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The impact of changes in preterm birth among twins on stillbirth and infant mortality in the United States

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Abstract

OBJECTIVE—To examine trends for preterm births, stillbirths, neonatal and infant deaths in twin births by gestational age and birth weight categories, as well as trends in induction of labor and cesarean delivery during 1995–2006.

STUDY DESIGN—A trend analysis was performed on data derived from the National Centers for Health Statistics' Vital Statistics Data files (1995–2006). The primary outcomes examined were preterm birth, stillbirth, neonatal and infant mortality.

RESULT—During the study period, rates of labor induction among twins decreased by 8% and rates of cesarean delivery increased by 35%. Concurrently, the preterm birth rate increased by 13% from 54% in 1995–96 to 61% in 2005–06. The overall stillbirth rate, and neonatal and infant death rates decreased during the same period by 21% (95% confidence interval (CI): 18–25%), 13% (95% CI: 9–16%) and 12% (95% CI: 8–15%), respectively. There were significant reductions in neonatal death rates related to respiratory distress syndrome (RDS; 48%, 95% CI: 41–54%) and congenital anomalies (25%, 95% CI: 16–33%) during the study period. Reductions in post-neonatal infant mortality were mainly in RDS (88%) and sudden infant death syndrome (26%). Mortality rates among infants born by either induction of labor or cesarean delivery fell during the study period and remained much lower than the overall infant mortality rate.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DISCLAIMER

The opinions expressed are solely the responsibility of the authors and do not necessarily reflect the official views of the Kaiser Permanente Community Benefit Funds, the National Institute of Child Health and Human Development, and the National Institute of Environmental Health Sciences of the National Institute of Health.

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CONCLUSION—The findings of this study suggest that during 1995–2006 there was an increase in preterm birth rates and a decrease in labor inductions with a sharp decline in stillbirth, neonatal and infant mortality rates.

INTRODUCTION

The rate of twin births has been increasing remarkably over the past three decades in the United States.^{1–4} The number of twin births rose by 47% from 1990 to 2010.³ The rising number of twin births has been linked primarily to increased use of assisted reproductive technology (ART) among older women.^{5–8} The increase in multiple births has been accompanied by an increase in preterm births.^{7,9,10}

The overall rate of preterm birth (less than 37^{0/7} weeks of gestation) rose from 10.6 to 12.8% between 1990 and 2006 and then dropped to 12.0% in 2010.³ This rate masks a remarkable difference in the rate of preterm birth between twin and singleton births. The preterm birth rate for twins increased from 40.9% in 1981 to 55.0% in 1997 (a relative increase of 34.5%).⁹ Whereas for singleton births, the preterm birth rate increased from 9.7% in 1990 to 11.1% in 2006 (a relative increase of 14.4%) and then dropped by 7% from 2006 to 2010.³ The overall increase in preterm births has been attributed to increases in preterm labor induction and preterm cesarean section among women at high risk for adverse pregnancy outcomes.^{6,11,12} Among twin births, preterm deliveries by either labor induction or cesarean delivery has increased from 21.9% in 1989–1991 to 27.3% in 1995–1997, a relative increase of 25%.⁹

The rising trends in preterm and low birth weight births among twin pregnancies as well as improved survival in these births, have significant, if not profound, implications for health resource utilization.¹³ The temporal increase in preterm birth and its associated decrease in fetal and infant mortality have been reported about a decade ago.^{5,14} The purpose of the current study was to examine recent temporal trends in twin preterm birth and its association with still birth and infant mortality in light of the current advancement in the obstetrics and neonatal care.

MATERIALS AND METHODS

Data source

We utilized the National Centers for Health Statistics (NCHS) Linked Birth/Infant Death data files¹⁵ as well as Natality and Fetal Death data files for the years 1995 to 2006. The Linked Birth/Infant Death data sets and the Fetal Deaths files are an integral part of the Vital Statistics Cooperative Program through which the NCHS routinely links infant deaths (<365 days of age) to birth certificates. The Linked Birth and Infant Death files contain the following information on the mother and infant: sociodemographic information, obstetric medical history, complications of the index pregnancy, in addition to labor and neonatal outcomes. Information on cause and time of each infant's death is also included in the data set. The quality of information in these databases has been previously published.^{16–18}

We restricted the analysis to twin fetuses and infants with a gestational age ≥ 20 weeks to avoid errors in gestational age estimation and to minimize interstate differences in reporting live births of borderline viability. Primary or repeat cesarean and induction of labor were included in the file from the birth certificates.

The gestational age was derived from the last menstrual period for more than 95% of the pregnancies. NCHS substitutes the clinical estimate of gestational age when data on the last menstrual period are either unavailable or incompatible with the reported birth weight.¹⁹ Preterm birth was defined as live birth before 37 completed weeks of gestation. Stillbirth was defined as fetal death after 20 completed weeks of gestation. Neonatal mortality was defined as infant death during the first 28 days of life and infant mortality was defined as the death of an infant within the first year of life.

The study was approved by the Kaiser Permanente Southern California-Institutional Review Board. The analyses were performed using SAS version 9.3 (SAS institute, Cary, NC, USA).

Statistical analysis

Stillbirths were examined within specific gestational age categories; neonatal and infant mortality rates were examined by gestational age as well as birth weight categories. These categories were chosen to create reasonable homogeneity with regard to prognosis. Each twin birth was treated separately (rather than as a twin set) as births constitute the denominator for fetal, neonatal and infant death rates. In any particular gestational age category, gestational age-specific stillbirth rates were estimated per 1000 fetuses at risk (that is, all fetuses stillborn or live born at that gestational age or later).

The time span of the study was divided into two periods (1995–1996 and 2005–2006). Time trends were first assessed by estimating gestational age-specific stillbirth rates over the two time periods. We chose to combine 2 years of data for statistical stability. Comparison of gestational age and birth weight-specific neonatal and infant mortality rates was performed between the two time periods. Cause-specific neonatal mortality rates for twins were examined separately. We used the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) to identify causes of deaths for the years 1995–96 and ICD-10-CM for the years 2005–06. Finally, because there is a higher risk of adverse perinatal outcomes in children conceived through ART²⁰ and because of the lower utilization of ART in the younger age group,²¹ we assessed temporal trends in stillbirth and infant mortality among twin pregnancies in the 18- to 29-year-old women. The relative risk (RR) and its 95% confidence intervals (CIs) were estimated to compare the rates between periods. To evaluate the significance of the temporal trend, we carried out Mantle–Haenszel χ^2 statistics for trend.

RESULTS

From 1995–96 to 2005–06 the rate of twin births rose by 24.4% (from 26.2 to 32.6 per 1000 live births; $P < 0.001$). The proportion of twins born at 32–33 weeks of gestational increased by 20.5%, from 8.2% in 1995–96 to 9.9% in 2005–06 ($P < 0.001$). The increase in the

proportion of twins born at 34–36 weeks of gestation was 17.4% ($P < 0.001$) from 32.8% of all twin live births in 1995–96 to 38.6% in 2005–06. Conversely, we observed a 12.9% (from 44.0% of all twin live births in 1995–96 to 38.3% in 2005–06) decrease in twin live births at 37 weeks of gestation. The overall preterm birth rate among twin live births increased by 13% from 54.4% in 1995–96 to 61.3% in 2005–06 ($P < 0.001$); the most marked increase was seen at 32–33 weeks of gestation. Figure 1 illustrates the overall distribution of twin live births during 1995–96 and 2005–06 by gestational age. A shift to the left has been noted as a result of temporal increase in preterm births during the study period. Although there is no clear pattern in the rate of preterm birth changes between 20–25 weeks of gestation, preterm birth declined by 7% at 26–27 weeks of gestation. Whereas the preterm birth rate increased at 28–31 weeks of gestation by 10%, and at 34–36 weeks of gestation by 16%. In contrast, the rate of twin births decreased by 24% at 37–41 weeks of gestation.

As shown in Table 1, stillbirth rates among twin pregnancies declined from 20.1 per 1000 fetuses in 1995–96 to 15.8 per 1000 fetuses in 2005–06 corresponding to a 21% (95% CI: 18%, 25%) overall decrease in the stillbirth rate. The decrease in stillbirth rate was evident at 28–31, 32–33 and 34–36 weeks of gestation where there was a marked increase in preterm birth (Figure 2). On the other hand, at 26–27 weeks of gestation, the stillbirth rate remained relatively unchanged, whereas the rate of twin births at this gestational age decreased by 7%. In contrast, the rate of stillbirth decreased by 28% at 37–41 weeks of gestation with a corresponding decrease of 24% in the rate of twin birth at that gestational age interval.

The rates and estimated RRs of gestational age-specific neonatal mortality among twin births are shown in Table 2. The overall rate of neonatal deaths among twin live births decreased by 13% (95% CI: 9%, 16%) from 23.1 per 1000 live births in 1995–96 to 20.2 in 2005–06. The decline was most evident in the 34–36 weeks gestational age category decreasing by 32% (95% CI: 20%, 43%).

Table 3 outlines birth weight-specific neonatal mortality rates. The pattern of decline in birth weight-specific neonatal mortality rate was consistent with gestational age-specific neonatal mortality decline as shown in Table 2. The overall birth weight-specific neonatal death rates among twin live births decreased significantly by 13% (95% CI: 9%, 16%) from 23.1 per 1000 live births in 1995–96 to 20.2 in 2005–06. Birth weight-specific neonatal mortality rates decreased significantly in every birth weight category except for birth weight < 500 , 1250–1999 and ≥ 4000 g. Decreasing rates were most evident in the 2500–3999 g birth weight category (38%, 95% CI: 21%, 52%) and at 2000–2499 g birth weight category (26%, 95% CI: 9%, 41%).

Gestational age-specific infant mortality rate has dropped for each gestational age category except for gestational age categories < 22 and ≥ 42 weeks (data not shown). Most of the decline was for those gestational ages between 28 and 41 weeks. The overall decrease in infant mortality rate was 12% (95% CI: 8%, 15%), a decline from 29.4 per 1000 live births in 1995–96 to 26.1 in 2005–06. Similar to neonatal mortality rates, the pattern of decline in birth weight-specific infant mortality paralleled the decline in gestational age-specific infant

mortality (data not shown). Infant mortality rate decreased for each birth weight category except for birth weight category < 500 g.

Table 4 outlines cause-specific neonatal death rates among all twin births in 1995–96 and 2005–06. There was a significant decrease in neonatal mortality attributed to respiratory distress syndrome (RDS; 48%), congenital anomalies (25%), complications of placenta, cord or membranes (23%), and all other causes (8%). Infection-related neonatal mortality rate increased during the study period (RR: 1.43, 95% CI: 1.19, 1.72).

Temporal changes in the rates of labor induction and cesarean delivery from 1995–96 to 2005–06 are displayed in Table 5. Overall, the rate of labor induction among twin births decreased during the study period. The decrease was most marked at 20–33 weeks of gestation (about 50%). On the other hand, cesarean delivery rate consistently increased in all gestational age categories between the same time periods. The neonatal mortality rate of infants born by labor induction or cesarean delivery declined between the two time periods and remained much lower than the overall neonatal mortality rate. In 1995–96, the overall neonatal mortality rates at 20–28, 29–33, 34–36 and 37+ weeks of gestation were 239.4, 14.4, 3.0 and 2.2, respectively. The corresponding overall neonatal mortality rates for 2005–06 were 261.5, 8.2, 1.9 and 1.1, respectively. The decline occurred both in preterm and term deliveries and was higher among deliveries by labor induction than by cesarean section.

With the implementation of ICD-10 in 1999, more detailed categories of underlying cause of death emerged. For example, in ICD-10, hypoplasia or dysplasia of lung on the death certificate in conjunction with prematurity will receive the diagnosis of primary atelectasis of the newborn. On the other hand, in ICD-9 such linkage does not exist. Therefore, in order to adjust the mortality rates obtained by ICD-10 to that of ICD-9, we used the published comparability ratios ($C_i = D_{i,ICD-10}/D_{i,ICD-9}$)²² that were derived using the 1996 death certificate files. The reported comparability ratios for congenital anomaly, maternal complications of pregnancy, RDS, complications of placenta/cord/membranes, intrauterine hypoxia, and infection were 0.9064, 1.0580, 1.0257, 1.0470, 0.9048 and 1.0199, respectively. Using these comparability ratios, the decrease in cause-specific neonatal mortality rates would have been 20% instead of 25% for congenital anomalies; 12% instead of 9% for maternal complication of pregnancy, 45% instead of 48% for RDS and 26% instead of 23% for complications of placenta/ cord/membranes. The increase in cause-specific neonatal mortality rates for intrauterine hypoxia would have been 11% instead of 8% and 68% instead of 43% for infection. These findings suggest that the effect of changes from ICD-9 to ICD-10 in our findings were minimal.

Restricting the analysis to women under the age of 30 years, who were unlikely to have received fertility treatment, resulted in findings similar to the overall analysis (data not shown).

DISCUSSION

This study demonstrated that twin births increased by 24.4% from 1995–96 to 2005–06 and there was a clear evidence of a shift in gestational age to the left. The observed shift was

independent of the change in the frequency of twin birth rates reflecting an increased rate of preterm birth among twins. The increase in preterm birth rate was most marked between 28 and 37 weeks of gestation with a corresponding decrease in stillbirth and neonatal mortality rates in those gestational ages. Neonatal mortality rates from RDS, congenital anomalies and complications of placenta, cord and membranes declined during the study period. Whereas infection-associated neonatal mortality rate increased during the same time period.

The twin birth rate increased during the study period and persistently increased after the study period.^{3,23,24} The increase in twin births is likely a result of increased use of *in-vitro* fertilization over the past two decades among women of advanced maternal age.²⁵ In the year 2000, it was estimated that less than 7% of twin pregnancies were conceived by ART in women aged 20–29 years. This is in contrast to 65.4% of twin pregnancies in women aged 45–49 years that are attributable to ART.²¹ As there is a greater yet minor risk of adverse perinatal outcomes in children conceived through ART,²⁰ the current study investigated its impact on the temporal trends in stillbirth and infant mortality after limiting the cohort to 18- to 29-year-old women. The decline in stillbirth and infant mortality during the study period in these younger women was similar to that found among all twin births (data not shown).

A closer examination of the data revealed that the frequency of twin births between 20 and 28 weeks of gestation decreased on average by about 5%. In contrast during the same interval period, the frequency of twin births at 28–37 weeks of gestation significantly increased coinciding with a decrease in the stillbirth rate at this gestational age. This finding suggests that induction of labor and cesarean delivery may have played a significant role in preventing fetal demise during the observed time period,^{26,27} at a cost of increasing the rate of premature births. Obstetric complications, placental abnormalities, fetal genetic/structural abnormalities, umbilical cord abnormalities, hypertensive disorders and other maternal medical conditions are the most common cause of stillbirth²⁸ that calls for immediate action such as induction of labor or cesarean. Using data in Tables 1, 2 and 5, we estimated that the increase in cesarean rates over the study period resulted in 50 603 additional cesarean sections (32 235 done preterm) and 19 438 additional preterm births, but was associated with 1166 fewer stillbirths and 797 fewer neonatal deaths than would have occurred in the 2005–06 had 1995–96 rates persisted. Many of the extra preterm births occurred at 34–36 weeks of gestation.

The finding of a substantial decrease in the proportion of twin births between 37 and 41 weeks of gestation is consistent with the idea that fetuses that would have been born in this gestational age interval were shifted to an earlier (preceding) gestational age interval. Interestingly, the stillbirth rate at term (37–41 weeks) decreased with similar magnitude to those delivered preterm (28–36 weeks). The concurrent decline in stillbirth rates at term and preterm births despite a low rate of induction of labor among term births might be related to the selective progression of healthier fetuses toward term gestation. Fetuses with complications are likely to be delivered through induction of labor or cesarean at late-preterm or early-term gestational ages. This is in agreement with American College of Obstetrics and Gynecology position in the presence of objective evidence of maternal or fetal compromise.²⁹

A study that used the National Center for Health Statistics data from 1995 to 2008²⁴ and a study that used the Washington State birth certificate and hospital discharge databases from 1981–1997²⁷ reported an increased rate of twin birth. Our study observed similar increase in recent years. In agreement with our findings, the Washington State study reported a marked increase in twin birth between 32 and 36 weeks of gestation and a decreasing trend at 37–42 weeks of gestation. Hartley and Hitti²⁷ also reported a decline in stillbirth rate among term births and neonatal mortality rate among term and preterm births, in contrast, we observed declining trends in stillbirth and neonatal mortality both at term and preterm births.

As the rate of induction of labor/cesarean and preterm deliveries increase over time,^{12,30} one would expect to see an increase in neonatal mortality rates because of the increase in the frequency of very preterm births. Our data clearly showed a decrease in neonatal and infant mortality rates among fetuses born with induction of labor and cesarean between the two time periods. Moreover, neonatal and infant mortality rates among these fetuses born by induction of labor and cesarean remained much lower than the overall neonatal mortality rate, suggesting advances in neonatal intensive care. The decrease in neonatal mortality is mostly attributable to reduction in neonatal death from RDS and complications of placenta, membranes and cord. The marked decrease in RDS-associated neonatal death is likely due to increased use of antenatal glucocorticoids and exogenous surfactant in at-risk infants. Congenital anomalies-associated neonatal death has decreased by 25% during the study period. Selective termination is the most likely explanation for this phenomenon. The increased risk of neonatal mortality from sepsis may reflect the increased vulnerability of more premature infants as well as the increased risk of iatrogenic infection from interventions. A similar trend was observed for infant mortality.

Using similar data from 1981–1997, Kogan⁹ and associates reported an increase in the rate of preterm births among twins. In that report, the twin infant mortality rates among intensive prenatal care utilizers were lower than the overall twin infant mortality rate. That trend has been maintained in the most recent years as demonstrated by our study findings.

The risk of fetal death at any given gestational age may be reduced by one or more of the following mechanisms: (1) fetuses that would have been born later, some possibly as fetal deaths, are shifted to an earlier interval enlarging the number in this earlier interval pool with fetuses less at-risk of stillbirth, (2) the shifting of birth timing within each interval may in itself avert some fetal deaths within that specific interval, and (3) an overall reduction in fetal death because of improved prenatal care. The first two mechanisms occur concurrently with the ‘shift to the left’ in the birth timing.

It is apparent that much of the reduction in neonatal deaths is due to factors other than induction or cesarean section that advances the birth timing. Conversely, this intervention may be responsible for much of the decrease in fetal death. Of course, one cannot determine to what extent intervention actually played a part in these observed reductions; it is possible that they are ecological associations confounded by other improvements in prenatal care. Yet, it is reasonable to view these percentages as estimates of the upper bound of impact that induction or cesarean section has on the reduction of fetal and neonatal deaths. Interestingly,

a recent study of stillbirth by Barrett *et al.*³¹ found that the impact of planned cesarean at term gestation on stillbirth is minimal.

As preterm births increased neonatal and infant mortality among twin births has declined significantly for each gestational age-specific category between 1995–96 and 2005–06, which are probably due to advanced clinical interventions introduced in more recent years, such as antenatal glucocorticoid therapy and exogenous surfactant.⁵ These interventions have also led to reductions in infant deaths among twins due to various conditions such as RDS.⁶ Rates of RDS and maternal complications of pregnancy have declined the most as causes of death among neonatal and infant mortality, contributing to the significant decreases in neonatal and infant deaths observed between 1995–96 and 2005–06.

The strength of this study is that it is generalizable as it represents all US births with racially, ethnically and socioeconomically diverse pregnant women. Despite these strengths, some limitations of the study need to be considered. The main limitation of this study is that we used gestational age at delivery as a proxy for timing of fetal death. Although there is discrepancy between gestational age at fetal birth and time of fetal death, a study by Genest *et al.*³² reported that the median time from antepartum fetal death until birth ranges from 22 to 38 h. Another limitation is that this study used a vital statistics database that did not permit the identification of ‘twin-sets’. In that respect, it was not possible to account for correlation in the outcome within twins, which may have resulted in tighter CIs. Further limitation of this study includes lack of information on chorionicity that limited our ability to assess the difference in outcomes in monochorionic vs dichorionic twins. In recent years, the ultrasound determination of gestational age has become an important part of obstetric practice. Changes in perinatal monitoring, perinatal screening for aneuploidy and changes in recommendation of iatrogenic delivery of monochorionic twins may have affected the changes in the preterm birth and stillbirth rates. As the birth certificate data did not allow for the evaluation of these variables, their impact could not be assessed. Differences in the distribution of the errors between the last menstrual period–based and the clinical-based gestational age estimates between the two time periods (1995–96 and 2005–06) could have potentially affect comparison. Similarly, the impact of changes in diagnostic coding from ICD-9 to ICD-10 on the observed trends is difficult to substantiate. Using Anderson *et al.*'s²² comparability ratios, we assessed whether the implementation of ICD-10 coding schemes in 1999 impacted our findings. Data obtained from our investigation indicate that changes in diagnosis code reporting from ICD-9 to ICD-10 likely had minimal effects on the observed cause-specific neonatal mortality rates with the exception of infection-related neonatal mortality. Even then the change in neonatal mortality rates during the two time periods observed in our study is an under-estimate of the true changes that would have been reported if there is no change in the coding schemes. As the cause of deaths in the birth certificate data was derived from ICD-9 codes, they were prone to random errors and may have caused misclassifications.

In conclusion, our study clearly showed that during 1995–2006 there was an increase in preterm birth rates and a decrease in labor inductions with a sharp decline in stillbirth, neonatal and infant mortality rates.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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% Change between 2005-06 and 1995-96

5 11 3 -8 -7 -2 -6 -8 4 10 11 16 18 19 20 20 9 7 -17 -40 -39 -32 -29

Figure 1.

Distribution of twin live births by gestational age, the United States, 1995–96 and 2005–06.

The graph that was constructed using the log scale is presented as a Supplementary Figure.

^aStillbirth rates are expressed per 1,000 births

Figure 2.

Gestational age-specific stillbirth rate among twin births, the United States, 1995–96 and 2005–06.

Table 1

Temporal changes in gestational age-specific rates of stillbirths among twin fetuses in the United States from 1995–2006

Gestational age (weeks)	1995–96		2005–06		Relative risk (95% CI) 2005–06 vs 1995–96
	Fetuses at risk	No. of stillbirths	Fetuses at risk	No. of stillbirths	
<22	199 335	901	272 316	1082	0.88 (0.80, 0.96)
22–23	197 499	760	269 856	824	0.79 (0.72, 0.88)
24–25	195 010	376	266 725	432	0.84 (0.73, 0.96)
26–27	192 256	264	262 898	337	0.93 (0.80, 1.10)
28–31	188 379	543	257 934	544	0.73 (0.65, 0.82)
32–33	174 721	271	237 307	262	0.71 (0.60, 0.84)
34–36	158 153	468	210 429	474	0.76 (0.67, 0.86)
37–41	92 196	390	106 646	327	0.72 (0.63, 0.84)
42+	3892	24	3722	25	1.09 (0.62, 1.91)
Total	199 335	3997	272 316	4307	0.79 (0.75, 0.82)

Abbreviation: CI, confidence interval.

^a Stillbirth rates are expressed per 1000 fetuses at risk.

Table 2

Gestational age-specific rates of neonatal deaths among twin live births in the United States: 1995–96 and 2005–06

Gestational age (weeks)	1995–96			2005–06			Relative risk (95% CI) 2005–06 vs 1995–96
	Live births	No. of neonatal death	^a Rate of neonatal death	Live births	No. of neonatal death	^a Rate of neonatal death	
<22	1719	780	453.8	2485	1098	441.9	0.96 (0.63, 1.05)
22–23	3063	1292	421.8	3946	1556	394.3	0.90 (0.87, 0.94)
24–25	3387	904	266.9	4667	1045	223.9	0.81 (0.75, 0.87)
26–27	4243	510	120.2	5321	545	102.4	0.83 (0.75, 0.93)
28–31	13 799	490	35.5	20 917	588	28.1	0.78 (0.70, 0.88)
32–33	16 576	163	9.8	26 955	206	7.6	0.77 (0.63, 0.95)
34–36	66 024	273	4.1	103 930	291	2.8	0.68 (0.57, 0.80)
37–41	88 376	215	2.4	103 064	208	2.0	0.83 (0.69, 1.00)
42+	3895	17	4.4	3729	19	5.1	1.17 (0.61, 2.25)
Total	201 082	4644	23.1	275 014	5556	20.2	0.87 (0.84, 0.91)

Abbreviation: CI, confidence interval.

^aRates of neonatal deaths are expressed per 1000 live births.

Table 3

Birth weight-specific neonatal death rates among twin live birth in the United States: 1995–96 and 2005–06

Birth weight in grams	1995–96		2005–06		Relative risk (95% CI) 2005–06 vs 1995–96
	Live births	No. of neonatal death	Live births	No. of neonatal death	
< 500	3494	1615	4734	2132	0.96 (0.83, 1.01)
500–749	5360	1673	6739	1902	0.90 (0.86, 0.95)
750–999	4306	492	5727	515	0.77 (0.69, 0.87)
1000–1249	4993	224	6906	257	0.82 (0.69, 0.98)
1250–1499	6051	141	9013	197	0.94 (0.76, 1.16)
1500–1999	26 257	197	39 614	272	0.91 (0.76, 1.10)
2000–2499	58 789	157	87 879	173	0.74 (0.59, 0.91)
2500–3999	91 437	139	114 131	107	0.62 (0.48, 0.79)
4000–6999	395	6	271	1	0.24 (0.03, 1.98)
Total	201 082	4644	275 014	5556	0.87 (0.84, 0.91)

^a Rates of neonatal deaths are expressed per 1000 live births.

Table 4

Cause-specific neonatal deaths in twin births, the United States, 1995–96 and 2005–06

Cause of death ^a	Neonatal deaths 1995–96		Neonatal deaths 2005–06		Relative risk (95% CI) 2005–06 vs 1995–96
	Number	Rate ^b	Number	Rate ^b	
Congenital anomalies	605	3.0	608	2.2	0.75 (0.67, 0.84)
Maternal complications of pregnancy	583	2.8	711	2.6	0.91 (0.81, 1.01)
Respiratory distress syndrome	542	2.5	379	1.4	0.52 (0.46, 0.59)
Complications of placenta/cord/membranes	381	1.8	395	1.4	0.77 (0.67, 0.89)
Intrauterine hypoxia	59	0.3	86	0.3	1.08 (0.78, 1.51)
Infection	170	0.7	326	1.2	1.43 (1.19, 1.72)
All other causes	2304	12.0	3051	11.1	0.92 (0.87, 0.97)
Total	4644	23.1	5556	20.2	0.89 (0.86, 0.93)

^a Cause of deaths using International Classification of Diseases, 9th Revision (ICD-9) code for 1995–96 and ICD-10 for 2005–06.

^b Rates are expressed per 1000 live births.

Table 5

Trends in labor induction and cesarean delivery rates and neonatal mortality rates among twin birth: 1995–2006

Gestational age (weeks)	Rate per 100 live births					
	Labor induction			Cesarean delivery		
	1995–96	2005–06	% Change	1995–96	2005–06	% Change
20–28	4.6	2.3	–50	51.5	72.3	+40
29–33	5.8	3.5	–40	59.2	77.0	+30
34–36	10.6	9.4	–11	53.1	71.9	+35
37+	15.9	17.5	+10	51.9	69.1	+33
Total	12.0	11.0	–8	53.3	71.7	+35

Neonatal mortality rate per 1000 live births by labor induction and cesarean delivery						
	Labor Induction			Cesarean delivery		
	1995–96	2005–06	% Change	1995–96	2005–06	% Change
20–28	199.5	219.8	+10	135.3	128.2	–5
29–33	13.6	6.8	–50	17.0	12.3	–28
34–36	3.3	1.3	–61	4.9	2.7	–45
37+	1.9	1.3	–32	2.6	1.4	–46
Total	6.2	4.3	–31	13.4	11.2	–16

The labor induction and cesarean section estimates are not mutually exclusive.