Maternal Risk Factors for Potential Maltreatment Deaths Among Healthy Singleton and Twin Infants

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Our aim was to evaluate the risk of death among healthy infants due to maltreatment, using national linked vital statistics data. The study population included all nonanomalous, full-term (≥ 37 weeks), non-low birthweight (> 2500 grams) infants born between 1995 and 2000 and their linked death certificates: 18,673,439 singleton pregnancies (36,864 deaths) and 77,800 twin pregnancies (356 pregnancies with a death). The underlying cause of death was characterized as due to maltreatment, sudden infant death syndrome (SIDS), and other causes, based on ICD-9 and ICD-10 codes, and modeled by maternal age using multinomial logistic regression; mothers aged 25 to 29 were the reference group. The highest risk for infant mortality was among the youngest mothers for maltreatment (AOR 2.45 and 1.95 for singleton mothers < 20 and aged 20 to 24, respectively; AOR 4.34 and 2.25 for twin mothers < 20 and aged 20 to 24, respectively). The risk of death overall and for each category was modeled by maternal age < 20, aged 20 to 24, and ≥ 25, with and without the father's age present on the birth certificate, with mothers ≥ 25 and father's age present as the reference group. All risks of death were significantly increased for mothers younger than age 25, with the highest risks among the youngest mothers and missing father's age. The pattern for twins was similar, with elevated risks among younger mothers with or without father's age present on the birth certificate. These results add to the body of knowledge regarding risk factors for infant mortality among healthy singletons and twins.

In 2004 the National Child Abuse and Neglect Data System estimated that there were 1490 child fatalities due to maltreatment, or a rate of 2.03 per 100,000 children aged 0 to 17 (US Department of Health and Human Services [USDHHS], 2006). Infants are at the highest risk, accounting for nearly half of all maltreatment deaths among children under age 18, for a rate of 18 per 100,000 infants (USDHHS, 2006). The Child Abuse Prevention and Treatment Act (CAPTA), as amended by the Keeping Children and Families Safe Act of 2003, is the federal legislation that provides minimum standards for defining child maltreatment that states must incorporate into their statutory definitions. Under CAPTA, child maltreatment means, at a minimum: 'any recent act or failure to act on the part of a parent or caretaker, which results in death, serious physical or emotional harm, sexual abuse, or exploitation, or an act or failure to act which presents an imminent risk of serious harm'. Child maltreatment fatalities are generally believed to be underreported by as much as 50% to 60% because of states' differing definitions of key terms, as well as miscoding of maltreatment deaths as deaths due to accidents, child homicides, and/or sudden infant death syndrome (SIDS; Crume et al., 2002; Ewigman et al., 1993; Herman-Giddens et al., 1999; McClain et al., 1993). National statistics indicate that nearly 80% of the perpetrators in child maltreatment were parents (USDHHS, 2006). The risk factors for child maltreatment that are identifiable from the vital records include young maternal age, prematurity, low birthweight, and congenital anomalies. Few studies have examined the association between maternal age and risk of infant death among healthy, full term infants (Phipps et al., 2002). The purpose of this study was to evaluate the increase in risk of death due to potential maltreatment compared to other causes among healthy, full term, nonanomalous infants, by maternal age and plurality, using national linked vital statistics data.

Methods

The datasets for this study included the Birth Cohort Linked Birth/Infant Death Data Set for 1995 to 2000 and the Matched Multiple Birth Data Set for 1995 to

2000 from the National Center for Health Statistics. For the Linked Birth/Infant Death Data Set, the birth certificates are linked to the infant death certificates, if the death occurred before 1 year of age. The Matched Multiple Birth Data Set reconstructs sibling sets in multiple pregnancies, also linking birth certificates to death certificates for infant deaths. Because the Birth Cohort Linked Birth/Infant Death Data Set includes a record for each live birth, the data were limited to only singleton births. In the Matched Multiple Birth Data Set, the data was limited to only twin births. 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. Limitations in vital statistics death data include the change in coding from the International Classification of Diseases, 9th Revision (ICD-9) to ICD-10 during the study period. For the Linked Birth/Infant Death Data Sets, the ICD-9 coding was used for all infant deaths in the 1995–1998 datasets, and the ICD-10 coding was used in the 1999 and 2000 datasets. For the Matched Multiple Birth Data Set, the ICD-9 coding was used for 1995 to 2000. Institutional Review Board approval was not sought for this study because we used public use, de-identified datasets.

The study population was limited to liveborn, singleton and twin nonanomalous, full term (≥ 37 weeks), non-low birthweight (> 2500 grams) infants. In twin pregnancies, we limited the study population to those pregnancies in which both infants met the inclusion criteria. The underlying cause of death was characterized as due to maltreatment, SIDS, and all other causes based on the ICD-9 and ICD-10 codes (see Table 1). Deaths were characterized as due to overt or potential maltreatment when the underlying cause of death included inhalation and ingestion of food or other object causing obstruction of respiratory tract or suffocation; accidental suffocation; other accidental causes and adverse effects; child battering and other maltreatment; and other homicide. Deaths due to SIDS were categorized as such. All other deaths were characterized as due to other causes. This wider definition was chosen to be more inclusive of possible neglect or negligence, as defined by the National Institute of Child Health and Human Development (Christoffel et al., 1992), and other researchers (Crume et al., 2002; Ewigman et al., 1993; McClain et al., 1993; Phipps et al., 2002). Mothers were grouped by age (< 20, 20–24, 25–29, 30–34, 35–39, and ≥ 40), race (black, white, other), smoking during pregnancy (smoker, nonsmoker, unknown), marital status (married, unmarried), parity (primiparas, multipara, unknown), and trimester prenatal care began (first or second trimester, third trimester, or no care).

Descriptive statistics of the study population by plurality and infant death are given in Table 2. Odds ratios and 95% confidence intervals were computed from multinomial logistic regression models, and estimated by the unconditional maximum-likelihood method, adjusting for maternal race (white, black, and others) and

Table 1

Distribution of Infant Deaths by Cause and Plurality

	Pregnancies	
	Singletons	Twins
Maltreatment deaths		
Suffocation	220	14
Child battering and maltreatment	419	6
Other accidental causes	2967	15
Other homicide	719	12
Total maltreatment deaths	4325	47
SIDS deaths	10,728	96
Other deaths		
Conditions originating in the perinatal period	4104	56
Congenital malformations and chromosomal abnormalities	6428	69
Infectious and parasitic diseases	1323	21
Benign and malignant neoplasms	447	12
Diseases of the respiratory system	2260	25
Other diseases	1994	8
All other causes (residual)	5255	22
Total other deaths	21,811	213
Total deaths	36,864	356

smoking status (smokers, nonsmokers, and unknown), males per pregnancy (0 or 1 for singletons; 0, 1, or 2 for twins), and father's age on the birth certificate (absent or present), with women aged 25 to 29 as the reference group within each plurality for all deaths, maltreatment deaths, SIDS deaths, and deaths due to other causes. The comparison group for all deaths, and each category of death was survivors; for twins, the comparison group was pregnancies in which both twins survived. These models are given in Table 3. Adjusting for marital status, parity, and adequacy of prenatal care did not significantly change the results and was not included in the final models. The overall risk of infant death, as well as death due to maltreatment, SIDS, and other causes, was additionally modeled by the combination of maternal age < 20, 20 to 24, and ≥ 25, and the father's age being present or absent on the birth certificate, with mothers ≥ 25 and father's age present as the reference group, controlling for maternal race, smoking, and infant gender. These models are given in Table 4. All analyses were conducted using SAS software, version 9.1.3.

Results

The study population included 18,673,439 singleton pregnancies (36,864 deaths) and 77,800 twin pregnancies (356 pregnancies with a death, including 14 pregnancies with deaths of both infants). Pregnancies with an infant death were more likely among younger and unmarried mothers, multiparas, those with late or no prenatal care (singletons only), smokers, with male infants, and pregnancies with missing father's age on the

Table 2

Description of the Study Sample: Nonanomalous, Non-Low Birthweight, Term Infants, US, 1995–2000

		Singleton pregnancies			Twin pregnancies		p value	
		All live births	Infant deaths	All pregnancies with both live births	Pregnancies with one or both infant deaths		Singletons	Twins
	N	18,673,439	36,864	77,444	356			
		%	%	Rate*	%	%	Rate*		
Maternal age									
Maternal age < 20		12.0	20.5	3.38	4.4	9.0	9.48		
20–24		24.5	32.2	2.59	16.4	28.4	7.97		
25–29		27.8	22.9	1.62	26.7	21.3	3.68	< .0001	< .0001
30–34		23.3	15.6	1.32	31.6	26.4	3.84		
35–39		10.5	7.4	1.39	17.5	12.9	3.39		
40		2.0	1.5	1.55	3.5	2.0	2.58		
Maternal race									
White		80.8	71.5	1.75	83.5	71.3	3.93		
Black		14.0	23.6	3.34	12.8	23.9	8.57	< .0001	< .0001
Other		5.3	4.9	1.83	3.7	4.8	5.97		
Marital status									
Married		69.2	51.9	1.48	78.2	63.2	3.71	< .0001	< .0001
Unmarried		30.8	48.1	3.09	21.8	36.8	7.77		
Parity									
Primipara		40.7	35.3	1.71	28.9	25.6	4.06		
Multipara		58.9	64.2	2.15	70.7	73.9	4.80	< .0001	.279
Unknown		0.4	0.5	2.36	0.4	0.6	8.03		
Prenatal care									
1st or 2nd trimester		94.5	92.8	1.88	95.9	93.8	4.50	< .0001	.050
3rd trimester or no care		5.4	7.2	3.59	4.1	6.2	6.90		
Smoking status									
Nonsmoker		71.8	62.2	1.71	74.8	67.1	4.12		
Unknown/Not stated		18.9	18.3	1.91	19.7	23.6	5.50	< .0001	.001
Smoker		9.3	19.5	4.14	5.4	9.3	7.83		
Gender mix									
Only female(s)		48.9	42.6	1.72	30.5	29.7	3.72		
One male, one female		—	—		35.3	32.9	4.28	< .0001	< .0001
Only male(s)		51.1	57.4	2.22	34.2	42.4	5.71		
Father's age									
Present		86.9	74.3	1.69	90.5	80.1	4.07	< .0001	< .0001
Absent		13.1	25.7	3.86	9.5	19.9	9.63		

Note: *Rate is per 1000 pregnancies

birth certificate (Table 2). Although more than 80% of infant deaths within both pluralities occurred by 6 months of age, the pattern differed by cause, as shown in Figure 1. By 3 months, more than two thirds of deaths due to other causes, about 60% of SIDS deaths, and about one third of maltreatment deaths, had occurred; by 6 months, these figures were more than 80%, 90%, and 60%, respectively, for both singletons and twins. For both pluralities, deaths due to maltreatment and SIDS peaked between 2 to 4 months of age, whereas deaths due to other causes peaked in the neonatal period, the first month of life. Because the pattern was very similar for singletons and twins, the numbers were combined for the figure, and presented by cause.

The infant death rate was 1.98/1000 live births for singletons, including 0.23/1000 live births for maltreatment deaths, 0.58/1000 live births for SIDS deaths, and 1.17/1000 live births for other deaths. Among twins, the death rate was 4.60/1000 pregnancies, including 0.61/1000 pregnancies for maltreatment deaths, 1.24/1000 pregnancies for SIDS deaths, and 2.75/1000 pregnancies for other deaths. When calculated per infant, the twin death rate was 2.39/1000 live births, including 0.31/1000 live births for maltreatment deaths,

Distribution of Infant Deaths by Cause
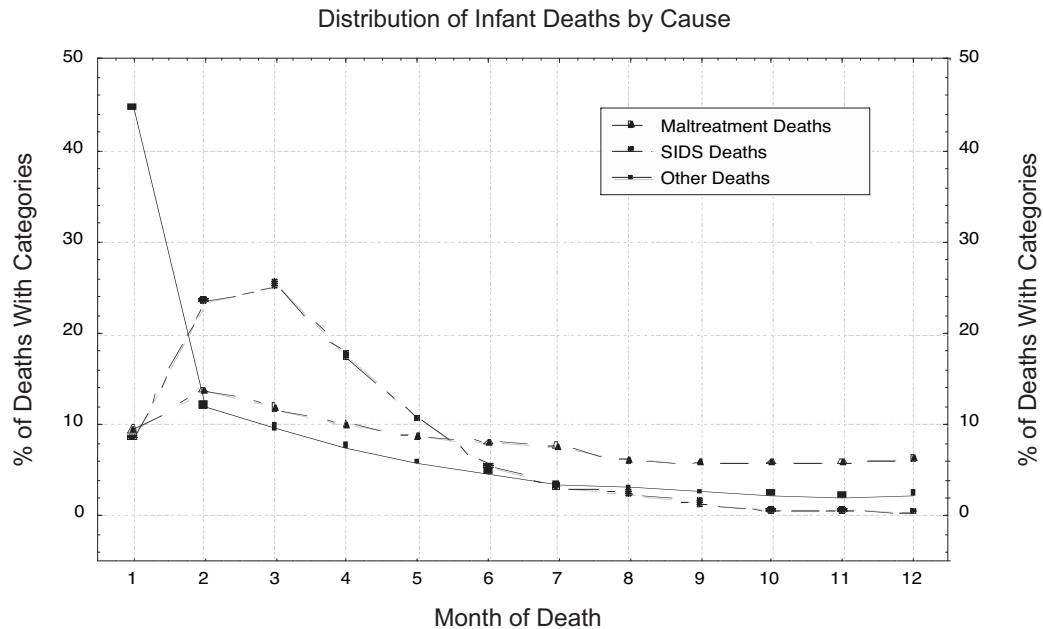
Figure 1
Distribution of infant deaths by cause.

0.63/1000 live births for SIDS deaths, and 1.45/1000 live births for other deaths, which was higher in every category compared to singletons (Table 3). The risk of death increased significantly for infants of mothers < 20 and 20 to 24 years of age compared to mothers aged ≥ 25 for both pluralities and each category of death, except for deaths due to other causes among twins. The risk for maltreatment deaths was highest among the youngest mothers of both singletons and twins, followed by the risk for SIDS deaths (Table 3).

The risk of singleton and twin infant death was additionally modeled by the combination of maternal age (< 20, 20–24, and ≥ 25), with and without the father's age present on the birth certificate, with mother's age ≥ 25 and father's age present as the reference group (Table 4). Among singletons, the risk of death overall, and in each category of death, was significantly greater among male infants and those born to black mothers, and mothers who smoked. Male gender was associated with a 29% increase in overall mortality, including a 26% increase in maltreatment death, 45% increase in SIDS death, and a 23% increase in death due to other causes. The risk of death by maternal age and father's age present or absent on the birth certificate was significantly increased for mothers younger than age 25, with the highest risks among the youngest mothers and missing father's age.

Among twins, the risk of death overall and in each category was significantly greater among male infants and those born to black mothers; among mothers who smoked, the risk was also increased overall and for SIDS deaths. The presence of two males significantly increased the overall risk of mortality by 52% and the risk due to maltreatment by 21%, due to SIDS by 91%, and due to other causes by 46%. The pattern by maternal age and father's age present or absent was similar to that for singletons, with elevated risks among younger mothers with or without father's age present on the birth certificate.

Discussion

These results quantify the substantial increased risk of infant death as a function of demographics even among healthy, full term singletons and twins, and particularly among those born to mothers aged 24 and younger. Over the past decade there have been significant reductions in infant mortality for all pluralities and at every gestation, but even among term births, twins have a 60% higher infant mortality rate than their singleton counterparts (Luke & Brown, 2006). In studies of postneonatal deaths, the highest risks are among the youngest mothers (Arntzen et al., 1995; Markovitz et al., 2005; Phipps et al., 2002), a finding confirmed in the present study. Although many factors were significantly higher among pregnancies with infant deaths, our results indicate that young maternal age is the predominant factor, compounded by the absence of paternal involvement (as indicated by the missing father's age on the birth certificate), and higher plurality. Missing father's name on the birth certificate, as a paternity measure and a proxy for paternal involvement, has been evaluated in other population-based studies, with results similar to our study. Gaudino et al. (1999) evaluated linked birth and death certificates for 1989 to 1990 for Georgia, and found that missing father's name on the birth certificate was associated with more than a twofold increased risk for infant mortality, regardless of maternal marital status.

Table 3a

Infant Mortality Rates and Odds of Infant Death by Plurality and Maternal Age*: Singletons

Maternal age Groups	Infant deaths		Maltreatment deaths		SIDS deaths		Other deaths	
	IMR¶	AOR (95% CI)	IMR	AOR (95% CI)	IMR	AOR (95% CI)	IMR	AOR (95% CI)
(N, pregnancies)		(36,864)		(4325)		(10,728)		(21,811)
< 20	3.38	1.58 (1.53–1.63)	0.49	2.45 (2.25–2.68)	1.16	2.07 (1.96–2.19)	1.73	1.24 (1.19–1.29)
20–24	2.59	1.40 (1.36–1.44)	0.36	1.95 (1.79–2.12)	0.88	1.71 (1.62–1.80)	1.36	1.19 (1.14–1.23)
25–29	1.62	1.00 (Reference)	0.16	1.00 (Reference)	0.43	1.00 (Reference)	1.03	1.00 (Reference)
30–34	1.32	0.85 (0.83–0.88)	0.11	0.76 (0.68–0.85)	0.29	0.72 (0.68–0.77)	0.92	0.92 (0.88–0.96)
35–39	1.39	0.89 (0.85–0.93)	0.13	0.85 (0.74–0.98)	0.27	0.65 (0.59–0.72)	1.00	0.99 (0.94–1.04)
≥ 40	1.55	0.99 (0.91–1.07)	0.10	0.70 (0.50–0.96)	0.25	0.61 (0.50–0.75)	1.20	1.17 (1.07–1.29)
Overall	1.98		0.23		0.58		1.17	

Note: Infant mortality rate is per 1000 live births (infants) for singletons, and as both 1000 live births (infants) for twins and 1000 pregnancies

*Models adjusted for black race, smoking during pregnancy, males per pregnancy, and missing father's age

***Underlying cause of death includes inhalation and ingestion of food or other object causing obstruction of respiratory tract or suffocation; other accidental causes and adverse effects; child battering and other maltreatment; and other homicide.

Table 3b

Infant Mortality Rates and Odds of Infant Death by Plurality and Maternal Age*: Twins

Maternal age Groups	Infant deaths			Maltreatment deaths			SIDS deaths			Other deaths		
	Infant	Pregnancy IMR¶	AOR (95% CI)	Infant	Pregnancy IMR	AOR (95% CI)	Infant	Pregnancy IMR	AOR (95% CI)	Infant	Pregnancy IMR	AOR (95% CI)
(N, pregnancies)			(356)			(47)			(96)			(213)
< 20	5.19	9.48	2.02 (1.32–3.10)	1.33	2.37	4.34 (1.62–11.64)	2.07	3.85	3.35 (1.62–6.93)	1.78	3.26	1.08 (0.55–2.10)
20–24	4.06	7.97	1.89 (1.39–2.56)	0.55	1.10	2.25 (0.96–5.26)	1.54	3.08	2.91 (1.67–5.08)	1.97	3.79	1.41 (0.94–2.12)
25–29	1.96	3.68	1.00 (Reference)	0.22	0.44	1.00 (Reference)	0.46	0.92	1.00 (Reference)	1.28	2.33	1.00 (Reference)
30–34	1.98	3.84	1.11 (0.82–1.51)	0.27	0.53	1.30 (0.55–3.04)	0.35	0.69	0.81 (0.42–1.56)	1.37	2.62	1.20 (0.82–1.74)
35–39	1.73	3.39	0.99 (0.69–1.43)	0.07	0.15	0.37 (0.08–1.70)	0.29	0.59	0.70 (0.31–1.60)	1.36	2.65	1.22 (0.79–1.88)
≥ 40	1.29	2.58	0.76 (0.35–1.65)	0.18	0.37	0.93 (0.12–7.34)	0.00	0.00	—	1.11	2.21	1.02 (0.43–2.38)
Overall	2.39	4.60		0.31	0.61		0.63	1.24		1.45	2.75	

Note: Infant mortality rate is per 1000 live births (infants) for singletons, and as both 1000 live births (infants) for twins and 1000 pregnancies

*Models adjusted for black race, smoking during pregnancy, males per pregnancy, and missing father's age

***Underlying cause of death includes inhalation and ingestion of food or other object causing obstruction of respiratory tract or suffocation; other accidental causes and adverse effects; child battering and other maltreatment; and other homicide.

Table 4

Odds of Infant Death by Risk Factors

Singleton pregnancies (N, pregnancies)	Infant death (36,864)	Maltreatment death* (4325)	SIDS deaths (10,728)	Other deaths (21,811)
White and other races	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Black race	1.58 (1.54–1.62)	2.33 (2.18–2.49)	2.21 (2.12–2.31)	1.47 (1.42–1.52)
Smoking: Nonsmoker	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Unknown/Not stated	1.22 (1.19–1.26)	0.90 (0.83–0.99)	1.05 (0.99–1.11)	1.27 (1.22–1.31)
Smoker	2.20 (2.14–2.26)	3.14 (2.92–3.37)	4.06 (3.89–4.24)	1.50 (1.44–1.57)
Gender: Female infant	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Male infant	1.29 (1.26–1.32)	1.26 (1.18–1.33)	1.45 (1.40–1.51)	1.23 (1.19–1.26)
Mother's age ≥ 25 + present father's age	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Mother's age 20–24 + present father's age	1.68 (1.64–1.73)	2.69 (2.48–2.92)	2.43 (2.31–2.56)	1.32 (1.27–1.36)
Mother's age < 20 + present father's age	2.22 (2.15–2.30)	3.85 (3.49–4.24)	3.32 (3.12–3.53)	1.67 (1.60–1.75)
Mother's Age ≥ 25 + missing father's age	2.50 (2.40–2.60)	4.06 (3.61–4.57)	3.30 (3.05–3.56)	2.05 (1.94–2.16)
Mother's Age 20–24 + missing father's age	3.06 (2.95–3.18)	5.63 (5.09–6.23)	4.97 (4.66–5.30)	2.14 (2.03–2.25)
Mother's Age < 20 + missing father's age	3.12 (3.01–3.25)	5.70 (5.13–6.33)	4.88 (4.56–5.22)	2.25 (2.13–2.37)
Twin pregnancies (N, pregnancies)	Any infant death (356)	Maltreatment deaths* (47)	SIDS deaths (96)	Other deaths (213)
White and other races	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Black race	1.65 (1.26–2.16)	3.21 (1.74–5.92)	2.41 (1.53–3.80)	1.83 (1.32–2.55)
Smoking: Nonsmoker	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Unknown/Not stated	1.42 (1.11–1.83)	1.09 (0.54–2.19)	1.33 (0.81–2.19)	1.40 (1.02–1.92)
Smoker	1.60 (1.10–2.32)	0.79 (0.19–3.28)	3.45 (1.96–6.08)	1.53 (0.91–2.57)
Gender: Two female infants	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
One female + male infant	1.16 (0.88–1.53)	0.87 (0.41–1.81)	1.06 (0.60–1.86)	1.26 (0.89–1.80)
Two male infants	1.52 (1.17–1.98)	1.21 (0.61–2.42)	1.91 (1.15–3.17)	1.46 (1.04–2.07)
Mother's age ≥ 25 + present father's age	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Mother's Age 20–24 + present father's age	2.15 (1.64–2.82)	2.92 (1.37–6.24)	3.89 (2.37–6.40)	1.52 (1.05–2.21)
Mother's Age < 20 + present father's age	2.91 (1.85–4.57)	9.34 (3.95–22.12)	6.16 (2.98–12.73)	1.00 (0.41–2.44)
Mother's age ≥ 25 + missing father's age	2.61 (1.78–3.85)	4.20 (1.58–11.21)	2.16 (0.85–5.47)	2.51 (1.57–4.02)
Mother's age 20–24 + missing father's age	3.34 (2.27–4.92)	4.30 (1.47–12.59)	7.17 (3.82–13.44)	2.09 (1.18–3.69)
Mother's age < 20 + missing father's age	2.79 (1.52–5.13)	2.45 (0.33–18.25)	5.02 (1.79–14.07)	2.19 (0.97–4.97)

Note: *Underlying cause of death includes inhalation and ingestion of food or other object causing obstruction of respiratory tract or suffocation; accidental mechanical suffocation; other accidental causes and adverse effects; child battering and other maltreatment; and other homicide.

Our findings indicate that more than one third of maltreatment death, more than half of SIDS deaths, and two thirds of deaths due to other causes, occurred by the third month of age, regardless of plurality. Several studies have documented early infancy as the highest risk period for abuse and neglect-related injuries and fatalities (Agran et al., 2003; DiScala et al., 2000; Overpeck et al., 1998; Reece & Sege, 2000; Stewart et al., 1993). Unfortunately, this is also the peak period for SIDS deaths and sudden and unexplained deaths in infancy, often making it difficult to distinguish the true etiology (American Academy of Pediatric [AAP] 1994, 2001, 2006; Leach et al., 1999; Reece, 1993). The period of the present study (1995–2000) is after the AAP issued their first recommendation that infants be put to sleep in a supine or side position in 2002, and also after the national Back To Sleep campaign of 1994, which informed the public about the risks associated with prone sleep positioning (AAP, Task Force on Infant Positioning and SIDS, 1994). Between 1992 and 1996, the prevalence of prone sleep positioning fell from 70% to 24%, paralleling a 38% decline in overall SIDS mortality in the United States (Mallory & Freeman, 2000; Willinger et al., 1998).

On a national basis, male infants have a 20% higher mortality rate than females (Mathews & MacDorman, 2006), as well as a higher risk of death due to maltreatment during infancy (USDHHS, 2006). Previous research has also reported male infants to be at greater risk for infanticide and infant injury death (Cummings et al., 1994; Marks & Kumar, 1993). For causes of respiratory infant death such as infant respiratory distress syndrome and SIDS, there is a consistent one third lower rate among female versus male infants. Recent research hypothesizes that this difference may be due to an X-linked dominant allele (Mage et al., 2006).

Our results indicate that even among healthy, full term infants, twins have a higher mortality risk

compared to singletons. Research has shown that more than one in five infertile women desired multiples over a singleton pregnancy (Ryan et al., 2004), but few families fully understand the physical and social implications (Bryan, 2003; D'Alton, 2004; Elster et al., 2000). Although the results of our study indicate a higher risk of death due to maltreatment among infants born to younger mothers, particularly twins, older mothers are also likely to be experiencing parenting difficulties. In a national cohort study of Danish singleton and twin births, parents of twins reported experiencing three times as much marital stress, and twins had 70% more impact on the mother's life compared to singletons (Pinborg et al., 2003). In a study of singletons, twins, and triplets born from assisted reproduction, Ellison et al. (2005) reported that for each additional multiple birth child, the odds of having difficulty meeting basic material needs more than tripled, and the odds of lower quality of life and increased social stigma more than doubled. They also found that each increase in multiplicity was associated with increased risks of maternal depression. Other studies have reported similar results, including higher incidence of severe parenting stress and less likelihood of mothers of twins returning to work after childbirth (Ellison & Hall, 2003; Glazebrook et al., 2004).

This study has several limitations, which should be considered in evaluating the results. First is the acknowledged change in the international coding of causes of death, from the ICD-9 to the ICD-10, during the period of the study. Known limitations of birth certificate data include the unreliability of selected items (such as maternal weight gain) and the high rate of missing values for other items (such as age of father; Martin et al., 2006). In addition, it is known that because of variation in the birth certificate from state to state, a per cent of records in the national data file will have items that are not stated: 0.5% for obstetric procedures, 0.6% for complications of labor and/or delivery, 0.5% for method of delivery, 1.0% for abnormal conditions of the newborn, and 0.9% for congenital anomalies of the newborn (Martin et al., 2006). A recent population-based validation study from Washington State (Lydon-Rochelle et al., 2005) compared data on the birth certificate to hospital discharge data. These researchers found that medical conditions and complications were underreported on birth certificates by about 50%. This suggests that the magnitude of the risks may be even higher than reported in our study. Despite these limitations, this study adds to the body of knowledge regarding risk factors for infant mortality among healthy singletons and twins.

Acknowledgments

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