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Pediatrics 2006;117;106-112

DOI: 10.1542/peds.2005-1286

This information is current as of January 6, 2006

The online version of this article, along with updated information and services, is located on the World Wide Web at:

<http://www.pediatrics.org/cgi/content/full/117/1/e106>

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Racial and Gender Differences in the Viability of Extremely Low Birth Weight Infants: A Population-Based Study

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The authors have indicated they have no financial relationships relevant to this article to disclose.

ABSTRACT

OBJECTIVE. The purpose of this study is to provide a race- and gender-specific model for predicting 1-year survival rates for extremely low birth weight (ELBW) infants by using population-based data.

METHODS. Birth and death certificates were analyzed for all children ($N = 5076$) with birth weights between 300 g and 1000 g who were born in Florida between 1996 and 2000. Semiparametric, multivariate, logistic regression analysis was used to model 1-year survival probabilities as a function of birth weight, gestational age, mother's race, and infant's gender. Estimated survival rates among different race/gender groups were compared by using odds ratios (ORs).

RESULTS. One-year survival rates for 5076 ELBW infants born between 1996 and 2000 did not change during the 5-year period (60–62%). The survival rate at ≤ 500 g was $\leq 14\%$ ($n = 716$). Survival rates at 501 to 600 g and 601 to 700 g were 36% and 62%, respectively. The survival rate reached $>85\%$ for infants of >800 g. Modeling indicated a survival advantage for female infants, compared with male infants (OR: 1.7; 95% confidence interval: 1.5–1.9), and for black infants, compared with white infants (OR: 1.3; 95% confidence interval: 1.1–1.5). Black female infants had 2.1 greater odds of survival than did white male infants.

CONCLUSIONS. This population-based study highlights the significant race and gender differences in 1-year survival rates for ELBW infants, as well as the interactions of these 2 factors. These findings can assist obstetricians and neonatologists not only in the care of ELBW infants but also in frank discussions with families.

www.pediatrics.org/cgi/doi/10.1542/peds.2005-1286

doi:10.1542/peds.2005-1286

Key Words

birth weight-specific mortality rate, low birth weight infant, infant death

Abbreviations

ELBW—extremely low birth weight
OR—odds ratio
CI—confidence interval
SGA—small for gestational age

Accepted for publication Jul 19, 2005

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THERE ARE ~4 million births annually in the United States.^{1,2} Among these births, extremely low birth weight (ELBW) infants remain <1% of the total. Ever-improving medical care and technologies have continued to lower the threshold at which survival is possible. However, the highest mortality and morbidity rates remain within this ELBW cohort.^{1,3-6}

There are few population-based studies of the survival of ELBW infants.¹ Most reports of ELBW survival rates are based on data for individual institutions or voluntary networks of hospitals, which limits the generalizability of the results to other populations.³⁻⁶ Studies are consistent with respect to ELBW infants having the highest mortality risk of all birth weight groups and exhibiting the greatest proportions of morbidities in a wide range of areas, including behavior, cognition, mobility, and sensation.⁷⁻¹¹ It is for this high-risk population of infants that it is most difficult for health care providers to feel confident regarding their medical decision-making. It is known that caregivers' perceptions of the likelihood of survival affect their treatment of premature infants.^{12,13} Often this perception of survival likelihood is based on limited data, personal experiences, and internal beliefs.¹²⁻¹⁴ In addition, parental attitudes often differ significantly from those of physicians and nurses regarding treatment of extremely premature infants.^{15,16} Although the general population is aware that there is a lower long-term, health-related quality of life for ELBW infants, individuals support life-saving treatment for all ELBW infants, with a role for parents in the decision-making process.^{16,17}

Delineating risk factors for death among ELBW infants is difficult because of limited samples sizes and the number of factors that must be considered. Both race and gender have been shown to be related significantly

to both overall survival and survival without major morbidity rates.^{4-6,18-23}

Because medical decisions regarding treatment have major effects on both ELBW infants and their families, it is imperative that obstetricians and neonatologists consider the most recent and specific data regarding survival rates. The purpose of this study is to provide a race- and gender-specific model for predicting survival rates for ELBW infants.

METHODS

Study Sample

By using the Florida birth vital statistics database, all singleton live births between 1996 and 2000 were identified. From these 976 824 records, 5663 infants were identified as having a birth weight between 300 g and 1000 g and a gestational age between 20 weeks and 35 weeks. Gestational age was determined from the date of the last menstrual period, as indicated on the birth certificate. If the last menstrual period was not available, then the clinical estimate of gestational age recorded on the birth certificate was used. Race was based on the maternal race designation on the birth certificate, and all records with either a white or black designation were included ($N = 5532$). Records were excluded if any of the following values necessary for analysis were missing: gestational age, birth weight, race, or gender. In addition, records with inconsistent birth weights and gestational ages were excluded. Inconsistent birth weight was defined as a birth weight that fell outside range of the gestational age-specific median weight ± 3 SDs. After exclusion of these 456 outliers, the final sample consisted of 5076 ELBW singleton infants. The sample was then stratified according to weekly gestational age and 100-g increments between 300 g and 1000 g (Table 1).

TABLE 1 Number of Florida Singleton Live-Born Infants Between 300 and 1000 g (1996–2000)

Gestational Age, wk	No. With Weight of							
	Total	300–400 g	401–500 g	501–600 g	601–700 g	701–800 g	801–900 g	901–1000 g
20	105	78	16	10	1	0	0	0
21	254	110	104	32	8	0	0	0
22	357	57	152	116	23	7	2	0
23	505	21	95	236	105	43	4	1
24	679	17	67	191	200	138	40	26
25	711	3	30	122	161	223	116	56
26	753	5	18	81	105	183	182	179
27	632	0	5	48	68	122	142	247
28	408	0	4	13	56	88	89	158
29	296	0	0	9	19	62	75	131
30	159	0	0	0	6	39	42	72
31	121	0	0	0	0	17	34	70
32	60	0	0	0	0	4	17	39
33	25	0	0	0	0	0	6	19
34	9	0	0	0	0	0	0	9
35	2	0	0	0	0	0	0	2
Total	5076	291	491	858	752	926	749	1009

Among these 5076 ELBW infants, death certificate information was merged to identify any death occurring at ≤ 1 year. ELBW infant survival rates were calculated according to weekly gestational age and birth weight, in 100-g increments (Table 2).

Statistical Analyses

Semiparametric, multivariate, logistic regression analysis was used to model survival probability as a function of birth weight, gestational age, mother's race, and infant's gender.^{24,25} This model eliminated the need for precise specification of the functional form of the model. Because the relationship between gestational age and birth weight is nonlinear, this model was a better choice than logistic or linear regression analysis.

Race- and gender-specific survival curves at designated gestational ages of 24, 26, and 28 weeks and birth weights of 500, 750, and 1000 g were created by using this model (Figs 1 and 2). Race- and gender-specific isomortality curves were also generated, allowing a continuum of birth weights and gestational ages to be viewed simultaneously (Fig 3). Odds ratios (ORs) and confidence intervals (CIs) were calculated to compare survival rates among different race and gender combinations (Table 3).

RESULTS

Across the 5 years studied, each year contributed between 18% and 21% of the sample. Within the entire cohort of 5076 infants, 51% percent were male and 47% were black. Fifty-nine percent ($n = 3011$) of the ELBW cohort (500–1000 g) remained alive at 1 year of age. Survival rates did not vary significantly across the 5-year study period, ranging from 60% to 62%. Gestational ages in the specified weight range of 300 to 1000 g were

between 20 weeks and 35 weeks (Table 1). The median birth weights at the earliest gestational ages of 22, 23, and 24 weeks were 482, 567, and 624 g, respectively, which is consistent with current fetal growth curves.^{26,27} Among infants of <1000 g, the most frequent gestational ages were 24 to 27 weeks (Table 1).

The birth weight (in 100-g increments)- and gestational age-specific survival rates are shown in Table 2. As expected, the lowest survival rates were noted for the earliest gestational ages, with survival rates among infants of ≤ 22 weeks ($n = 716$) being at best 11%. At 23 weeks, the survival rate was 27%. Survival rates reached $\geq 85\%$ once gestational ages reached 28 weeks. Because of the truncation of data at 1000 g, the survival rates at the later gestational ages of 30 to 35 weeks represent survival rates among small-for-gestational age (SGA) infants. Within all gestational age groups, survival rates increased as weight increased.

With the use of semiparametric logistic regression models, survival rates at designated birth weights of 500, 750, and 1000 g were generated for all 4 gender and race combinations (Fig 1). At any given birth weight, black female infants had the greatest survival advantage and white male infants had the lowest survival rate. Across all gestational ages for a given birth weight, female infants survived at a higher rate than did male infants, and black infants survived at a higher rate than did white infants. The largest survival differences were observed at the lowest gestational ages.

To isolate the effect of birth weight on survival rates, gestational age-specific predicted survival curves were generated for all race and gender combinations at 24, 26, and 28 weeks (Fig 2). Predicted survival rates improved for all race/gender groups as birth weight increased. As gestational age increased, the range of predicted survival

TABLE 2 Gestational Age- and Birth Weight-Specific Survival Rates Among Florida Singleton Live-Born Infants (1996–2000)

Gestational Age, wk	Weight-Specific Survival Rate, %							
	Total	300–400 g	401–500 g	501–600 g	601–700 g	701–800 g	801–900 g	901–1000 g
20	5	4	6	10	0	NA	NA	NA
21	6	2	6	19	13	NA	NA	NA
22	11	2	5	15	39	71	50	NA
23	27	0	11	27	35	56	50	0
24	54	24	36	40	62	62	73	81
25	69	0	40	50	63	76	83	91
26	76	20	33	51	78	77	83	84
27	83	NA	20	48	72	89	89	88
28	85	NA	25	77	79	80	88	91
29	91	NA	NA	89	58	90	96	92
30	87	NA	NA	NA	83	79	83	94
31	86	NA	NA	NA	NA	76	91	86
32	88	NA	NA	NA	NA	75	88	90
33	88	NA	NA	NA	NA	NA	100	84
34	78	NA	NA	NA	NA	NA	NA	78
35	100	NA	NA	NA	NA	NA	NA	100
Total	61	4	14	36	62	76	86	88

NA indicates not applicable, ie, no infants in the weight/gestational age category.

FIGURE 1
 Infant survival probability according to gestational age at specific birth weights of 500 g (A), 750 g (B), and 1000 g (C). Survival probability is plotted for specific race and gender combinations. Declines in survival probabilities with advancing gestational age represent SGA effects (B and C).

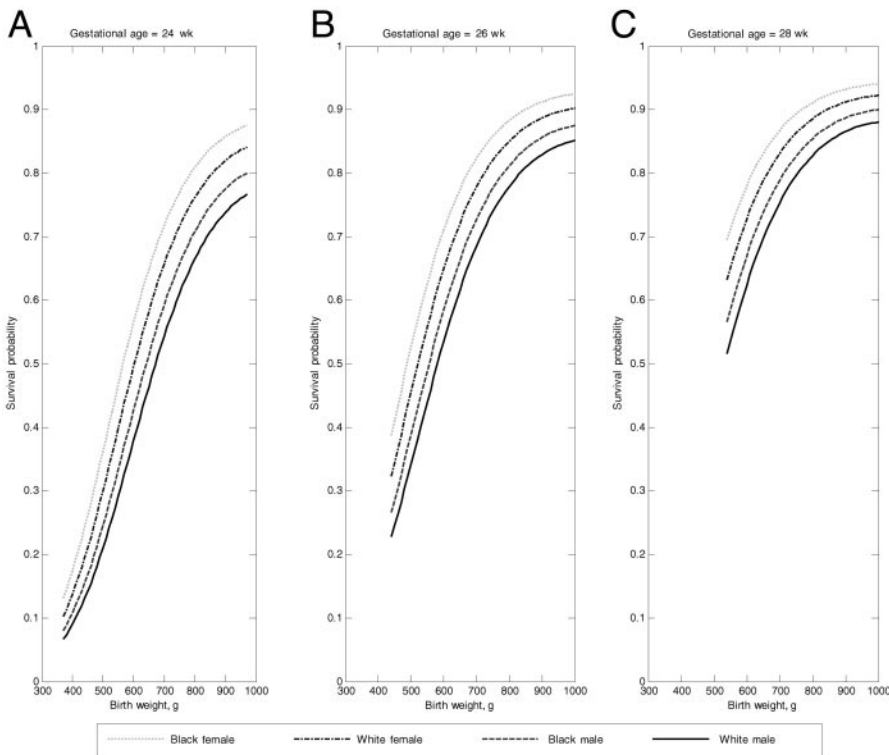
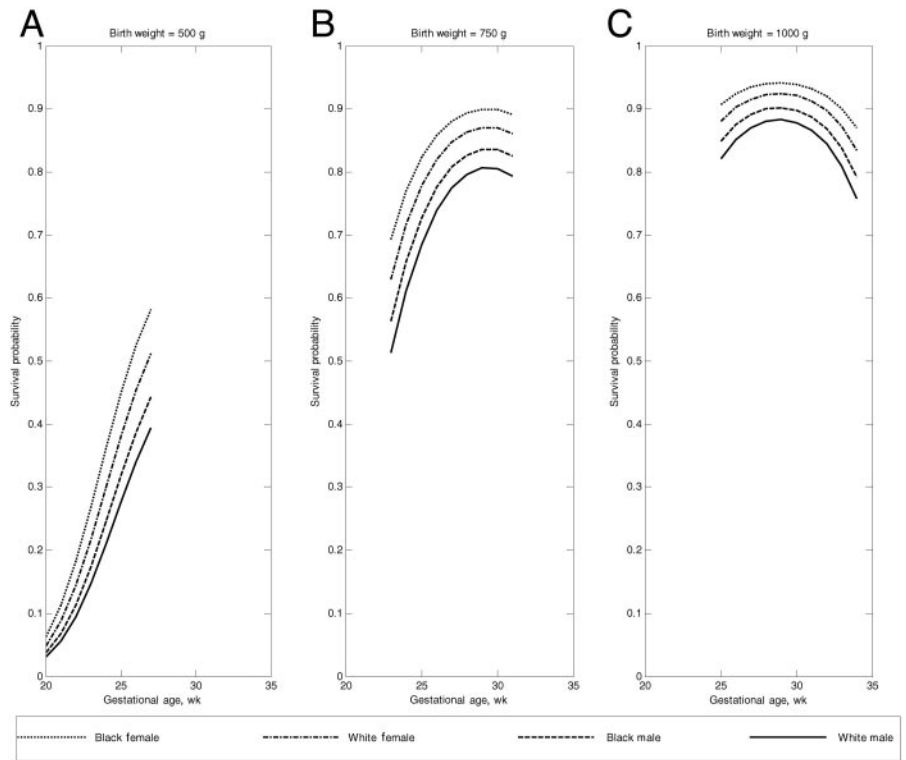


FIGURE 2
 Infant survival probability according to birth weight at specific gestational ages of 24 weeks (A), 26 weeks (B), and 28 weeks (C). Survival probability is plotted for specific race and gender combinations.

FIGURE 3
Isomortality contour plots of survival probability, in 10% increments, for specific race and gender combinations (A, black female; B, black male; C, white female; D, white male).

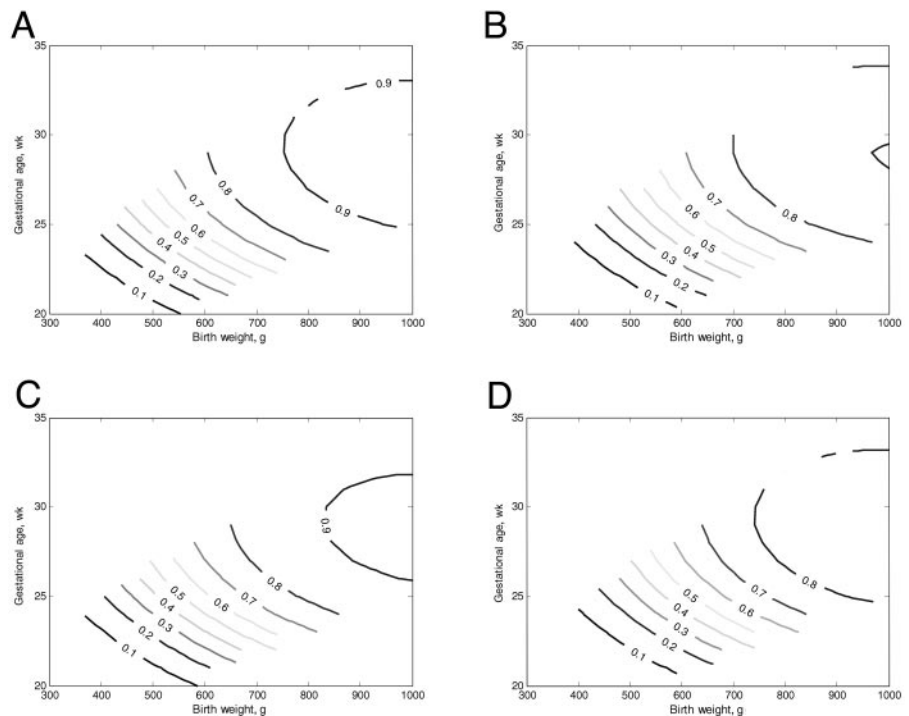


TABLE 3 Influence of Race and Gender on Survival Rates Among ELBW Infants (<1000 g)

	OR	95% CI	P
Black versus white	1.3	1.1–1.5	.001
Female versus male	1.7	1.5–1.9	<.001
White female versus white male	1.6	1.3–2.0	<.001
Black male versus white male	1.2	1.0–1.5	.04
Black female versus white male	2.1	1.7–2.6	<.001
Black male versus white female	0.8	0.6–0.9	.009
Black female versus white female	1.3	1.1–1.6	.01
Black female versus white male	1.8	1.4–2.2	<.001

rates narrowed. As in previously published reports, the deleterious effect of birth weights in the SGA range was demonstrated in all 3 curves.²⁸ As birth weights declined below commonly accepted SGA weights for all 3 gestational age-specific curves, survival rates decreased.^{26,27}

In addition to the SGA effect on survival rates, the effects of race and gender were apparent in these curves. Female survival rates were higher than male survival rates in all 3 gestational age curves and across the entire range of birth weights. Black survival rates were always higher than white survival rates. In addition, the effect of female gender on survival rates seemed larger than the effect of black race. Both race and gender effects became more distinct at lower weights and gestational ages.

To illustrate more clearly the effects of race and gender across a continuum of gestational ages and birth weights, isomortality contour plots were constructed (Fig 3). These plots provided survival estimates in 10%

increments for all plausible birth weight and gestational age combinations. As expected, as weight and gestational age increased, survival rates also increased. The effects on survival rates of additional maturity and weight were greater at gestational ages of <27 weeks and birth weights of <700 g for all 4 plots. Survival rates were higher for female and black infants at all gestational age and birth weight combinations.

To quantify the differences in survival rates among the various race/gender groups shown graphically in Figs 1 and 2, ORs with 95% CIs were computed on the basis of predicted survival rates, with the semiparametric model (Table 3). Overall, the odds of survival for black ELBW infants were 1.3 times (95% CI: 1.1–1.5) those for white ELBW infants. The odds of survival for female infants were 1.7 times (95% CI: 1.5–1.9) those for male infants. Combining race and gender, the largest advantage was seen among black female infants, compared with white male infants, with a 2.1 (95% CI: 1.7–2.6) increased odds of survival. Although white infants in general had lower survival rates than did black infants, black male survival rates were lower than white female rates, with an OR of 0.8 (95% CI: 0.6–0.9).

DISCUSSION

There are several published reports of survival rates among ELBW infants.^{3–5} However, those reports did not distinguish survival rates according to both race and gender. In addition, small sample sizes and single-institution data limited the utility of those reports. We present easy-to-use, up-to-date, race- and gender-spe-

cific, survival estimates for infants born at <1000 g. These survival probabilities are based on a large, population-based sample of >5000 infants in a recent period (1996–2000).

With >1500 infants at <24 weeks of gestation, we were able to provide survival estimates at the extreme limit of prematurity. The survival rate remained quite poor among infants at ≤ 22 weeks (survival rate: 11%). Even at 23 weeks, the survival rate was only 27%. With an extremely high risk of severe morbidities, resuscitation of these infants remains highly controversial.^{29,30} However, survival rates did show improvement even at these early gestational ages as birth weights increased above the median birth weight for the gestational age, which should be considered in decisions regarding treatment.

The issue of black race conferring a survival advantage among premature infants has been debated. Some studies showed a distinct advantage,^{5,21} whereas other studies found no significant difference.^{20,31,32} We found that black race conferred a significant survival advantage at 1 year of age across all gestational ages among ELBW infants. The steepest part of the survival curves in Figs 2 and 3 occurred among the lower birth weights and gestational ages, indicating increasing advantage of black race as the degree of prematurity increases. In addition, the OR for black versus white survival was 1.3 (95% CI: 1.1–1.5), favoring black race. Our results suggest that race plays an important role in estimates of survival rates and therefore may affect treatment decisions.

Female gender increased the odds of survival regardless of race (OR: 1.7; 95% CI: 1.5–2.0), with both black and white female infants having higher survival rates than black and white male infants. This result is consistent with other studies that demonstrated a female survival advantage.^{4–6,19,23} In a study by La Pine et al,⁶ the female survival rate was 20% higher than the male survival rate among infants born at <800 g. Using our isomortality contour graphs and comparing within-race survival rates between male and female infants, we also found survival advantages of 10% to 20% for female infants.

With similarity to other studies, we found that the greatest weekly improvements in survival rates occurred between 25 and 28 weeks of gestation and between 600 and 800 g.^{5,33} After 28 weeks, survival rates approached 90% and less difference in survival rates among race/gender groups was seen. In addition, we found little change in survival rates for ELBW infants during the latter half of the 1990s.³⁴

Limitations of this study centered on the use of merged birth and death certificate data. On the basis of matched birth and death certificates, it is not possible to distinguish the type of treatment received at the earliest gestational ages. Some infants at ≤ 24 weeks might have received comfort care alone, whereas others might have

been treated more aggressively. If infants who received comfort care only could have been excluded, then the estimates of survival rates at ≤ 24 weeks and ≤ 500 g would have been higher than those reported here. Admittedly, survival data alone do not provide enough information for caregivers to decide on initiation or continuation of treatment. We intend to extend this research to include the significant morbidities associated with delivery at <1000 g.

This study does provide survival estimates from population-based data. This allows for a large sample size for rare events such as delivery at ≤ 24 weeks of gestation. In addition, the sample represents a heterogeneous group of ELBW infants delivered in multiple settings, which allows the results to be more generalizable than results based on data from individual institutions.

This study highlights the significant differences in survival rates between male and female infants and between black and white infants, as well as the interactions of these 2 factors. Obstetricians will continue to face difficult decisions regarding the care of mothers in preterm labor at very early gestational ages, and neonatologists will continue to struggle with decisions regarding the initiation and withdrawal of care for extremely premature infants. The data presented here are intended to assist both groups not only in management but also in frank discussions with families.

ACKNOWLEDGMENTS

This work was supported by Children's Medical Services, Florida Department of Health, and Maternal Child Health and Education Research and Data Center, University of Florida.

We thank the following professionals whose cooperation and expertise facilitated completion of this study: Meade Grigg, Florida Department of Health; Randy Carter, University at Buffalo, State University of New York; and Waldemar Carlo, University of Alabama, Birmingham.

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This information is current as of January 6, 2006

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