METHODOLOGIC ISSUES

Drowning surveillance: how well do E codes identify submersion fatalities

Gordon S Smith, John D Langley

Abstract

***Objectives*—The aim was to determine in New Zealand: (1) to what degree the International Classification of Diseases Supplementary Classification (ICD) external cause (E) codes for drowning identify all deaths involving drowning; (2) how the other drowning deaths are distributed across E codes; and (3) whether the proportion of drownings not identified by traditional ICD E codes has changed over time.**

***Methods*—Mortality files for the period 1977–92, which were coded in the range E800-E999 (external causes of injury and poisoning), were searched electronically using the keyword "drown".**

***Results*—2718 cases that involved drowning were identified. This represents a 17.7% increase in the number of cases one would identify using ICD drowning E codes alone. The majority (65%) of the 408 drownings not coded as such were coded as motor vehicle traffic crashes. The number of drownings that were not identified by ICD E codes remained relatively constant over time, although the number of deaths E coded as drowning declined significantly in recent years.**

***Conclusion*—Standard ICD E codes for drowning do not identify all drowning related deaths, which may make comparisons of injury rates between countries difficult, especially for injuries such as drownings and burns that can be both nature of injury and external cause codes. Multiple cause coding and the inclusion of free text narratives are an important tool to improve the value of a country's vital statistics for injury prevention, and facilitate comparisons with other countries.**

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Most studies of injury fatalities rely on use of standard groupings of codes to identify the injuries of interest. Little consideration is given to cases that may be missed by this approach, due either to misclassification or to the coding rules needed to define a single underlying cause even when there are multiple events in the sequence of events leading to death. The most widespread coding system for studying injury causes is the International Classification of Diseases Supplementary Classification (ICD) of external causes of injury and poisoning (E) codes.[1] As part of the International Collaborative Effort (ICE) on Injury Statistics,[2 3] studies are being undertaken that seek to evaluate and compare differences in vital statistics using specific injury types. One such study is on drownings, and participating countries are being asked to use the following standard codes to identify drownings and compare rates between countries.

E830: Accident to watercraft causing submersion

E832: Other accidental submersion or drowning in water transport accident

E910: Accidental drowning and submersion

E954: Suicide and self inflicted injury by submersion (drowning)

E964: Assault by submersion (drowning)

E984: Submersion (drowning) undetermined whether accidentally or purposely inflicted

Although this is the complete range of specific E codes for submersion injuries listed in ICD, it does not identify all cases of drowning in a country because there are drownings that occur under other circumstances and are thus coded with other E codes. There are well defined coding rules that give precedent to the initiating event for certain causes such as transportation, for example a motor vehicle going off the highway into the water. A single code does not capture that the person may then have drowned from what may have been a very minor traffic crash. An insight into the potential significance of such cases is provided by reference to some of the exclusions for E910 listed in ICD 9.[1] The full list of exclusions is:

- Diving accident (NOS) resulting in injury except drowning (E883.0)
- Diving with insufficient air supply (E913.2)
- Drowning and submersion due to cataclysm (E908–E909)
- Machinery accident (E919.0–E919.9)
- Transport accident (E800.0–845.9)
- Effect of high or low pressure (E902.2)
- Injury from striking against objects while in running water (E917.2)

Table 1 Drownings in New Zealand 1977–92. Distribution of cases identified by electronic search on the word "drown" according to assigned E codes

Assigned E codes	*Frequency (%)*
Drowning codes	
E830 Accident to watercraft causing submersion	412 (17.8)
E832 Other accidental submersion or drowning in water transport accident	9 (4.3)
E910 Accidental drowning and submersion	1024 (44.1)
E954 Suicide and self inflicted injury by submersion (drowning)	277 (11.0)
E964 Assault by submersion (drowning)	7 (0.3)
E984 Submersion (drowning) undetermined whether accidentally or purposely inflicted	94 (4.0)
Subtotal	1913 (82.4)
Non-drowning codes	
E810–E819 Motor vehicle traffic accidents	264 (11.4)
E820–E825 Motor vehicle non traffic accidents	16 (0.7)
E831, E833–E838 Water transport accidents	16 (0.7)
E840–E848 Air and space transport accidents	16 (0.7)
E880–E888 Accidental falls	19 (0.8)
E900–E909 Accidents due to natural and environmental factors	12 (0.5)
E950–E953, E955–E959 Suicide and self inflicted injury	30 (1.3)
Others	35 (1.5)
Subtotal	408 (17.6)
Total	2321 (100.0)

Table 2 Drownings in New Zealand 1977–92. Distribution of "other" drownings by common three digit E codes

Assigned E codes	*Frequency (%)*
E816 Motor vehicle traffic accident due to loss of control, without collision on the highway	220 (53.9)
E815 Other motor vehicle traffic accident involving collision on the highway	31 (7.6)
E957 Suicide and self inflicted injuries by jumping from a high place	22 (5.4)
E825 Other motor vehicle non-traffic accident of other and unspecified nature	14 (3.4)
E838 Other and unspecified water transport	11 (2.7)
E884 Other fall from one level to another	11 (2.7)
E841 Accident to powered aircraft, other, and unspecified	10 (2.5)
Miscellaneous (none greater than n=9)	89 (21.8)
Total	408 (100.0)

In the case where a drowning resulted from a single motor vehicle incident in which the vehicle failed to take a corner and crashed into a river, this would be coded as E816: Motor vehicle traffic accident due to loss of control, without collision on the highway. In this case when a single underlying cause of death statistic is used there is no way to determine that this death occurred due to drowning. Thus, rates based on the E codes listed for the proposed international drowning study will underestimate the frequency of all deaths where drowning was involved. The degree of the underestimate would depend on the physical environment in a given country, such as the length of roadway alongside lakes and rivers.

The aim of this study was to examine the following issues for New Zealand: (1) to what degree the ICD drowning E codes identify all deaths involving drowning; (2) how the drowning deaths are distributed across the full range of E codes; and (3) whether the proportion of drownings not identified by traditional ICD codes has changed over time.

An accurate assessment of all drowning and drowning related deaths is important to understand the true extent of the problem and ensure compatibility when comparing data between countries. In addition by focusing analyses on just single underlying causes of death we may be missing important opportunities for prevention, such as surviving an automobile crash into the water by ensuring a timely escape from the submerged vehicle, or installation of barriers to prevent drowning suicides resulting from jumping from high bridges.

Methods

New Zealand maintains an electronic national mortality data file. All injury deaths are coded according to the ICD E code rules.[1] Injury diagnoses and multiple causes of death are not coded. For each injury death there is an electronic field of up to 95 characters of narrative that is used to briefly describe the circumstances of death, including the nature of injury. There are no specific guidelines for completing this field. Information for this field is obtained from a variety of sources, including death certificates, coroner reports, and hospital files.

Mortality files for the period 1977–92, coded in the range E800–E999, were electronically searched using the key word "drown". In addition the standard ICD codes for drowning (E 830, 832, 910, 954, 964, and 984) were also examined. Trends in drowning deaths were evaluated using the GENMOD procedure.

Results

For the period 1977–92, 2310 drownings were recorded under the drowning codes listed above (E830, E832, E910, E954, E964, E984) of which only 397 did not have the word "drown" specifically listed in the free text. By searching for the term "drown" we identified 2321 cases. The narrative search thus revealed an additional 408 cases or 17.7% more cases than those recorded in drowning codes, resulting in a total of 2718 drowning related deaths identified by our study.

Table 1 shows the distribution of the drownings identified by the narrative search according to the E code groupings under which they were classified.

The majority (65%) of the extra 408 drownings discovered in the narrative search (hereafter referred to as "other" drownings) were coded as E810–E819: Motor vehicle traffic accidents. These incidents represent 11.4% of the drownings. The remainder of the "other" drownings were evenly distributed over a range of E code groupings (table 1).

Table 2 provides greater detail of the classification of the other drowning deaths, by listing the most common three digit E code categories to which they were coded. Three findings are of note. First, single vehicle crashes (E816) accounted for just over half of all cases and represent 9.4% of the drownings. For the same period there was a total of 2233 single vehicle crashes (E816), and drowning was mentioned as an outcome in the free text in 9.8% of these. Second, is the large number of suicide and self inflicted injuries by jumping from a high place (E957). Reference solely to E954 (suicide by drowning) will underestimate the size of all suicides involving drowning by 7%. Finally, a similar problem, although less significant, arises when seeking to determine the incidence of drownings associated with

water transport. The drowning codes in table 1 suggests there are 521 cases (E830, E832). Reference to non-drowning codes in table 1, however, suggests there were an additional 16 cases.

Analysis of the free text data provided more detail as to the exact circumstances of the injuries that were not E coded as drowning but mentioned "drown . . .." in the free text. Among the 30 additional suicides (table 1) identified by free text the largest category was jumping from a bridge with no other injury mentioned (14 cases). A further eight cases fell into the water but clearly had other injuries, four cases were suicides by driving automobiles into the water, three were associated with drug overdoses, and one case involved a self inflicted bullet wound to the chest and subsequent drowning in the water. Similarly for the 19 unintentional falls that had drowning mentioned in the free text, seven had no mention of other injuries but fell from places such as bridges, wharves or into pools, seven had clear evidence of head injuries from falls from rocks or cliffs into the water, three were swept off rocks and fell into rock pools with no mention of injury, one case was described as drowning after breaking his jaw in a fall and another after a spinal cord injury from diving into shallow water.

Analysis of drowning deaths over time (fig 1) found no change in the number of drowning related deaths that were coded as other injuries (non-drowning ICD E codes), although as a proportion of all drowning deaths they increased. There was however a significant drop in drowning deaths overall by 7% per year ($p < 0.0001$), due to the decline in the number of deaths E coded as drowning.

Discussion

The analyses presented here show that estimates of the incidence of all drowning related deaths in New Zealand will be underestimated by reference solely to the specific drowning E codes because deaths involving drowning can be assigned to other external causes such as motor vehicle crashes. It is likely that a similar situation exists in other countries. As indicated in our study, the actual rate for all types of drownings in New Zealand is increased by almost 18% if we use the free text search for the word "drown" to identify those cases classified elsewhere in the ICD coding system. The majority of the drownings that were not identified by standard ICD drowning codes were due to transportation related deaths (312 of 408 or 76.5%), of which most were due to motor vehicles (table 1). While the problem of drownings coded as traffic injuries has been recognised, to date, other than a study of drownings in one California County[4] we are unaware of any studies in peer reviewed literature that examine transportation related drownings. Baker *et al* estimated that about 5% of all drownings in the USA are due to motor vehicles,[5] although it is not described how these were determined. In Canada motor vehicles are estimated to be responsible for 7% of drownings[6] compared with our estimate of 11% for New Zealand. The proportion is likely to vary by country depending on both the completeness of case ascertainment and proximity of highways to bodies of water.

Many injuries, including drowning, are multifactorial and not well described by a single cause. In addition many may be more preventable early in the sequence of events (for example barriers to prevent motor vehicles going off an unprotected highway into the ocean or a depressed person jumping off a high bridge and drowning). In these circumstances it would be appropriate to code the initiating event as the primary or underlying cause of death. However, much important information is lost by relying on a single cause of death. The ICD coding rules recognise that there may be multiple factors responsible for a death and have defined rules to select a single underlying cause of death for the purpose of tabulating causes of death.[1] There are clear rules that give preference for transportation over other causes such as fires or drowning. However the rules for deciding on other single underlying causes are much less clear for injuries such as suicide, the only exception being for natural and environmental factors (for example floods or tidal waves: E908–E909), which take precedence over drowning. No guideline is provided in the ICD, for example, to clarify if a drowning resulting from a suicide jump from a high place, such as a bridge, should be classified as E954, suicide by submersion (drowning), or E957, suicide by jumping from a high place.

The determination of underlying cause of death is also confounded by the fact that blunt physical trauma may indeed be the actual cause of death for some falls/jumps from a high place. It is often difficult to determine if the subject dies from a ruptured aorta or from drowning, especially if necropsies are not done. The free text in our study did not mention the presence of other injuries for any of the suicide falls. However, it is well known that falls/jumps, such as those occurring from the Auckland Harbour Bridge, can result in serious blunt trauma injuries. Even in these cases however, drowning may be the actual cause of death. In almost half the drownings coded as unintentional falls

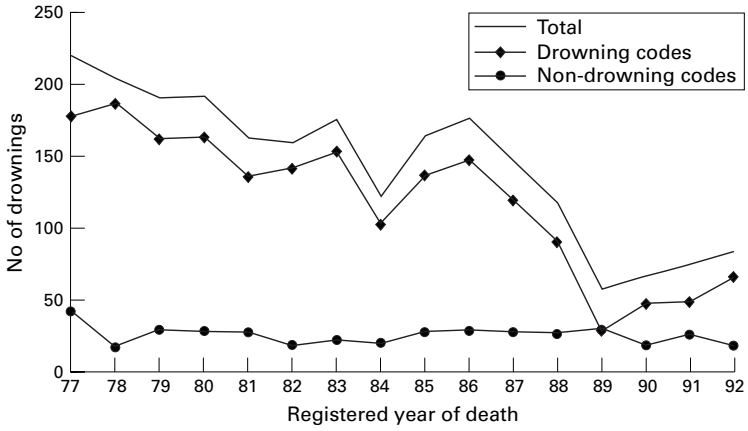

Figure 1 Identified drownings by underlying cause 1977–92.

there were descriptions of obvious associated injuries such as those to the head.

The multiple cause of death classification system[7 8] is used by some countries in an effort to recognise that multiple diseases or conditions are often related to a person's death (for example diabetes and heart disease). This system relies on the selection of one single underlying cause but also codes other related conditions. In the case of injuries this means that the external cause or E code is used as the underlying cause and that other conditions written on the death certificate can be coded. However, these can only be nature of injury codes and the system does not allow for multiple E codes. Drownings, burns, and poisonings are, however, injuries where the cause and nature of injury are similar. Drownings for example can be identified by the four digit nature of injury code ICD 994.1, drowning and non-fatal submersion. We found only one preliminary report that examined both N and E codes for drownings using 1987 data from Canada. The study found that 15% of all drowning deaths were not identified by drowning E codes but only by the nature of injury code N 994.1.[6] The distribution of other E codes was similar to our study. The study did however raise concerns that some of the deaths may have been miscoded or due to data entry errors. The author did not have access to free text or death certificates to check the event descriptions. Unfortunately, multiple cause of death data are not available in New Zealand nor in most other countries. In the absence of multiple cause data, the free text provides a useful alternative that is probably as valuable and has the added advantage of providing more insight into the circumstances surrounding the drowning.

Many other studies have shown the value of multiple cause of death data and that even when a single underlying cause of death is used there can be wide differences in practices in certifying the single underlying cause.[8–14] In addition, several articles have discussed the problem of under counting injury deaths (especially in the elderly) through the selection of associated diseases or complications (for example pneumonia) as the underlying cause of death.[15 16] However, we found only one other article that specifically examined discrepancies in coding causes for injury deaths and these compared death certificates only with more in-depth case records.[17] For our study it should be emphasised that the revised estimate of intentional self drownings (n = 116, 4.9%) probably remains an underestimate. For example, some of the single vehicle motor vehicle crashes may be intentionally self inflicted. Support for this view is provided by a detailed investigation into drownings in the Auckland area. The study estimated that 28% of all adult drownings were intentionally self inflicted.[18]

It is also recognised that when multiple causes of death are recorded the tendency to select specific conditions as the single underlying cause may vary both over time, within a country, and between countries.[8] We were also concerned in our study that changes may have occurred over time in coding practice for drownings. Our analyses revealed that the number of "other" drowning deaths changed little and that there had been an overall decline in deaths coded as due to drownings (fig 1). Similar declines have been noted in other countries.[3 19]

Considerable attention has been given to improvement of rules for selecting a single underlying cause of death for diseases but not for injuries. A recent report for the US National Center for Health Statistics has attempted to define these rules for injury hospitalisation but they are not yet internationally recognised.[20] To date there have not been published validation studies of the consistency of injury cause of death coding either between coders in the same country or between countries.

Other studies have documented the value of free text to both more fully understand the circumstances surrounding an injury and to use it to identify specific injuries missed by conventional coding. The National Traumatic Occupational Fatalities surveillance system in the United States, for example, records the limited free text description of "how the injury occurred" from work related death certificates.[21] This narrative has been used to identify "missed" tractor related deaths because these can be correctly coded as motor vehicles according to ICD 9 rules if they occur on a public roadway. The addition of free text on the vital statistics data also provides a valuable opportunity to verify the coding of specific causes of death and is the reason the system was implemented in New Zealand. It also gives the potential for going back easily and reclassifying causes of death if coding rules change. It is also possible to "train" computers to code narrative data through pattern recognition of key strings of text. Future use of such methods for coding free text could lead to improved means to code key variables.[22]

In the absence of specific guidelines on the contents of the free text field, it seems likely that the estimates of drowning produced in our study are underestimates because limited space may have precluded mention of injury diagnosis in some cases. Adding a mandatory diagnostic field that addresses the type of injury causing death would remedy this problem and will be available in New Zealand for 1995 mortality data onwards. An indication of the potential significance of further drownings is provided by reference to the New Zealand Water Safety Councils' (NZWSC) independent estimates. These are obtained from a variety of sources in New Zealand. For the period 1980–92 inclusive, they estimated there were 2297 drownings, 35% more than that derived from our free text analyses (n = 1706) for the same period, and still 217 cases more than the estimate of 2080 from combining free text and E codes for drowning. Differences in coding frames and potentially different criteria for counting a case preclude a simple determination of why this discrepancy exists. From a national perspective the discrepancy is of considerable concern given that the NZWSC is seen as the principal organisation for promoting water safety. Future

research in this area should give priority to matching the two data files with a view to determining where the discrepancies occur and arriving at an accurate estimate of the incidence of all drownings and specific drowning types.

Given the considerable observed and potential undercount of drownings in New Zealand based on standard ICD codes, caution should also be exercised in comparing injuries, such as drownings, between countries. The likelihood of coding some drownings to another underlying cause is not unique to New Zealand as the same coding rules apply elsewhere. While some countries cause of death statistics allow for coding multiple diseases relating to the cause of death, including several nature of injury codes, only a single underlying external cause of injury is usually reported. The recording of multiple E codes has been recommended for injury hospitalisations[23] to enable the sequence of injury causes to be better described but, as yet, the rules to describe the sequencing of several causes such as a jump from a high place followed by drowning (for suicide) have not been determined. However, the expansion of multiple E codes to the well established tradition for disease deaths would allow for a more complete understanding of injury causes, especially in the absence of free text fields such as exist in New Zealand.

Much important information on injury aetiology is lost by reliance on a single underlying cause of death to describe the series of events that ultimately leads to an injury death. Some effective prevention strategies may in fact be missed by focusing only on underlying causes of injury. Examples include erecting barriers around hazardous roadways in close proximity to water, or preventing an epileptic seizure from resulting in a drowning death. Multiple cause coding and inclusion of free text narratives are an important tool available to any country wishing to improve the value of their vital statistics for injury prevention, and comparisons with other countries.

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1 World Health Organisation. *International classification of diseases, 1975 revision.* Geneva: WHO, 1977.
2 Smith GS, Langlois JA, Rockett IRH. International comparisons of injury mortality: hypothesis generation, ecological studies, and some data problems. *Proceedings of the International Collaborative Effort on Injury Statistics*. Volume 1. Hyattsville, MD: National Center for Health Statistics, 1995;**13**:1–15. (DHHS publication No (PHS) 95–1252.)
3 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. Melbourne Meeting: Working Papers. Hyattsville, MD: Public Health Service, Centers for Disease Control and Prevention, National Center for Health Statistics, 1996;**6**:1–29. (DHHS publication No (PHS) 96–1252.)
4 Wintemute GJ, Kraus JF, Teret SP, *et al.* Deaths resulting from motor vehicle immersions: the nature of the injuries, personal and environmental contributing factors, and potential interventions. *Am J Public Health* 1990;**80**:1068–70.
5 Baker SP, O'Neill B, Ginsburg MJ, *et al. The injury fact book.* 2nd Ed. New York, NY: Oxford University Press, 1992.
6 Bracker A. Drowning deaths: a cross-analysis of external cause and nature of injury codes. Ottawa, ON: Canadian Centre for Health Information, Statistics Canada. *Health Reports* 1989;**1**:225–8.
7 Israel RA, Rosenberg HM, Curtin LR. Analytical potential for multiple cause-of-death data. *Am J Epidemiol* 1986;**124**:161–81.
8 Lindahl BIB, Johansson LA. Multiple cause-of-death data as a tool for detecting artificial trends in the underlying cause statistics: a methodological study. *Scand J Soc Med* 1994;**2**:145–58.
9 Gittelsohn A, Royston PN. *Annotated bibliography of cause-of-death validation studies 1958–1980.* Hyattsville, MD: National Center for Health Statistics, 1982. (DHHS publication No (PHS) 82–1363. Vital and health statistics, data evaluation and methods research; series 2; No 89.)
10 World Health Organisation. The accuracy and comparability of death statistics. *WHO Chronicle* 1967;**21**:11–17.
11 Jougla E, Papoz L, Balkau B, *et al.* EURODIAB Subarea C Study Group: death certificate coding practices related to diabetes in European countries: the "Eurodiab Subarea C" Study. *Int J Epidemiol* 1992;**21**:343–51.
12 Percy C, Stanek E, Gloeckler L. Accuracy of cancer death certificates and its effect on cancer mortality statistics. *Am J Public Health* 1981;**71**:242–50.
13 Percy C, Muir C. The international comparability of cancer mortality data. *Am J Epidemiol* 1989;**129**:934–46.
14 Kelson M, Farebrother M. The effect of inaccuracies in death certification and coding practices in the European Economic Community on international cancer mortality statistics. *Int J Epidemiol* 1987;**16**:411–14.
15 Fife D. Injuries and deaths among elderly persons. *Am J Epidemiol* 1987;**126**:936–41.
16 Langlois JA, Smith GS, Baker SP, *et al.* International comparisons of injury mortality in the elderly: issues and differences between New Zealand and the United States. *Int J Epidemiol* 1995;**24**:136–43.
17 Moyer LA, Boyle CA, Pollock DA. Validity of death certificates for injury-related causes of death. *Am J Epidemiol* 1989;**130**:1024–32.
18 Cairns FJ, Koelmeyer TD, Smeeton WMI. Deaths from drowning. *N Z Med J* 1984;**97**:65–7.
19 Smith GS, Brenner RA. The changing risks of drowning for adolescents in the US and effective control strategies. *Adolescent Medicine; State of the Art Reviews* 1995;**6**:153–69.
20 Center for Health Policy Studies. *Recommended coding guidelines for external cause of injury for hospital discharge data.* Final report for the National Center for Health Statistics, Contract Number 200–92–7031. Center for Policy Studies, 9700 Patuxent Woods Drive, Columbia, MD 21046, 1994.
21 Jenkins EL, Hard DL. Implications for the use of E-codes of the International Classification of Diseases and narrative data in identifying tractor-related deaths in agriculture, United States, 1980–1986. *Scand J Work Environ Health* 1992;**92**(18)suppl 2:49–50.
22 Sorock GS, Smith GS, Reeve GR, *et al.* Three perspectives on work-related injury surveillance systems: narrative data analysis, date set linkage, and comprehensive company-wide surveillance. *Am J Ind Med* 1997;**32**:116–28.
23 National Committee on Vital and Health Statistics Appendix VI. *Report on the need to collect external cause-of-injury codes in hospital discharge data.* National Center for Health Statistics. The National Committee on Vital and Health Statistics 1991 annual report. Hyattsville, MD: National Center for Health Statistics, 1992:84–124. (DHHS publication No (PHS) 29–1205.)