Rates of Pediatric Injuries by 3-Month Intervals for Children 0 to 3 Years of Age

Phyllis F. Agran, MD, MPH*; Craig Anderson, DHSc, PhD*; Diane Winn, RN, MPH*; Roger Trent, PhD‡; Lynn Walton-Haynes, DDS, MPH‡; and Sharon Thayer, MPH*

ABSTRACT. *Objective.* **Mortality and morbidity data on childhood injury are used to construct developmentally appropriate intervention strategies and to guide pediatric anticipatory counseling on injury prevention topics. Effective anticipatory guidance depends on detailed injury data showing how risks change as children develop. Conventional age groupings may be too broad to show the relationship between children's development and their risk of various causes of injury. Previous studies revealed differences in overall rates and specific causes of injury by year of age. However, single year of age rates for children younger than 4 years may not reflect the variations in risk as a result of rapid developmental changes. This study was designed to analyze injury rates for children younger than 4 years by quarter-year intervals to determine more specifically the age period of highest risk for injury and for specific causes.**

Methods. **We used data from 1996–1998 California hospital discharges and death certificates to identify day of age and external cause of injury (E-code) for children younger than 4 years. The number of California residents for each day of age was estimated from US Census of estimates of California's population by year of age for the midpoints (1996–1998). Rates were calculated by 3-month intervals. We grouped the E-codes into major categories that would be particularly relevant for developmentally related risks of injury specific to young children. The categorization took into account physical, motor, behavioral, and cognitive developmental milestones of children 0 to 3 years.**

Results. **There were a total of 23 173 injuries; 636 resulted in death. The overall annual rate for children aged 0 to 3 years was 371/100 000. Beginning at age 3 to 5 months, the overall rate of injury rapidly increased with increased age, peaking at 15 to 17 months. The mean injury rate calculated for each single year of age did not reflect the variation and the highest rate of injury by quarter year of age for children younger than 1 year, 1 year, and 2 years. The leading major causes of injury in descending order were falls, poisoning, transportation, foreign body, and fires/burns. The overall rate of the major category of falls exceeded poisoning, the second leading cause of injury, by a factor of 2. Age-related differences were detected within each major cause of injury. For children 0 to 12 months of age, there was a different leading cause of specific injury for each 3-month period: other falls from height (0–2 months), battering (3–5 months), falls from furniture (6–8 months), and nonairway foreign body (9–11 months). Hot liquid and vapor injuries were the leading specific causes for children 12 to 17 months. Poisoning by medication was the leading specific cause of injury for all age groups from 18 to 35 months and exceeded poisoning by other substances. Pedestrian injury was the leading specific cause of injury for all age groups from 36 to 47 months. Fall from furniture has the highest rates of specific causes of falls from age 3 to 47 months. Fall from stairs peaked at age 6 to 8 months and 9 to 11 months. Fall from buildings was highest at 24 to 26 months. Poisoning by medication peaked at age 21 to 23 months, but poisoning by other substances peaked at 15 to 17 months. The motor vehicle occupant injury rates were fairly stable over the age span of this study. The pedestrian injury rate increased beginning at age 12 to 14 months and by 15 to 17 months was double that of the motor vehicle occupant. Foreign body had a marked peak at age 9 to 11 months. Both battering and neglect rates were highest among infants 0 to 2 and 3 to 5 months. Bathtub submersions had a narrow peak at age 6 to 11 months. Other submersions peaked at 12 to 14 months and remained high until 33 to 35 months.**

Conclusions. **We departed from usual groupings of E-codes and devised groupings that would be reflective of age-related developmental characteristics. Differences in rates by narrow age groups for young children can be related to developmental achievements, which place the child at risk for specific causes of injury. We found marked variability in both rates and leading causes of injury by 3-month interval age groupings that were masked by year of age analyses. Children aged 15 to 17 months had the highest overall injury rate before age 15 years. This coincides with developmental achievements such as independent mobility, exploratory behavior, and hand-to-mouth activity. The child is able to access hazards but has not yet developed cognitive hazard awareness and avoidance skills. A remarkable finding was the high rate of battering injury among infants 0 to 5 months, suggesting the need to address potential child maltreatment in the perinatal period. Poisoning was the second major leading cause of injury; more than two thirds were medication. Cultural factors may influence views of medications, storage practices, use of poison control system telephone advice, and risk of toddler poisoning. The pedestrian injury rate doubled between 12 and 14 months and 15 and 17 months and exceeded motor vehicle occupant injury rates for each 3-month interval from 15 to 47 months. Pedestrian injury has not received suf-**

From the *University of California, Center for Health Policy and Research, Pediatric Injury Prevention Research Group, Irvine, California; and ‡Epidemiology and Prevention for Injury Control Branch, California Department of Health Services, Sacramento, California.

Received for publication Nov 4, 2002; accepted Feb 13, 2003.

The contents of this study are solely the responsibility of the authors and do not necessarily represent the official views of the National Center for Injury Prevention and Control.

Reprint requests to (P.F.A.) 100 Theory, Ste 110, University of California, Irvine, Health Policy and Research, Irvine, CA 92697-5800. E-mail: pagran@uci.edu

ficient attention in general and certainly not in injury prevention counseling for children younger than 4 years. Anticipatory guidance for pedestrian injury should be incorporated before 1 year of age. Effective strategies must be based on the epidemiology of childhood injury. Pediatricians and other pediatric health care providers are in a unique position to render injury prevention services to their patients. Integrating injury prevention messages in the context of developmental assessments of the child is 1 strategy. These data can also be used for complementary childhood injury prevention strategies such as early intervention programs for high-risk families for child abuse and neglect, media and advocacy campaigns, public policies, and environmental and product design. *Pediatrics* **2003;111:e683–e692. URL: http://www.pediatrics.org/cgi/content/full/111/6/e683;** ***child, injury, causes of injury, injury hospitalization and death, age.***

ABBREVIATIONS. OSHPD, Office of Statewide Health Planning and Development; E-code, external cause of injury code; TIPP, The Injury Prevention Program.

In 2000 in the United States, unintentional and assault injuries accounted for 42% of deaths of children aged 1 to 4 years[1] and 29% of emergency department visits for children aged 0 to 5 years.[2] National Center for Injury Prevention and Control fatality data for 2000 revealed differences in overall rates by single year of age for children younger than 15 years. The highest overall injury death rate was for children younger than 1 year: 34/100 000. Injury death rates progressively decreased through 9 years of age to a low of 7/100 000. These mortality data revealed differences by year of age for many causes of injury, such as pedestrian, motor vehicle occupant, and drowning.[3] As of 2000, national estimates of nonfatal injuries treated in emergency departments also revealed differences by single year of age. The nonfatal estimated injury rate was highest for children 2 years of age and second highest for children aged 1 year. After 2 years of age, the rates progressively decreased through 6 years of age.[4] A recent study of nonfatal injuries in children younger than age 1 year seen in US emergency departments found a rate of 108.2/1000, documenting the burden of injury among infants.[5]

Mortality and morbidity data on childhood injury are used to construct developmentally appropriate intervention strategies and to guide pediatric anticipatory counseling on injury prevention topics. Effective anticipatory guidance depends on detailed injury data showing how risks change as children develop. Conventional age groupings, such as 1 to 4 years for injury data, may be too broad to show the actual relationship between children's development and their risks for various causes of injury. In our previous study using California hospital discharge data and death data, we demonstrated that traditional age groupings of years 1 to 4, 5 to 9, and 10 to 14 did not adequately reflect variation in rates within each age group and masked differences that cut across these age groups.[6]

We hypothesized that because of rapid changes in development in early childhood, even single year of age analyses may be inadequate to reflect variation in risk of injury for children younger than 4 years. This study was designed to analyze injury rates for children younger than 4 years by quarter-year intervals to determine more specifically the age period of highest risk for injury overall and for specific causes.

METHODS

We defined injury in this study as an injury hospitalization or death. We used data from California hospital discharges and California death certificates for 1996–1998 to identify the day of age and external cause of injury to California children younger than 4 years. We examined data for 3 years because this procedure produced larger numbers and more stable rates. Hospital discharge data for California hospitals in 1996–1998 were obtained from the Office of Statewide Health Planning and Development (OSHPD), California Health and Human Services Agency. By law, each civilian hospital in California must report data to OSHPD on each hospital discharge, including external cause of injury codes (E-codes)[7] for each initial hospitalization for injury. (Subsequent hospitalizations for the same injury are not E-coded.) OSHPD edits each discharge report for accuracy. We used the version of the publicly available data that includes age reported in years and days for children up to their fourth birthday.

Death certificate data for 1996–1998 were obtained from the Office of Health Information and Research, California Department of Health Services. The precise age of decedents was calculated from their dates of birth and death.

From each data set, we selected records of California residents who were younger than 4 years and had a principal E-code of E800–E869, E880–E929, or E950–E999 as the principal E-code or underlying cause of death. To avoid double counting, hospital discharges that involved a death were excluded.

We grouped the E-codes into major categories that would be relevant for developmentally related risks of injury specific to young children (Table 1). The categorization took into account physical, motor, behavioral, and cognitive developmental milestones of children aged 0 to 3 years. These differed in some ways from the groupings recommended by the National Center for Injury Prevention and Control for unintentional injury.[8,9] Injuries as a result of assaults (E960–E969) were combined with hunger, thirst, exposure, and neglect (E904). Six injuries reported as self-inflicted (E950–E959) and 203 injuries with unknown intent (E980–E989) were assigned to specific categories by mechanism. Young children are not able to form the intent to harm themselves. We created a new category, foreign body (E911, E912, and E915), because these injuries have in common the hazard of small objects and food. All transportation injuries were grouped together.

Within these major categories, specific categories were also examined. Unlike the National Center for Injury Prevention and Control recommended groupings, we combined traffic and nontraffic events in each of the transportation subcategories. On the basis of our previous experience, we found that medical record documentation often lacks information on location of transportation injuries. The E-codes used to define each major and specific category are shown in Table 1.

A number of E-codes, or cause-of-injury codes, that are important in other age groups include only a small number of cases in these data. There were 60 assaults with firearms and 10 assaults with cutting or piercing instruments. These injuries are included under the specific category "other listed assaults."

The number of California residents for each day of age younger than 4 years was estimated from US Census estimates of California population by year of age for the midpoints of 1996–1998.[10] The estimates for the 3 years were summed and interpolated linearly to provide population estimates by day of age. The slope connecting the midpoints of year 0 and year 1 was extended to birth, and the slope connecting the midpoints of year 2 and year 3 was extended to the day before the fourth birthday.

Injury hospitalizations, deaths, and person-years were summed over age ranges of 91 or 92 days to produce 16 three-month periods covering ages from birth to the day before the fourth birthday. The denominators for these 3-month age periods ranged from 382 000 to 405 000 person-years. Annual rates of injury hospitalization and death were calculated for 3-month age periods for each major and specific cause with at least 10 cases of injury

TABLE 1. E-Codes for Injury Categories and Subcategories

Major Category	Specific Category	*ICD-9-CM* E-Codes
Assault and neglect	Battering	E967.0–967.9
	Other listed assaults	E960.0–966, 968.0–968.6
	Unlisted, unspecified, and late effects of assaults	E968.8, 968.9, 969
	Neglect	E904.0–904.9, 968.4
Bites and stings	Dog bites	E906.0
	Other bites and stings	E905.0–905.6, 905.9, 906.1–906.5, 906.9
Burn/fire	Fire/flame	E890.0–899, 958.1, 988.1
	Hot liquids and vapors	E924.0, 924.2, 958.2, 988.2
	Other and unspecified	E924.1, 924.8, 924.9, 958.7, 988.7
Cut/pierce		E920.9–920.9, 956, 986
Fall	Buildings	E882
	Furniture	E884.2, 884.4, 884.5
	Playground equipment	E884.0
	Stairs	E880.9
	Other falls from heights	E880.0, 880.1, 881.0, 881.1, 883.0–883.9, 884.1, 884.3, 884.6, 884.9, 957.0–957.9, 987.0–987.9
	Falls on the same level	E885, 886.0, 886.9
	Other and unspecified	E888
Foreign body	Airway obstruction—food	E911
	Airway obstruction—nonfood	E912
	Nonairway foreign body	E915
Poisoning	Medications	E850.0–858.9, 950.0–950.5, 980.0–980.5
	Other substances	E860.0–869.9, 950.6–952.9, 972, 980.6–982.9
Struck by, against		E916–917.9, 973, 975
Submersion/drowning	Bathtub	E910.4
	Other and unspecified	E830.0–830.9, 832.0–832.9, 910.0–910.3, 910.8, 910.9, 954, 984
Transportation	Bicyclist	E810–825 (.6), 826.1
	Motor vehicle occupant	E810–825 (.0, .1)
	Pedestrian	E810–825 (.7)
	Other and unspecified	E800.0–807.9, 810–825 (.2–.5, .8, .9), 826.0, 826.2–829.9, 831.0–831.9, 833.0–845.9, 958.5, 958.6, 988.5, 988.6
All other injuries	Firearms, except assault	E922.0–922.3, 922.8, 922.9, 955.0–955.4, 985.0–985.4
	Foreign body, eye	E914
	Machinery	E919.0–919.9
	Environmental, except bites, stings, and neglect	E900.0–903, 905.8, 906.8, 907–909.9, 928.0–928.2
	Overexertion	E927
	Suffocation, except choking	E913.0–913.9, 953.0–953.9, 983.0–983.9
	Other and unspecified	E846–848, 887, 918, 921.0–921.9, 922.4, 923.0–923.9, 925.0–926.9, 928.8–929.9, 955.5, 955.6, 955.9, 958.0, 958.3, 958.4, 958.8, 958.9, 959, 970.0–978, 985.5, 985.6, 988.0, 988.3, 988.4, 988.8, 988.9, 989, 990.0–999

hospitalization or death. Three-month age periods with 10 injuries had rates of 2 or 3 per 100 000 and, using the Poisson distribution, 95% confidence limits 1 per 100 000 below the rate and 2 per 100 000 above the rate. Rates of 20 per 100 000 had 95% confidence limits within 5 per 100 000 of the rate. Rates of 89 per 100 000 had 95% confidence limits within 10 per 100 000 of the rate.

RESULTS

There were a total of 23 173 injuries from January 1, 1996, through December 31, 1998. Of these, 636 (3%) resulted in death. The overall annual rate for children aged 0 to 3 years was 371/100 000. The annual injury rates by quarter year of age are shown in Table 2.

Beginning at age 3 to 5 months, the overall rate of injury rapidly increased with increased age and peaked at age 15 to 17 months. After age 15 to 17 months, the rates slowly decreased to a low at age 42 to 44 months (Fig 1).

The mean injury rate calculated for each single year of age did not reflect the variation and the highest rate of injury by quarter year of age for children younger than 1 year, 1 year, and 2 years. For children younger than 1 year, the annual average rate masked the 25% greater rate for children aged 9 to 11 months. The rate for those aged 15 to 17 months was 6% higher than the mean rate for the 1-year-old age group. The injury rate for children 24 to 26 months was 13% higher than the mean rate for the 2-year-old age group. For children 3 years of age (36–47 months), the rates were fairly uniform throughout each quarter year and were the lowest overall (Table 2).

The leading major causes of injury in descending order were falls, poisoning, transportation, foreign body, and fires/burns (Fig 2). The overall rate of the major category of falls exceeded poisoning, the second leading cause of injury, by a factor of 2. Age-related differences were detected within each major cause of injury.

Falls

"Other fall from height" was the most frequent specific cause of fall at 0 to 2 months (Fig 3). Other fall from height decreased with each age interval from 3 to 14 months. Fall from furniture was the leading cause of fall for all age groups 3 months of

TABLE 2. Number and Annual Rate of Injury Hospitalization and Death Per 100,000, Age Younger Than 4 Years, and Rates by 3-Month Age Intervals: California, 1996–1998

Category of Injury	Overall		Age (Mo)																				
	n	Rate	0–2	3–5	6–8	9–11	12–14	15–17	18–20	21–23	24–26	27–29	30–32	33–35	36–38	39–41	42–44	45–47	0–11	12–23	24–35	36–47
Fall																						
Furniture	2032	32	25	34	46	37	36	46	45	39	35	32	30	29	21	22	21	24	35	41	32	22
Buildings	664	11	—	—	—	4	10	13	16	16	22	16	15	16	13	9	7	10	1	14	17	10
Stairs	551	9	4	3	21	22	12	10	9	9	10	7	6	6	7	7	5	5	12	10	7	6
Playground equipment	395	6	—	—	—	—	—	—	6	7	7	8	11	9	9	13	12	14	—	4	9	12
Other fall from height	1354	22	49	33	29	15	11	17	22	19	21	19	17	19	17	20	19	22	31	17	19	20
Fall on the same level	921	15	4	4	7	9	12	20	23	19	20	19	21	15	16	14	19	13	6	18	19	16
Other and unspecified	899	14	9	6	11	15	13	17	16	19	17	20	16	19	12	12	14	14	10	16	18	13
All falls	6816	109	92	80	114	101	94	126	136	128	132	121	115	115	95	96	98	101	97	121	121	98
Poisoning																						
Medication	2290	37	20	8	15	39	44	51	58	69	60	56	49	33	30	23	16	16	21	56	49	21
Other substance	1067	17	15	10	7	24	35	36	35	28	21	13	12	11	8	7	5	6	14	34	14	7
All poisoning	3357	54	35	18	23	64	79	87	93	98	81	68	62	45	38	30	21	22	35	89	64	28
Transportation																						
Pedestrian	1294	21	—	—	—	3	14	28	23	25	29	26	31	26	31	28	23	37	2	23	28	30
Motor vehicle occupant	1195	19	18	20	20	17	14	14	16	13	19	20	18	23	24	23	20	26	19	14	20	23
Bicyclist	182	3	—	—	—	—	—	—	—	—	5	1	4	5	5	6	7	7	—	1	4	6
Other and unspecified	162	3	—	—	—	—	—	3	—	4	3	3	4	5	4	3	4	—	1	2	4	3
All transportation	2833	45	20	23	22	21	30	45	42	44	56	51	56	59	65	60	54	72	22	40	56	63
Foreign body																						
Nonairway foreign body	1385	22	10	6	26	58	49	40	29	28	21	16	16	15	13	12	8	11	25	36	17	11
Airway obstruction—food	387	6	16	5	5	8	9	12	11	8	6	4	4	4	4	—	—	—	9	10	5	2
Airway obstruction—nonfood	374	6	8	4	14	18	13	11	6	4	5	4	—	—	—	—	—	—	11	9	3	1
All foreign body	2146	34	33	15	45	84	71	63	46	40	32	25	22	21	18	15	10	14	44	55	25	14
Burn/fire																						
Hot liquids and vapors	1260	20	5	8	20	33	56	53	41	26	16	12	12	13	8	9	6	6	17	44	13	8
Fire/flame	226	4	3	3	3	—	3	7	4	5	5	—	3	4	2	3	5	4	3	5	3	4
Other and unspecified	465	7	7	—	9	16	27	18	10	10	4	—	—	3	3	2	—	—	9	16	3	2
All burn/fire	1951	31	15	14	32	50	86	78	55	41	24	17	18	20	14	15	13	12	28	65	20	13
Assault and neglect																						
Battering	716	11	44	41	23	13	13	9	7	5	5	6	5	4	3	2	3	—	30	9	5	3
Other listed assaults	181	3	6	2	4	3	—	3	3	3	—	3	4	3	3	—	3	—	4	3	3	3
Unlisted, unspecified, and late effects of assaults	271	4	13	14	8	4	5	3	3	4	—	—	—	3	—	—	—	—	10	4	2	1
Neglect	118	2	12	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	1	1	—
All assaults and neglect	1286	21	76	62	36	22	21	17	14	12	10	11	12	10	9	6	8	5	49	16	11	7
Submersion/drowning																						
Bathtub	180	3	—	4	13	13	4	5	—	—	—	—	—	—	—	—	—	—	8	3	1	—
Other and unspecified	902	14	—	—	5	12	26	22	25	19	21	20	17	19	13	11	10	9	4	20	17	9
All submersion/drowning	1082	17	—	4	17	26	29	27	26	20	22	21	18	20	14	12	10	9	12	26	20	11
Bites and stings																						
Dog bites	326	5	—	—	—	—	3	5	7	7	9	7	6	8	6	4	7	8	1	6	8	6
Other bites and stings	462	7	4	3	2	7	9	9	12	11	10	8	6	8	8	8	8	6	4	10	8	7
All bites and stings	788	13	4	3	4	9	12	15	19	17	19	15	12	16	14	12	15	14	5	16	16	14
Struck by, against	781	12	9	7	8	10	12	11	13	16	19	15	16	14	13	10	14	12	9	13	16	12
Cut/pierce	485	8	3	—	3	3	8	9	9	11	8	9	12	11	8	9	9	9	3	9	10	9
All other injuries	1648	26	49	33	28	32	25	33	28	31	26	23	21	23	19	17	22	13	36	29	23	18
All injuries	23173	371	337	262	333	423	468	509	481	458	430	375	364	354	306	284	276	283	339	479	381	287

— indicates rate not calculated for cells with fewer than 10 cases.

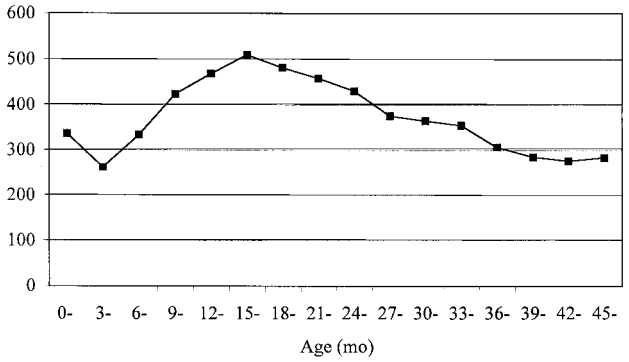

Fig 1. Annual rate of injury hospitalization and death per 100 000 population, by 3-month age periods, 0 to 4 years: California, 1996–1998.

age and older. Peak rates of injury from fall from furniture were at 6 to 8 months and 15 to 17 months. Fall from stairs peaked at age 6 to 8 months and 9 to 11 months. Fall from buildings was highest at 24 to 26 months,. Fall from playground equipment was not numerous enough to calculate rates until age 18 to 20 months, and the rate more than doubled by age 39 to 41 months (Table 2).

Poisoning

Poisoning by medication was the leading specific cause of injury in this study. Beginning at 9 to 11 months, the rate progressively rose to a peak at 21 to 23 months and then steeply declined to a low at 42 to 47 months (Fig 3). The injury rate for poisonings by other substances was consistently lower than the rate for medications for all age groups, except for age 3 to 5 months The highest rates of poisoning by other substances were among children 12 to 20 months. The peak rate was at a younger age, 15 to 17 months, compared with the peak rate for poisoning by medications.

Transportation-Related Injuries

The motor vehicle occupant injury rates were fairly stable over the age span of this study, ranging from a low at age 21 to 23 months to a high at the upper age group of the study, 45 to 47 months (Fig 3). At age 12 to 14 months, the pedestrian injury rate was equal to that of motor vehicle occupant rate. At age 15 to 17 months, the pedestrian injury rate was double that of the motor vehicle occupant rate and remained higher than the occupant rate for all subsequent age groups (Fig 3).

Foreign Body

Nonairway foreign bodies were mostly in the gastrointestinal tract and exceeded airway obstruction, both food and nonfood. Nonairway foreign body had a peak rate for children aged 9 to 11 months, which decreased by 50% by age 18 to 20 months. Nonfood airway obstruction was highest from age 6 to 15 months and peaked at the same age as nonairway foreign body, 9 to 11 months.

Burns

Burn injuries from hot liquids and vapors had much higher rates than burns from fire/flame. The overall rate of burns from hot liquids/vapors was 5 times that of fire/flames. The rate steeply rose to a peak at 12 to 14 months and then declined to a low at 42 to 47 months. The rate of injury from fire/flame was fairly constant over the age range of this study.

Assault and Neglect

The peak rates of assault and neglect were between 0 and 5 months with the rates for battering far exceeding neglect. The rate for battering was highest for infants 0 to 2 months and 3 to 5 months. The rate of battering injury rapidly declined by 9 to 11 months. Neglect showed a pattern similar to battering with the highest rates at 0 to 2 and 3 to 5 months.

Submersion/Drowning

Bathtub submersion/drowning injury rates had a very narrow age range, largely confined to children aged 6 to 11 months. "Other and unspecified submersion/drowning," which includes pool and spa submersions, nearly equal bathtub submersions for 9- to 11-month-olds and then showed a 2-fold increase in the 12- to 14-month-old age group. The rates remained high until age 33 to 35 months and then declined to a low at 45 to 47 months.

Marked variability in rates and leading causes of injury by quarter year of age is illustrated in Fig 4. The leading cause of specific injury was different for each 3-month age group from 0 to 11 months. The leading specific cause of injury was "other fall from height" for 0 to 2 months, battering for 3 to 5 months, fall from furniture for 6 to 8 months, and nonairway foreign body for 9 to 11 months. From 12 to 36 months, there were fewer specific causes of injury. From 12 to 17 months of age, hot liquid/vapor burns was the leading specific cause of injury. Poisoning by medication was the leading cause of injury for all age groups from 18 to 35 months of age, and pedestrian injury had the highest rate from 36 to 47 months of age. There was also marked variability in the rates. For example, the rate of poisoning, the leading cause of injury for children 21 to 23 months, was 3 times higher than the rate for the leading cause of injury (pedestrian) for children aged 42 to 44 months.

DISCUSSION

Our previous analysis of the annual rates of pediatric injury hospitalizations/death for children aged 0 to 19 years in a large state with E-coding of hospital discharge data provided an overview of the age-specific causes of injury.[6] Age-related differences were found for many of the major and specific causes of injury by single year of age. We also found that children aged 1 year had the highest injury rates before 15 years of age.

This study focused on more detailed analyses of children younger than 4 years. This age group is unique in terms of rapid growth and developmental changes, which influence risk for a number of specific causes of injury. We departed from usual group-

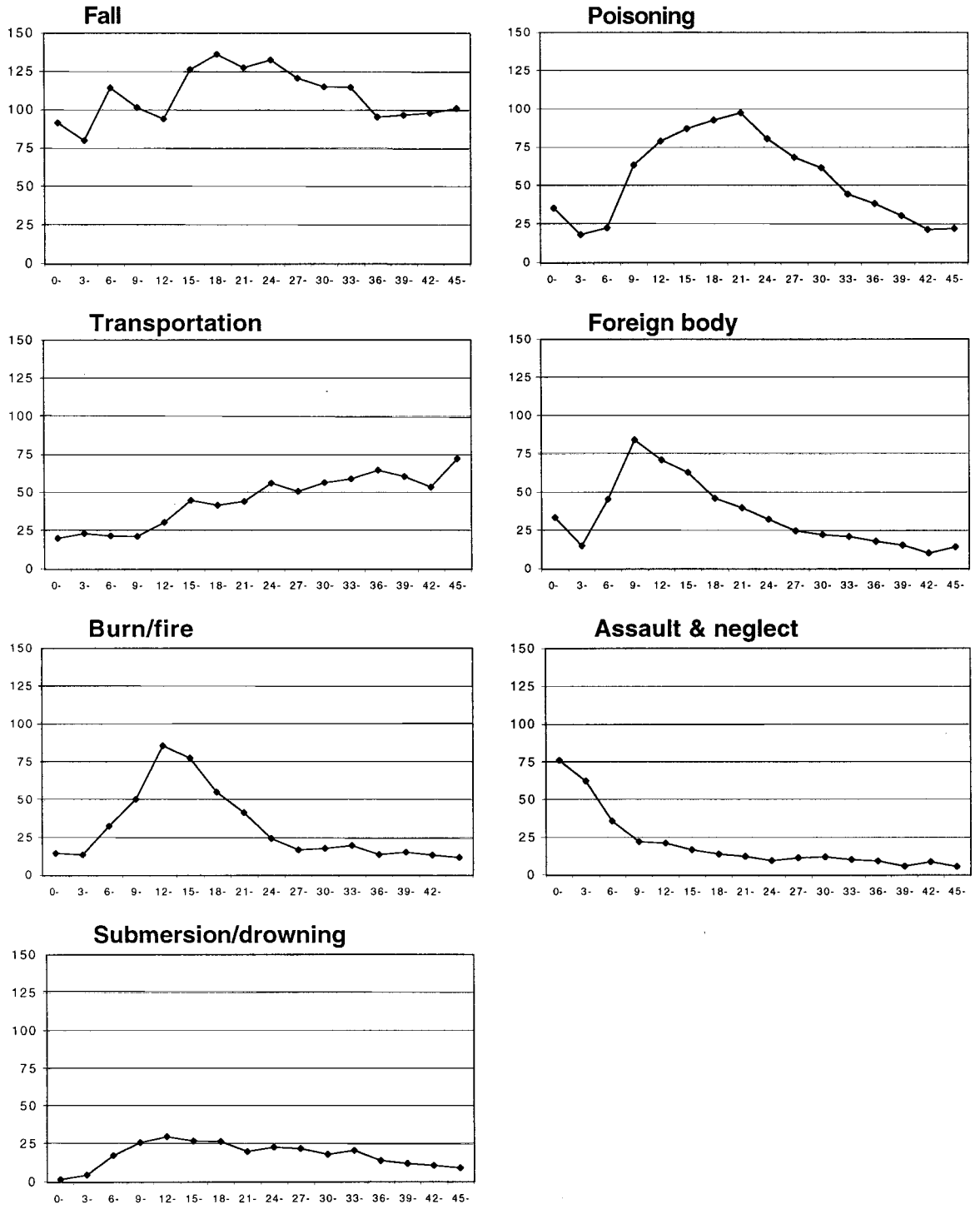

Fig 2. Annual rate of injury hospitalization and death per 100 000 population, by major category of injury and 3-month age intervals, 0 to 4 years: California, 1996–1998.

ings of E-codes and devised groupings that would be reflective of age-related developmental characteristics of children aged 0 to 3 years. These developmental features have implications for risk of injury. For example, very young children are at risk for foreign body ingestion. They have the mobility to gain access to small objects and explore objects by hand-to-mouth activity. The airway and gastrointestinal tract are more readily obstructed because they are smaller compared with older children. Because the same developmental features place the child at risk for both airway and gastrointestinal foreign bodies, the E-codes were grouped. From an injury prevention perspective, these categories should be grouped together as the prevention strategies are similar.

Annual rates of injury were calculated by 3-month intervals of age for both broad categories and the more specific causes of injury. We found marked variability in both rates and specific causes of injury by 3-month age groupings. Year-of-age analysis

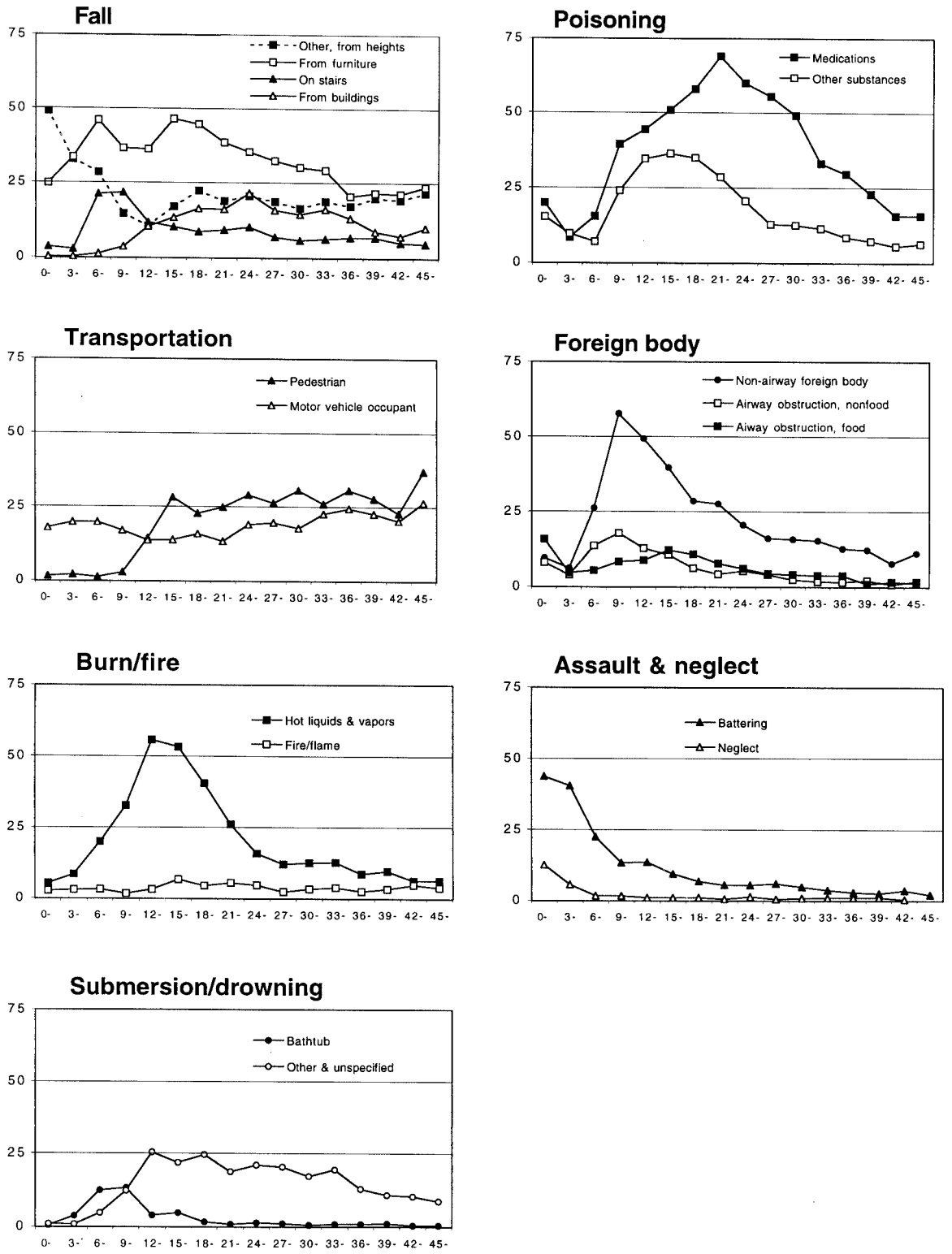

Fig 3. Annual rate of injury hospitalization and death per 100 000 population, by specific category of injury and 3-month age intervals, 0 to 4 years: California, 1996–1998.

masked leading causes for narrower age groups and masked trends and patterns that transected year-of-age groupings. Substantial variability was detected in leading causes of injury rates by quarter year of age among children younger than 1 year.

Children aged 15 to 17 months had the highest overall injury rate, 94% higher than that of children aged 3 to 5 months, who had the lowest rate. Injury rates were above 400/100 000 from age 9 to 26 months. This coincides with developmental achievements such as independent mobility, exploratory behavior, and hand-to-mouth activity. The child is able to gain access to hazards but has not yet developed cognitive hazard awareness and avoidance skills. It

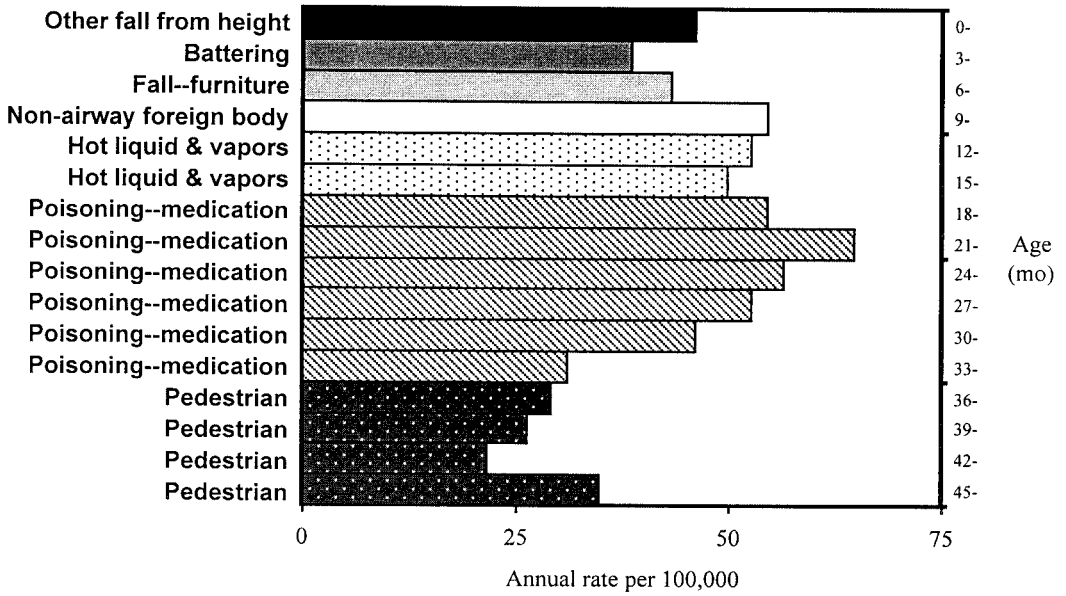

Fig 4. Annual rate of the leading specific cause of injury hospitalization and death per 100 000 population by 3-month age intervals, 0 to 4 years: California, 1996–1998.

is interesting that Rowntree,[11] in a classic article published in 1950 on "accidents" among children younger than 2 years, grouped injuries by developmental milestones. He found that the most frequent medically attended injuries were among children who were already walking and up to 16 months of age, which he characterized as "beginning to walk and becoming inquisitive."

Using developmental milestones and providing anticipatory guidance to discuss injury hazards has been the approach of The Injury Prevention Program (TIPP) of the American Academy of Pediatrics.[12] Data from our study can be used to enhance the 1994 recommendations of TIPP. For example, the early onset of pedestrian injury, the increase with increased age, and the extent of pedestrian injuries indicate that pedestrian injury prevention should receive greater emphasis. Anticipatory guidance for pedestrian injury should be incorporated before 1 year of age.

A remarkable finding in this study was the highest rates of battering injury among infants 0 to 5 months. A number of studies have similarly found that infant homicides and head injury from child abuse are higher in the early months of life. Overpeck et al[13] found that half of the homicides among infants occurred by the fourth month. In a study of trauma in infants younger than 3 months, 28% were attributable to abuse/neglect.[14] Reece and Sege[15] found that the median age for head injury as a result of abuse was 4 months, the same high-risk period identified in this study. The mean age of child abuse was significantly younger than that of unintentional injury in a 10-year retrospective review.[16] Health care professionals who provide prenatal care and early newborn infant care should not only be alert to risk factors for intentional child injury but also should be proactive in early intervention services. These infants/families may benefit from referral services for home visits as well as injury prevention counseling services. Some home visitation programs have documented reductions in injury, abuse, and neglect.[17] Recognizing the need for incorporation of violence prevention, the American Academy of Pediatrics is developing the Violence Injury Prevention Program as the companion to TIPP. This tool along with guidelines and policies will enhance pediatricians' efforts to prevent and identify families that are at risk for child maltreatment and abuse.

Fall was the leading cause of injury for all ages, and the rate was nearly twice that of the second leading cause, poisoning. However, this finding does not yield sufficient information for crafting appropriate prevention strategies. Unless falls are broken down by specific causes, we are limited in understanding risk factors for the various types of falls. Fall from furniture was the leading specific cause of falls for all children, except for the 0- to 2-month age group. "Other fall from height" was the leading cause of falls for the 0- to 2-month infants, and many of these may be falls from being dropped. Nearly 12% of infant falls for infants 6 months of age or younger were dropped, most commonly by an older sibling.[18] In a study of short vertical falls among infants aged 0 to 10 months, being dropped by a caregiver was the only characteristic associated with significant injury compared with rolling or fall from furniture.[19] Falls from stairs had a narrow peak between 6 and 11 months. This can be related to the onset of crawling and independent mobility. Infant walkers are a contributor to falls from stairs.[20] Specific prevention messages for this age group should include the use of stair gates and the elimination of infant walkers.

Poisoning was the second major leading cause of injury for children 0 to 3 years, and more than two thirds were by medications. Poisoning by medication was the leading specific cause of injury for all 3-month intervals from 18 to 35 months; the highest rate was for those aged 21 to 23 months. This trend

was masked by year-of-age analysis. Considerable outreach efforts have been undertaken by poison control centers, and a universal 1–800 number has been established. Child-resistant containers and blister packaging for medications have reduced childhood poisonings substantially,[21] yet poisoning by medications remains a leading cause of injury for young children. Cultural factors and views of medicines and vitamins may influence storage practices and risks of toddler poisoning.[22] Additional research is needed on types of medications and circumstances of ingestion to design more effective interventions.

Pedestrian injuries markedly increased from 9 to 14 months and then doubled between 12 to 14 months and 15 to 17 months, making the rate twice that of the occupant rate. The pedestrian injury rate exceeded motor vehicle occupant injury rates for each 3-month age interval from 15 to 47 months of age. Pedestrian injury was the leading specific cause of injury for children aged 36 to 47 months. Many of these pedestrian injuries among young children are attributable to nontraffic driveway backover events as well as traffic events.[23–25] The most recent data for the State of California revealed that children aged 1 year had the highest number of pedestrian deaths.[26] These data indicate that pedestrian injury, both driveway backover events and traffic events, should be addressed earlier and receive more emphasis than is currently suggested in the TIPP.[12] Supervision and preventing access of young children to areas used by vehicles are essential prevention measures. Environmental measures such as speed reduction in residential neighborhoods are additional strategies for the prevention of pediatric pedestrian injuries.[27] Vehicle design, which includes sensors and cameras to detect small children behind vehicles, offers potential for prevention of residential driveway backovers.

Nonairway foreign body was the largest specific cause in the foreign body category. The rate of airway obstruction caused by food was substantially lower than for nonfood items but peaked at the same age. Poisonings and foreign body ingestion, both airway and nonairway obstruction involving food and nonfood items, have similar developmental risk factors: independent mobility, exploration, hand-to-mouth activity, and the pincer grasp as well as anatomic/physiologic features such as airway size and drug metabolism. The Consumer Product Safety Commission has issued small parts regulations for toys and products intended for use by children younger than 3 years.[28]

In California, drowning is the leading cause of death for children aged 1 to 4 years. Age-related patterns were detected. Submersion/drowning rates from bathtubs had a very narrow peak, 6 to 11 months, the same age as falls from stairs. Other and unspecified submersion/drowning, which includes pool submersion, had the highest rates between 9 and 17 months. Messages for drowning prevention need to consider both bathtub and residential pool risks for young children. In this study, the overall rates of submersions were not high; however, because submersions have a high case fatality rate, prevention is critical.

Limitations

Assignment of E-codes is contingent on adequate medical record documentation and sufficiently detailed codes. This study demonstrated limitations in understanding injuries from fall. Many E-codes for fall are insufficient for characterizing risk factors. Adding codes on certain causes of injury is 1 approach to make the category more discriminating. However, many causes may result from unusual events that would be difficult to classify under any system.

Injuries as a result of battering may be underreported because of insufficient or incomplete information at hospital discharge regarding intention.[29] Unintentional pediatric trauma is often difficult to distinguish from child abuse.[30] These unrecognized or undocumented cases of child abuse may inflate rates from other causes, such as falls.

Patterns of childhood injury in California may be different from those in other states and regions. For example, childhood deaths in house fires are less frequent in California than in other states, whereas pool drownings are more frequent.[31] However, to the extent that age-related patterns of injury reflect developmental changes, they may be similar in different regions.

Implications

Effective strategies must be based on the epidemiology of childhood injury. The differences in rates by narrow age groups (quarter-year intervals in this study) can be related to the achievement of developmental milestones that contribute to the child's risk for specific causes of injury. Pediatricians and other pediatric health care providers are in a unique position to render injury prevention services to their patients. Integrating injury prevention messages in the context of developmental assessments of the child is 1 strategy. Enhancements to office-based counseling offering parents the opportunities to practice and develop strategies for managing the risk of injury warrant exploration. These data can also be used for complementary childhood injury prevention strategies such as early intervention programs for high-risk families for prevention of child abuse and neglect. Media programs, environmental changes in and around the home, product design, advocacy, and appropriate policy measures are other complementary measures.

ACKNOWLEDGMENTS

This study was supported by grant R49/CCR919796 from the Centers for Disease Control and Prevention, National Center for Injury Prevention and Control.

REFERENCES

1. Hoyert DL, Freedman MA, Strobino DM, Guyer B. Annual summary of vital statistics—2000. *Pediatrics.* 2001;108:1241–1255
2. Weiss HB, Mathers LJ, Furjuoh SN, Kinnane JM. *Child and Adolescent Emergency Department Visit Databook.* Pittsburgh, PA: Center for Violence and Injury Control, Allegheny University of the Health Sciences; 1997
3. National Center for Injury Prevention and Control. Web-based Injury Statistics Query and Reporting System (WISQARS) Injury Mortality Reports, 1999–2000. Available at: webapp.cdc.gov/sasweb/ncipc/mortrate10.html. Accessed January 6, 2003.

4. National Center for Injury Prevention and Control. Web-based Injury Statistics Query and Reporting System (WISQARS) Nonfatal Injury Reports. Atlanta, GA: Centers for Disease Control and Prevention; 2002. Available at: webapp.cdc.gov/sasweb/ncipc/nfirates.html. Accessed January 6, 2003
5. Powell EC, Tanz RT. Adjusting our view of injury risk: The burden of nonfatal injuries in infants. *Pediatrics.* 2002;110:792–796
6. Agran PF, Winn DG, Anderson CL, Trent R, Walton-Haynes, L. Rates of pediatric and adolescent injuries by year of age. *Pediatrics.* 2001;108(3). Available at: www.pediatrics.org/cgi/content/full/108/3/e45.
7. *International Classification of Diseases. Ninth Revision. Clinical Modification (ICD-9-CM*). 5th ed. Washington, DC: National Center for Health Statistics (NCHS) and Health Care Financing Administration; 1996
8. National Center for Injury Prevention and Control, Centers for Disease Control and Prevention. Recommended framework of E-code groupings for presenting injury mortality and morbidity data. Available at: www.cdc.gov/ncipc/whatsnew/matrix2.htm. Accessed January 6, 2003
9. Centers for Disease Control and Prevention. Recommended framework for presenting injury mortality data. *MMWR Recomm Rep*. 1997;46(RR-14):1–30
10. Population Estimates Program, Population Division, U.S. Census Bureau. *Population Estimates for the U S. and States by Single Year of Age and Sex: July 1, 1996–1998 (ST-99–13, ST-99–12, ST-99–11*). Washington, DC: US Department of Commerce; 2000. Available at: www.census.gov/population/estimates/state/stats/st-99–13.txt,/st-99–12.txt,/st-99–11. Accessed January 6, 2003
11. Rowntree G. Accidents among children under two years of age in Great Britain. *J Hyg* (now *Epidemiol Infect*). 1950;48:323–337 (Reprinted in *Inj Prev.* 1998;4:69–76)
12. American Academy of Pediatrics. *The Injury Prevention Program.* Elk Grove, IL: American Academy of Pediatrics; 1994
13. Overpeck MD, Brenner RA, Trumble AC, Trifiletti LB, Berendes HW. Risk factors for infant homicide in the United States. *N Engl J Med.* 1998;339:1211–1216
14. Stewart G, Meert K, Rosenberg N. Trauma in infants less than three months of age. *Pediatr Emerg Care.* 1993;9:199–201
15. Reece RN, Sege R. Childhood head injuries. Accidental or inflicted? *Arch Pediatr Adolesc Med.* 2000;154:11–15
16. DiScala C, Sege R, Guohua L, Reece R. Child abuse and unintentional injuries. *Arch Pediatr Adolesc Med.* 2000;154:16–22
17. David and Lucille Packard Foundation. Home visiting: recent program evaluations. *Future Child.* 1999;9(1):inside back cover
18. Warrington SA, Wright CM, ALSPAC Study Team. Accidents and resulting injuries in premobile infants: data from the ALSPAC study. *Arch Dis Child.* 2001;85:104–107
19. Tarantino CA, Dowd MD, Murdock TC. Short vertical falls in infants. *Pediatr Emerg Care.* 1999;15:5–8
20. American Academy of Pediatrics, Committee on Injury and Poison Prevention. Injuries associated with infant walkers. *Pediatrics.* 2001;108:790–792
21. Schieber RA, Gilchrist J, Sleet DA. Legislative and regulatory strategies to reduce childhood unintentional injuries. *Future Child.* 2000;10:111–136
22. Mull DS, Agran PF, Winn DG, Anderson CL. Household poisoning exposure among children of Mexican-born mothers: an ethnographic study. *West J Med.* 1999;171:16–19
23. Agran PA, Winn DG, Anderson CL. Differences in child pedestrian injury events by location. *Pediatrics.* 1994;93:284–288
24. Winn DG, Agran PA, Castillo DN. Pedestrian injuries to children younger than 5 years of age. *Pediatrics.* 1991;88:776–782
25. Nadler EP, Courcoulas AP, Gardner MJ, Ford HR. Driveway injuries in children: risk factors, morbidity and mortality. *Pediatrics.* 2001;108:326–328
26. Lynn Walton-Haynes. Pedestrian injuries to young children. *EPICgram.* May 2002. Report No. 5, California Department of Health Services, Epidemiology and Prevention for Injury Control Branch. Available at: http://www.dhs.ca.gov/epic/documents/epicgram5-pedestrian.pdf. Accessed April 15, 2003
27. Agran P, Winn D, Anderson C, Tran C, Del Valle C. The role of the physical and traffic environment in child pedestrian injuries. *Pediatrics.* 1996;98:1096–1103
28. US Consumer Product Safety Commission, Office of Compliance. Method for identifying toys and other articles intended for use by children under 3 years of age which present choking, aspiration, or ingestion hazards because of small parts. 16 CFR Part 1501; 2002
29. Winn D, Agran P, Anderson C. Sensitivity of hospitals' E-coded data in identifying causes of children's violence-related injuries. *Public Health Rep.* 1995;110:277–282
30. Boyce MC, Melhorn KJ, Vargo G. Pediatric trauma documentation. Adequacy for assessment of child abuse. *Arch Pediatr Adolesc Med.* 1996;150:730–732
31. Wilson MD, Baker SP, Teret SP, Shock S, Garbarino J. *Saving Children: A Guide to Injury Prevention.* New York, NY: Oxford University Press; 1991

Rates of Pediatric Injuries by 3-Month Intervals for Children 0 to 3 Years of Age

Phyllis F. Agran, Craig Anderson, Diane Winn, Roger Trent, Lynn Walton-Haynes and Sharon Thayer

Pediatrics 2003;111;e683
DOI: 10.1542/peds.111.6.e683

PEDIATRICS
OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Rates of Pediatric Injuries by 3-Month Intervals for Children 0 to 3 Years of Age

Phyllis F. Agran, Craig Anderson, Diane Winn, Roger Trent, Lynn Walton-Haynes and Sharon Thayer

Pediatrics 2003;111;e683
DOI: 10.1542/peds.111.6.e683