Ethnic Differences in Neonatal and Postneonatal Mortality

Nancy A. Hessol, MSPH*, and Elena Fuentes-Afflick, MD, MPH‡§‖

ABSTRACT. *Objective.* **Ethnic disparities in infant mortality have been consistently documented in the United States, but these disparities are poorly understood. Although the infant mortality rate in the United States has fallen to record low rates, since 1971 the ethnic disparity between black and white infants has remained unchanged or increased. In 2001, the infant mortality rate among black infants was ~2.5 times higher than the rate among white and Hispanic infants. The objective of this study was to identify ethnic differences in neonatal and postneonatal mortality as well as the causes and risk factors among infants born in California.**

Methods. **Secondary analysis was performed of 1 277 393 singleton infants live-born to black, Latina, and white women from the California linked birth-infant death certificate from 1995 to 1997. The dependent variables were infant death (defined as an infant who died in the first year of life [death <365 days]), neonatal death (death during the first 27 days of life), and postneonatal death (death between 28 and 364 days of life). Cause-specific neonatal and postneonatal infant mortality rates (per 100 000 live births) were calculated for each ethnic group. χ^2 and exact test statistics were used to compare the distribution of maternal and infant characteristics and cause-of-death rates by maternal ethnicity. Logistic regression analysis was used to compute odds ratios (ORs) and 95% confidence intervals (CIs) to estimate the relationship between maternal ethnicity, maternal and infant factors, and risk of infant mortality.**

Results. **In both the neonatal and postneonatal periods, black women had higher infant mortality rates than Latina or white women for conditions originating in the perinatal period (including respiratory distress syndrome) and symptoms, signs, and ill-defined conditions (including sudden infant death syndrome). After adjusting for maternal and infant characteristics, there were no significant ethnic differences for neonatal mortality. For postneonatal mortality, black women had a higher risk (OR: 1.25; 95% CI: 1.10-1.42) and Latina women had a lower risk (OR: 0.80; 95% CI: 0.71-0.89) compared with white women after adjusting for maternal and infant factors. In analyses of all ethnic groups combined, as well as ethnic-specific analyses, the strongest predictors of neonatal and postneonatal death were infant birth weight of <2499 g and gestational age of <33 weeks.**

Conclusions. **Causes of infant mortality and risk factors for infant mortality differed by maternal ethnicity, indicating a need to tailor prevention and education efforts, especially during the postneonatal period. To achieve national infant mortality goals, health professionals and policy makers should continue to emphasize the importance of early and continuous prenatal care and develop new strategies to reduce the incidence of low birth weight and premature infants. Ethnic-specific approaches may be needed to further reduce infant mortality rates and achieve our national goal to eliminate ethnic disparities in perinatal outcomes.** *Pediatrics* **2005; 115:e44–e51. URL: www.pediatrics.org/cgi/doi/10.1542/peds.2004-0478;** ***ethnicity, infant mortality, neonatal, postneonatal.***

ABBREVIATIONS. SIDS, sudden infant death syndrome; ICD-9-CM, *International Classification of Diseases, 9th Edition, Clinical Modification*; OR, odds ratio; CI, confidence interval.

For the past several decades, neonatal mortality (death during the first 27 days of life) in the United States has been declining at a faster rate than postneonatal mortality (death between 28 and 364 days of life).[1–3] However, neonatal mortality still accounts for the majority of all infant deaths (deaths within the first 364 days of life).[3,4] The decline in neonatal deaths has been largely attributed to improvements in neonatal intensive care and, more recently, to the introduction and use of surfactant therapy.[5,6] Improvements in neonatal survival have led also to postponement of some infant deaths from the neonatal to the postneonatal period.

Ethnic disparities in infant mortality have been consistently documented in the United States,[7] but these disparities are poorly understood.[8] Although the infant mortality rate in the United States has fallen to record low rates,[9] since 1971 the ethnic disparity between black and white infants has remained unchanged or increased.[3,9,10] In 2001, the infant mortality rate among black infants was ~2.5 times higher than the rate among white and Hispanic infants.[3]

The increase in ethnic differences in neonatal mortality may be related to inequities in the provision of health care.[11] The ethnic gap in postneonatal mortality is increasing also, but effective use of interventions to prevent sudden infant death syndrome (SIDS), birth defects, infections, and injuries could help narrow the ethnic gap.[12]

California is the most populous and among the most ethnically diverse states in the nation. For the period of 1999–2001, Latinas represented the majority of child-bearing women in the state and had an infant mortality rate (5.1 per 1000 live births) that

From the Departments of *Medicine, ‡Epidemiology and Biostatistics, and §Pediatrics and the ‖Medical Effectiveness Research Center for Diverse Populations, School of Medicine, University of California, San Francisco.
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Address correspondence to Nancy A. Hessol, MSPH, Department of Medicine, University of California, 405 Irving St, 2nd Floor, San Francisco, CA 94122. E-mail: nancyh@itsa.ucsf.edu

was closer to non-Hispanic white women (4.7 per 1000 live births) than non-Hispanic black women (11.6 per 1000 live births).[3] The objective of this study was to identify ethnic differences in neonatal and postneonatal mortality as well as the causes and risk factors among infants born in California.

METHODS

From the 1995–1997 California linked birth-infant death data set, we selected all live-born singleton infants born to women from the 3 largest racial/ethnic groups of child-bearing women in the United States[13]: non-Hispanic black (black), Hispanic white (Latina), and non-Hispanic white (white) women. The Committee on Human Research at the University of California, San Francisco, approved this study.

The dependent variables were infant death (defined as an infant who died in the first year of life [death < 365 days]), neonatal death (death during the first 27 days of life), and postneonatal death (death between 28 and 364 days of life). We also included 3 other infant characteristics associated with infant mortality[3]: gender, birth weight, and gestational age.

The primary independent variable was maternal ethnicity. Other independent variables included maternal age, education, birthplace, and parity, all based on birth certificate information. Marital status was dichotomized as nonmarried and married. In California, the method for determining marital status changed during the study period. In 1995 and 1996, an algorithm that compared parental surnames defined marital status, and in 1997 marital status was ascertained by direct question.[14,15] Utilization of prenatal care was categorized according to Kotelchuck's Adequacy of Prenatal Care Utilization Index,[16] which adjusts for the time of enrollment in care, the number of prenatal visits, infant gender, birth weight, and gestational age.

We created separate variables for tobacco use during pregnancy, maternal diabetes, and maternal anemia, which are coded as complications of pregnancy on the California birth certificate. A combined variable was created for 2 other complications of pregnancy that tend to occur together, previous premature infant and previous low birth weight infant. A medical complications variable was created for the presence of at least 1 of the following pregnancy complications: cardiac disease, chronic hypertension, and renal disease. A variable was created also for any of the following labor and delivery complications: abnormal presentation, abruptio placenta, amnionitis and sepsis, cord prolapse, fever, labor eclampsia, placenta previa, precipitous labor, or labor preeclampsia.

Cause of infant death, obtained from the death certificate, was coded according to the *International Classification of Diseases, 9th Edition, Clinical Modification* (ICD-9-CM).[17] Cause-specific neonatal and postneonatal infant mortality rates (per 100 000 live births) were calculated for each ethnic group. Birth certificate records that were missing information on the dependent or independent variables (6.7% of all singleton births) were excluded from all analyses.

We used χ^2 and exact test statistics to compare the distribution of maternal and infant characteristics and cause-of-death rates by maternal ethnicity. Logistic regression analysis was used to compute odds ratios (ORs) and 95% confidence intervals (CIs) to estimate the relationship between maternal ethnicity, maternal and infant factors, and risk of infant mortality. We evaluated the correlation matrix for any evidence of multicollinearity before finalizing the models. Commercially available software was used for all statistical analyses.[18]

RESULTS

Using the study criteria, we selected all singleton live-born infants born in California during 1995–1997 to black (n = 100 583), Latina (n = 665 056), and white women (n = 511 754) who had complete data for all study variables.

Black women were more likely to have missing data for maternal age, education, birthplace, utilization of prenatal care, and parity than Latina or white women (P = .001), but the proportion of births with missing data for each variable was <4% in any ethnic group (data not shown). Black women were more likely to have missing data for infant birth weight (0.05% vs 0.02% [Latina] and 0.03% [white]; P = .001) and gestational age (5.5% vs 3.7% [Latina] and 3.7% [white]; P = .001).

Black and Latina women had a higher percentage of adolescent and nonmarried child-bearing, inadequate utilization of prenatal care and multiparity than white women (Table 1). Compared with black and white women, Latinas had the lowest educational attainment, the highest proportion of foreign-born women, and the lowest rate of tobacco use.

Infant outcomes also varied by maternal ethnicity (Table 1). Black women had the highest rates of very low and moderately low birth weight infants, very premature and moderately premature infants, and infant death. The rates of adverse infant outcomes among black women were approximately twice as high as the rates among Latina or white women. Latina and white women had similar rates of all infant outcomes.

Cause of neonatal and postneonatal mortality varied by maternal ethnicity as well (Table 2). Infants born to black women had a higher neonatal mortality rate than Latina and white women for diseases of the circulatory system, diseases of the respiratory system, conditions originating in the perinatal period (including premature/low birth weight infant and respiratory distress syndrome), and symptoms, signs, and ill-defined conditions (including SIDS). Infants born to Latina women had a higher neonatal mortality rate for congenital anomalies compared with black and white women.

Among the causes of postneonatal death, black women had a higher rate than Latina and white women for infectious and parasitic diseases, congenital anomalies, conditions originating in the perinatal period (including respiratory distress syndrome), symptoms, signs, and ill-defined conditions (including SIDS), and injury and poisoning.

After adjusting for maternal and infant characteristics, there were no longer any significant ethnic differences in the risk of neonatal mortality (Table 3, column 2). In the adjusted analyses, there was a significantly increased risk of neonatal death associated with inadequate prenatal care, >3 prior live births, maternal diabetes, male infant, very low infant birth weight, moderately low infant birth weight, very premature gestation, moderately premature gestation, and postterm gestation. On the other hand, there was a significantly decreased risk of neonatal death associated with older maternal age, more years of maternal education, unmarried mother, women with medical complications, and high birth weight infants.

After adjusting for maternal and infant characteristics, there was a significantly increased risk of postneonatal death associated with black mothers, fewer years of maternal education, unmarried mother, inadequate prenatal care, >3 prior live births, tobacco use during pregnancy, maternal diabetes, labor and delivery complications, male infant, very low infant birth weight, moderately low infant birth weight,

TABLE 1. Distribution (%) of Selected Maternal and Infant Characteristics, by Maternal Ethnicity: California, 1995–1997

Characteristics	Maternal Ethnicity			
	Black (n = 100 583)	Latina (n = 665 056)	White (n = 511 754)	P Value
Maternal age, y				<.001
<18	7.5	6.6	2.4	
18–26	48.6	51.1	32.5	
27–34	32.9	33.1	46.3	
>34	11.0	9.2	18.8	
Maternal education, y				<.001
<9	1.4	28.0	0.9	
9–11	18.7	29.0	8.9	
12	40.9	27.3	30.9	
13–15	27.6	11.4	27.2	
>15	11.5	4.3	32.2	
United States–born	92.9	31.0	90.3	<.001
Unmarried	60.8	38.5	21.7	<.001
Utilization of prenatal care				<.001
Inadequate	14.9	17.2	8.4	
Intermediate	16.2	19.9	16.2	
Adequate	37.6	39.2	47.0	
Adequate plus	31.3	23.8	28.4	
Number of previous live births				<.001
0	38.1	35.9	42.6	
1–3	63.5	57.4	54.2	
>3	8.5	6.7	3.2	
Tobacco use	3.2	0.8	3.8	<.001
Prior low birth weight or premature infant*	2.7	1.0	2.4	<.001
Medical complications	0.7	0.3	0.7	<.001
Anemia	1.4	0.8	0.8	<.001
Diabetes	1.4	1.8	1.7	<.001
Labor and delivery complications	8.6	7.1	7.9	<.001
Male infant	50.7	50.9	51.4	<.001
Birth weight, g				<.001
Very low, <1500	2.0	0.8	0.6	
Moderately low, 1500–2499	7.8	3.7	3.3	
Normal, 2500–4000	83.5	84.9	82.2	
High, >4000	6.7	10.6	13.9	
Gestational age, wk				<.001
Very premature, <33	3.8	1.9	1.3	
Moderately premature, 33–37	10.1	7.7	6.2	
Term, 38–42	76.5	80.5	82.6	
Postterm, >42	9.6	10.0	9.9	
Infant death (<365 d)	1.0	0.5	0.4	<.001
Neonatal death (<28 d)	0.6	0.3	0.3	<.001
Postneonatal death (28–364 d)	0.4	0.2	0.2	<.001

* Parous women only

very premature gestation, and moderately premature gestation (Table 3, column 3). Conversely, there was a significantly decreased risk of neonatal death associated with Latina mothers, older maternal age, more years of maternal education, foreign-born mother, primiparous women, and high birth weight infants.

To determine if the relationship between infant and maternal characteristics and infant mortality varied by ethnicity, we conducted separate multiple-regression analyses for each ethnic group. Among black and white women, maternal age of ≥35 years was significantly associated with a lower risk of neonatal death than a maternal age of 18 to 26 years (Table 4). Interestingly, in all 3 ethnic groups, unmarried women had a decreased risk of neonatal mortality than married women. Among black women, inadequate and intermediate use of prenatal care carried a significantly increased risk of neonatal death as compared with adequate use of prenatal care. Among white women, primiparity was associated with a significantly lower risk of neonatal death, and among Latina and white women, high parity (>3 prior live births) was associated with a significantly increased risk of neonatal death when compared with 1 to 3 prior live births. Medical complications were associated with a significantly lower risk of neonatal death only for Latina and white women. Maternal diabetes was associated with an increased risk of neonatal death in Latina women, and labor and delivery complications were associated with an increased risk in white women.

Among infants born to Latina and white women, males had a significantly higher risk of neonatal death than females (Table 4). In all 3 ethnic groups, very low and moderately low birth weight infants were significantly more likely to experience neonatal death than normal birth weight infants. Similarly, very premature and postterm infants were more likely to experience death in the first 27 days than

TABLE 2. Cause of Death (ICD-9-CM) Rate Per 100 000 Live Births for Neonatal (N) and Postneonatal (P) Mortality, by Maternal Ethnicity: California, 1995–1997

Cause of Death (ICD-9-CM Code)	Black		Latina		White	
	N (n = 581)	P (n = 397)	N (n = 2011)	P (n = 1103)	N (n = 1315)	P (n = 865)
Infectious and parasitic diseases (001–139)	2.98	16.90*	1.05	12.33*	2.54	7.43*
Neoplasms (140–239)	0.00	0.00	0.60	2.86	1.17	1.76
Endocrine, nutritional, and metabolic diseases and immunity disorders (240–279)	1.99	5.97	4.06	3.76	1.95	2.93
Diseases of the blood and blood-forming organs (280–289)	1.99	1.00	0.45	1.50	0.39	1.37
Mental disorders (290–319)	0.00	0.00	0.00	0.15	0.00	0.00
Diseases of the nervous system and sense organs (320–389)	1.99	11.93	1.05	6.02	2.35	6.64
Diseases of the circulatory system (390–459)	17.90*	14.91	5.71*	9.62	5.86*	7.23
Diseases of the respiratory system (460–519)	8.95*	18.89	3.46*	13.38	2.74*	11.14
Diseases of the digestive system (520–579)	3.98	5.97	1.50	4.21	1.56	3.52
Diseases of the genitourinary system (580–629)	1.99	2.99	1.50	0.75	0.98	1.17
Complications of pregnancy, childbirth, and puerperium (630–679)	0.00	0.00	0.15	0.15	0.00	0.00
Disease of the skin and subcutaneous tissue (680–709)	0.00	0.00	0.00	0.30	0.00	0.00
Diseases of the musculoskeletal system and connective tissue (710–739)	0.99	0.00	0.15	0.30	0.20	0.00
Congenital anomalies (740–759)	91.47*	58.66*	105.10*	43.46*	86.17*	33.22*
Certain conditions originating in the perinatal period (760–779)†	417.57*	39.77*	172.32*	9.77*	142.26*	6.64*
Premature, low birth weight infant (765)	132.23*	1.99	48.72*	0.30	30.87*	0.39
Respiratory distress syndrome (769)	36.79*	11.93*	16.99*	1.05*	14.66*	0.98*
Symptoms, signs, and ill-defined conditions (780–799)‡	21.87*	175.97*	4.06*	41.35*	6.84*	70.93*
SIDS (798)	14.91*	152.11*	2.26*	32.03*	3.32*	58.23*
Injury and poisoning (800–999)	3.98	41.76*	1.20	15.94*	2.00	15.05*

* $P < .05$.
† Includes premature/low birth weight infant (ICD-9-CM code 765) and respiratory distress syndrome (ICD-9-CM code 769).
‡ Includes SIDS (ICD-9-CM code 798).

term infants in all 3 ethnic groups. High birth weight infants had a lower risk of neonatal death than normal birth weight infants, and this was significant in Latina and white infants.

In ethnic-specific analyses of postneonatal death, older maternal age was associated with a decreased risk in Latina and white women (Table 5). In all 3 ethnic groups, having <12 years of education was significantly associated with an increased risk of postneonatal mortality, and among white women, having >15 years of education was associated with a decreased risk. Although foreign-born women generally had a reduced risk of postneonatal death in all 3 ethnic groups, this was only statistically significant in Latina women. In contrast to neonatal mortality, unmarried women in all 3 ethnic groups had a significantly elevated risk of postneonatal death. Only white women who smoked had a significantly increased risk of postneonatal mortality. Compared with adequate use of prenatal care, Latina and white women with inadequate use had an elevated risk of postneonatal death.

In all 3 ethnic groups, primiparity was associated with a significantly lower risk of postneonatal death, and among Latina women, higher parity was associated with a significantly increased risk of neonatal death when compared with 1 to 3 prior live births (Table 5). Latina women with maternal diabetes and white women with labor and delivery complications had an elevated risk of postneonatal death.

Among infants born to women in all 3 ethnic groups, males had a significantly higher risk of postneonatal death than females (Table 5). In all 3 ethnic groups, very low and moderately low infant birth weight conferred a significantly increased risk of postneonatal death when compared with normal birth weight infants. Among infants born to white women, high infant birth weight experienced a lower risk of postneonatal death than normal birth weight infants. Compared with term infants, very premature infants born to black and white women and moderately premature infants born to white women had an increased risk of postneonatal death.

DISCUSSION

In this large, multiethnic study, we found considerable ethnic differences in neonatal and postneonatal infant mortality, including underlying cause of death. Latina women had a higher neonatal mortality for congenital anomalies than black or white women, and black women had a higher neonatal and postneonatal mortality rate for respiratory distress syndrome or SIDS than Latina or white women. Our results substantiate what other studies have found regarding racial and ethnic differences in the leading causes of infant death.[8,19–21] Several studies have found ethnic differences in dietary (folic acid intake),[22] genetic,[23] environmental,[20] and health service factors,[19,24] and these variations may lead to ethnic differences in cause of infant death. In the case of SIDS, the Chicago Infant Mortality Study[20] found that black women were more likely to put their in-

TABLE 3. ORs (95% CIs) for Infant Mortality: California, 1995–1997

Characteristic	Neonatal Mortality (N = 3907)	Postneonatal Mortality (N = 2365)
Maternal ethnicity		
Black	0.91 (0.82–1.02)	1.25 (1.10–1.42)
Latina	0.94 (0.85–1.04)	0.80 (0.71–0.89)
White	1.00	1.00
Maternal age, y		
<18	1.02 (0.87–1.20)	1.13 (0.95–1.35)
18–26	1.00	1.00
27–34	0.90 (0.83–0.98)	0.78 (0.70–0.86)
>34	0.83 (0.74–0.94)	0.80 (0.69–0.92)
Maternal education, y		
<9	1.06 (0.93–1.19)	1.29 (1.11–1.50)
9–11	1.06 (0.95–1.17)	1.20 (1.07–1.35)
12	1.00	1.00
13–15	0.95 (0.86–1.05)	0.84 (0.74–0.95)
>15	0.83 (0.73–0.95)	0.76 (0.65–0.90)
Non-US birthplace	0.97 (0.88–1.07)	0.74 (0.65–0.83)
Unmarried	0.74 (0.69–0.80)	1.40 (1.28–1.54)
Utilization of prenatal care		
Inadequate	1.15 (1.02–1.29)	1.39 (1.24–1.56)
Intermediate	1.10 (0.97–1.25)	0.98 (0.86–1.12)
Adequate	1.00	1.00
Adequate plus	1.02 (0.93–1.12)	1.03 (0.92–1.14)
Number of previous live births		
0	0.97 (0.90–1.05)	0.68 (0.62–0.75)
1–3	1.00	1.00
>3	1.30 (1.14–1.49)	1.38 (1.18–1.60)
Tobacco use	1.02 (0.84–1.25)	1.46 (1.21–1.77)
Prior low birth weight or premature infant	1.02 (0.85–1.22)	0.90 (0.68–1.19)
Medical complications	0.44 (0.29–0.66)	1.15 (0.74–1.78)
Anemia	0.97 (0.69–1.36)	1.16 (0.80–1.68)
Maternal diabetes	1.31 (1.03–1.66)	1.55 (1.19–2.02)
Labor and delivery complications	1.00 (0.92–1.09)	1.13 (1.00–1.28)
Male infant	1.10 (1.03–1.18)	1.38 (1.27–1.50)
Infant birth weight, g		
Very low, <1500	109.91 (95.40–126.63)	13.69 (11.17–16.78)
Moderately low, 1500–2499	9.12 (8.04–10.35)	3.97 (3.48–4.53)
Normal, 2500–4000	1.00	1.00
High, >4000	0.72 (0.58–0.89)	0.71 (0.60–0.84)
Infant gestational age, wk		
Very premature, <33	4.03 (3.50–4.64)	1.52 (1.25–1.85)
Moderately premature, 33–37	1.61 (1.41–1.85)	1.34 (1.17–1.54)
Term, 38–42	1.00	1.00
Postterm, >42	1.49 (1.27–1.75)	1.06 (0.91–1.24)

fant in a prone sleeping position and were less likely to report having been advised about infant sleep position than white women. The National Infant Sleep Position Study found black maternal race to be independently associated with increased prone and decreased supine placement of the infant.[24] Both these studies indicate that greater and more effective educational outreach needs to be extended to black families and their health providers to reduce the risk of SIDS further.

In addition, we also were able to compare and contrast mortality in the neonatal period with the postneonatal period. Notably, we failed to find evidence of ethnic differences in the risk of neonatal mortality in adjusted analyses. However, black mothers had a significantly increased risk during the postneonatal period, whereas Latina mothers had a significantly decreased risk of infant death when compared with white mothers. Much of this ethnic variation in the postneonatal period is due to SIDS, which occurred at a higher rate among infants born to black mothers, followed by white mothers, and was lowest for Latina mothers. This finding corresponds to results from several other recent studies that have evaluated changes in SIDS deaths over time and between different racial groups. In those studies, greater reductions in infant mortality due to SIDS were seen for Latina and white infants compared with black infants.[8,21] Additional study is needed to understand whether differences in postneonatal care contribute to the higher risk of death among infants born to black mothers and lower risk among infants born to Latina mothers.

We had several surprising findings. Unmarried women had a significantly decreased risk of neonatal death (OR: 0.74; Table 3) and a significantly increased risk of postneonatal death (OR: 1.40) when compared with married women. This pattern of decreased risk in the neonatal period and increased risk in the postneonatal period was also seen for medical complications (OR: 0.44 and 1.15, respectively) and may indicate a greater attention to infants born to traditionally high-risk women early in the neonatal period, followed by a waning of this effect or possibly less social support in the postneonatal period.

TABLE 4. ORs (95% CIs) for Neonatal Infant Mortality, by Ethnicity: California, 1995–1997

Characteristic	Black (n = 100 583)	Latina (n = 665 056)	White (n = 511 754)
Maternal age, y			
<18	0.82 (0.53–1.26)	0.98 (0.81–1.20)	1.32 (0.95–1.85)
18–26	1.00	1.00	1.00
27–34	0.89 (0.72–1.11)	0.90 (0.80–1.01)	0.91 (0.78–1.05)
>34	0.64 (0.46–0.89)	0.94 (0.80–1.11)	0.79 (0.66–0.95)
Maternal education, y			
<9	1.65 (0.79–3.44)	1.08 (0.94–1.24)	0.70 (0.40–1.21)
9–11	0.88 (0.66–1.17)	1.12 (0.98–1.27)	0.98 (0.79–1.21)
12	1.00	1.00	1.00
13–15	0.92 (0.73–1.15)	0.94 (0.80–1.12)	0.96 (0.82–1.12)
>15	0.75 (0.54–1.06)	0.76 (0.57–1.01)	0.89 (0.75–1.05)
Non-US birthplace	0.86 (0.59–1.27)	0.97 (0.87–1.09)	0.97 (0.79–1.19)
Unmarried	0.61 (0.51–0.75)	0.77 (0.69–0.85)	0.78 (0.67–0.90)
Utilization of prenatal care			
Inadequate	1.52 (1.10–2.10)	1.06 (0.91–1.24)	1.19 (0.96–1.47)
Intermediate	1.84 (1.29–2.62)	0.93 (0.78–1.11)	1.21 (0.97–1.50)
Adequate	1.00	1.00	1.00
Adequate plus	1.27 (0.98–1.65)	0.97 (0.85–1.10)	1.01 (0.87–1.18)
Number of previous live births			
0	1.22 (0.99–1.49)	1.00 (0.89–1.11)	0.86 (0.75–0.97)
1–3	1.00	1.00	1.00
>3	1.20 (0.87–1.66)	1.32 (1.10–1.57)	1.45 (1.11–1.90)
Tobacco use	0.74 (0.44–1.26)	1.00 (0.63–1.57)	1.11 (0.87–1.43)
Prior low birth weight or premature infant	1.22 (0.82–1.80)	0.95 (0.71–1.27)	1.00 (0.76–1.32)
Medical complications	0.42 (0.15–1.21)	0.45 (0.25–0.78)	0.43 (0.21–0.85)
Anemia	1.65 (0.85–3.16)	0.91 (0.54–1.53)	0.76 (0.41–1.40)
Maternal diabetes	0.72 (0.32–1.63)	1.38 (1.01–1.88)	1.38 (0.90–2.11)
Labor and delivery complications	0.88 (0.70–1.11)	0.93 (0.82–1.05)	1.17 (1.02–1.36)
Male infant	0.92 (0.77–1.10)	1.11 (1.00–1.22)	1.17 (1.04–1.32)
Infant birth weight, g			
Very low, <1500	126.76 (85.93–187.01)	114.66 (94.62–138.93)	93.14 (72.63–119.45)
Moderately low, 1500–2499	6.56 (4.52–9.51)	9.63 (8.10–11.44)	8.96 (7.23–11.09)
Normal, 2500–4000	1.00	1.00	1.00
High, >4000	0.68 (0.27–1.67)	0.73 (0.53–0.99)	0.72 (0.53–0.99)
Infant gestational age, wk			
Very premature, <33	2.49 (1.71–3.61)	4.20 (3.47–5.10)	4.54 (3.54–5.82)
Moderately premature, 33–37	0.57 (0.36–0.90)	1.75 (1.45–2.10)	1.90 (1.52–2.39)
Term, 38–42	1.00	1.00	1.00
Postterm, >42	1.57 (1.02–2.40)	1.58 (1.26–1.97)	1.32 (1.01–1.74)

Our data also showed that mothers with >3 prior live births had an increased risk of neonatal (OR: 1.30; Table 3) and postneonatal death (OR: 1.38). This pattern was seen consistently in all 3 ethnic groups (Tables 4 and 5) and may indicate that women become less attentive or more complacent about infant health care with increasing number of children. We have reported in prior studies that multiparous women had a higher risk of inadequate use of prenatal care.[25] It is also possible that women with >3 previous live births are more likely to have shorter interpregnancy intervals, which can result in an increased risk of adverse perinatal outcomes.[26] To further evaluate risk of infant death among women with >3 prior live births, we performed separate logistic regression models looking at cause-specific outcomes to determine if there was an indication that multiparous women were more at risk for certain causes of infant death such as SIDS. After controlling for all the other variables in our logistic models, we found that the OR for SIDS among women with >3 children was higher (1.66 [95% CI: 1.28–2.16]) but not statistically higher than the odds for congenital anomalies (1.40 [95% CI: 1.17–1.67]). More research is needed to further explore the relationship between parity and complacency in regard to infant health care.

Previous studies have found that gestational diabetes mellitus is more common in Latina women than in black and white women[27–29] and that after adjusting for other risk factors Latinas are >2 times more likely than black[29] and white[27] women to develop gestational diabetes mellitus. Given that we found gestational diabetes in Latina women to be associated with a significantly higher risk of both neonatal and postneonatal mortality, more attention should be given to preventing gestational diabetes mellitus in Latina women.

We found that infant characteristics had a greater effect on infant mortality than maternal factors, which is consistent with previous studies.[3,10,30] In analyses of all ethnic groups, as well as ethnic-specific analyses, the strongest predictors of neonatal and postneonatal death were infant birth weight of <2499 g and gestational age of <33 weeks. Our results underscore the need to further reduce the risk of low birth weight and premature infants. For example, infections or inflammatory disease may contribute to ethnic differences in the risk of premature delivery, and nutritional factors may contribute to ethnic variation in the risk of low infant birth weight.[31]

Our findings are subject to several limitations. We analyzed data from 1 state, California, and our re-

TABLE 5. ORs (95% CIs) for Postneonatal Infant Mortality, by Ethnicity: California, 1995–1997

Characteristic	Black (n = 100 583)	Latina (n = 665 056)	White (n = 511 754)
Maternal age, y			
<18	1.19 (0.79–1.79)	1.15 (0.91–1.46)	1.05 (0.74–1.48)
18–26	1.00	1.00	1.00
27–34	0.92 (0.72–1.19)	0.82 (0.71–0.95)	0.68 (0.58–0.81)
>34	0.86 (0.59–1.24)	0.80 (0.64–1.00)	0.77 (0.62–0.96)
Maternal education, y			
<9	1.69 (0.81–3.54)	1.24 (1.03–1.48)	1.69 (1.09–2.63)
9–11	1.40 (1.07–1.82)	1.16 (0.98–1.36)	1.24 (1.01–1.52)
12	1.00	1.00	1.00
13–15	1.03 (0.79–1.34)	0.97 (0.77–1.21)	0.72 (0.60–0.87)
>15	0.85 (0.54–1.34)	1.04 (0.72–1.48)	0.72 (0.58–0.88)
Non-United States birthplace	0.70 (0.41–1.19)	0.73 (0.63–0.84)	0.81 (0.62–1.06)
Unmarried	1.66 (1.30–2.12)	1.31 (1.16–1.49)	1.40 (1.20–1.64)
Tobacco use	1.37 (0.90–2.11)	0.80 (0.44–1.45)	1.57 (1.25–1.98)
Utilization of prenatal care			
Inadequate	1.11 (0.83–1.48)	1.37 (1.16–1.63)	1.61 (1.31–1.97)
Intermediate	0.97 (0.70–1.35)	1.03 (0.85–1.24)	0.93 (0.73–1.16)
Adequate	1.00	1.00	1.00
Adequate plus	0.88 (0.67–1.14)	1.02 (0.86–1.20)	1.09 (0.92–1.29)
Number of previous live births			
0	0.62 (0.48–0.80)	0.70 (0.60–0.81)	0.69 (0.59–0.80)
1–3	1.00	1.00	1.00
>3	1.32 (0.96–1.80)	1.54 (1.25–1.90)	1.11 (0.81–1.52)
Previous low birth weight or premature infant	0.56 (0.27–1.15)	0.92 (0.56–1.50)	1.11 (0.76–1.62)
Medical complications	1.15 (0.42–3.29)	1.07 (0.53–2.18)	1.19 (0.61–2.32)
Anemia	1.73 (0.91–3.29)	1.14 (0.63–2.08)	0.88 (0.44–1.77)
Diabetes	1.32 (0.58–2.99)	1.93 (1.38–2.69)	1.03 (0.60–1.75)
Labor and delivery complications	0.79 (0.57–1.11)	1.15 (0.95–1.38)	1.28 (1.05–1.57)
Male infant	1.45 (1.19–1.78)	1.25 (1.11–1.41)	1.52 (1.32–1.74)
Infant birth weight, g			
Very low, <1500	9.87 (6.38–15.27)	22.07 (16.55–29.42)	8.18 (5.57–12.02)
Moderately low, 1500–2499	3.00 (2.23–4.03)	5.40 (4.47–6.53)	3.02 (2.39–3.80)
Normal, 2500–4000	1.00	1.00	1.00
High, >4000	0.84 (0.50–1.42)	0.85 (0.67–1.08)	0.57 (0.43–0.75)
Infant gestational age, wk			
Very premature, <33	1.67 (1.10–2.54)	1.30 (0.98–1.73)	1.76 (1.23–2.52)
Moderately premature, 33–37	1.14 (0.82–1.59)	1.19 (0.97–1.45)	1.70 (1.36–2.12)
Term, 38–42	1.00	1.00	1.00
Postterm, >42	0.94 (0.64–1.40)	1.08 (0.87–1.35)	1.07 (0.84–1.37)

sults may not be nationally representative. However, because one eighth of all US births, and nearly one third of all Latino births, occur in California,[13] our results are likely to be relevant for many other areas of the United States. Second, we focused on the 3 largest racial/ethnic groups of child-bearing women in the United States, and our results may not be applicable to other ethnic groups. Asian and Pacific Islanders represent ~11% of all live births in California but were not included in these analyses because they are a heterogeneous group, comprised of many national origin and ethnic subgroups, and the effect of country of origin on perinatal outcomes varies considerably.[32] Underreporting of maternal risk factors, and the severity or intensity thereof, on the birth certificate could also affect our results. For example, pregnancy complications such as tobacco use during pregnancy may be underreported.[33] However, if this information is underreported on the birth certificate, our results are conservative estimates of the true effect of these variables on the risk of infant death. Similarly, gestational age is reported less accurately than birth weight on the birth certificate,[8,34] and this difference in reporting accuracy could have affected our comparisons of the risk of low birth weight and prematurity on infant death. Finally, vital records data sets do not contain information about factors such as quality of prenatal care, quality of neonatal and postneonatal care, and community or environmental factors, any of which may affect the risk of infant death.[8,35]

CONCLUSIONS

To achieve national infant mortality goals, health professionals and policy makers should continue to emphasize the importance of early and continuous prenatal care and develop new strategies to reduce the incidence of low birth weight and premature infants. Other prevention measures include increasing education about folic acid intake, use of genetic counseling and screening, and prevention of gestational diabetes; improving access to surfactant therapy to prevent respiratory distress syndrome; and increasing education about "Back to Sleep," SIDS prevention efforts. Ethnic-specific approaches may be needed to reduce infant mortality rates further[5,8] and achieve our national goal to eliminate ethnic disparities in perinatal outcomes.

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