

International Comparisons of Drowning Mortality: the value of multiple cause data

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Introduction

Comparisons of disease rates between countries have identified wide variations in incidence between countries. Many of these differences have been found to be real and have led to important suggestions for identifying etiological factors. However, some of these differences are due to variations in mortality coding practices between countries. Previous work, both as part of this injury, ICE and others has also identified wide variations in injury rates between countries.^{1,2,3} However, questions have been raised as to whether these observed variations are due to real differences in incidence or due, in part, to differences in coding practices for injury deaths. For example, our earlier work suggested that dramatic differences in fall mortality between New Zealand and the United States may be due in large part to differences in coding injury deaths in the elderly.^{4,5,6}

As part of this ICE on injury statistics, the Wet ICE Collaborative group has been using drownings as a sentinel, or tracer condition to examine in detail differences in injury rates in order to uncover potential problems, and differences in coding injury deaths between countries. Unintentional or "accidental" drowning deaths were found to vary widely between countries. However, when drownings were examined with the matrix developed to examine injuries regardless of intent, there was much less variation in rates. This suggests big differences in coding intent. For example, 40% of all drownings in England and Wales were coded as undetermined intent (E984), while only 5% were so coded in the United States and New Zealand (only 1% in Israel).^{3,7,8}

Injuries may also have multiple causes that are not adequately described by single underlying causes of death. Multiple cause of death coding records all conditions listed on the death certificate. Many drowning deaths for example may be coded as due to other causes such as transportation, or falls. Our earlier work found that 17.6% of all drownings were coded with other injuries as the underlying cause.⁹ In addition disease conditions may be coded as the underlying cause (UC).^{10,11,12,13} WHO coding rules actually specify that drownings related to epilepsy should be coded as epilepsy rather than injury.¹⁰ This study seeks to evaluate international differences in drowning rates and coding practices between those countries in the injury ICE that we identified with some form of with multiple cause coding.

Methods

ICD code N994.1 and drowning E-codes E830, E832, E910, E954, E964 & E984 were used to identify all drowning deaths using multiple cause of death data from England and Wales, Canada, Denmark and The United States. Free text searches for the word drown were used to identify multiple cause drownings in New Zealand.

Multiple cause data for the United States was for 1995. The same year was used for Canada, but multiple cause data was available for only 20% of all injury deaths (from certain provinces). Data for England and Wales was for 1995-97. Denmark did not have full multiple cause codes but include one primary injury (N) code only. This data was for 1994-95 and was coded using ICD-10 which we converted to ICD-9 codes for comparability. New Zealand did not use multiple cause code data, but we used their free text data for 1992-97 using the word "drown" and other possible permutations to identify drownings as described in our earlier work.⁹

Results

The traditional drowning E-codes do not identify all drownings as defined by the nature of injury codes for drowning (N991.4) or by free text search (Table 1a & b). E-codes only identified 82.4% of drownings in New Zealand and 94.0% in England. In England, 35.5% of drownings were of undetermined intent (E984) while in most other countries it was less than 5%, although in Denmark it was 12.8% (Table 1). Motor vehicle traffic deaths comprise 11.4% of drownings in New Zealand but only 0.9% in Denmark. Only a small percentage of the drowning N-code deaths were coded with disease as the underlying cause (Table 2). These range from 5.5% in England and Wales, to only 1.9% in the United States, and 4.9% in New Zealand (data not shown).

Table 1a: Comparison of drowning deaths N991.4 by Country for injury deaths. (Number)

Assigned E codes	USA No.	CANADA No.	ENGLAND/ WALES No.	DENMARK No.	NEW ZEALAND No.
Drowning codes					
E830 Boat damage	288	113	29	27	412
E832 Boat - no damage	254	74	32	19	99
E910 Accidental drowning	3757	498	665	111	1024
E954 Suicide drowning	405	123	233	197	277
E964 Assault drowning	62	4	11	2	7
E984 Undetermined drowning	242	50	596	58	94
Subtotal	5008	863	1566	414	1913
Non-drowning codes					
E810-E819 Motor vehicle traffic	448	82	46	4	264
E820-E825 Motor vehicle non traffic	29	42	1	-	16
E831, E833-E838 Water transport	38	11	5	1	16
E840-E848 Air and space transport	29	7	5	-	16
E880-E888 Accidental falls	77	6	2	-	19
E900-E909 Natural/environmental	45	1	6	-	12
E950-E953, E955-E959 Suicide	79	11	11	2	30
E960-E963, E965-E989 Homicide	29	1	1	-	-
E980-E983, E985-E989 Undetermined	10	1	13	2	-
Other injuries	64	5	9	27	35
Subtotal	848	167	99	36	408
Total injuries	5856	1030	1665	450	2321

Table 1b: Comparison of drowning deaths N991.4 by Country for injury deaths. (Percent)

Assigned E codes	USA (%)	CANADA (%)	ENGLAND/W ALES (%)	DENMARK (%)	NEW ZEALAND (%)
Drowning codes					
E830 Boat damage	4.9	11	1.7	6	17.8
E832 Boat - no damage	4.3	7.3	2	4.2	14.3
E910 Accidental drowning	64.2	48.3	40	24.7	44.1
E954 Suicide drowning	6.9	11.9	13.9	43.8	11.9
E964 Assault drowning	1.1	0.4	0.7	0.4	0.3
E984 Undetermined drowning	4.1	4.9	35.5	12.8	4
Subtotal	85.5	83.8	94	92	82.4
Non-drowning codes					
E810-E819 Motor vehicle traffic	7.7	7.9	2.8	0.9	11.4
E820-E825 Motor vehicle non traffic	0.5	4.1	0.1	--	0.7
E831, E833-E838 Water transport	0.6	1.1	0.3	0.2	0.7
E840-E848 Air and space transport	0.5	0.7	0.3	--	0.7
E880-E888 Accidental falls	1.3	0.1	0.1	--	0.8
E900-E909 Natural and environmental	0.7	0.1	0.4	--	0.5
E950-E953, E955-E959 Suicide	1.3	1.1	0.7	--	1.3
E960-E963, E965-E989 Homicide	0.5	0.1	0.1	--	-
E980-E983, E985-E989 Undetermined	0.2	0.1	0.8	0.4	-
Other injuries	1.2	0.5	0.5	6	1.5
Subtotal	14.5	16.2	5.9	8	17.6
Total injuries	100	100	100	100	100

Table 2: Comparison of deaths with drowning as nature of injury (N994.1) by underlying cause, disease vs. injury, USA, Canada, England and Wales.

	USA		CANADA		ENGLAND/WALES	
	No.	(%)	No.	(%)	No.	(%)
Drowning E	5008	(83.9)	863	(81.8)	1566	(88.9)
Other injury	848	(14.2)	167	(15.8)	99	(5.6)
Disease deaths	113	(1.9)	25	(2.4)	96	(5.5)
Total deaths	5969	(100)	1055	(100)	1761	(100)

* Denmark no disease deaths UC with primary injury

The drowning nature of injury code (N994.1) was used as one of the multiple cause codes for 98.8% of the drowning E-codes as the underlying cause in the United States, 97.3% in Canada and 98.9% in England and Wales (Table 3). In contrast only 18.8% of the boat trauma deaths in the United States had N994.1 in any field.. The underlying causes of death for drownings identified by N994.1 are presented in the injury matrix format (regardless of intent)⁷ in Table 4 and summarized by intent in Table 3. Suffocation/asphyxia was the underlying cause for 4.2% of drownings in Denmark but only 0.1% in Canada.

Table 3: Drowning deaths as underlying cause and proportion with N994.1 on record by country.

Drowning Mechanism	USA	Canada	England/ Wales
Boat	96.8	94.0	98.4
Accident	99.1	97.6	97.8
Suicide	98.9	96.9	100
Homicide	92.5	100	100
Undetermined	99.1	98.0	99.7
TOTAL	98.8	97.3	98.9
Boat trauma	18.8	NA	11.9

Table 4a. Injury matrix for drownings (N994.1) by country, number of injuries

Mechanism	Number			
	USA	Canada	England/Wales	Denmark
1 Cutting/pierce	3	-	1	-
2 Drowning	5008	863	1566	414
3 Fall/pushed	133	11	4	1
4 Fire/burn	9	-	-	1
5 Firearm	3	-	-	1
6 Machinery	16	3	-	2
7 MV traffic	458	83	46	4
8 Pedal cyclist, other	5	-	-	1
9 Pedestrian, other	-	-	-	1
10 Transport, other	96	61	35	1
11 Natural/environ	45	1	6	1
12 Overexertion	-	-	-	-
13 Poisoning	19	1	2	1
14 Struck by, against	3	-	-	-
15 Suffocation	17	5	1	19
16 Other specified	9	2	9	0
17 NEC	18	-	-	1
18 Unspecified	14	-	13	2
19 Adverse effects	-	-	2	-
Total injury	5856	1030	1665	450

Table 4b. Injury matrix for drownings (N994.1) by country, distribution of injuries

Mechanism	Percent distribution			
	USA	Canada	England/Wales	Denmark
1 Cutting/pierce	0.1	-	0.1	-
2 Drowning	85.5	83.8	94.0	92.0
3 Fall/pushed	2.2	1.0	0.2	0.2
4 Fire/burn	0.2	-	-	0.2
5 Firearm	0.1	-	-	0.2
6 Machinery	0.3	0.3	-	0.4
7 MV traffic	7.7	7.9	2.8	0.9
8 Pedal cyclist, other	0.1	-	-	0.2
9 Pedestrian, other	-	-	-	0.2
10 Transport, other	1.6	5.9	2.1	0.2
11 Natural/environ	0.8	0.1	0.4	0.2
12 Overexertion	-	-	-	-
13 Poisoning	0.3	0.1	0.1	0.2
14 Struck by, against	0.1	-	-	-
15 Suffocation	0.3	0.5	0.1	4.2
16 Other specified	0.2	0.2	0.5	-
17 NEC	0.3	-	-	0.2
18 Unspecified	0.1	-	0.8	0.4
19 Adverse effects	-	-	0.1	-
Total injury	100	100	100	100

Death certificates often include medical diagnoses with the drowning deaths. Table 5 shows those drownings where the medical condition was listed as the underlying cause of death. For all drownings, medical conditions were the underlying cause of death for 1.9% of drownings in the United States, 2.4% in Canada and 5.5% in England and Wales. Additional analyses (not shown) found that 4.9% of drownings in New Zealand had a medical condition as an underlying cause. Denmark did not have full multiple cause data. Heart disease was the underlying cause of 0.8% of drownings in the United States, 0.7% in Canada, 0.4% in England and Wales and 1.1% in New Zealand.

Table 5: Medical conditions as underlying cause of death with drowning (N994.1) listed on death certificate. Number (and percent) of deaths by country.

Disease Group (ICD Code)	U.S.	Canada	England/ Wales
Neoplasm (140-239)	3 (0.1)	-	-
Metabolic (240-279)	1 ^x	-	1 (0.1)
Alcohol/drug abuse/dependence (303-305)	4 (0.1)	1 (0.1)	-
Mental retardation (319)	-	1 (0.1)	-
Epilepsy (345)	41 (0.7)	15 (1.4)	85 (4.8)
Other CNS, PNS ² (340-344, 344-359)	4 (0.1)	-	-
Acute MI ³ (410)	7 (0.1)	3 (0.3)	-
Other ischaemic HD ⁴ (411-414)	6 (0.1)	3 (0.3)	7 (0.4)
Cardiac dyschymias (427)	3 (0.1)	-	-
Ill defined HD ⁴ (429)	17 (0.3)	1 (0.1)	-
Other HD ⁴ (390-409, 415-426, 428)	11 (0.2)	-	-
Cerebrovascular (430-438)	3 (0.1)	-	1 (0.1)
Asthma (493)	-	-	1 (0.1)
Other respiratory (460-492, 494-519)	4 (0.1)	1 (0.1)	-
GI & GU ⁵ (520-629)	2 ^x	-	-
Other congenital heart (746)	2 ^x	-	1 (0.1)
Newborn (760-779)	5 (0.1)	-	-
Total disease	113 (1.9)	25 (2.4)	96 (5.5)
AII N994.1	5969 (100)	1055 (100)	1761 (100)

1 hypoglycaemia non-diabetic 2512

2 central and peripheral nervous system; includes demyelinating disease, cerebral palsy, muscular dystrophy

3 myocardial infarction

4 heart disease

5 gastrointestinal and genitourinary

^x less than 0.1%

For epilepsy the WHO coding rules states that this should be the underlying cause for drowning deaths.¹³ This rule was the result of pressure upon WHO from international epilepsy groups. Table 6 shows the analysis of drowning and epilepsy codes for the United States (ICD code for epilepsy is 345, but there is also a code 780.3 for non-specific convulsions that may include some epilepsy cases). In the United States, epilepsy is not always coded as the underlying

cause; only 41 of 51 cases (80%) were. In addition, 149 cases of drowning also have a convulsion (780.3) code; fifteen of these cases also have an epilepsy code. There is considerable variation in the proportion of drownings coded with epilepsy as the underlying cause: United States (0.7%), Canada (1.4%), England and Wales (4.8%) and New Zealand (1.1%).

Table 6. Drowning and epilepsy, USA 1995.

WHO rule says epilepsy should be coded as underlying cause for drowning. ICD 780.3 convulsion also exists

Underlying cause	All deaths	Epilepsy (ICD 345)	Convulsion (ICD 780.3)	Both (ICD 345 & 780.3)
Drowning E codes no 994.1	63	1	1	-
Drowning E codes with 994.1	5008	7	140	-
Subtotal Drowning	5071	8	141	-
Other injury with 994.1	920	2	8	-
Epilepsy with 994.1	41	41	15	15
Convulsion with 994.1	-	-	-	-
TOTAL	6032	51	164	15

SUMMARY

	All drowning		Drowning with N994.5		Epilepsy U/C
	No.	(%)	No.	(%)	
Any drownings with epilepsy (N or E code)	51	(0.8%)	50	(0.8)	41
Any drownings only convulsion	149	(2.5%)	148	(2.5)	-
Total either	200	(3.3%)	198	(3.3)	41
Total drownings	6032	(100)	5969	(100)	41

An important issue in analysing multiple cause data is to determine what is the main or immediate cause of death. The issues involved in this are discussed in depth in the accompanying paper in this symposium by Chris Cox.¹⁴ For the purposes of our analysis, we selected the immediate cause as the first listed injury on the death certificate. Aside from drowning, the next listed immediate cause was asphyxiation/strangulation (0.7%), hypothermia (0.4%) and head injury (0.1%) for all the drowning deaths identified (Table 7). When all boating fatalities (including boating trauma E830-838) were examined, only 74.1% had drowning listed as the intermediate cause, with head injury (7.5%) listed as the next leading cause (Table 8). These results are shown graphically in Figure 1 by the main injury groups.

Multiple cause data provide a useful means to understand what exactly are the injuries resulting from boating deaths. They also suggest that occupant protection may be an important, but previously unrecognized issue, in boating fatalities.

Table 7. Drowning deaths (all E-codes) by immediate cause of death and any injury on death certificate, U.S. 1995

	Immediate cause		Any injury	
	No.	(%)	No.	(%)
Drowning (N994.1)	4938	(97.4)	5008	(90.3)
Asphyxia/strangulation	22	(0.7)	37	(0.7)
Hypothermia	20	(0.4)	83	(1.5)
Head injury	13	(0.3)	82	(1.5)
Internal injury	7	(0.1)	33	(0.6)
Early complications	11	(0.2)	20	(0.4)
Fracture spine/back	4	(0.1)	11	(0.2)
Poisoning	2*		99	(1.8)
Burns	1*		6	(0.1)
Toxic effects	0		16	(0.3)
Late effects	1*		13	(0.2)
Comp surg/med care	0		1*	
Multiple sites	17	(0.3)	32	(0.6)
Other/unspec. sites	6	(0.1)	38	(0.6)
Other injuries	17	(0.3)	48	(0.9)
No injury codes	22	(0.4)	22	(0.4)
TOTAL	5071	(100)	5549	(100)

* less than 0.1%

Table 8. Boating fatalities by immediate cause of death compared to any injury in record axis, U.S. 1995

	Immediate cause		Any injury	
	No.	(%)	No.	(%)
Drowning(N994.1)	565	(74.1)	580	(61.5)
Head injury	57	(7.5)	93	(9.9)
Internal injury	29	(3.8)	60	(6.4)
Hypothermia	14	(1.8)	43	(4.6)
Toxic effects	8	(1.0)	10	(1.1)
Blood vessels	8	(1.0)	11	(1.2)
Fracture spine/back	5	(0.7)	7	(0.7)
Burns	4	(0.5)	5	(0.5)
Early complications	4	(0.5)	5	(0.5)
Asphyxia/strangulation	2	(0.3)	3	(0.3)
Multiple sites	31	(4.1)	73	(7.7)
Other/unspec. sites	17	(2.2)	39	(4.1)
Other injuries	13	(1.7)	9	(1.0)
No injury codes	5	(0.7)	5	(0.5)
TOTAL	762	(100)	943	(100)

Conclusions

Multiple cause of death data allow all deaths due to drowning to be identified, not just those coded using standard ICD codes. The wide variation in the proportion of all drownings coded to the various underlying cause categories suggests that some of the wide variation in drowning rates between countries may in fact be due to differences in coding practices. Accidental drowning rates (E910) are low in England but 36% of drownings are of undetermined intent, much higher than for other countries. Even among injury deaths the proportion of drownings classified as other causes indicate that many drowning deaths are missed by traditional E codes. In addition there are wide variations in selecting drowning as the underlying cause. Multiple cause coding is a means of improving our understanding of injury etiology and determining if differences in injury rates are real or due to differences in coding practices. They may also provide important information on exactly what type of injuries people die from, which may be useful in designing prevention strategies. However, more work is needed to fully understand

how injury data are coded and processed in different countries¹⁵ and how it influences multiple cause analyses.

References

1. Rockett IRH, Smith GS. Homicide, suicide, motor vehicle crash and fall mortality: United States' experience in a comparative perspective. *American Journal of Public Health*, 1989; 79:1396-1400.
2. Smith GS, Langlois JA, Rockett, IRH. International comparisons of injury mortality: Hypothesis generation, ecological studies and some data problems. In: *Proceedings of the International Collaborative Effort on Injury Statistics. Volume 1.* National Centre for Health Statistics, Hyattsville, MD. DHHS Publication No. (PHS) 95-1252, 1995;13:1-18.
3. Fingerhut L, Cox C, Warner M. International comparative analysis of injury mortality: Findings from the ICE on Injury Statistics. *NCHS Advance Data*, No. 303, October 1998. NCHS, CDC, U.S. Department of Health and Human Services.
4. Rooney C. Differences in the coding of injury deaths between England & Wales and the United States. In: *Proceedings of the International Collaborative Effort on Injury Statistics Volume II.* National Centre for Health Statistics, Hyattsville, MD. (DHHS Publication No. (PHS) 96-1252, 1996;15:1-23.
5. Rockett IRH and Smith GS. Suicide misclassification in an international context. In: *Proceedings of the International Collaborative Effort on Injury Statistics. Volume I.* National Centre for Health Statistics, Hyattsville, MD. (DHHS Publication No. (PHS) 95-1252, 1995;26:1-18.
6. Langlois JA, Smith GS, Baker SP, Langley J. International comparisons of injury mortality in the elderly: issues and differences between New Zealand and the United States. *International Journal of Epidemiology*, 1995;24:136-143.
7. Centers for Disease Control and Prevention. Recommended framework for presenting injury mortality data. *MMWR* 1997; 46 (RR-14):6-7.
8. Smith GS and the Wet ICE Collaborative Group. International Comparisons of Injury mortality databases: evaluation of their usefulness for drowning prevention and surveillance. In: *Proceedings of the International Collaborative Effort on Injury Statistics. Volume II.* National Centre for Health Statistics, Hyattsville, MD (DHHS Publication No. (PHS) 96-1252, 1996;6:1-29.
9. Smith GS, Langley JD. Drowning surveillance: how well do E codes identify submersion fatalities: *Injury Prevention*, 1998;4:135-139.
10. Israel RA, Rosenberg HM, Curtin IR. Analytical potential for multiple cause-of-death

data. *American Journal of Epidemiology*, 1986;124(2)161-79.

11. Rosenberg HM, Kochanek KD. The death certificate as a source of injury data. In: *Proceedings of the International Collaborative Effort on Injury Statistics, Volume I*. National Centre for Health Statistics, Hyattsville, MD (DHHS Publication No. (PHS) 95-1252, 1995:8-1.
12. National Centre for Health Statistics. *Vital statistics, instructions for classifying the underlying cause of death. NCHS instruction manual; part 2a*. Hyattsville, MD: Public Health Service. Published annually.
13. World Health Organization. *Manual of the International Statistical Classification of Diseases, Injuries, and Causes of Death, based on the recommendations of the Ninth Revision Conference, 1975. Volume I*. Geneva: World Health Organization. 1977.
14. Cox C S. Multiple Cause of Death and Injury. In: *Proceedings of the International Collaborative Effort on Injury Statistics, Volume 3*. National Center for Health Statistics, Hyattsville, MD. In this proceedings.(DHHS Publication 2000).
15. Rooney C, Warner M, Fingerhut LA. Mortality registration and classification results. In: *Proceedings of the International Collaborative Effort on Injury Statistics, Volume 3*. National Center for Health Statistics, Hyattsville, MD. In this proceedings. (DHHS Publication 2000)

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

