Trends in Postneonatal Mortality Attributable to Injury, United States, 1988–1998

Kay Marie Tomashek, MD, MPH; Jason Hsia, PhD; and Solomon Iyasu, MBBS

ABSTRACT. *Objective.* Half of all postneonatal mortality (PNM; deaths among infants aged 28–364 days) in the United States is caused by potentially preventable causes such as sudden infant death syndrome, infections, and injuries. A detailed analysis of PNM attributable to injury has not been conducted and may provide useful data in prioritizing prevention strategies and targeting high-risk populations.

Methods. The authors used US infant death certificate data to analyze trends in PNM caused by injury during 1988–1998. Attending physicians, medical examiners, or coroners report cause of death on death certificates using a format specified by the World Health Organization and endorsed by the Centers for Disease Control and Prevention. The major causes of PNM by type of injury were evaluated, and trends were compared over time. Injury-related deaths per 100 000 live births were examined by race and region of residence. Rate ratios between black and white infants also were calculated.

Results. Among major causes of PNM during the study period, injury mortality declined the least (13.0% decline; from 29.6 to 25.7 per 100 000 live births). All types of unintentional injury deaths declined except for mechanical suffocation rates, which increased from 4.8 to 7.1. Homicide rates increased slightly (8.5%) from an 11-year low in 1988 and accounted for a greater proportion of all PNM caused by injury by 1998 (27.5% in 1998, 22.1% in 1988). Overall, PNM rates attributable to injury declined less among blacks (8.7%) than whites (13.6%) during the study period, and rates were on average 2.6 times higher among black infants (range: 2.4–3.0). Unintentional injury declined less among blacks (15.4%) than among whites (24.9%), in part because of an increase in motor vehicle crash-related mortality rates among black infants. Although black infants were more than 3 times as likely to be a victim of homicide than white infants (range: 3.0–4.4), increases in homicide rates were similar among black infants (9.9%) and white infants (10.6%) from 1988 through 1998. Racial disparities in PNM attributable to injury varied by region. PNM rates attributable to injury increased only among black infants residing in the Midwest (10.2%) and West (27.7%) as a result of increases in unintentional injury (ie, motor vehicle crash-related deaths in the West and mechanical suffocation in the Midwest) and homicide rates in these regions. Homicide rates increased among all infants regardless of race, except for infants residing in the Northeast.

Conclusions. Overall PNM rates attributable to injury declined, yet rates of mechanical suffocation increased and large regional and racial disparities persisted. Death certificates have limited information to help explain the observed differences. Because injuries are frequently preventable, prevention strategies should encourage formation of infant and child death review teams to help identify community and system factors that may contribute to injury deaths. Health care providers can assist parents in providing a safe environment for infants by counseling on age-appropriate injury prevention as part of their anticipatory guidance and serving as child advocates. Additional studies should examine regional differences in death investigation practices, case ascertainment, and reporting of deaths attributed to intentional injuries. *Pediatrics* 2003;111:1219–1225; *postneonatal, injury, preventable death, anticipatory guidance.*

ABBREVIATIONS. PNM, postneonatal mortality; CDC, Centers for Disease Control and Prevention; SIDS, sudden infant death syndrome.

Injuries, including unintentional injuries, homicides, and injuries of undetermined intent (accidental or purposely inflicted), account for nearly 5% of deaths among infants (children aged 0–364 days) in the United States, contributing an average of 1110 deaths per year between 1988 and 1998.[1] Of all injury-related infant deaths, almost 90% occur during the postneonatal period (ie, 28–364 days after birth) and are largely preventable. Parents can help prevent postneonatal injuries by providing a safe environment for infants. Health care providers can assist parents by giving age-appropriate anticipatory guidance and counseling about injury prevention at the many routine well-child health care visits during this period.

For health care providers to act in these capacities, they need to be knowledgeable about the leading causes of injury mortality among infants. Several studies have identified sociodemographic risk factors for injury-related death among infants,[2,3] but a detailed investigation of these deaths by race, region of residence, and type of injury has not been conducted in recent years. We analyzed changes in postneonatal mortality (PNM) rates in the United States between 1988 and 1998 that were attributable to injury and evaluated racial and regional differences and trends in total and cause-specific injury mortality rates.

METHODS

We analyzed US vital statistics data using the 1988–1998 Centers for Disease Control and Prevention's (CDC's) National Center for Health Statistics public-use mortality files (numerator data) and natality files (denominator data).[1,4] The center's linked birth-death files were not used because files are not available for the years 1992 through 1994. We restricted our analysis to infants born to US residents.

Cause-specific PNM rates, the number of postneonatal deaths for a specific underlying cause-of-death category per 100 000 live births for a given year, were calculated for major causes of PNM. We derived cause-of-death data from the underlying cause of death reported on the death certificate and as defined by the *International Classification of Diseases, Ninth Revision*.[5] Attending physicians, medical examiners, or coroners report cause of death on death certificates using a format specified by the World Health Organization and endorsed by the CDC. The leading causes were defined by National Infant Mortality Surveillance methodology used in previous federal surveillance reports.[6] This methodology differs from the methodology used by National Center for Health Statistics only in the ranking methodology and not in the way that injury-related deaths are categorized by *International Classification of Diseases, Ninth Revision* groupings. We compared major causes of PNM rates by proportion and by percentage change from 1988 through 1998.

We conducted a more detailed analysis of postneonatal deaths for which the underlying cause of death was coded as unintentional injury, homicide, or injury intent undetermined. Subgroups of unintentional injury include deaths as a result of mechanical suffocation, obstructive suffocation, motor vehicle crashes, fire, drowning, falls, poisoning, or other unintentional injury. PNM rates attributable to the 5 major causes of PNM and cause-specific PNM rates attributable to injury were assessed by proportion and by percentage change from 1988 through 1998. We assessed temporal trends in injury rates by using linear regression with respect to calendar year. Furthermore, we compared rates by US census region (Northeast, Midwest, South, and West). Data were analyzed by using Statistical Analysis System 6.12 (SAS Institute, Inc, Cary, NC).

Racial differences in PNM rates attributable to injury in the United States overall and within census regions were compared by calculating rate ratios, defined as the rate for black infants divided by the rate for white infants. The analysis was limited to black and white infants because the mortality data derived from the death certificate are based on infant race, and misreporting of decedent's race is not uncommon for other racial and ethnic groups.[6]

RESULTS

Between 1988 and 1998, there were 132 385 postneonatal deaths in the United States. In 1998, there were 9453 postneonatal deaths, the second lowest annual number of deaths in the 11-year period. In that year, sudden infant death syndrome (SIDS) ac-counted for the greatest proportion of all postneonatal deaths (27.9%). Other major causes were birth defects (18.2%), infectious diseases (12.3%), injury (10.7%), and perinatal conditions (6.9%). Overall, PNM rates for these 5 major causes declined between 1988 and 1998: 41.1% for perinatal conditions (from 28.0 to 16.5 deaths per 100 000 live births), 34.1% for SIDS (from 363.7 to 239.8), 27.1% for infectious diseases (from 40.5 to 29.5), 24.4% for birth defects (from 57.7 to 43.6), and 13.2% for injury (from 29.6 to 25.7; Fig 1). The decline for PNM attributable to injury, although the smallest among the 5 major causes, was statistically significant ($P < .01$).

During the study period, 12 209 postneonatal deaths were attributable to injury for an average of 1110 deaths per year (range: 1005–1247). The majority were attributable to unintentional injury, nearly half of which were the result of a combination of mechanical suffocation (suffocation by plastic bag, falling earth, or other substance; lack of air in a closed place; accidental hanging while not in bed; wedging, oronasal obstruction, or overlying in bed or cradle; or unspecified means such as asphyxia or strangulation), obstructive suffocation (inhalation, aspiration, or ingestion of food or other object resulting in obstruction of the respiratory tract), and motor vehicle crash-related deaths (Table 1). The proportion of deaths attributable to unintentional injury decreased from 74.6% to 66.2%, and the overall PNM rate attributable to unintentional injury decreased from 22.0 to 17.0 per 100 000 live births ($P < .01$). Rates of all types of unintentional injury decreased during the study period except for mechanical suffocation rates, which increased 47.9% (from 4.8 to 7.1; $P < .01$). In contrast, rates of obstructive suffocation decreased by 60.0% (from 3.5 to 1.4; $P < .01$) and rates of motor vehicle crash-related deaths declined by 25.5% (from 5.1 to 3.8; $P = .17$).

Between 1988 and 1998, the proportion of postneonatal injury deaths attributable to homicide increased from 22.1% to 27.5%. Annual rates of homicide were slightly greater than the 1988 baseline in all years, increasing from 6.5 to 7.1 deaths per 100 000 live births during the study period, although the linear trend was not significant ($P = .39$; Table 1).

Fig 1. Major causes of mortality among infants aged 28 to 364 days—United States, 1988–1998.
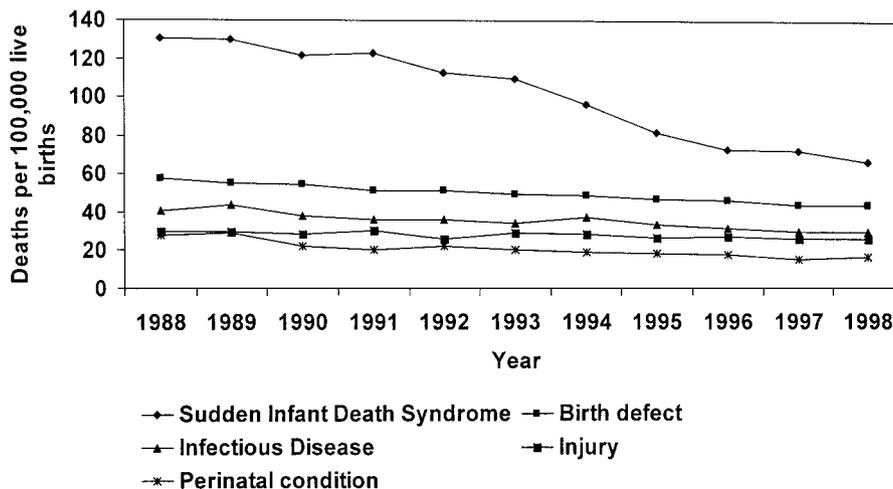
TABLE 1.   PNM Rate* for Injury as Underlying Cause of Death, by Type of Injury and Race, United States, 1988 and 1998

Type of Injury	ICD-9 Code	All Postneonates				White Postneonates				Black Postneonates			
		1988 (N = 1156)		1998 (N = 1014)		1988 (N = 752)		1998 (N = 651)		1988 (N = 382)		1998 (N = 333)	
		Rate	%	Rate	%	Rate	%	Rate	%	Rate	%	Rate	%
Unintentional		22.0	74.6	17.0	66.2	18.8	77.9	14.2	68.1	40.8	68.3	34.5	63.3
Mechanical suffocation	913.0–913.9	4.8	16.2	7.1	27.6	3.6	14.9	5.6	26.9	10.8	18.1	15.7	28.8
Obstructive suffocation	911.0–912.9	3.5	11.8	1.4	5.4	2.9	12.0	1.3	6.2	7.0	11.7	2.1	3.9
Motor vehicle crash	810.0–825.9	5.1	17.4	3.8	14.8	5.2	21.3	3.5	16.6	6.0	10.0	6.6	12.0
Fire	890.0–899.9	3.0	10.0	1.0	3.8	2.2	9.2	0.7	3.2	7.0	11.8	3.0	5.4
Drowning	910.0–910.9	1.9	6.6	1.5	6.0	1.7	7.1	1.5	7.1	3.6	6.0	2.1	3.9
Falls	880.0–888.9	1.0	3.3	0.5	1.9	0.9	3.6	0.4	2.2	1.6	2.6	0.7	1.2
Poisoning	850.0–869.9	0.4	1.4	0.1	0.4	0.3	1.3	0.0	0.2	0.9	1.6	0.5	0.9
Other unintentional	800.0–807.9, 826.0–849.9, 870.0–879.9, 900.0–909.9, 914.0–949.9	2.3	7.8	1.6	6.2	2.1	8.5	1.2	5.7	3.9	6.6	3.9	7.2
Homicide	960.0–969.9	6.5	22.1	7.1	27.5	4.7	19.5	5.2	25.1	16.1	27.0	17.7	32.5
Injury intent undetermined	980.0–989.9	1.0	3.4	1.6	6.2	0.6	2.7	1.4	6.8	2.8	4.7	2.3	4.2
All types of injury	E800.0–E969.9 E980.0–E989.9	29.6	100.0	25.7	100.0	24.2	100.0	20.8	100.0	59.8	100.0	54.5	100.0

ICD-9 indicates *International Classification of Diseases, Ninth Revision.*[14]
* Number of deaths per 100000 live births.

Homicide deaths exceeded unintentional deaths caused by mechanical suffocation and motor vehicle crashes for most of the study period (Fig 2). Rates of injury of undetermined intent (accidental or purposely inflicted) increased 60.0% (from 1.0 to 1.6) during the study period ($P < .05$) and by 1998 accounted for 6.2% of all PNM attributable to injury, up from 3.4% in 1988.

PNM rates attributable to injury declined less among black infants (8.7%) than white infants (13.6%); rates were on average 2.6 times greater (range: 2.4–3.0) among black infants than white infants from 1988 through 1998 (Table 1). Unintentional injuries accounted for 63.3% of all injury-related postneonatal deaths among black infants and 68.1% among white infants by 1998. Rates of unintentional injury decreased among both black infants (15.4%) and white infants (24.5%), although rates of mechanical suffocation increased among white infants (55.6%) and black infants (45.4%) and motor vehicle crash-related death rates increased among black infants (10.0%). Rates of unintentional injury among black infants were on average 2.3 times higher than rates among white infants (range: 2.1–2.7). Rates of mechanical suffocation among black infants were on average 2.6 times higher than rates among white infants (range: 2.0–3.4). Rate ratios for motor vehicle crash-related deaths ranged from 1.2 to 2.2 (average: 1.6) during the study period.

Homicide rates accounted for 25.1% and 32.5% of all injury-related deaths among white and black infants, respectively, by 1998. From 1988 through 1998, homicide rates increased by 10.6% among white infants and 9.9% among black infants. Rates of homicide were on average 3.6 times higher among black infants than white infants, and rate ratios for homicide were higher than those for all unintentional injury or any single cause of unintentional injury during the study period (range: 3.0–4.4).

PNM rates attributable to injury declined in all US census regions during the study period (Table 2). Injury rates were consistently the lowest in the

Fig 2. Five leading causes of PNM attributed to injury—United States, 1988–1998.
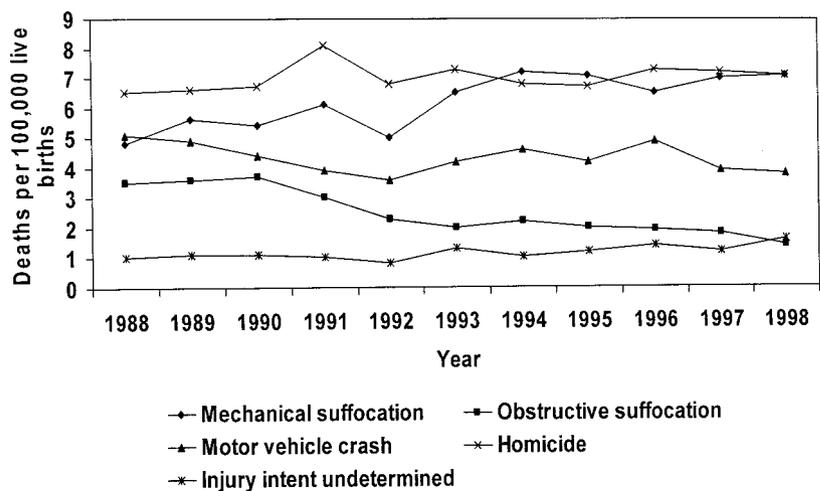
TABLE 2. Rates of and Percentage Change* in Postneonatal Injury Mortality, by Type of Injury, Race and Region of Residence, United States, 1988–1998

Type of Injury	All Postneonates					White Postneonates					Black Postneonates				
	Northeast	Midwest	South	West	Overall	Northeast	Midwest	South	West	Overall	Northeast	Midwest	South	West	Overall
Unintentional	12.7–10.0	23.3–19.9	28.9–21.0	18.6–13.6	22.0–17.0 (−22.7%)	11.3–7.5	19.8–15.3	22.6–17.9	19.3–13.0	18.9–14.2 (−24.9%)	21.3–24.3	47.3–49.6	49.2–33.4	20.5–29.7	40.9–34.6 (−15.4%)
Suffocation Mechanical	2.2–5.1	6.5–9.3	4.8–8.3	5.2–4.8	4.8–7.1 (+47.9%)	1.8–3.5	4.5–6.1	3.2–7.4	4.8–4.3	3.6–5.6 (+55.6%)	4.1–13.5	20.0–31.1	9.9–11.8	10.2–9.9	10.8–15.7 (+45.4%)
Obstructive	2.4–0.4	3.2–1.3	5.9–2.4	1.3–0.7	3.5–1.4 (−60.0%)	2.3–0.4	2.6–1.4	4.8–2.2	1.3–0.8	2.9–1.3 (−55.2%)	3.3–0.9	6.4–0.8	9.6–3.3	1.7–0	7.0–2.1 (−70.0%)
Motor vehicle crash	2.1–1.7	3.5–3.8	7.5–4.7	5.8–4.0	5.1–3.8 (−25.5%)	2.5–1.8	3.8–3.3	6.9–4.0	6.5–4.0	5.2–3.5 (−32.7%)	0.8–1.8	2.4–5.9	9.6–7.6	3.4–11.9	6.0–6.6 (+10.0%)
Homicide	6.3–4.6	7.2–9.1	6.3–7.2	6.3–6.8	6.5–7.1 (+9.2%)	4.4–3.9	4.0–4.9	4.8–5.6	5.6–5.9	4.7–5.2 (+10.6%)	16.4–9.0	27.3–35.3	11.4–12.8	18.8–27.7	16.1–17.7 (+9.9%)
Injury intent undetermined	0.8–0.3	0.9–1.0	1.0–2.3	1.3–2.1	1.0–1.6 (+60.0%)	0.7–0.4	0.5–0.7	0.4–2.1	1.1–1.9	0.6–1.4 (−57.1%)	1.6–0	3.2–1.7	2.7–3.0	5.1–4.0	2.8–2.3 (−17.9%)
Total all types of injury	19.8–14.9	31.3–30.0	36.2–30.5	26.1–22.5	29.6–25.7 (−13.2%)	16.4–11.8	24.3–20.9	27.8–25.6	26.0–20.8	24.2–20.9 (−13.6%)	39.3–33.3	77.8–86.6	63.3–49.2	44.4–61.4	59.8–54.6 (−8.7%)

* Values are the 1988 rate–1998 rate and the percentage difference between the rates in parentheses. A positive percentage indicates an increased rate, and a negative percentage indicates a decreased rate.

Northeast, and the percentage decline in the injury rate was 1.6 to 5.8 times greater than in the other regions. The Northeast generally had lower annual rates of unintentional injuries and homicides than the other regions, and unlike the other regions, homicide rates in the Northeast decreased from 1988–1998. The South had the highest annual PNM rates attributable to injury for most of the study period as a result of consistently higher unintentional injury rates. However, the South had the second greatest decrease in postneonatal injury rates and the greatest decline in unintentional injury rates from 1988–1998.

Within regions, PNM rates attributable to injury were lower among white infants than black infants, and except in the South, rates declined more among white infants (Table 2). Among black infants, rates varied considerably by region. Black infants in the Midwest and West had increased PNM rates during the study period: injury became the second-leading cause of PNM among black infants residing in the Midwest and third among blacks in the West. Factors that contributed to this increase included an increase in unintentional injury rates as a result of motor vehicle crash-related deaths in the West and mechanical suffocation in the Midwest. In addition, homicide rates among blacks in the Midwest and West increased so that by 1998, homicides made up 40.8% and 45.1% of all postneonatal injury deaths in these regions, respectively.

DISCUSSION

Injuries were an important contributor to infant mortality and a significant public health problem in the United States between 1988 and 1998. PNM rates attributable to injury declined less than the other preventable causes of infant mortality during the study period. Moreover, PNM rates attributable to mechanical suffocation increased among all infants, whereas all other types of unintentional injury declined. Significant regional and racial disparities in PNM rates attributable to injury persisted.

Despite these troubling statistics, PNM attributable to some types of injury has declined. PNM rates attributable to obstructive suffocation, fire, drowning, falls, and poisoning decreased between 1988 and 1998 among all infants regardless of race. Motor vehicle crash-related PNM rates declined among white infants during the study period. Injury prevention strategies, such as comprehensive and repetitive counseling in the primary care setting for parents on injury prevention,[7,8] educational campaigns,[9] community programs,[10–12] legislation,[13–15] and federal safety regulations,[16–18] may have contributed to these trends. Changes in an infant's environment as a result of these strategies and others, such as the increased use of child safety seats[19] and residential smoke detectors,[20,21] also may have played a role. Improvements in health care networks and facilities such as the expansion of trauma centers, burn treatment centers, and regional poison control centers may have enhanced secondary prevention efforts.[22,23]

Between 1988 and 1998, PNM rates attributable to mechanical suffocation increased among all infants

regardless of race and region except for infants residing in the West. This increase may reflect a diagnostic shift away from SIDS, stemming from the publication of a stricter case definition of SIDS in 1991[24] followed by initiation of more extensive evaluations of sudden infant deaths, including death scene investigations, in a growing number of states. Indeed, no appreciable increase in the rate of mechanical suffocation occurred after 1996, when the federal death scene guidelines for SIDS were released. The observed increase in PNM attributable to mechanical suffocation may also stem from an increase in absolute risk as more infants are enrolled in child care centers and spend more time with caregivers who may be less knowledgeable about safe sleeping environments for infants.[25,26] A recent case series study found the leading causes of mechanical suffocation to be wedging of an infant between a bed or mattress and a wall or crib frame, followed by oronasal obstruction by a plastic bag, pillow, or soft bedding, followed by overlaying.[27] Despite a federal crib standard[28] and a long-standing national campaign to promote safe infant sleep environments,[29–31] suffocation deaths attributable to oronasal obstruction and overlaying increased between 1980 and 1997, and suffocation attributable to wedging increased and then remained constant after 1986.[27] An expanded focus of the Back-to-Sleep campaign to educate the public about the dangers of soft bedding; unsafe bed-sharing arrangements (with multiple individuals or with parents who smoke or are under the influence of alcohol); and the use of cribs, beds, mattresses, and other consumer products that do not meet federal standards may help reduce deaths attributable to mechanical suffocation.[31] Additional epidemiologic studies to understand better the role of risky infant sleep environments in the causal pathway leading to death are needed to design more effective prevention strategies.

Homicide rates were greater than the 1988 baseline rate for every year during the study and the proportion of postneonatal injury deaths attributable to homicide increased from 1988 through 1998. Even so, infant homicide deaths may be underascertained[32] and misclassified.[2] The creation of infant and child death review teams[33] and a more critical approach to death scene investigation for sudden unexplained infant deaths may have contributed to better detection of homicides and, hence, the small increase in PNM rate attributable to homicide. Conversely, the slight change in homicide rate may represent a true increase; national survey data suggest that the incidence of child maltreatment, especially severe maltreatment, a critical antecedent of homicide, may be increasing.[34] Prevention efforts should focus on giving anticipatory guidance to parents and supporting families in ways that prevent child maltreatment, detecting risk factors for maltreatment, and referring families for treatment for problems identified. As part of well-child visits in infancy, health care providers should ask about child care arrangements, parental support systems, discipline techniques, parental physical and mental health status, gun ownership, domestic violence, and use of drugs.[35,36] In addition, health care providers should assess parent-child bonding and parental ability to cope with stressful situations such as a child's crying, that may trigger maltreatment. Furthermore, health care providers can play an active role by having a high index of suspicion for child maltreatment and documenting and reporting cases of suspected child maltreatment.[37,38] They can advocate for public policies and programs that support families, and promote targeted services such as home visitation interventions to reduce child abuse and neglect among high-risk groups.[39–41]

Motor vehicle crash-related PNM rates increased among black infants, especially those residing in the Midwest and West, despite mandatory child passenger safety laws in each state and an increase in the reported use of child safety seats during the study period.[42,43] Factors that may contribute to this increase in motor vehicle crash-related PNM rates include the increased amount of time that an infant is an occupant in a car,[44] misuse of child safety seats such as improper anchorage or positioning of the seat,[42,45] higher speed limits as of 1987 on rural interstate roadways,[46] and gaps in coverage and enforcement of state child passenger safety laws (eg, few states require that infants be rear facing).[47,48] In addition, the rate increase could be the result of decreased child safety seat use among black infants in combination with 1 of the factors listed above.[49–51] Prevention efforts should focus on culturally appropriate interventions known to be effective in reducing motor vehicle crash-related fatalities, namely, ensuring access to a child safety seat for low-income families by supporting child safety seat distribution programs,[52] promoting correct use of child safety seats through anticipatory guidance and parent and caregiver education, and enforcement of adult safety belt use and child passenger safety laws.[51,53]

Our study findings are limited by the accuracy of cause-of-death and intent of injury data on infant death certificates.[2,32,40] In addition, the data set is limited in that no information is provided on the perpetrator, motive, or circumstances for the injury, whether a death scene investigation was done or whether autopsy or death scene investigation results were used or were available before the death certificate was filed.[40] Formation of local infant and child death review teams should be encouraged to improve the information collected on injury-related deaths and to help identify community and system factors that may contribute to these unexpected deaths.[54] Additional studies should examine regional differences in death investigation practices, case ascertainment, and reporting of deaths attributed to intentional injuries.

Injuries can be prevented by ensuring that all infants live in a safe environment. Although parents play a major role in injury prevention, safe environments can be created through legislative efforts; federal safety regulations; injury prevention interventions; and parent and caregiver education through community programs, public educational campaigns, and anticipatory guidance at clinic visits.

Health care providers can assist parents in creating a safe environment for infants by providing age-appropriate injury prevention counseling as part of their anticipatory guidance and by advocating pediatric injury prevention policies and programs. Health care providers can also contribute by educating medical students and residents about injury. Residency training programs and continuing medical education can play an important role by increasing physicians' knowledge about injury epidemiology and effective prevention strategies and by enhancing their counseling skills.

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