at birth. Hospital level was treated as a categorical variable using dummy variable coding. The final model included the following main effects and second-order and third-order interactions: W, R, H, $W \cdot R$, $W \cdot H$, $R \cdot H$, $W \cdot R \cdot H$, W^2, $W^2 \cdot R$. The other interaction terms such as $W^2 \cdot H$ were not significant. Ninety-five percent confidence intervals for the probability of death were computed for

Table 2. Distribution of Live Births by Hospital Level of Care and Birthweight

Birthweight (g)	Level I-A n(%)	Level I-B n(%)	Level II-A n(%)	Level II-B n(%)	Level III n(%)	Total n(%)
500–1499	421 (14)	326 (11)	586 (19)	920 (30)	797 (26)	3050 (100)
1500–2499	3172 (19)	2045 (12)	4126 (24)	4768 (28)	3000 (18)	17,111 (100)
≥ 2500	80,578 (24)	37,447 (11)	97,208 (29)	90,005 (27)	29,042 (9)	334,280 (100)
Total	84,171 (24)	39,818 (11)	101,920 (29)	95,693 (27)	32,839 (9)	354,441 (100)

each weight, race, and hospital combination using estimated values and their standard errors, which are functions of the covariance matrix of the regression coefficients, computed by BMDP's logistic regression routine (BMDP Statistical Software Inc, Berkeley, Calif, 1988). Birthweight distribution was divided into 250-g intervals, and all infants with a birthweight in the interval were classified at the midpoint of the interval.

Although birth certificates do include information about maternal complications, this information was not considered reliable enough to include in the analysis.

Results

Four hospitals met the guidelines for Level III classification, 8 met Level II-B criteria, 17 met Level II-A criteria, 11 met Level I-B criteria, and 79 met Level I-A criteria. The distribution of births between the different hospital levels is shown in Table 2. The impact of regionalization was clearly evident at the Level I-A and Level III centers. Although 24% of all deliveries occurred at Level I-A hospitals, only 14% of very low birthweight deliveries occurred at these hospitals. In contrast, 9% of all deliveries occurred at Level III centers, but 26% of very low birthweight infants were born in these centers.

Interpretation of Level I-B and Level II-A statistics was more difficult. Level II-A hospitals had a lower than expected rate of very low birthweight babies, in contrast to Level I-B. This difference could be attributed to selective referral of women in preterm labor or a lower risk population that gave birth to fewer very low birthweight infants. Examination of birth distribution by race, age, education, and marital status of the mother revealed a lower risk population demographically at Level II-A hospitals than at either Level I-A or I-B.

The predicted neonatal mortality rates and 95% confidence intervals are shown in Tables 3 and 4. Black and white babies born at Level I-A hospitals who weighed less than 2250 g fared worse than those born at Level III hospitals. The confidence intervals begin to overlap in the 2250-g to 2499-g weight class, particularly for white infants, and do overlap for infants weighing more than 2750 g among both races. There are no statistically significant differences between the remaining hospital levels for infants of any weight, though there is a clear trend toward improved mortality for white babies weighing less than 1500 g who were born at Level III centers.

Discussion

Our data demonstrated no improvement in outcome as measured by neonatal mortality for normal birthweight infants born at higher level centers. This conclusion supports the work of others who have demonstrated the safety of the small obstetrics unit for the delivery of normal birthweight infants. Although many such units are closing,[10–12] no data exist to support the indiscriminant closure of such units for quality-assurance reasons. Some differences may exist between hospitals at the same level; that question is not addressed in this paper. The model assumes similarity of hospitals within levels and addresses only the question of systematic differences between levels.

Only one study has examined outcomes in geographic service areas with different types of perinatal care available locally. Black and Fyfe[13] found that in the context of a regionalized system of care, women who lived where local services were provided by lower level hospitals fared as well as those who lived where local services were provided by higher level centers. In addition, Nesbitt et al[14] found that in rural communities, where the majority of women travel elsewhere to give birth, a greater proportion of women had complicated deliveries, higher rates of prematurity, and higher costs of neonatal care than in communities where most women gave birth to their infants in the local hospital. This difference was presumed to be related to the availability of local services, as there was no apparent reason to suspect that it was geographic variability in risk status that resulted in higher rates of transfer. Although it is difficult to control for all potential confounders in this type of research, these data together suggest that further centralization of obstetric services would not be beneficial, and may have a detrimental effect on perinatal outcome.

Our study provides additional insight into the relationship between neonatal mortality and hospital level of

Table 3. Logistic Regression Model of Neonatal Mortality of Black Infants, by Birthweight and Level of Care (per 1000 Live Births, 95% CI)

Birthweight (g)	Level I-A	Level I-B	Level II-A	Level II-B	Level III
500–749	807.5 (701.1–913.9)	688.6 (575.1–802.1)	672.6 (573.0–772.2)	640.0 (572.4–707.6)	670.1 (605.4–734.8)
750–999	569.4 (422.4–716.4)	409 (297.9–520.1)	403.7 (309.6–497.8)	374.7 (317.5–431.9)	391.0 (333.0–449.0)
1000–1249	315.3 (201.6–429.0)	193.1 (129.8–256.4)	197.7 (142.8–252.6)	182.4 (150.1–214.7)	183.1 (150.8–215.4)
1250–1499	150.4 (90.6–210.2)	83.7 (55.5–111.9)	90.1 (64.0–116.2)	84.0 (67.9–100.1)	79.6 (64.5–94.7)
1500–1749	70 (42.6–97.4)	37.1 (24.8–49.4)	42.1 (29.9–54.3)	40.0 (31.8–48.2)	35.5 (28.2–42.8)
1750–1999	34.1 (21.2–47.0)	17.6 (11.7–23.5)	21.1 (15.0–27.2)	20.5 (16.0–25.0)	17.0 (13.3–20.7)
2000–2249	18 (11.3–24.7)	9.1 (6.0–12.2)	11.5 (8.2–14.8)	11.4 (8.9–13.9)	8.9 (6.7–11.1)
2250–2499	10.4 (6.5–14.3)	5.2 (3.2–7.2)	6.9 (4.7–9.1)	7.0 (5.4–8.6)	5.1 (3.7–6.5)
2500–2749	6.6 (4.1–9.1)	3.3 (2.1–4.5)	4.6 (3.2–6.0)	4.8 (3.6–6.0)	3.3 (2.5–4.1)
2750–2999	4.6 (2.6–6.6)	2.3 (1.3–3.3)	3.4 (2.2–4.6)	3.6 (2.6–4.6)	2.3 (1.7–2.9)
3000–3249	3.5 (1.9–5.1)	1.7 (0.9–2.5)	2.7 (1.7–3.7)	2.9 (2.1–3.7)	1.8 (1.2–2.4)
3250–3499	3 (1.4–4.6)	1.5 (0.7–2.3)	2.4 (1.4–3.4)	2.7 (1.9–3.5)	1.5 (0.9–2.1)
3500–3749	2.8 (1.0–4.6)	1.4 (0.6–2.2)	2.4 (1.2–3.6)	2.7 (1.7–3.7)	1.4 (0.8–2.0)
3750–3999	2.9 (0.9–4.9)	1.4 (0.4–2.4)	2.6 (1.2–4.0)	3.0 (1.8–4.2)	1.5 (0.7–2.3)
4000–4249	3.4 (0.9–5.9)	1.6 (0.4–2.8)	3.1 (1.3–4.9)	3.7 (1.9–5.5)	1.7 (0.7–2.7)
4250–4499	4.3 (0.6–8.0)	2 (0.2–3.8)	4.1 (1.2–7.0)	4.9 (2.2–7.6)	2.2 (0.6–3.8)
4500–4749	6 (0.0–12.1)	2.8 (0.0–5.7)	5.9 (1.0–10.8)	7.4 (2.5–12.3)	3.0 (0.5–5.5)
4750–5000	9.2 (0.0–19.8)	4.3 (0.0–9.2)	9.5 (0.5–18.5)	12.1 (2.3–21.9)	4.7 (0.2–9.2)

care for low birthweight infants. Low birthweight infants born at Level I-A centers clearly did not fare as well as those born elsewhere. Existing data support antenatal referral of women at risk for preterm delivery to higher level centers. This is the basic premise of regionalized obstetric care, and these data clearly show that such referral was taking place. Some women will inevitably give birth to low birthweight infants at centers with lower levels of care because the patient is too close to the time of delivery to transport. It is difficult to determine what this percentage is, but obstetrics units with lower levels of care should strive to keep this rate as low as possible.

Previous studies have suggested that the presence of a neonatal intensive care unit is responsible for improved outcome in low birthweight infants born at higher level

Table 4. Logistic Regression Model of Neonatal Mortality of White Infants, by Birthweight and Level of Care (per 1000 Live Births, 95% CI)

Birthweight (g)	Level I-A	Level I-B	Level II-A	Level II-B	Level III
500–749	793.8 (745.0–842.6)	762.7 (684.5–840.9)	734.4 (638.8–785.0)	736.1 (696.5–775.7)	647.1 (589.5–704.4)
750–999	582.1 (520.4–643.8)	539.2 (445.1–633.3)	502.8 (447.9–557.7)	505.6 (463.1–548.1)	417.4 (364.9–469.9)
1000–1249	350 (300.4–399.6)	312.8 (241.5–384.1)	283.3 (244.9–321.7)	286.0 (256.2–315.8)	230.3 (196.6–264.0)
1250–1499	181.9 (153.7–210.1)	159.1 (120.1–198.1)	141.7 (121.3–162.1)	143.5 (127.2–159.8)	117.7 (99.5–135.9)
1500–1749	89.3 (75.8–102.8)	77.5 (59.1–95.9)	68.6 (58.8–78.4)	69.7 (61.5–77.9)	59.8 (50.2–69.4)
1750–1999	44.2 (37.7–50.7)	38.3 (29.9–46.7)	33.9 (29.2–38.6)	34.5 (30.4–38.6)	31.3 (26.0–36.6)
2000–2249	27 (23.9–30.1)	19.8 (15.7–23.9)	17.6 (15.2–20.0)	17.9 (15.7–20.1)	17.3 (14.2–20.4)
2250–2499	12.4 (10.8–14.0)	10.8 (8.6–13.0)	9.6 (8.4–10.8)	9.8 (8.6–11.0)	10.1 (8.1–12.1)
2500–2749	7.1 (6.1–8.1)	6.3 (5.1–7.5)	5.6 (4.8–6.4)	5.8 (5.0–6.6)	6.3 (4.9–7.7)
2750–2999	4.4 (3.8–5.0)	3.9 (3.1–4.7)	3.5 (3.1–3.9)	3.6 (3.2–4.0)	4.2 (3.2–5.2)
3000–3249	2.9 (2.5–3.3)	2.6 (2.0–3.2)	2.3 (1.9–2.7)	2.4 (2.0–2.8)	3.0 (2.2–3.8)
3250–3499	2 (1.6–2.4)	1.8 (1.4–2.2)	1.6 (1.4–1.8)	1.7 (1.5–1.9)	2.3 (1.5–3.1)
3500–3749	1.4 (1.2–1.6)	1.3 (0.9–1.7)	1.2 (1.0–1.4)	1.2 (1.0–1.4)	1.8 (1.2–2.4)
3750–3999	1.2 (1.0–1.4)	1.1 (0.7–1.5)	1 (0.8–1.2)	1.0 (0.8–1.2)	1.6 (1.0–2.2)
4000–4249	1 (0.8–1.2)	0.9 (0.5–1.3)	0.9 (0.7–1.1)	0.9 (0.7–1.1)	1.5 (0.9–2.1)
4250–4499	0.9 (0.7–1.1)	0.9 (0.5–1.3)	0.8 (0.6–1.0)	0.8 (0.6–1.0)	1.4 (0.6–2.2)
4500–4749	0.9 (0.5–1.3)	0.9 (0.5–1.3)	0.8 (0.6–1.2)	0.8 (0.4–1.2)	1.5 (0.7–2.3)
4750–5000	1 (0.6–1.4)	0.9 (0.3–1.5)	0.8 (0.4–1.2)	0.9 (0.5–1.3)	1.7 (0.5–2.9)

centers.[8,15–18] These data suggest a trend for improved outcome for very low birthweight white infants born at Level III centers, but not for those born at Level II-B centers, which also have neonatal intensive care available. This would suggest that the addition of neonatologists and an intensive care unit to a center that would otherwise be classified as Level II does not necessarily duplicate the services available at Level III centers. This conclusion is speculative, however, and should be researched further to determine the optimal role of various centers in the context of a regionalized system.

In conclusion, this study supports regionalized obstetric care as it exists, ie, providing centralized care for high-risk patients and lower levels of care locally for low-risk patients. Future research should address the impact of centralization of all services on neonatal outcomes among low-risk patients in areas where local low-risk care was previously available.

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