

Multiple Cause of Death and Injury

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Mortality data are routinely tabulated utilizing a single underlying cause of death which identifies only one cause that is considered to have initiated the sequence of events leading to death. However, seldom is there a single factor involved in a death and often other diseases or conditions are contributory, such as diabetes and heart disease. The practice of publishing single cause of death data results in much loss of information as to factors involved in the death. For injuries this has been even more problematic because two types of ICD-9 codes are used to describe injuries, one which describes the nature of the injury (e.g., head injury), and the other which describes the mechanism of the injury (e.g., fall). By convention only the external cause (e.g., fall) is routinely published.^{1,2}

Multiple cause of death information is obtained from death certificates and can be coded using several different automated coding systems (ACME, TRANSAX, MICAR, etc.) that are described elsewhere.³ The implementation of automated multiple cause of death coding allows for: 1) the coding of all the reported conditions on the death certificate and, 2) the utilization of a set of standardized coding rules for determining the Underlying Cause of Death thereby increasing consistency of death certificate coding. In the United States, the routine coding of the multiple causes of death began in 1968.

Prior to the routine coding of the multiple causes of death, injury researchers were limited to the analysis of a single underlying external cause of death, which describes the mechanism that caused the injury death such as a car crash or a fall. However, this single external cause code did not describe the resulting injuries that were listed on the death certificate. The implementation of multiple cause-of-death coding made data available on the nature of all reported injuries sustained in fatal injury events. For example, in the event of a car crash fatality, the underlying external cause of death code describes the type of car crash and the multiple cause-of-death codes describe the types of injuries sustained (e.g., head trauma, hip fractures, etc.). In addition, death certificates may include information on more than one external cause for a injury death. Specific coding rules are utilized in the U.S. for selecting the underlying cause of death when more than one external cause is listed on the death certificate.⁴ All external and nature of injury conditions listed on the death certificate are coded and provided in the multiple cause of death codes, including in most cases the external cause code selected as the underlying cause of death.

Many countries now collect and code information on multiple causes of death. However, there are often significant differences in the registration and coding practices for each country. The International Collaborative Effort on Injury Statistics (Injury ICE) commissioned a questionnaire to collect information regarding mortality registration and coding practices in each participating country and has presented the results from this questionnaire at this symposium.⁵ Some countries such as, the U.S., the U.K., Canada, and Australia, provide all the conditions listed on the death certificate. Others provide a limited number of conditions and

still others identify a single nature of injury code or a "main injury" diagnosis associated with the underlying external cause of death.

One of the goals of the Injury ICE is to compare injury data internationally. However, to date most of these analyses have been restricted to comparative analysis of the underlying external cause of death.⁶ Even in the United States, which has had multiple cause of death data for over 20 years, the primary emphasis of injury mortality research remains focused on the underlying external causes of injury death. The Injury ICE collaborators hope to develop a framework for presenting injury statistics that both identifies the types of injuries sustained in injury deaths as well as the external mechanism that caused the death.

A further complication towards conducting international comparisons of injury mortality is the significant variation in the coding and tabulation of multiple cause of death data among the Injury ICE collaborating countries. Some countries utilize guidelines published by WHO in the volumes of the ninth revision of the International Classifications of Diseases (ICD-9).⁷ These guidelines provide a hierarchy for selecting the primary nature of injury code when more than one type of injury is listed on the death certificate. Other countries may select the first listed injury as the primary injury. Further attempts will be made to ascertain what selection process is utilized by those countries that currently code a primary injury diagnosis. Since many countries code at least a principal injury diagnosis for injury deaths we may want to select this level of analysis to maximize the comparison of international data in future studies.

This paper further examines the published multiple cause of death data for injury deaths in the U.S. as a first step in comparing fatal injuries between countries.

There are two types of multiple cause of death codes available in the U.S., entity axis and record axis codes. Entity axis multiple cause codes are the ICD coded conditions from the death certificate listed in the same order that they appear on the death certificate. The entity axis code itself includes information about which line of the certificate it was listed on and whether more than one condition was listed per line. These data are unedited; they are entered on the data file in the order that they appear on the death certificate. The number of diagnoses and level of detail on the certificate varies widely from one certifier to the other, even for the same conditions.

The record axis codes are the edited version of the multiple cause data derived by an editing program (TRANSAX) which edits the conditions listed on the death certificate. TRANSAX edits inconsistent information appearing on the death certificate or combines conditions listed separately on the certificate that according to the ICD-9 should be entered as one code.⁸ Record axis multiple cause codes do not include any information regarding their placement on the death certificate, they are entered on the data tape in numerical order from lowest to highest. The record axis editing process seeks to standardize the diagnoses as much as the available data will allow. Therefore, for each injury death the following information is available: unedited entity axis codes which provide information about the actual location and order of the injury on the death certificate and edited record axis codes that do not include information regarding the location and order of the injury on the death certificate.

Both record and entity axis codes have important uses in injury mortality research, but they

each serve different purposes. Each researcher must decide which is the better data source for their analysis. The practical implication of this coding issue is that if we want to conduct international comparisons of the patterns of injury in injury fatalities we must find a comparable way to analyze data across different countries.

One crude approximation of determining the "main injury" in injury fatalities in the U.S. would be to use the first listed injury code in the entity axis codes which assumes that the certifier records the most serious injury first. Attempting to define a main injury diagnosis in this manner may be somewhat controversial since presumably death certifiers do not fill out death certificates with the understanding that the data might be tabulated in this way. The instructions to the certifiers are to enter data in the causative order and not necessarily in order of severity. Furthermore, the certifier may not always be certain which of many severe injuries actually caused the death. One of the many activities the Injury ICE will be conducting is determining how consistent selection rules are between countries that code a main injury diagnosis code and to establish in the future common coding guidelines for data comparability. As a first step in this process, the 1995 U.S. Multiple Cause of Death data file⁹ was analyzed to determine how injury conditions were currently coded in the U.S.

Number of Injury Conditions

Table 1 shows the number of injury conditions listed on death certificates for injury deaths for the U.S. in 1995. There were a total of 226,130 injuries coded from the death certificates for 147,891 injury deaths. This is an average of about 1.5 injuries per death. Less than 1% of injury deaths had an external cause of injury coded without an associated nature of injury code. Sixty-four percent of all injury deaths in 1995 had only one nature of injury diagnosis code reported on the death certificate. Therefore, for nearly two-thirds of the 1995 U.S. injury deaths, the main injury is already defined, with the remaining 36% to be defined after consensus on coding guidelines for main injury is reached among the international collaborators.

Framework for Injury Diagnosis Codes for Mortality

An additional goal of the Injury ICE is to develop standardized formats for presenting injury data. This symposium included a proposal for the adoption of a framework or matrix for presentation of injury diagnosis codes for morbidity.^{10,11} The proposed framework for coding injury diagnosis codes for use with injury morbidity data has been adapted for this analysis to illustrate its potential use with mortality data. [See Appendix I] These frameworks provide a cross-classification format that allows for further analysis of both the type of injury (fractures, internal organ injury, trauma, etc.) and the site of the injury (brain, thorax, extremities, etc.). We will continue to work closely with our international partners on refining this framework to allow for consensus in the presentation format of nature of injury codes for both morbidity and mortality injury analyses.

What can be gained from a matrix presentation of the multiple causes of death in injury mortality?

The matrix presentation format utilized in this analysis provides interesting insight into the patterns of reported injuries that result from different external causes of death. The underlying external causes of death are grouped by mechanism and intent in the recommended format for presenting injury mortality data.¹² All injury conditions listed on the death certificate were included in these analyses.

Figure 1 shows the types of injuries associated with four different external causes of injury death: motor-vehicle traffic, firearm, cut or pierce, and fall deaths. Fractures account for 30% of all injuries sustained in fall deaths, 13% in motor-vehicle deaths, and a very small percentage of injuries sustained in firearm and cut/pierce deaths. Conversely, open wounds account for 78% and 68% of the injuries reported in firearm and cut/pierce deaths while they make up less than 1% of the injuries in motor vehicle or fall deaths.

Internal organ injuries account for about 45% of all injuries sustained in motor-vehicle traffic and fall deaths. By utilizing the matrix approach to injury diagnosis, differences in the location of the internal organ injury can be further examined. As shown in Figure 2, 84% of internal organ injuries in fall deaths are brain injuries. However, half of all internal organ injuries sustained in motor vehicle deaths are to the brain and 26% occur in the thorax. By further classifying internal organ injuries by site a very different pattern of injury emerges.

Figure 3 provides a second example of the importance of the matrix, by examining the pattern of fracture injuries associated with motor vehicle and fall fatalities in the U.S. for 1995. Overall, fractures account for 13% of all injuries reported for motor vehicle deaths and 29% of all fall deaths, indicating twice as many fractures are reported in fall deaths than motor vehicle deaths. As was the case for internal organ injuries, fracture patterns by body site are quite different for these two external causes. Thirty-five percent of all fractures sustained in motor vehicle deaths are to the skull, 24% are to the spine and back, 11% are to lower extremities, with less than 1% to the hip. However, nearly half (48%) of all fractures recorded in fall deaths are hip fractures with other lower extremity fractures the next most frequently recorded fracture in fall deaths (16%).

Figure 4 shows how the pattern of specific type of injury differs based on the intent provided in the external cause. This graph demonstrates the differences in the location of internal organ injuries for firearm deaths. Internal organ injuries account for 15% of all injuries recorded in firearm suicide deaths and range up to 20% of all injuries recorded in unintentional firearm deaths. The location of the internal injuries is very different however depending on the manner of death. Eighty percent of the internal organ injuries in firearm suicide deaths are to the brain, 54% of the internal organ injuries are to the brain in unintentional firearm deaths, and 31% are to the head in firearm homicides. There are significantly more internal injuries to the thorax and abdomen in firearm homicides than in the other firearm intent categories.

These are just a few examples of the types of analyses that illustrate the value of multiple cause analyses. More detailed analysis will provide greater insight into the types of injuries associated with each external cause of injury death.

How can multiple cause of death data be used to further identify injuries that are not captured by the underlying cause of death?

Another use of the multiple cause-of-death data is to further identify certain types of external causes of injury that are not listed as the underlying cause of death but appear on the death certificate as a contributing cause of death. There are a limited number of mechanisms of injury death that can be coded in ICD-9 both as external cause codes (E800-E999) and as nature of injury codes (800-999). For example, deaths caused by suffocation will be coded with an underlying external cause of death code of E911-E913, E953, E963, or E983. Deaths involving asphyxiation and strangulation but not primarily caused by suffocation can be coded with a nature of injury code of 994.7 as a multiple cause of death.

Figure 5 illustrates how multiple cause-of-death data can provide additional information about the number of deaths caused by suffocation or involving suffocation. In 1995, there were 10,376 deaths with suffocation listed as the underlying cause of death. Sixty-nine percent of these deaths were also coded with an ICD-9 diagnosis code of 994.7 (asphyxiation and strangulation), 31% of these deaths did not have coded information involving asphyxiation or strangulation in the multiple causes of death data. An additional 1,234 deaths are noted where suffocation was not determined to be the underlying cause of death but asphyxiation and strangulation were listed as contributing injuries in that death. Ninety-two percent of these deaths were injury deaths with motor vehicle traffic the most frequently coded underlying cause of death (28%). In these cases, it would seem that while the death was not ultimately determined to be principally caused by suffocation, suffocation did however play a part in the injury fatality. This is an important concept for understanding the causal pathways in an injury death. By examining the multiple causes of death, it is possible to capture additional information about certain types of injuries that contributed to deaths that were ultimately attributable to other external causes.

The multiple causes of death data also provide an additional opportunity to investigate the role of "secondary" external cause codes. These are additional codes for mechanisms of injury that were not determined to be the underlying external cause of death but also contributed to the injury death. Table 2 highlights the number of secondary external cause of death codes that appear in the multiple cause data for selected injury deaths. In 1995, there were 4,143 additional external causes coded for all injury deaths. The most commonly reported secondary external cause codes are for poisoning and suffocation. This table provides yet another illustration that by further examining the multiple causes of death there is a wealth of additional information available from death certificate data to injury researchers.

Conclusion

The analyses presented provide examples of a few of the practical uses of multiple cause of death data. They are meant to stimulate discussion among the ICE collaborators as to how to approach multiple cause data for injuries. By using an agreed upon framework for defining type and site of injury, injury researchers could use multiple cause -of-death data to determine the number of reported head injuries in a given year and what are the associated external causes or mechanisms of death. An additional application would be to examine the pattern of injuries sustained in car crash fatalities and the trends over time as additional safety features are implemented.

It is hoped that the proposed framework for presentation of the nature of injury codes from multiple cause of death data will be useful for comparative studies by other countries. However, much work remains to be done prior to any detailed comparisons of injury data between countries.

First, we need to conduct a comprehensive review of the number of countries that code multiple cause data and answer the following questions:

How many conditions are coded from the death certificate?

Is the coding process automated?

What version of ICD is used for coding death certificates?

What years of data are available?

Is multiple cause of death data coded for all deaths or a sample?

Second, to maximize the scope of the international collaboration we need to determine a consistent method for identifying a main injury diagnosis code. In addition, we will need to determine what coding guidelines are used to select the main injury for those countries that already do so.

Third, consensus must be reached on the framework for presentation of injury diagnosis data for morbidity and the adaptation for use with mortality data.

Finally, we need to recruit collaborators who would be willing to conduct a comprehensive review of their countries multiple cause coding procedures, be willing to work to achieve data comparability of the main injury diagnosis code and who would be willing to provide tabulated data for analysis.

Although there is a lot of work ahead we believe that this paper shows the usefulness and importance for these efforts. We look forward to working with other countries to conduct these analyses.

References

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Appendix I

Injury Mortality Matrix Codes for Body Region of Injury (Axis A)

Please note: the following list can be used if ICD is coded to the 4th digit; if only 3-digit codes are available follow instructions next to **.

1. Skull and Brain: excl. face ^(1,2) (incl. scalp)	800-801, 803-804 850-854 873.0-873.1 873.8-873.9 951		
		** Code 873 under Other	
		** Code 873 under Other	
2. Face	802 830 848.0 - 848.1 870 - 872 873.2 - 873.7 910 918 920-921 925.1 940 947.0 950		
		** Code 848 under Other	
		** Code 873 under Other	
		** Code 925 under Other	
		** Code 947 under Other	
Head ^(1,2) (Skull&Brain&Face)	800-804 850-854 870-873 830 848.0 - 848.1 910 918 920 - 921 925.1 940 947.0 950-951		
		** Code 848 under Other	
		** Code 925 under Other	
		** Code 947 under Other	
3. Neck ^(2,3,5,8)	807.5 - 807.6 848.2 874 900 925.2 947.1		
		**Code 807 under Thorax	
		**Code 848 under Other	
		**Code 925 under Other	
		**Code 947 under Other	

4. Thorax ^(4,5)	807.0 - 807.4	**Code 807 under Thorax
	848.3 - 848.4	**Code 848 under Other
	860 - 862	
	875	
	879.0 - 879.1	**Code 879 under Other
	901	
	922.0 - 922.1	**Code 922 under Other
5. Abdomen, pelvic contents, genital organs	947.2	**Code 947 under Other
	863 - 868	
	878	
	879.2 - 879.5	**Code 879 under Other
	902	
	922.2	**Code 922 under Other
	922.4	**Code 922 under Other
6. Spine and Back ^(6,7,8)	926.0	**Code 926 under Other
	947.3 - 947.4	**Code 947 under Other
	805	
	806	
	876 - 877	
	922.3	**Code 922 under Other
	839.0 - 839.5	**Code 839 under Other
7. Upper Extremity	847	
	952 - 953	
	810 - 818	
	831 - 834	
	840 - 842	
	880 - 887	
	903	
	912 - 915	
	923	
	927	
	943 - 944	
955		
959.2 - 959.5	**Code 959 under Other	

8. Lower Extremity and Bony Pelvis ⁽⁶⁾	808	
	821-827	
	835 - 838	
	843 - 845	
	846	
	848.5	**Code 848 under Other
	890-897	
	904	
	916 - 917	
	924	
	928	
	945	
	956	
	959.6 - 959.7	**Code 959 under Other
17. (Neck of femur fracture) ⁽⁹⁾	820	
9. Other and Ill-Defined Body Region	809	
	819	
	828	
	829	
	839.6 - 839.9	** Code 839 under Other
	848.8 - 848.9	** Code 848 under Other
	869	
	879.6 - 879.9	**Code 879 under Other
	911	
	919	
	922.8 - 922.9	**Code 922 under Other
	926.1	**Code 926 under Other
	926.8 - 926.9	**Code 926 under Other
	929	
	941-942	
	946	
	947.8 - 947.9	**Code 947 under Other
	948-949	
	954	
	957	
	959.0 - 959.1	**Code 959 under Other
	959.8 - 959.9	**Code 959 under Other
10. Foreign Bodies	930-939	
11. Poisonings	960-979	
12. Toxic Effects	980-989	
13. Other and Unspec Effects of External Causes	990-995	

Effects of reduced temperature	991
Effects of heat and light	992
Drowning	994.1
Asphyxiation and strangulation	994.7
Electrocution	994.8
All other Effects of External Causes	990, 993, 994.0, 994.2-994.6, 994.9, 995
14. Late Effects	905-909
15. Early Traumatic Complications	958
16. Complications of Surgical and Medical Care	996-999
18. No Injury	No diagnosis codes above 799

Notes to Body Region of Injury Classification

(1) Include 804 under *Head* (instead of *Multiple Body Regions*) even though it reads: *Multiple fractures involving skull or face with other bones*: assume that principal fracture is to the skull or face.

(2) Code all injuries to blood vessels of Head or Neck (900) under *Neck*; it is not easy to distinguish whether blood vessel is part of head or neck based only on third or fourth digit of ICD

(3) Injuries to trachea (typically categorized at 4th or 5th digit which is not available for mortality data) is classified under *Neck* (instead of *Thorax*)

(4) Injuries to the *trunk* unless otherwise specified are coded under *Other* since these injuries could be to the region of the thorax, abdomen or back

(5) Fx to larynx and trachea (807.5-807.6) are coded under *Neck* unless 3rd digit code only, then code under *thorax* and assume injury (fx) is more likely to be to ribs and /or sternum.

(6) Injuries to sacrum and coccyx are coded under *Spine* as they are typically only distinguishable from other injuries to the spine at the 4th or 5th digits.

(7) Injuries to buttock region (e.g., 877) are coded under *Spine and Back*

(8) Injuries classified under *Neck* include only those injuries to the front of the neck or soft tissue; injuries to the neck portion of the spine are classified under *Spine and Back*

(9) Neck of femur fractures have been classified separately.

Injury Mortality Matrix Codes for Nature of Injury
(Axis B)

1. Fractures ^(1,2)	800-805; 807-829
2. Dislocations	830 - 839
3. Sprains and Strains	840-848
4. Crushing Injury	925-929
5. Amputation of Limbs	885-887; 895-897
6. Injury to Internal Organs ^(2,3,4,5) incl. CNS injuries	860-869 850-854 952-953 806
7. Nerves ⁽⁴⁾	950-951; 954-957
8. Blood Vessels	900-904
9. Open Wounds ^(3,5)	870-884, 888-894
10. Superficial Injuries	910-919
11. Contusions	920-924
12. Burns	940-949
13. Effects of Foreign Bodies	930-939
14. Other Injury - (other and unspecified)	959
Multiple sites	959.8
All other sites	959.0-959.7
Unspecified sites	959.9
15. Poisonings	960-979
16. Toxic Effects	980-989
17. Other and Unspec. Effects of External Causes	990-995
Effects of reduced temperature	991
Effects of heat and light	992
Drowning	994.1
Asphyxiation and strangulation	994.7
Electrocution	994.8
All other Effects of External Causes	990, 993, 994.0, 994.2-994.6, 994.9, 995
18. Late Effects of Injuries etc.	905-909
19. Early Complications of trauma	958
20. Complications of Surgical and Medical Care	996-999
21. No Injury	No diagnosis codes above 7990

Notes to Nature of Injury Classification

(1) **Fractures** include skull fractures with intracranial injury; **HOWEVER**, if data are coded to the fourth digit; include the following codes (i.e. intracranial injuries with skull fx) under Injury to Internal Organs:

800.1 - 800.4	801.1 - 801.4
800.6 - 800.9	801.6 - 801.9
803.1 - 803.4	804.1 - 804.4
803.6 - 803.9	804.6 - 804.9

(2) **Fractures** exclude spine fxs with SCI; they are classified under **Injuries to Internal Organs**;

(3) **Injuries to Internal Organs** include CNS injuries (injuries to the brain and spinal cord); they also include injuries to larynx, trachea, pharynx and thyroid; they do NOT include injuries to internal structures of the eye, ear, and nose (these are included under **Open Wounds**);

(4) **Injuries to Nerves** exclude injuries to nerve roots to spine and spinal plexus (953) -- these are included under **Injury to Internal Organs**;

(5) **Open Wounds** includes injuries to the larynx, trachea, pharynx and thyroid; **HOWEVER**, if data are only coded to the fourth digit, include codes 874.0-874.5 (i.e. injuries to larynx, trachea, pharynx and thyroid) under **Injury to Internal Organs**.

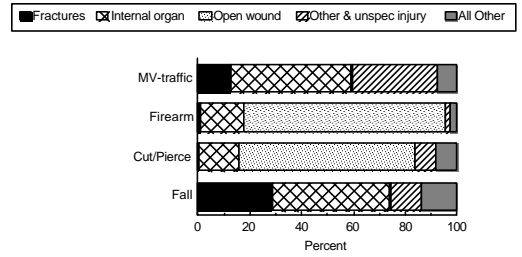
(6) The United States Multiple Cause of Death does not include 4th digit classification for intracranial injuries with skull fx (800-804) or injuries to larynx, trachea, pharynx and thyroid (874.0-874.5).

Table 1. Percent distribution of nature of injury conditions for injury deaths (n = 147,891), U.S., 1995

Number of injury conditions on death certificate	Percent of certificates
0	0.9
1	64.0
2	23.7
3	7.2
4	2.5
5+	1.7
Total	100.0

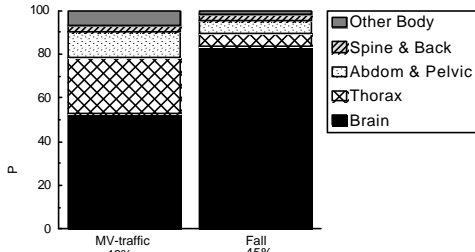
Note: Injury conditions are defined as ICD-9 codes: 800.0 - 999.9

Figure 1. Injuries associated with specified external causes: U.S., 1995



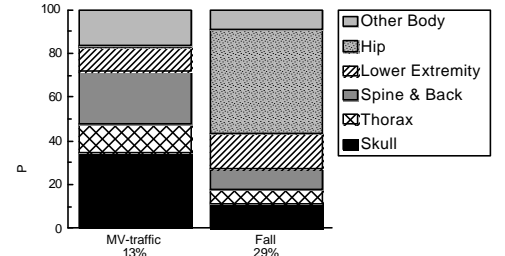
NOTE: See Injury Mortality Matrix Codes for Nature of Injury (Axis B) for ICD-9 coding definitions.

Figure 2. Internal organ injuries by body site associated with motor vehicle and fall fatalities: U.S., 1995



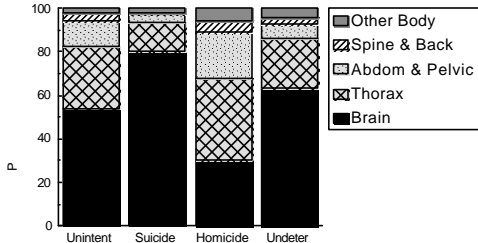
NOTE: See Injury Mortality Matrix Codes for Body Region of Injury (Axis A) and Nature of Injury (Axis B) for ICD-9 coding definitions.

Figure 3. Fracture injuries by body site associated with motor vehicle and fall fatalities: U.S., 1995



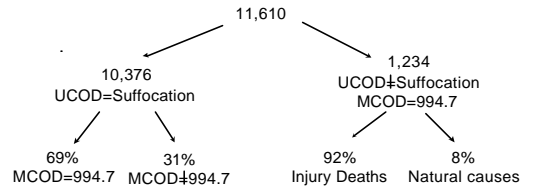
NOTE: See Injury Mortality Matrix Codes for Body Region of Injury (Axis A) and Nature of Injury (Axis B) for ICD-9 coding definitions.

Figure 4. Internal organ injuries by body site associated with firearm fatalities: U.S., 1995



NOTE: See Injury Mortality Matrix Codes for Body Region of Injury (Axis A) and Nature of Injury (Axis B) for ICD-9 coding definitions.

Figure 5. Deaths caused by or involving suffocation, U.S., 1995



NOTE: Suffocation is defined as Underlying Cause of Death (UCOD)= E911-913.9, E953.0-9, E963, E983.0-9 or Multiple Cause of Death (MCOD) = 994.7

Table 2. Number of secondary E-codes by Underlying Cause of Death, U.S., 1995

	Total injury deaths	Underlying Cause of Death					
		MVTC	Firearm	Poison	Falls	Suffoc	Unspec.
Number of Deaths	147,891	42,452	35,957	16,307	11,275	10,376	7,878
Secondary E-code							
MVTC	59	13	4	10	4	4	8
Firearm	93	3	48	5	1	1	7
Poison	1,608	63	45	1,193	33	90	16
Falls	60	0	3	15	13	3	2
Suffocation	684	110	46	134	94	35	128
Other Spec	45	3	4	5	11	7	5
NEC	84	0	20	10	2	15	2
Unspec.	144	10	15	39	6	22	7
Other E codes	340	9	56	68	28	41	36
Total	3,117	211	241	1,479	192	218	211
% of deaths with a secondary E-code	2.1	0.5	0.7	9.1	1.7	2.1	2.7

Note: E-codes are defined as ICD-9 codes: E800.0 - E999.9

Proportion of all injuries associated with drowning and boating cases: U.S., 1995

