

## Child Injury Deaths: Comparing Prevention Information from Two Coding Systems

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**Objectives** The International Classification of Disease (ICD) external cause of injury E-codes do not sufficiently identify injury circumstances amenable to prevention. The researchers developed an alternative classification system (B-codes) that incorporates behavioral and environmental factors, for use in childhood injury research, and compare the two coding systems in this paper. **Methods** All fatal injuries among children less than age five that occurred between January 1, 1992, and December 31, 1994, were classified using both B-codes and E-codes. **Results** E-codes identified the most common causes of injury death: homicide (24%), fires (21%), motor vehicle incidents (21%), drowning (10%), and suffocation (9%). The B-codes further revealed that homicides (51%) resulted from the child being shaken or struck by another person; many fires deaths (42%) resulted from children playing with matches or lighters; drownings (46%) usually occurred in natural bodies of water; and most suffocation deaths (68%) occurred in unsafe sleeping arrangements. **Conclusions** B-codes identify additional information with specific relevance for prevention of childhood injuries.

**Key words** child; injuries; mortality; classification; prevention public health.

Injury is the leading cause of death among children from age one through age 18 (Baker, O'Neill, Karpf, 1992; Office of Statistics & Programming, National Center for Injury Prevention & Control, 2002). Research on fatal childhood injuries has historically relied on data from existing sources, that is, data routinely collected for another purpose. Death certificate data, compiled by the National Vital Statistics System, are a common and important source for studies of fatal injuries. There are several benefits in using these mortality data: Filing a death certificate is mandated nationwide, the data elements are standardized, and an internationally recognized coding system developed by the World Health Organization, the International Classification of Diseases (ICD) is used. Furthermore, the ICD, 9th Revision (ICD-9) includes a supplemental classification scheme for external causes of injury and poisoning, termed "E-codes."

These codes help to classify environmental events, circumstances, and conditions as the cause of injury (e.g., motor vehicle crash), and are used in addition to a code indicating the nature of the condition (e.g., femur fracture). Despite these attributes, vital records typically lack important details on the circumstances of the injury event, especially for young children (Ewigman, Kivlahan, & Land, 1993). Consequently, the value of cause of death information from death certificates has significant limitations when used for identifying potential injury prevention strategies (Langley, 1982, 1984; Langley & Chalmers, 1999).

Research in the area of child maltreatment and injury prevention reinforces the limitations of ICD-9 E-codes for identifying modifiable risk factors for child injury (Ewigman et al., 1993; Peterson, Ewigman, & Kivlahan, 1993; Stiffman, Schnitzer, Adam, Kruse, &

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Ewigman, 2002). Although the E-codes provide some information about environmental factors involved in injuries, it is typically not enough to impact development of prevention strategies. The authors' childhood injury research was initiated in 1988, and recognizing the significant limitations of E-codes, they (with colleagues Drs Coleen Kivlahan and Michael Stiffman) developed a coding system for injury prevention research purposes. The system incorporates important information on the circumstances of the injury event that is often missing in the ICD, including behavioral and environmental factors that contribute to fatal injuries among young children. The authors call the codes "B-codes," for behavioral and environmental codes.

The B-code system designed for use in children less than 5 years old consists of 90 three-digit codes divided into three categories (Table I lists broad classification categories. A list of all codes and coding instructions is available from the first author). The system was based on the assumption that prevention of fatal injuries among young children is often dependent upon adult behavior as well as environmental factors. Specifically, fatal injuries may be prevented when adults avoid behaviors that inflict injuries directly, protect children from exposure to hazardous circumstances and provide for a child's nutritional and medical needs. These assump-

**Table I.** Classification of Behavioral Causes of Fatal Injury Among Children (B-Codes), Broad Classification Categories

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Inflicted injuries (B800–B829)
Injuries inflicted by personal agents (B800–B804)
Injuries inflicted by physical agents (B810–B828)
Injuries inflicted by unknown agents (B829)
Injuries because of unmet basic needs (B830–B839)
Injuries because of exposure to hazardous agents or circumstances (B850–B990)
Exposure to guns (B850–B859)
Exposure to hazardous sleeping arrangements (B860–B868)
Exposure to hazardous domestic appliances, tools, other electrical hazards (B869–879)
Exposure to medications or poisons (B880–B889)
Exposure to heights (B890–B899)
Exposure to fire hazards (B900–B909)
Exposure to water hazards (B910–B919)
Exposure to choking hazards (B920–B922)
Exposure to entrapment hazards (B930–B939)
Exposure to operating farm machinery (B940–B949)
Exposure to strangulation hazards (B950–B959)
Exposure to vehicular hazards (B960–B970)
Miscellaneous hazards (B978–B979)
Inadequate information (B990)

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tions underlie the major categories of the B-code system: inflicted injuries, injuries resulting from exposure to hazardous circumstances, and injuries because of unmet basic needs. The information used to assign individual B-codes includes the behavior performed (or not performed) in the context of the environment and the circumstances preceding the fatal injury event.

The conceptual basis for the B-code system emerged during intensive review of the 384 fatality cases reported in the Missouri Child Fatality Study (Ewigman et al., 1993). In the course of that study, initial versions of the coding system were proposed and developed during the iterative process of reviewing and categorizing each death. Once the Missouri Child Fatality Study was complete and the B-code system developed, the codes were applied to information on a sample of injury deaths reported to the Missouri Child Fatality Review Program (CFRP). Following this initial application of B-codes, personnel with the CFRP felt that it was advantageous to apply the B-codes to all injury deaths among young children, which led to further revision and refinement of the B-codes. Because of their origins in the Missouri Child Fatality Study, which attempted to ascertain and describe the circumstances of injury deaths among young children, B-codes were developed specifically for classifying injury deaths among children less than 5 years of age.

The purpose of this analysis was to evaluate the usefulness of the B-codes when compared with the assigned ICD-9 E-code. B-code and E-code classifications among children less than age five, who died in Missouri between 1992 and 1994 were compared. The findings are reported here and the advantages, limitations, and potential uses of the B-codes are discussed.

## Methods

All fatal injuries among children less than 5 years old that occurred between January 1, 1992, and December 31, 1994, were selected for study from Missouri's CFRP. Although there is significant variation in CFRP across the United States, the primary purpose of most programs is to ensure accurate and complete information on the circumstances leading to a child's death, and use this information to provide insight for prevention of future deaths (Webster, Schnitzer, Jenny, Ewigman, & Alario, 2003). In Missouri, the statewide CFRP consists of multidisciplinary teams that review all child deaths in each of the 114 counties and the City of St. Louis. When a child death occurs, the local county CFRP team gathers and discusses detailed information on the nature and

circumstances of the death and records pertinent findings, including information on injury risk factors, on a standard data collection form.

B-codes were assigned using a computer algorithm developed for this purpose by data analysts in the Department of Family and Community Medicine at the University of Missouri-Columbia, under the direction of Dr Ewigman. The algorithm was developed using information available from the CFRP data forms. An electronic version of the CFRP data for 1992–1994 was obtained and a SAS® based computer algorithm was used to assign B-codes. All computer assigned B-codes were checked for consistency by conducting cross tabulations of B-code categories with relevant data from the forms. Inconsistencies were checked by hand and data were recoded to the correct code when necessary. When a B-code could not be assigned using the computer algorithm, the data form was examined to determine if it contained adequate information and if so, a B-code was assigned manually. The CFRP data were linked to death certificate records and the ICD-9 E-codes were obtained from death certificate data.

Descriptive analyses were conducted using SAS Institute, Inc. (1999). The leading causes of injury death documented by the death certificate E-code were identified. Then, for each of the leading causes, the information provided by the E-code was compared with that contained in the B-code assigned to each deceased child. Information provided by the B-codes and E-codes is presented and compared.

### Results

There were 283 injury deaths among children less than age five identified by the CFRP during the three-year study period. A majority (55.8%) of the children were younger than 2 years and 65.7% were male (Table II).

Of the 283 deaths, 69 (24.4%) had a homicide E-code (E860–E869), 200 (70.7%) had unintentional injury E-codes (E800–E929), and 14 (4.9%) had an E-code indicating that it was undetermined whether the death was attributable to homicide or was accidental (E980–E989). A cross tabulation of the major subgroups of E-codes and B-codes is given in Table III. As shown, most of the homicides were assigned a corresponding inflicted injury B-code and most of the unintentional injuries were assigned an exposure to hazards B-code. The two unintentional injury E-codes with inflicted injury B-codes include a child that died in a fire determined to be arson on the CFRP form, and a child whose injuries

**Table II.** Descriptive Demographics for all Fatal Injuries Among Children Less Than 5 Years Old in Missouri, 1992–1994

Demographic Characteristics	Injuries [n (%)]
Age (in years)	
<1	93 (32.8)
1	65 (23.0)
2	56 (19.8)
3	41 (14.5)
5	28 (9.9)
Race	
African-American	88 (31.1)
Other	195 (68.9)
Sex	
Male	186 (65.7)
Female	97 (34.3)
Mother's age (11) <sup>a</sup>	
<20	43 (15.8)
20–24	99 (36.4)
25–29	66 (24.3)
30–34	40 (14.7)
35+	24 (8.8)
Mother's education (29) <sup>a</sup>	
<HS	126 (49.6)
HS Grad	75 (29.5)
College	53 (20.9)
Injury witnessed by caregiver? (54) <sup>a</sup>	
Yes	72 (31.4)
No	157 (68.6)
Substantiated abuse or neglect	
Yes	95 (33.6)
No	188 (66.4)
Custody	
Natural mother	254 (89.8)
Natural father	117 (41.3)
Both	110 (38.9)

<sup>a</sup>number missing.

**Table III.** Frequency of E-Codes and B-Codes by Major Subgroup Heading

B-Codes	E-Codes			Total [n (%)]
	Homicide	Unintentional Injury	Intent Undetermined	
Inflicted injury	62	2	3	67 (23.8)
Exposure to hazards	3	198	8	209 (74.1)
Unmet needs	4	0	2	6 (2.1)
Total [n (%)]	69 (24.5)	200 (71.0)	13 (4.5)	282 (100) <sup>a</sup>

<sup>a</sup>1 missing—not enough information to assign a B-code.

were identified by the CFRP team as inflicted with a hard rubber ball thrown by another child.

The major categories of unintentional injury deaths ( $n = 200$ ) were fire-related injuries (60 deaths), motor vehicle-related injuries (58 deaths), drowning (28 deaths), and mechanical suffocation (25 deaths). Each of these categories are discussed in more detail below. The corresponding exposure to hazards categories in the B-code system ( $n = 201$ ) include 61 deaths resulting from exposure to fire hazards (B900–B909), 58 deaths from vehicular hazards (B960–B971), 32 deaths involving water hazards (B910–B919), 22 deaths involving hazardous sleeping arrangements (B860–B869) and 9 deaths because of strangulation or

suffocation hazards not related to sleeping arrangements (B950–B959).

The broad E-code and B-code categories correspond closely. However, important differences emerge when the individual codes are examined. These differences are demonstrated in Tables IV–X, which present comparison data for the 69 homicide deaths, the 4 leading categories of unintentional injury death, and the 14 deaths of undetermined intent (E980–E989), and are discussed in detail in the following six sub-sections.

### **Homicide (E960–E969)**

Most of the homicides were coded as child abuse homicides (E967). This E-code includes a fourth digit that

**Table IV.** Homicide by E-Code with Corresponding B-Codes, Children Less Than 5 Years Old, Missouri, 1992–1994

Homicide and Injury Purposely Inflicted by Other Persons–E960-E969 ( $n = 69$ )			
E-Code	Number of children (%)	B-Code	Number of children (%)
Perpetrator of child abuse, by unspecified person (E967.9)	37 (53.6)	Inflicted by shaking, dropping, striking, or throwing with hands, feet, or other body parts (B800)	27 (39.1)
		Inflicted by unknown agent (B829)	6 (8.7)
		Inflicted by suffocation or strangulation with a physical object (B817)	2 (2.9)
		Inflicted by suffocating or strangulating with hands or other body part (B803)	1 (1.5)
		Unmet needs of the newborn (B831)	1 (1.5)
Assault by other or unspecified means (E968.8, E968.9)	10 (14.5)	Inflicted by shaking, dropping, striking, or throwing with hands, feet, or other body parts (B800)	5 (7.2)
		Inflicted by unknown agent (B829)	2 (2.9)
		Inflicted with a blunt weapon (B820)	1 (1.5)
		Inflicted by suffocating or strangulating with hands or other body part (B803)	1 (1.5)
		Exposure to suffocation or strangulation hazard, cause unknown (B959)	1 (1.5)
Assault by firearms and explosives (E965)	8 (11.6)	Inflicted using handgun, rifle, shotgun, or other firearm (B810)	8 (11.6)
Assault by hanging and strangulation (E963)	6 (8.7)	Inflicted by suffocating or strangulating with hands or other body part (B803)	3 (4.3)
		Inflicted by shaking, dropping, striking, or throwing with hands, feet, or other body parts (B800)	1 (1.4)
		Inflicted by suffocation or strangulation with a physical object (B817)	1 (1.4)
		Unmet needs of the newborn (B831)	1 (1.4)
Criminal neglect (E968.4)	3 (4.4)	Unmet nutritional needs (B830)	2 (2.9)
Assault by striking with a blunt or thrown object (E968.2)	2 (2.9)	Placement in other unsafe sleeping arrangement (B863)	1 (1.4)
		Inflicted by shaking, dropping, striking, or throwing with hands, feet, or other body parts (B800)	2 (2.9)
Assault by fire (E968.0)	1 (1.4)	Use of fire, cooking appliances, flammable products by a person over 12 years old (B904)	1 (1.4)
Assault by hot liquid (E968.3)	1 (1.4)	Inflicted using hot liquid, other hot substance, or hot object (B815)	1 (1.4)
Assault by poisoning, drugs and medicinal substances (E962.0)	1 (1.4)	Inflicted using a poison or medication (B814)	1 (1.4)

identifies the perpetrator of the abuse by their relationship to the decedent (father, mother, etc.); however, all homicide deaths in this sample were coded E967.9, perpetrator of child abuse *by unspecified person*. The B-codes for inflicted injuries provide information on the circumstances and mechanism of injury only. Most of the homicides were inflicted by shaking, dropping, striking, or throwing (Table IV).

For the E-code assault categories where the mechanism is specified, the B-codes provide additional useful information on the circumstances of injury for assault by hanging or strangulation and criminal neglect. For the E-code categories of assault by hot liquid or poisoning, the E-codes and B-codes provide comparable information. And, for firearm homicides, the E-codes provide more specificity as to the type of firearm used (handgun, shotgun, etc.).

**Accidents Caused by Fire and Flames (E890–E899)**

Thirty percent of all unintentional injury deaths were because of fire-related injuries. Almost all of the deaths (97%) were assigned E890, conflagration in a private dwelling. A fourth digit E-code can be assigned that provides information on whether the death resulted from burns, smoke or fumes, or other causes. Table V details the corresponding B-codes assigned to these fire deaths. The B-codes in this category provide information on how the fire started. Here, over 40% of the fires resulted from children playing with matches or lighters, 25% resulted from defective wiring, and 18% from hazardous heating, lighting, or electrical sources.

**Motor Vehicle Accidents (E810–E825)**

E-codes for the 58 motor vehicle-related deaths are presented in Table VI with the corresponding B-codes. When the decedent was a motor vehicle passenger, the B-codes include information on whether the decedent was restrained or not. Forty-nine percent of the fatally injured motor vehicle passengers (18/37) were unrestrained.

**Accidental Drowning and Submersion (E910)**

Drowning was the third leading cause of fatal unintentional injury with 28 (14%) deaths (Table VII). A fourth digit E-code is available for drowning that provides additional information on the decedent’s activity, use of diving equipment and bathtub drownings. In contrast, the B-codes provide information on the water hazard where the drowning occurred. From these B-code data it is evident that almost twice as many children drown in natural bodies of water (13) as drown in swimming pools (7) in this age group in Missouri, that is, almost one-half (46.4%) of all drownings occurred in natural bodies of water.

**Accidental Mechanical Suffocation (E913)**

The fourth leading cause of unintentional injury death was accidental mechanical suffocation (Table VIII). A fourth digit E-code is available to code suffocation that occurs in a bed or cradle, by plastic bag, cave-in, lack of air in an enclosed space or other, and unspecified means. More than half (56%) of the suffocation deaths were coded as occurring in a bed or cradle (E913.0). The B-codes provide additional specificity regarding the role of soft sleeping surfaces, overlying, improperly used or malfunctioning cribs and other unsafe sleeping

**Table V.** Fire-Related Deaths by E-Code with Corresponding B-Codes, Children Less Than 5 Years Old, Missouri, 1992–1994

Accidents Caused by Fire and Flames—E890–E899 (n = 60)			
E-Code	Number of children (%)	B-Code	Number of children (%)
Conflagration in private dwelling (E890)	58 (96.7)	Exposure to a child using matches, lighters, other fire ignition materials (B900)	23 (38.3)
		Use of defective wiring or appliances (B905)	15 (25.0)
		Use of hazardous heating, lighting, or electrical sources (B903)	11 (18.3)
		Residence fire, cause unknown. (B909)	7 (11.7)
		Inflicted by arson (B821)	1 (1.7)
		Use of fire, cooking appliances, flammables by person over 12 years old (B904)	1 (1.7)
		Conflagration not in building or structure (E892)	1 (1.7)
Accident caused by ignition of clothing (B893.8—from other special sources)	1 (1.7)	Exposure to a child using matches, lighters, other fire ignition materials (B900)	1 (1.7)

**Table VI.** Motor Vehicle-Related Deaths by E-Code with Corresponding B-Codes, Children Less Than 5 Years Old, Missouri, 1992–1994

Motor Vehicle Traffic, and NonTraffic Vehicle Accidents—E810–E825 (n = 58)			
E-Code	Number of children (%)	B-Code	Number of children (%)
Motor vehicle traffic accident, child was a passenger (E812.1, E815.1, E816.1, E819.1)	34 (58.6)	Nonprovision or nonuse of proper child passenger restraints in a motor vehicle (B961)	17 (29.3)
		Motor vehicle hazard, other, restraints used (B968)	10 (17.2)
		Motor vehicle hazard, other, restraint use unknown (B969)	4 (6.9)
		Vehicle hazard, unknown. (B971)	2 (3.5)
		Exposure to creek, river, pond, lake (B914)	1 (1.7)
Motor vehicle traffic accident, child was a pedestrian (E814.7)	12 (20.7)	Child pedestrian in a street, road, or highway with motor vehicle traffic (B964)	10 (12.1)
		Exposure of pedestrian child to nontraffic moving motor vehicle (B963)	2 (3.5)
Other motor vehicle nontraffic accident, child was a pedestrian (E822.7)	8 (13.8)	Exposure of pedestrian child to nontraffic moving motor vehicle (B963)	8 (13.8)
Other motor vehicle nontraffic accident, child was passenger (E823.1, E825.1)	3 (5.2)	Exposure to operating farm machinery, type nonspecified (B940)	1 (1.7)
		Nonprovision or nonuse of proper child passenger restraints in a motor vehicle (B961)	1 (1.7)
		Exposure of pedestrian child to nontraffic moving motor vehicle (B963)	1 (1.7)
Motor vehicle traffic accident, child was pedal cyclist (E813.6)	1 (1.7)	Child riding a bicycle on a street (B962)	1 (1.7)

**Table VII.** Drowning Deaths by E-Code with Corresponding B-Codes, Children Less Than 5 Years Old, Missouri, 1992–1994

Accidental Drowning and Submersion—E910 (n = 28)			
E-Codes	Number of children (%)	B-Codes	Number of children (%)
Other accidental drowning or submersion (E910.8)	14 (50.0)	Exposure to creek, river, pond, or lake (B914)	6 (21.4)
		Exposure to a swimming pool (B910)	5 (17.8)
		Exposure to a bathtub filled with water (B912)	1 (3.6)
		Exposure to buckets or other household water containers (B913)	1 (3.6)
		Exposure to well, cistern, septic tank, sewer (B915)	1 (3.6)
Submersion while engaged in other sport or recreational activity without diving equipment (E910.2)	5 (17.9)	Exposure to creek, river, pond, or lake (B914)	3 (10.7)
		Exposure to a swimming pool (B910)	2 (7.1)
Unspecified accidental drowning or submersion (E910.9)	5 (17.8)	Exposure to creek, river, pond, or lake (B914)	4 (14.3)
		Exposure to well, cistern, septic tank, sewer (B915)	1 (3.6)
Submersion in bathtub (E910.4)	4 (14.3)	Exposure to a bathtub filled with water (B912)	4 (14.3)

arrangements in suffocation of young children. These unsafe sleeping arrangements were responsible for 17 deaths, 68% of all deaths were because of mechanical suffocation.

### ***Injury Undetermined Whether Accidentally or Purposely Inflicted (E980–E989)***

Five percent (14) of the deaths have an undetermined intent E-code (Table IX). This group of codes includes

**Table VIII.** Suffocation Deaths by E-Code with Corresponding B-Codes, Children Less Than 5 Years Old, Missouri, 1992–1994

Accidental Mechanical Suffocation—E913 ( <i>n</i> = 25)			
E-Code	Number of children (%)	B-Code	Number of children (%)
Accidental mechanical suffocation in bed or cradle (E913.0)	14 (56.0)	Placement on soft sleeping surface (B862)	5 (20.0)
		Placement in unsafe sleeping arrangement leading to overlying (B864)	3 (12.0)
		Placement in improperly used or malfunctioning crib (B861)	3 (12.0)
		Placement in other unsafe sleeping arrangement (B863)	2 (8.0)
		Exposure to suffocation hazards or wedging (B951)	1 (4.0)
Accidental mechanical suffocation, unspecified means (E913.9)	5 (20.0)	Placement in other unsafe sleeping arrangement (B863)	2 (8.0)
		Placement in unsafe sleeping arrangement leading to overlying (B864)	1 (4.0)
		Placement in improperly used or malfunctioning crib (B861)	1 (4.0)
		Exposure to suffocation hazards or plastic bags or objects (B952)	1 (4.0)
Accidental mechanical suffocation by plastic bag (E913.1)	4 (16.0)	Exposure to suffocation hazards or plastic bags or objects (B952)	4 (16.0)
Accidental mechanical suffocation, other specified means (E913.8)	2 (8.0)	Exposure to strangulation hazards (B950)	1 (4.0)
		Exposure to suffocation hazards or wedging (B951)	1 (4.0)

**Table IX.** Deaths of Undetermined Intent by E-Code with Corresponding B-Codes, Children Less Than 5 Years Old, Missouri, 1992–1994

Injury Undetermined Whether Accidentally or Purposely Inflicted—E980–E989 ( <i>n</i> = 14)			
E-Code	Number of children (%)	B-Code	Number of children (%)
Injury by other or unspecified means, undetermined whether accidentally or purposely inflicted (E988.8, E988.9)	5 (35.7)	Inflicted by shaking, dropping, striking, or throwing with hands, feet or other body parts (B800)	3 (21.4)
		Unmet needs of the newborn (B831)	1 (7.1)
		Inadequate information to categorize (B990)	1 (7.1)
Poisoning by solid or liquid substances, undetermined whether accidentally or purposely inflicted (E980)	3 (21.4)	Exposure to medications, drugs, or poisons (B880)	3 (21.4)
Hanging, strangulation, suffocation, undetermined whether accidentally or purposely inflicted (E983)	3 (21.4)	Placement in other unsafe sleeping arrangement (B863)	2 (14.3)
		Unmet needs of the newborn (B831)	1 (7.1)
Submersion, undetermined whether accidentally or purposely inflicted (E984)	1 (7.1)	Exposure to wading pool (B916)	1 (7.1)
Injury by firearms, airguns and explosives, undetermined whether accidentally or purposely inflicted (E985)	1 (7.1)	Handling or cleaning loaded handguns, rifles, shotguns, or other firearms by an adult (B851)	1 (7.1)
Burn injury, undetermined whether accidentally or purposely inflicted (E988.1)	1 (7.1)	Exposure to residence fire, cause unknown (B909)	1 (7.1)

many of the categories used for unintentional injuries (poisoning, drowning, etc.) with the qualifier added that it is undetermined whether the injury was accidentally or purposely inflicted. Here, B-codes provided additional specificity to the largest category of undetermined injuries: Injury by other or unspecified means. Three of these injuries were inflicted by shaking, dropping, striking or throwing, and one infant died because of unmet needs of the newborn. One death had too little information to assign a B-code. B-codes added little additional information for undetermined injuries classified as poisoning, fire or burns, firearms, and drowning.

## Discussion

The authors described classification of fatal injuries among children less than 5 years old using a coding system (B-codes) that incorporates information on the circumstances of the injury, and compared these B-codes with ICD-9 E-codes. This comparison demonstrated that B-codes are particularly useful for identifying potentially preventable circumstances for homicide, fire, drowning, and suffocation deaths among young children. Specifically, information that the child was shaken, dropped or struck by an adult in 51% of the homicides was provided by the B-code. Although there are numerous E-codes for mechanism of homicide injury (strangulation, drowning, firearms, etc.), most of the fatal injuries in the data were assigned an E-code of child abuse by unspecified person (E967.9). The child abuse E-code provides no information on the mechanism of injury. One potential advantage of the E-codes (over B-codes) is the fourth digit of the E967 code that is designed to identify the perpetrator of the abuse. However, all data were coded “.9—by unspecified person,” showing this advantage to be merely theoretical. The use of E967.9 may reflect the lack of detail on the death certificate necessary to assign a fourth digit E-code (Gellert, Maxwell, Durfee, & Wagner, 1995; Herman-Giddens et al., 1999; Moyer, Boyle, & Pollock, 1989; Rosenberg & Freedman, 2000). Importantly, information on the mechanism of inflicted injury among young children is lost when relying on E-coded data alone.

The fire-related E-codes were, perhaps, even less helpful than the homicide codes for informing prevention. From the E-codes, we learn only that most of the children died in fires in private dwellings. From the B-codes, however, we were able to identify children playing with matches or lighters as a contributing factor in 42% of the fire-related deaths. This information is critical for determining the causes and for developing potential prevention strategies.

Similarly, B-codes for drowning and suffocation deaths provide crucial information regarding the circumstances of injury that is not captured with E-codes. B-codes document the specific water hazard in drowning deaths. In Missouri, more young children died in natural bodies of water (13) than in swimming pools and bathtubs combined (12). This may be a reflection of exposure—a rural state with many natural bodies of water; or, perhaps, swimming pool and bathtub drownings have been more effectively prevented. Although B-codes do not provide insight into why more children died in natural bodies of water, these data are pertinent for identifying future research needs or public health policy priorities. Likewise, the B-codes identified a variety of unsafe sleeping arrangements (soft sleeping surface, co-sleeping leading to overlying, improper or malfunctioning cribs, etc.) as critical factors in suffocation deaths among young children. Focus on providing a safe sleeping environment might be an effective strategy for reducing these deaths.

In contrast, E-codes for motor vehicle injuries are quite useful for classifying these child injury deaths. The primary advantage of using the motor vehicle B-codes is that they identify restraint use for motor vehicle passengers. Given that restraint use is mandated in the age group studied, documenting that the passenger was unrestrained in almost one-half of the motor vehicle fatalities has important public health policy implications.

First conceived around 1988, the B-codes were developed and applied to CFRP data in the early 1990s. Since that time, the International Collaborative Effort (ICE) on injury statistics was formed in an effort to improve international comparability and quality of injury data (National Center for Health Statistics, Centers for Disease Control & Prevention, 2003). ICE has worked on a number of projects including development of a framework for reporting external cause of injury codes and the International Classification of External Causes of Injury (ICECI). The ICECI provides detailed codes for seven data elements: intent, mechanism of injury, object or substance producing injury, place of occurrence, activity when injured, alcohol use, and drug use (Consumer Safety Institute & WHO Collaborating Center on Injury Surveillance, 2003). Although the researchers have not used the ICECI, the detailed codes are clearly an improvement over the ICD codes both in the level of detail available and the organization of codes by injury data element. However, some of the important prevention information identified by using B-codes, and particularly pertinent to prevention of childhood injuries (restraint use in motor vehicles, unsafe sleeping



arrangements, how a house fire started) are not included in the ICECI codes.

The ICE has also worked on evaluating the use of multiple cause of death data to provide additional insight into injury deaths. Injury mortality data are usually based on the external cause of injury code; however, death certificates may also include codes for the nature of injuries sustained, such as fracture, head injury, or burn (Fingerhut, 2002). These codes help define injury death and may provide useful information for prevention. For example, Fingerhut (2002) documents that pedal cyclists are more likely than other transportation-related deaths to incur head injuries, which implies that bicycle helmets may be a reasonable prevention strategy. However, even use of the multiple cause of death codes does not identify whether the decedent was actually wearing a helmet at the time of injury, important prevention information provided by B-codes.

### **Limitations of B-Codes**

There are several limitations to the use of B-codes. First, B-codes were developed using the ICD-9 E-codes as a model and are compared to E-codes in this paper; however, the 10th revision of the ICD (ICD-10) is now in use for mortality data. The B-codes have not yet been compared to ICD-10 coded deaths to see if the advantages of using B-codes remain the same. However, examination of the ICD-10 codes indicates that many of the advantages of B-codes described here will persist with ICD-10 coded data. For example, like the ICD-9, the ICD-10 external cause codes for smoke, fire, and flames (X00-X09) do not include information on how the fire started (an advantage of the B-codes). Similarly, the ICD-10 external cause codes related to motor vehicle injuries do not include information on restraint use in motor vehicle passengers. Langley & Chalmers, (1999) noted that coding circumstances of injury in ICD-10 still falls short for many injury prevention needs. It is important to note here that the ICD-9 (and hence, E-codes) remains in current use for coding morbidity data, such as hospital discharge and medical clinic data. Although B-codes have been used exclusively with fatality data to date, the coding system could be very useful for categorizing nonfatal injuries that receive medical attention.

Second, the B-codes were developed while reviewing detailed circumstances of injury deaths among children less than 5 years old, and were based on the young child's dependence on adults for protection from hazards. Although the codes are potentially applicable to injury deaths among older children, they have only been

applied to information on deaths among young children, to date.

Further, application of B-codes requires additional detail over that typically included on the death certificate. Therefore, B-codes are best used in conjunction with a comprehensive CFRP. Moreover, like other coding schemes, the B-codes consolidate important information on cause of death into a single code. Injuries, however, often have multiple causes or result from a series of circumstances (Christoffel et al., 1992). Nevertheless, the intent of this coding scheme is to provide a summary, not a fine-grained process analysis of particular injury events. Use of B-codes in conjunction with ICD external cause of injury codes will provide a more complete picture of the injury event, and help identify potential preventive measures. Finally, reliability of the coding system has not yet been established.

### **Advantages of B-Codes**

Despite these limitations, B-codes offer several advantages. Although the B-codes have not yet been used by other states, the potential for widespread use of B-codes in CFRP exists. Currently, at least 48 states and the District of Columbia have a CFRP (Webster et al., 2003). Child fatality review efforts have recently received federal funding, the development of a national data system with standardized data elements has been identified as a top priority, and there is interest in using B-codes in this national data system (Theresa Covington, personal communication, March 3, 2003).

In addition, B-codes use a single code to summarize important information on circumstances of injury death among children, information that is important for prevention and public health policy and that is not available from the ICD coding on the death certificate. B-codes are particularly useful for deaths because of inflicted injury, fire, drowning and suffocation, the leading causes of death among young children.

### **Recommendations for Further Development of the B-Codes**

This paper describes the development of a coding system that provides key information on the circumstances of fatal injury among young children. This information is useful for identifying prevention strategies or advising public health policy, and is an important supplement to that provided by the E-code. However, there are several limitations to use of the B-codes and additional development and further refinement in three particular areas will greatly enhance the usefulness of B-codes in the future. The most important additional development of

B-codes is a comparison of B-codes to the ICD-10 external cause of injury codes (V01-Y98), to see if the advantages of the B-codes for identifying risk factors amenable to prevention remain. A second important area for future development is to assess the usefulness of B-codes for identifying prevention information for injuries among older children. The authors have begun this work by applying B-codes to injuries among older children, assessing when codes were not available to adequately capture the injury circumstances, and refining the classification system to include applicable codes. Once E-code information is obtained on these older children, a comparison of the two codes can be completed. Finally, it is critical that the reliability of the coding system be assessed. That is, if people are trained in the application of these codes, given the same information on injury circumstances, will they reliably apply the codes in the same manner? Reliability must be measured if the codes are to be useful in other states or on a larger national scale.

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