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The Changing Risk of Infant Mortality by Gestation, Plurality, and Race: 1989–1991 Versus 1999–2001

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Abstract

OBJECTIVE—Our aim was to quantify contemporary infant mortality risks and to evaluate the change by plurality, gestation, and race during the most recent decade.

PATIENTS AND METHODS—The study population included live births of 20 to 43 weeks' gestation from the 1989–1991 and 1999–2001 US Birth Cohort Linked Birth/ Infant Death Data Sets, including 11 317 895 and 11 181 095 live births and 89 823 and 67 129 infant deaths, respectively. Adjusted odds ratios and 95% confidence intervals were calculated to evaluate the change in risk by plurality and gestation and to compare the change with that for singletons.

RESULTS—Overall, the infant mortality risk decreased significantly for singletons, twins, and triplets but nonsignificantly for quadruplets and quintuplets. Compared with singletons, significantly greater reductions were experienced by twins overall and at <37 weeks and triplets at <29 weeks. The largest reduction was for triplets at 20 to 24 weeks and for quadruplets and quintuplets at 25 to 28 weeks. For white infants, significant reductions were achieved overall for singletons, twins, and triplets and at every gestation. For black infants, significant reductions occurred for singletons overall and at every gestation, for twins at <37 weeks, and for triplets at 25 to 28 weeks. Compared with white infants, black infants had significantly lower risks before and higher risks after 33 weeks, although between 1989–1991 and 1999–2001 this survival advantage at earlier ages diminished, and the risk at later gestations increased.

CONCLUSIONS—The improvements in survival were greater for multiples versus singletons and for white versus black infants. Within each plurality, at each gestation the racial disparity in mortality has widened.

Keywords

infant mortality; birth weight; gestation; plurality; racial disparities

During the 1990s, a series of major changes in medical practice, clinical guidelines, and national recommendations occurred in the United States and other industrialized nations,

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paralleling the rise in multiple pregnancies and potentially affecting national neonatal and postneonatal mortality risks. First, the rapid rise in multiple births, which occurred during this decade, accounted for 2.3% and 3.1% of all live births in 1990 and 2000, respectively; triplets and higher-order multiples accounted for an increasing proportion of multiple births (3.1% and 5.8%, respectively). An estimated 53% of all multiple births, including 80% of triplet and higher-order births, are the result of assisted reproductive technologies,[1,2] which have been reported to be at higher risk for adverse pregnancy outcomes.[3–6] The use of assisted reproductive technologies carries a 30% to 50% risk of resulting in a multiple pregnancy, depending on the medications and techniques used. Older maternal age requires more aggressive therapies to achieve a pregnancy, including transferring more embryos. Triplet and higher-order pregnancies (quadruplets and quintuplets), which were uncommon before the widespread use of assisted reproductive technologies, are the fastest growing multiple pregnancies, rising more than fourfold since 1980. Born an average of nearly 7 weeks earlier and at half the birth weight of singletons, triplets comprise >90% of higher-order multiples. The 2 most important factors affecting perinatal mortality are gestational age and relative birth weight; with each additional fetus, both of these factors are compromised. Compared with singletons, infants of multiple pregnancies are much more likely to be born early preterm and very low birth weight, important factors contributing to their excess morbidity and mortality.

Second, the threshold of viability was lowered and the survival of extremely low birth-weight infants improved in the 1990s.[7] Survival rates during the second half of the last decade were 11% for 401 to 500 g, 27% for 501 to 600 g, 63% for 601 to 700 g, 74% for 701 to 800 g, and 30% for 23 weeks' gestation; 52% for 24 weeks' gestation; and 76% for 25 weeks' gestation.[7] Although perinatal mortality has declined from the 1980s through the 1990s, perinatally related disability among survivors has remained unchanged or has risen, depending on the population studied.[8–23] For very low birth-weight infants (<1500 g), mortality rates declined by ~50% in the early 1990s,[24,25] but since 1995, no additional improvements in mortality or morbidity have been seen, ending a long-term trend of improving outcomes for these infants.[25,26]

Third, major changes occurred in the contemporary management of premature births, including the widespread use of antenatal corticosteroids and postnatal surfactant.[27–29] In 1993, the results of 3 randomized clinical trials of intrathecal instillation of surfactant, administered for the prevention or treatment of neonatal respiratory distress syndrome (RDS), reduced the severity of early respiratory disease and the morbidity and mortality associated with RDS.[27,30,31] In 1994, the National Institutes of Health issued consensus statement 95 on the effect of corticosteroids for fetal maturation on perinatal outcomes.[32] The consensus panel concluded that antenatal corticosteroid therapy for fetal maturation reduces mortality, RDS, and intraventricular hemorrhage in pre-term infants and was a rare example of a technology that yields substantial cost savings in addition to improving health. Subsequent research indicated that with this intervention, the risks for mortality or major disability were comparable for very low birth-weight infants from singleton and multiple pregnancies.[33] Although postneonatal corticosteroid therapy demonstrated short-term pulmonary benefits, survival did not improve,[34] and associated increases in neurodevelopmental delays and cerebral palsy raised serious concerns about long-term adverse sequelae. For these reasons, the American Academy of Pediatrics 2002 Committee Statement recommended against the routine use of systemic postnatal corticosteroids for the prevention or treatment of chronic lung disease in very low birth-weight infants.[35]

Fourth is the implementation of national guidelines for infant sleeping positions to reduce sudden infant death syndrome (SIDS) deaths. In 1992, the American Academy of Pediatrics Task Force on Infant Positioning and SIDS issued its first recommendation that infants be

put to sleep in a supine or side position.[36] The Back to Sleep campaign was initiated in 1994 to inform the public about the risks associated with prone sleep positioning of infants, with the goal of further reducing the prevalence of prone positioning in the United States.[37] Between 1992 and 1996, the prevalence of prone sleep positioning fell from 70% to 24%, paralleling a 38% decline in overall SIDS mortality for the United States.[38,39] These declines were smaller for black than for nonblack populations, reflecting a higher prevalence of prone positioning in the former group.[40] The purpose of this study was to quantify infant mortality risks by gestation, plurality, and race and to evaluate how medical advances and national recommendations have influenced these risks during the 1990s.

METHODS

The data sets for this study included the Birth Cohort Linked Birth/Infant Death Data Set for 1989–1991 and 1999–2001, the earliest and most recent years for which plurality-specific data are available. The methodology takes advantage of 2 existing data sources: state-linked files for the identification of linked birth and infant death certificates, and National Center for Health Statistics (NCHS) natality and mortality computerized statistical files, the source of computer records for the 2 linked certificates. All states link infant death certificates with their corresponding birth certificates for legal and statistical purposes. When the birth and death of an infant occur in different states, copies of the records are exchanged by the state of death and the state of birth to affect a link. In addition, if a third state is identified as the state of residence at the time of birth or death, that state is also sent a copy of the appropriate certificate by the state where the birth or death occurred. The NCHS natality and mortality files, produced annually, include statistical data from birth and death certificates that are provided to NCHS by states under the Vital Statistics Cooperative Program. The data have been coded according to uniform coding specifications, have passed rigid quality control standards, have been edited and reviewed, and are the basis for official US birth and death statistics. To initiate processing, NCHS obtains matching birth certificate numbers from states for all infant deaths that occurred in their jurisdiction. This information is used to extract final, edited mortality and natality data from the NCHS natality and mortality statistical files. Individual birth and death records are selected from their respective files and linked into a single statistical record, thereby establishing a national linked record file. After the initial linkage, NCHS returns to the states where the deaths occurred with computer lists of unlinked infant death certificates for follow-up linking. If the birth occurred in a state different from the state of death, the state of birth identified on the death certificate is contacted to obtain the linking birth certificate. State additions and corrections are incorporated, and a final, national linked file is produced.

Three-year periods were chosen to dampen year-to-year fluctuations. The data were limited to liveborn infants of 20 to 43 weeks' gestation. To reduce implausible birth weight-gestational age combinations, the data were cleaned in the following manner: for each week of gestation, the upper range for birth weight was defined using the gender-specific 97th percentile for singletons[41] and the lower limit as the 5th percentile for triplets.[42] The data were grouped by weeks of gestation as 20 to 24, 25 to 28, 29 to 32, 33 to 36, 37 to 40, and 41 to 43 weeks. Plurality of each infant was categorized as singletons, twins, triplets, and quadruplets plus quintuplets. Infant mortality was defined as death from 0 to 364 days after birth.

The analyses included several aspects. First, plurality-specific infant mortality rates were calculated overall and by gestation periods for 1989–1991 and 1999–2001 and adjusted odds ratios (AORs) and 95% confidence intervals (CIs) calculated to evaluate the change in risk (improvement in survival) between the 2 time periods. Each of the plurality-specific AORs was then compared with the singleton AORs to evaluate whether the magnitude of change

was greater or lesser than the change for singletons during the 2 time periods. Second, these analyses were repeated separately for infants born to white women and to black women. Third, the plurality-specific infant mortality rates were compared for white versus black infants overall and by gestational periods for 1989–1991 and 1999–2001 and AORs and 95% CIs calculated to evaluate the difference in risk between the 2 racial groups during each time period.

RESULTS

The study population for 1989–1991 and 1999–2001 included 11 317 895 and 11 181 095 live births and 89 823 and 67 129 infant deaths, respectively. Between the 2 time periods, there was a shift to older maternal ages, higher maternal education, more adequacy of prenatal care, and a decrease in smoking during pregnancy overall and for each plurality. Mean length of gestation and birth weight declined significantly overall and for each plurality (Table 1).

The percent distribution of live births and infant deaths by gestation for plurality and race in 1989–1991 and 1999–2001 are shown in Table 2. Overall, live births were more likely to be delivered earlier at term, at 37 to 40 weeks, and less likely to be delivered at 41 to 43 weeks. Among live births in multiple pregnancies, this trend included a reduction in births at 37 to 40 weeks as well and an increase in the proportion of births at 33 to 36 weeks. Among infant deaths, there was an increase in the proportion born at the border of viability, 20 to 24 weeks, and an overall reduction in the proportion of deaths at later gestational ages. At 20 to 24 weeks, the proportion of live births from multiple versus singleton pregnancies was 10-fold higher and the proportion of infant deaths twice as great.

The plurality- and gestation-specific infant mortality rates and AORs and 95% CIs, indicating the change in risk of death between 1989–1991 and 1999–2001 are given in Table 3. Overall, the risk of infant death declined significantly for singletons, twins, and triplets but not for quadruplets and quintuplets. For singletons, this improvement was at every gestation; for twins, at births <41 weeks; for triplets, at births <37 weeks; and for quadruplets and quintuplets, only among births between 25 and 28 weeks. Compared with singletons, significantly greater reductions were experienced by twins overall and at gestations <37 weeks and by triplets at gestations <29 weeks.

These analyses were repeated, limiting the sample to only infants born to white women (Table 4) and only infants born to black women (Table 5). Among white infants, the risk of infant mortality reflected the same pattern as the total population, with significant improvements overall for singletons, twins, and triplets but non-significantly for quadruplets and quintuplets. For singletons, this improvement was at every gestation; for twins, for births <41 weeks; for triplets, at births <37 weeks; and for quadruplets and quintuplets, only among births between 25 and 28 weeks. Compared with singletons, significantly greater reductions were experienced by twins overall and at gestations <29 weeks and at 33 to 36 weeks and by triplets at gestations <29 weeks. Among black infants, the risk of infant mortality declined significantly for singletons, overall and at every gestation; for twins, at births <37 weeks; and for triplets, at 25 to 28 weeks. Compared with singletons, only twins born at 25 to 28 weeks had significantly greater improvement in survival, whereas twins overall and those born at 37 to 40 weeks had significantly greater decline in survival.

A comparison of the plurality- and gestation-specific infant mortality rates and AORs and 95% CIs for white versus black infants within each of the 2 time periods is given in Table 6. In general, the declines in infant mortality rates were greater for white than for black infants. Overall, the racial disparity in risk of infant mortality decreased for singletons and triplets

but increased for twins. Within gestational categories, black singleton infants had significantly lower risks before and higher risks after 33 weeks, and black twin infants had significantly lower risks at gestations <25 weeks and higher risk between 33 and 40 weeks. Between 1989–1991 and 1999–2001, this survival advantage at earlier ages diminished substantially and the risk at later gestations increased.

DISCUSSION

The results of this study demonstrate the significant reductions in infant mortality that has been achieved during the 1990s. These reductions have been greater for twins and triplets compared with singletons, greater for early preterm (<33 weeks) compared with moderate preterm (33–36 weeks) and term (37–43 weeks) births and for white compared with black infants. The dramatic improvement in survival for infants born at the border of viability (≤24 weeks) may represent the widespread use and effectiveness of newer technologies, such as high-frequency oscillatory ventilation, inhaled nitric oxide, and antenatal steroids, but it may also reflect more accurate gestational dating with a greater proportion of births from assisted reproductive technology (ART), particularly to white women. Although national estimates on the use of ART by race are not available, research has indicated racial disparities in outcomes, with black women having higher rates of spontaneous losses and lower live birth rates compared with other racial and ethnic groups.[43] This distinction by method of conception is not currently possible; it soon will be with future data based on the 2003 revision of the birth certificate. It is estimated that ARTs contributed 39% to 43% of the increase in triplet and higher-order multiple births in the United States since 1996, with ~40% because of ovulation-inducing drugs.[1,44] The twin and triplet rates for ART patients are estimated to be 14-fold and 54-fold higher, respectively, than for the United States as a whole.[44]

Plurality and Racial Disparities in Infant Mortality

The results of this study quantify the improvement in plurality-specific infant mortality rates overall and within gestational periods for all births and for white versus black infants. Although the improvement in survival was greater for twins and triplets compared with singletons, the proportion of deaths among multiples actually increased during the 1990s. The proportion of live births that were multiples increased from 2.4% to 3.2% between the 2 time periods, whereas the proportion of infant deaths increased from 10.6% to 13.6%. Among white infants, multiples accounted for 2.4% and 3.3% of live births and 11.0% and 14.1% of infant deaths in 1989–1991 and 1999–2001, respectively. Among black infants, multiples accounted for 2.7% and 3.5% of live births and 10.7% and 22.2% of infant deaths, respectively, during the 2 time periods. The known survival advantage of black infants at earlier gestations diminished during the 1990s, and their mortality risk at older gestational ages increased. Many reasons may underlie this widening racial disparity in infant survival, including access to appropriate health care and newer technologies, as well as differences in health behaviors. The 2003 report *Unequal Treatment* by the Institute of Medicine summarized 2 decades of health disparities research.[45] Some researchers have suggested that minority children are less likely to benefit from new technologies, such as inhaled steroids, with physicians prescribing them less often than in adults or in nonminority patients.[46] This factor of differing access to technology may be less of an issue in obstetric and neonatal care. For example, Hamvas et al,[29] in their study of surfactant therapy on neonatal mortality among blacks and whites, found that the technology resulted in greater reductions in mortality for white infants and that the difference was not explained by access to surfactant or antenatal corticosteroid therapies. Maternal and family health behaviors may also contribute to this increased risk, such as infant sleeping practices. Positioning infants in a prone sleeping position, associated with one third of all SIDS deaths, is more common

among black families,[47,48] despite the success of the American Academy of Pediatrics national Back to Sleep campaign during the 1990s.[49] In their analysis of racial differences in infant mortality, Muhuri et al[50] reported that non-Hispanic blacks had more than a twofold excess odds for 3 causes of infant mortality (RDS, short gestation/low birth weight, and maternal complications) compared with non-Hispanic whites, which are closely related to their twofold greater risk of delivering a low birth-weight infant.

Birth certificate data provide our only national perinatal database on the outcome of pregnancy in the United States. When linked with the infant death records, this information provides important insights into relationships between perinatal factors and the timing and causes of infant death. The use of vital statistics data has limitations.[51–55] First, there is the potential for misclassification of gestational age. We have attempted to minimize this error by cleaning the data to eliminate implausible birth weight-gestational age combinations, but it is still possible that some remain despite this effort. Second, because of the intracluster correlation of mortality risk for infants born in a multiple versus singleton pregnancy, the risk of death for these infants is acknowledged to be greater, beyond that because of lowered birth weight and younger gestational age.[56,57] The annual linked birth and death files are reported as individual births, although NCHS has released a matched multiple birth file that links multiple births to the same mother; this matched file is only available for births between 1995 and 2000, which includes only a portion of the time period evaluated in the current study. Despite these limitations, the use of multiyear, population-based data provides the best available data for evaluating national trends in live births and infant deaths.

CONCLUSIONS

Infant mortality rates have declined substantially during the 1990s, although the racial disparity in survival widened. Multiple births contribute disproportionately to infant mortality in large part because of their tendency to be born prematurely. The improved survival of smaller and more immature infants has long-term social, economic, and health implications.

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Abbreviations

RDS	respiratory distress syndrome
SIDS	sudden infant death syndrome
NCHS	National Center for Health Statistics
AOR	adjusted odds ratio
CI	confidence interval
ART	assisted reproductive technology

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TABLE 1

Characteristics of the Study Population According to Plurality, 1989–1991 and 1999–2001

Characteristic	Singletons		Twins		Triplets		Quadruplets and Quintuplets[a]		All Pluralities	
	1989–1991	1999–2001	1989–1991	1999–2001	1989–1991	1999–2001	1989–1991	1999–2001	1989–1991	1999–2001
No. of mothers[b]	11 044 953	10 820 505	132 185	169 934	2648	6395	152	375	11 179 938	10 997 209
Maternal age, mean (SD), y	26.4 (5.7)	27.1 (6.2)	27.7 (5.6)	29.2 (6.2)	29.8 (4.8)	31.9 (5.2)	29.9 (4.3)	31.3 (4.4)	26.4 (5.7)	27.2 (6.2)
Maternal age groups, %										
<20	12.8	11.9	7.7	6.0	2.6	1.2	1.4	0.5	12.7	11.7
20–34	78.4	75.0	80.5	73.4	80.6	68.9	84.7	75.0	78.4	74.9
>34	8.8	13.1	11.7	20.6	16.8	29.9	13.9	24.6	8.9	13.4
Maternal race, %										
White	79.2	78.8	77.9	79.0	87.8	89.3	93.0	92.5	79.2	78.8
Black	16.3	15.2	18.9	16.7	10.1	7.4	5.3	4.5	16.4	15.3
Other	4.5	5.9	3.3	4.3	2.1	3.3	1.8	3.1	4.4	5.9
Maternal education, %										
≤12 y	57.7	52.7	53.5	43.2	37.6	25.2	30.5	24.0	57.6	52.5
≥16 y	16.9	24.3	19.9	32.8	35.3	50.4	33.2	48.6	17.0	24.6
Primipara, %	41.6	41.0	20.6	22.0	18.7	21.8	18.1	16.1	41.1	40.4
Married, %	72.2	66.7	73.8	73.3	88.5	91.8	93.1	96.4	72.3	67.0
Smoker, %	12.4	9.3	11.7	7.6	6.2	2.4	3.0	1.2	12.4	9.3
Adequate prenatal care, %[c]	66.4	73.0	70.9	78.1	81.6	83.0	78.1	85.5	66.6	73.2
No. of infants	11 044 953	10 820 505	264 370	339 868	7946	19 185	626	1537	11 317 895	11 181 095
Gestational age, mean (SD), wk	39.2 (2.2)	38.9 (2.2)	36.0 (3.6)	35.5 (3.4)	32.8 (3.9)	32.3 (3.7)	30.9 (4.5)	29.7 (3.7)	39.1 (2.3)	38.8 (2.3)
Birth weight, mean (SD), g	3336 (549)	3312 (540)	2424 (649)	2370 (626)	1803 (592)	1714 (555)	1504 (720)	1298 (535)	3313 (570)	3281 (570)
Birth weight categories, %										
<1500 g	1.0	1.0	8.9	9.3	27.4	32.4	55.3	69.2	1.2	1.3
1500–2499 g	5.0	5.1	41.5	45.1	62.4	61.2	36.4	28.6	5.9	6.4
≥2500 g	94.0	93.9	49.5	45.6	10.1	6.4	8.3	2.2	92.9	92.3
No. of Infant deaths	80 262	57 952	8902	8024	584	1005	75	148	89 823	67 129
Neonatal (0–27 d)	46 145	35 352	6989	6407	495	887	68	126	53 697	42 772
Postneonatal (28–364 d)	34 117	22 600	1913	1617	89	118	7	22	36 126	24 357

[a] Quadruplets and quintuplets include 558 quadruplets and 68 quintuplets in 1989 –1991 and 1356 quadruplets and 181 quintuplets in 1999 –2001.

[b] The numbers of mothers were calculated based on the number of infants per pregnancy, but because some multiple pregnancies may have included fetal deaths, this is only an estimate.

[c] Adequacy of prenatal care is based on a modification of the Kessner criterion and includes month prenatal care began, number of prenatal visits, and length of gestation.

TABLE 2

Percentage Distribution of Live Births and Infant Deaths According to Gestation for Plurality and Race, 1989–1991 and 1999–2001

Gestational Age and Years	Live Births									Infant Deaths								
	All Pluralities			Singletons			Multiples			All Pluralities			Singletons			Multiples		
	All	White	Black	All	White	Black	All	White	Black	All	White	Black	All	White	Black	All	White	Black
20–24 wk																		
1989–1991	0.2	0.2	0.6	0.2	0.1	0.5	1.9	1.5	3.6	23.8	20.4	32.5	21.2	17.5	30.2	45.6	43.2	51.6
1999–2001	0.3	0.2	0.7	0.2	0.1	0.6	1.9	1.6	3.6	30.9	27.2	40.4	27.1	22.9	37.5	54.9	53.3	59.7
25–28 wk																		
1989–1991	0.4	0.3	1.0	0.4	0.3	0.8	3.1	2.7	5.0	13.1	12.4	15.1	11.7	10.8	14.0	24.9	25.4	23.8
1999–2001	0.5	0.4	1.0	0.4	0.3	0.9	3.5	3.2	5.3	12.1	11.5	13.4	10.8	10.0	12.7	20.0	20.7	18.5
29–32 wk																		
1989–1991	1.0	0.8	2.1	0.8	0.6	1.8	8.4	7.8	11.2	7.0	7.0	7.0	6.7	6.7	6.8	9.1	9.5	8.2
1999–2001	1.2	1.0	2.0	0.9	0.7	1.7	10.3	10.1	11.7	6.3	6.5	5.7	6.0	6.2	5.6	8.1	8.5	6.7
33–36 wk																		
1989–1991	7.5	6.5	12.3	6.8	5.8	11.6	34.9	35.0	34.8	12.3	12.5	11.8	12.5	12.6	12.1	11.0	11.7	9.3
1999–2001	8.6	8.0	11.7	7.4	6.8	10.7	42.7	43.4	40.2	12.2	13.0	10.1	12.6	13.4	10.3	10.1	10.6	8.4
37–40 wk																		
1989–1991	67.0	67.2	64.8	67.5	67.7	65.5	47.2	48.6	40.3	33.0	35.7	25.8	35.9	39.0	28.2	8.2	9.0	5.8
1999–2001	72.7	73.1	69.5	73.8	74.3	70.7	39.0	39.3	36.3	31.8	34.4	25.0	35.8	39.1	27.8	6.4	6.4	6.2
41–43 wk																		
1989–1991	23.8	25.0	19.2	24.3	25.5	19.6	4.5	4.4	5.1	10.8	12.0	7.8	11.9	13.4	8.6	1.1	1.0	1.2
1999–2001	16.8	17.3	15.1	17.3	17.8	15.6	2.5	2.4	2.9	6.7	7.3	5.3	7.7	8.4	6.1	0.5	0.5	0.5

TABLE 3

The Change in Risk of Infant Death According to Plurality and Gestation for All Races, 1999–2001 vs 1989–1991

Variable	1989–1991			1999–2001			AOR[a]			Comparison to Singleton AORs[b]		
	Live Births	Infant Deaths	IMR[c]	Live Births	Infant Deaths	IMR	AOR	95% CI	*P*	AOR/AOR	95% CI	*P*
All Gestations												
Singletons	11 044 953	80 262	7.27	10 820 163	57 951	5.36	0.760	0.752–0.768	<.0001	1.000		
Twins	264 370	8902	33.67	339 665	8023	23.62	0.730	0.707–0.753	<.0001	0.960	0.928–0.993	.019
Triplets	7946	584	73.50	19 147	1005	52.49	0.731	0.654–0.818	<.0001	0.962	0.860–1.076	.501
Quads and Quints	626	75	119.81	1537	148	96.29	0.842	0.614–1.157	.291	1.109	0.807–1.522	.524
≤24 wk												
Singletons	22 035	17 045	773.54	22 825	15 718	688.63	0.664	0.635–0.694	<.0001	1.000		
Twins	4626	3955	854.95	5788	4267	737.21	0.471	0.424–0.523	<.0001	0.710	0.634–0.795	<.0001
Triplets	383	342	892.95	850	665	782.35	0.377	0.255–0.557	<.0001	0.567	0.383–0.841	.005
Quads and Quints	61	48	786.89	147	106	721.09	0.965	0.471–1.978	.926	1.454	0.708–2.984	.308
25–28 wk												
Singletons	38 820	9390	241.89	39 897	6263	156.98	0.601	0.579–0.624	<.0001	1.000		
Twins	7717	2205	285.73	10 613	1597	150.48	0.446	0.413–0.482	<.0001	0.742	0.682–0.809	<.0001
Triplets	637	144	226.06	1840	207	112.50	0.422	0.326–0.546	<.0001	0.702	0.541–0.911	.008
Quads and Quints	82	23	280.49	336	32	95.24	0.357	0.173–0.734	.004	0.593	0.288–1.222	.156
29–32 wk												
Singletons	92 735	5380	58.01	92 534	3470	37.50	0.644	0.615–0.674	<.0001	1.000		
Twins	20 783	820	39.46	30 370	654	21.53	0.557	0.499–0.622	<.0001	0.866	0.768–0.975	.017
Triplets	1968	49	24.90	5999	76	12.67	0.560	0.386–0.811	.002	0.869	0.598–1.263	.462
Quads and Quints[d,e]	483	4	8.28	1054	10	9.49	0.987	0.290–3.365	.985	1.533	0.449–5.230	.495
33–36 wk												
Singletons	752 670	10 037	13.34	805 193	7277	9.04	0.699	0.678–0.722	<.0001	1.000		
Twins	91 211	1009	11.06	144 690	883	6.10	0.595	0.541–0.654	<.0001	0.851	0.770–0.940	.002
Triplets[f]	4958	49	9.88	9458	57	6.03	0.654	0.438–0.977	.038	0.936	0.626–1.399	.747
37–40 wk												
Singletons	7 453 913	28 836	3.87	7 986 844	20 741	2.60	0.704	0.691–0.717	<.0001	1.000		
Twins	127 775	783	6.13	139 343	578	4.15	0.756	0.675–0.847	<.0001	1.074	0.958–1.204	.222

Variable	1989–1991			1999–2001			AOR[a]			Comparison to Singleton AORs[b]		
	Live Births	Infant Deaths	IMR[c]	Live Births	Infant Deaths	IMR	AOR	95% CI	*P*	AOR/AOR	95% CI	*P*
≥41 wk												
Singletons	2 684 780	9574	3.57	1 872 870	4482	2.39	0.698	0.673–0.724	<.0001	1.000		
Twins	12 235	107	8.75	8861	44	4.97	0.703	0.486–1.017	.062	1.008	0.695–1.460	.968

Quads indicates quadruplets; quints, quintuplets; IMR, infant mortality rate.

[a] Odds of infant death within each plurality group in 1999 –2001 vs 1989 –1991 adjusted for maternal age (<20, 20 –34, and >34 years), smoking (nonsmoker, smoker, and unknown), and parity (0, 1–3, ≥4, and unknown).

[b] The plurality-specific change in risk of infant death between 1999 –2001 and 1989 –1991 compared with the change for singletons.

[c] Deaths per 1000 live births.

[d] Includes quadruplets and quintuplets born 29 to 32 weeks and later.

[e] Rates are based on small numbers (<20 in the numerator) and should be interpreted with caution.

[f] Includes triplets born 33 to 36 weeks and later.

TABLE 4

The Change in Risk of Infant Death According to Plurality and Gestation for White Women, 1999–2001 vs 1989–1991

Variable	1989–1991			1999–2001			AOR[a]			Comparison to Singleton AORs[b]		
	Live Births	Infant Deaths	IMR[c]	Live Births	Infant Deaths	IMR	AOR	95% CI	*P*	AOR/AOR	95% CI	*P*
All Gestations												
Singletons	8 752 132	52 785	6.03	8 528 898	38 189	4.48	0.767	0.757–0.778	<.0001	1.000		
Twins	205 864	5986	29.08	268 282	5341	19.91	0.711	0.683–0.739	<.0001	0.926	0.889–0.966	<.0001
Triplets	6980	481	68.91	17 099	805	47.08	0.677	0.599–0.766	<.0001	0.883	0.780–0.999	.049
Quads and quints	582	70	120.27	1420	134	94.37	0.825	0.589–1.155	.263	1.075	0.767–1.506	.675
≤24 wk												
Singletons	11 639	9257	795.34	12 350	8744	708.02	0.634	0.596–0.675	<.0001	1.000		
Twins	2820	2497	885.46	3627	2707	746.35	0.383	0.332–0.441	<.0001	0.604	0.517–0.705	<.0001
Triplets	318	287	902.52	697	539	773.31	0.323	0.208–0.502	<.0001	0.510	0.327–0.795	.003
Quads and quints	56	43	767.86	141	100	709.22	0.903	0.445–1.834	.790	1.424	0.699–2.900	.330
25–28 wk												
Singletons	22 412	5705	254.55	23 837	3833	160.80	0.577	0.550–0.605	<.0001	1.000		
Twins	5130	1526	297.33	7381	1112	150.66	0.418	0.381–0.458	<.0001	0.724	0.653–0.804	<.0001
Triplets	529	113	213.61	1584	160	101.01	0.407	0.304–0.545	<.0001	0.706	0.526–0.949	.021
Quads and quints	77	23	298.70	310	25	80.65	0.280	0.131–0.601	.0008	0.486	0.226–1.043	.064
29–32 wk												
Singletons	56 388	3533	62.66	60 525	2350	38.83	0.608	0.575–0.643	<.0001	1.000		
Twins	14 712	580	39.42	22 834	468	20.50	0.531	0.466–0.605	<.0001	0.873	0.758–1.006	.060
Triplets	1722	41	23.81	5374	60	11.16	0.489	0.325–0.735	.0005	0.803	0.532–1.213	.298
Quads and quints[d,e]	449	4	8.91	969	9	9.29	1.037	0.302–3.568	.956	1.705	0.495–5.872	.397
33–36 wk												
Singletons	508 298	6670	13.12	582 903	5118	8.78	0.676	0.651–0.702	<.0001	1.000		
Twins	70 997	729	10.27	115 997	629	5.42	0.569	0.508–0.637	<.0001	0.842	0.747–0.948	.005
Triplets[f]	4411	40	9.07	9444	46	4.87	0.528	0.336–0.828	.005	0.781	0.497–1.227	.283
37–40 wk												
Singletons	5 922 951	20 563	3.47	6 332 831	14 917	2.36	0.709	0.693–0.724	<.0001	1.000		
Twins	102 977	587	5.70	111 671	393	3.52	0.689	0.603–0.787	<.0001	0.972	0.849–1.113	.683

Variable	1989–1991			1999–2001			AOR[a]			Comparison to Singleton AORs[b]		
	Live Births	Infant Deaths	IMR[c]	Live Births	Infant Deaths	IMR	AOR	95% CI	*P*	AOR/AOR	95% CI	*P*
41–43 wk												
Singletons	2 230 444	7057	3.16	1 516 452	3227	2.13	0.698	0.669–0.729	<.0001	1.000		
Twins	9228	67	7.26	6772	32	4.73	0.823	0.534–1.270	.382	1.179	0.763–1.822	.458

Quads indicates quadruplets; quints, quintuplets; IMR, infant mortality rate.

[a] Odds of infant death within each plurality group in 1999 –2001 vs 1989 –1991 adjusted for maternal age (<20, 20 –34, and >34 years), smoking (nonsmoker, smoker, and unknown), and parity (0, 1–3, ≥4, and unknown).

[b] The plurality-specific change in risk of infant death between 1999 –2001 and 1989 –1991 compared with the change for singletons.

[c] Deaths per 1000 live births.

[d] Includes quadruplets and quintuplets born 29 to 32 weeks and later.

[e] Rates are based on small numbers (<20 in the numerator) and should be interpreted with caution.

[f] Includes triplets born 33 to 36 weeks and later.

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TABLE 5

The Change in Risk of Infant Death According to Plurality and Gestation for Black Women, 1999–2001 vs 1989–1991

Variable	1989–1991			1999–2001			AOR[a]			Comparison to Singleton AORs[b]		
	Live Births	Infant Deaths	IMR[c]	Live Births	Infant Deaths	IMR	AOR	95% CI	*P*	AOR/AOR	95% CI	*P*
All gestations												
Singletons	1 800 819	24 191	13.43	1 649 176	16 943	10.27	0.717	0.700–0.734	<.0001	1.000		
Twins	49 913	2726	54.62	56 805	2399	42.23	0.616	0.569–0.667	<.0001	0.859	0.790–0.934	<.0001
Triplets	801	101	126.09	1421	174	122.45	0.724	0.496–1.056	.101	1.009	0.691–1.475	.961
≤24 wk												
Singletons	9773	7311	748.08	9555	6350	664.57	0.682	0.638–0.729	<.0001	1.000		
Twins	1740	1404	806.90	1982	1431	722.00	0.604	0.513–0.710	<.0001	0.885	0.743–1.055	.173
Triplets	63	54	857.14	133	107	804.51	1.069	0.487–2.348	.877	1.568	0.712–3.453	.264
25–28 wk												
Singletons	15 206	3394	223.20	14 338	2148	149.81	0.629	0.591–0.670	<.0001	1.000		
Twins	2417	644	266.45	2846	429	150.74	0.503	0.435–0.583	<.0001	0.800	0.682–0.938	.006
Triplets	101	31	306.93	212	43	202.83	0.498	0.280–0.887	.019	0.792	0.443–1.414	.430
29–32 wk												
Singletons	33 066	1648	49.84	27 456	947	34.49	0.699	0.642–0.762	<.0001	1.000		
Twins	5481	224	40.87	6357	160	25.17	0.605	0.487–0.752	<.0001	0.865	0.685–1.094	.226
Triplets[d]	212	7	33.02	422	14	33.18	0.961	0.358–2.574	.939	1.374	0.511–3.697	.529
33–36 wk												
Singletons	209 736	2938	14.01	176 023	1753	9.96	0.759	0.713–0.807	<.0001	1.000		
Twins	17 364	256	14.74	22 871	208	9.09	0.650	0.539–0.783	<.0001	0.856	0.704–1.042	.122
Triplets[d,e]	425	9	21.18	654	10	15.29	0.914	0.386–2.166	.843	1.205	0.507–2.861	.673
37–40 wk												
Singletons	1 179 518	6814	5.78	1 165 282	4713	4.04	0.756	0.727–0.785	<.0001	1.000		
Twins	20 339	164	8.06	21 087	159	7.54	1.051	0.829–1.333	.679	1.392	1.094–1.770	.007
41–43 wk												
Singletons	353 520	2086	5.90	256 522	1032	4.02	0.722	0.668–0.780	<.0001	1.000		
Twins[d]	2572	34	13.22	1662	12	7.22	0.645	0.318–1.308	.230	0.893	0.439–1.819	.756

IMR indicates infant mortality rate.

[a] Odds of infant death within each plurality group in 1999 –2001 vs 1989 –1991 adjusted for maternal age (<20, 20 –34, and >34 years), smoking (nonsmoker, smoker, and unknown), and parity (0, 1–3, ≥4, and unknown).

[b] The plurality-specific change in risk of infant death between 1999 –2001 vs 1989 –1991 compared with the change for singletons.

[c] Deaths per 1000 live births.

[d] Rates are based on small numbers (<20 in the numerator) and should be interpreted with caution.

[e] Includes triplets born 33 to 36 weeks and later.

TABLE 6

Comparison of the Risk of Infant Death According to Plurality and Gestation for Black Versus White Women, 1999–2001 vs 1989–1991

Variable	1989–1991					1999–2001				
	Infant Mortality Rate[a]		AOR[b]			Infant Mortality Rate[a]		AOR[b]		
	Black	White	AOR	95% CI	*P*	Black	White	AOR	95% CI	*P*
All gestations										
Singletons	13.43	6.03	2.094	2.061–2.127	<.0001	10.27	4.48	2.228	2.187–2.269	<.0001
Twins	54.62	29.08	1.802	1.718–1.890	<.0001	42.23	19.91	2.074	1.972–2.182	<.0001
Triplets	126.09	68.91	2.172	1.710–2.758	<.0001	122.45	47.08	2.642	2.201–3.171	<.0001
≤24 wk										
Singletons	748.08	795.34	0.756	0.707–0.808	<.0001	664.57	708.02	0.827	0.779–0.878	<.0001
Twins	806.90	885.46	0.571	0.480–0.679	<.0001	722.00	746.35	0.875	0.769–0.996	.044
Triplets	857.14	902.52	0.534	0.253–1.128	.123	804.51	773.31	1.115	0.691–1.798	.659
25–28 wk										
Singletons	223.20	254.55	0.819	0.778–0.861	<.0001	149.81	160.80	0.903	0.851–0.958	.0007
Twins	266.45	297.33	0.817	0.729–0.916	.0005	150.74	150.66	0.951	0.838–1.078	.429
Triplets	306.93	213.61	1.977	1.209–3.234	.007	202.83	101.01	2.248	1.497–3.375	<.0001
29–32 wk										
Singletons	49.84	62.66	0.739	0.694–0.787	<.0001	34.49	38.83	0.837	0.773–0.906	<.0001
Twins	40.87	39.42	0.926	0.787–1.091	.360	25.17	20.50	1.171	0.971–1.412	.099
Triplets	33.02	23.81	1.409	0.542–3.662	.497	33.18	11.16	2.626	1.366–5.046	.003
33–36 wk										
Singletons	14.01	13.12	0.979	0.936–1.025	.373	9.96	8.78	1.080	1.021–1.142	.007
Twins	14.74	10.27	1.277	1.101–1.482	.001	9.09	5.42	1.513	1.289–1.776	<.0001
37–40 wk										
Singletons	5.78	3.47	1.534	1.491–1.578	<.0001	4.04	2.36	1.628	1.574–1.684	<.0001
Twins	8.06	5.70	1.304	1.091–1.558	.003	7.54	3.52	1.862	1.532–2.265	<.0001
41–43 wk										
Singletons	5.90	3.16	1.701	1.616–1.790	<.0001	4.02	2.13	1.829	1.701–1.967	<.0001
Twins	13.22	7.26	1.840	1.212–2.795	.004	7.22	4.73	1.354	0.682–2.689	.394

[a]Deaths per 1000 live births.

[b] Odds of infant death within each plurality group, black versus white, adjusted for maternal age (<20, 20 –34, and >34 years), smoking (nonsmoker, smoker, and unknown), and parity (0, 1–3, ≥4, and unknown).