New Zealand Injury Prevention Strategy indicators of injury death: Are we counting all the cases?

Colin Cryer | Pauline Gulliver | Ari Samaranayaka | Gabrielle Davie | John Langley
INJURY PREVENTION RESEARCH UNIT UNIVERSITY OF OTAGO

Christine Fowler
SECTOR SERVICES MINISTRY OF HEALTH

March 2010

ISBN 0-908958-82X
OR085

UNIVERSITY of OTAGO
SAPERE AUDE
Te Whare Wānanga o Otāgo
NEW ZEALAND

NZIPS indicators of injury death:
Are we counting all the cases?

Colin Cryer

Pauline Gulliver

Ari Samaranayaka

Gabrielle Davie

John Langley

Injury Prevention Research Unit

University of Otago

Christine Fowler

Sector Services

Ministry of Health

March 2010

ISBN 0-908958-82-X OR085

Recommended Citation:

Cryer C, Gulliver P, Samaranayaka A, Davie G, Langley J, Fowler C. NZIPS indicators of injury death: Are we counting all the cases? IPRU Occasional Report OR085 Dunedin: Injury Prevention Research Unit, University of Otago, March 2010.

Contents

Tables and Figures 6
Abbreviations 7
Acknowledgements 8
Summary 9
Background 9
Purpose 11
Aims: 11
Cause of injury death 12
Methods 13
Results 14
Discussion 16
Introduction: 19
Purpose 22
Aims: 22
Theoretical definition of injury death 23
Methods 25
Aim 1: To characterize the subgroups where there is a discrepancy 25
Population 25
Sources of data 25
Linkage of NMDS to MC 25
Operational definitions of injury 26
Choice of time to death threshold 26
Description of the mismatch by selected variables 27
Aim 2: To describe any lack of correspondence between data captured in NMDS and MC. 27
Statistical method 27
Aim 3: Identify an optimal method of identifying injury deaths from the Mortality Collection 28
Process of capture of mortality diagnoses 28
Literature review 28
Theoretical and operational definitions of injury death 29
Mismatch between WHO coding rules and the theoretical definition of injury death 29
Description of the likely differences in case ascertainment at a theoretical level. 30
Review of a sample of records 30
Results 33
Aim 1: To characterize the subgroups where there is a discrepancy 33
Linkage of NMDS to MC 33
Description of the mismatch by selected variables 34

Aim 2: To describe any lack of correspondence between data captured on the NMDS and the MC. 39

Correspondence by age, sex, cause and intent 39

Aim 3: Identify an optimal method of identifying injury deaths from the Mortality Collection 41

Process of capture of mortality diagnoses on the MC 41

Literature review 42

Theoretical and proposed operational definitions of injury death 42

Mismatch between WHO coding rules and the theoretical definition of injury death 44

Results of the review of a sample of records 45

Illustration of the discrepancies between NMDS and MC 46

Case Scenarios 47

Discussion 53

Theoretical definition of injury death 53

Patterns of discrepancy between NMDS PDx and MC UCoD 53

Implications for the operational definition of injury 60

Discussion of the review of a sample of records and their implications for the partially specified proposed operational definition of injury death 61

What needs to be done to finalise the new operational definition? 63

Correspondence of NMDS and MC data 64

Strengths and Limitations 65

Conclusions 66

Recommendations 67

References 71

Attachment 1: The capture of mortality data 73

Attachment 2: Systematic Literature Review 83

Tables and Figures

Table 1: The number of people with an NMDS PDx who died and were assigned a medical UCoD, by subgroup and time to death. 31
Table 2: The mismatch between NMDS and MC by gender and age. 36
Table 3: The mismatch between NMDS and MC by external cause, intent and principal diagnosis of the first hospital discharge after injury. 37
Table 4: The mismatch between NMDS and MC by principal diagnosis of the last hospital discharge before death, severity of injury, comorbid conditions and whether the person died in hospital. 38
Table 5: Correspondence between the data captured by NMDS and MC for E-code group 40
Table 6: Correspondence between the data captured by NMDS and MC for Intent. 40
Table 7: Results of the review of a sample of records: codes showing the likelihood that injury was a necessary cause of death (1&2 = likely; 3&4 = unlikely). 46
Table 8: Number and percentage of %UCoD=NI for deaths within 7 days of injury for older people, falls, FNOF and gender. 57

Figure 1: Trend in the NZIPS all fatal injury rate. 9
Figure 2: Correspondence between age as recorded on NMDS and age as recorded on MC. 39

Abbreviations

ABS	Australian Bureau of Statistics
CF	Christine Fowler
COPD	Chronic Obstructive Pulmonary Disease
CVA	Cerebrovascular Accident
CVD	Cerebrovascular Disease (ie. stroke)
E-code	WHO ICD external cause of injury code
FN	False Negative
FNOF	Fractured Neck of Femur
FP	False Positive
ICD	International Statistical Classification of Diseases and Related Heath Problems
ICD-10	ICD 10th Revision
ICD-10-AM	ICD 10th Revision, Australian Modification
ICE	International Collaborative Effort on Injury Statistics
ICISS	ICD-based Injury Severity Score
IHD	Ischaemic Heart Disease
LTNZ	Land Transport New Zealand
MC	Mortality Collection
MCoD	Medical Certificate of Causes of Death
MI	Myocardial Infarction
MoH	Ministry of Health
MoT	Ministry of Transport
MVTC	Motor Vehicle Traffic Crash
NHI	National Health Index
NI	Non-injury
%NI	Percentage of deaths with an underlying cause of death of non-injury
NMDS	National Minimum Data Set
NZIPS	New Zealand Injury Prevention Strategy
PDx	Principal Diagnosis
PDx(1st)	PDx on the first discharge record after the injury event
PDx(last)	PDx on the last discharge record before death (or on which it is recorded as discharged dead.
PG	Pauline Gulliver
TBI	Traumatic Brain Injury
UCoD	Underlying Cause of Death
WHO	World Health Organization

Acknowledgements

This research was supported by the New Zealand Accident Compensation Corporation (ACC). The views expressed in this paper are those of the authors and do not necessarily reflect those of the ACC. We thank Renate Kreisfeld and James Harrison, Research Centre for Injury Studies Flinders University of South Australia, for their helpful comments, on the penultimate draft of this manuscript. This work is based on data supplied to the Injury Prevention Research Unit at the University of Otago by the Ministry of Health.

Summary

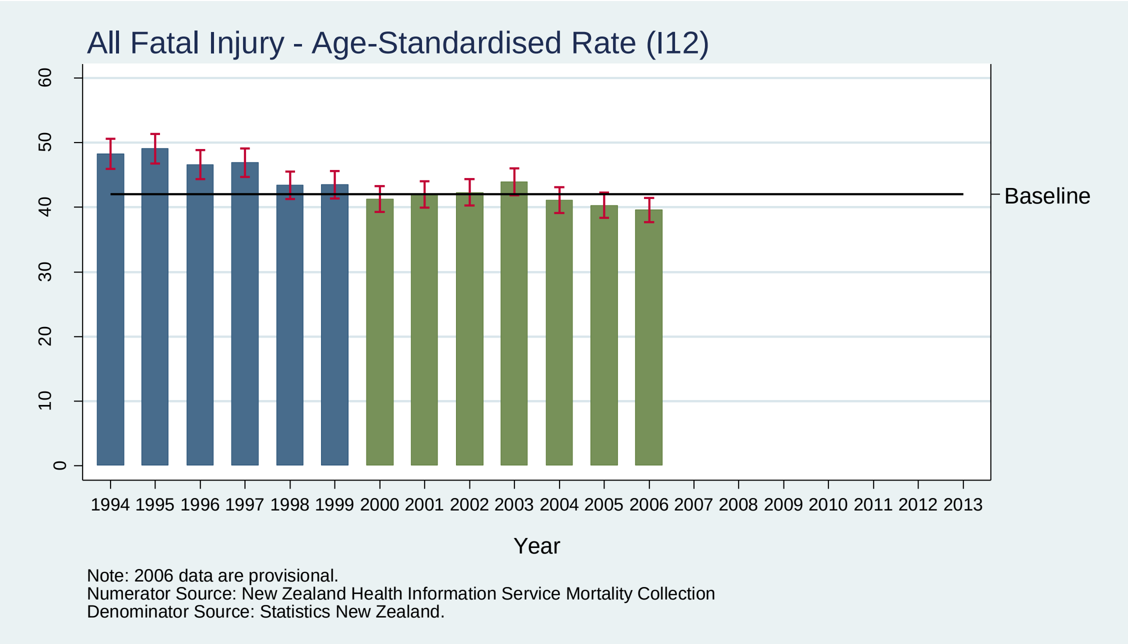
For those just wishing to read the “bottom line” findings of this work, please go to the Discussion and Recommendations starting on page 16.

Background

The New Zealand Injury Prevention Strategy (NZIPS) was established in 2003. Since its introduction, there has been a desire to measure improvements in injury incidence in New Zealand. This desire led to the development of injury outcome indicators: for fatal and serious non-fatal injury.

An example of a fatal injury indicator is shown in Figure 1. This figure shows a decline in the 2006 fatal injury rate from the baseline, which is based on the data for 2001 to 2003.

Figure 1: Trend in the NZIPS all fatal injury rate.



The operational definition of injury death, used in these NZIPS fatal injury indicators, is an underlying cause of death (UCoD) in the ICD10 range V01-Y36. That is, any external cause of injury code excluding:

- Complications of surgical and medical care
- Sequelae of external causes of morbidity and mortality
- Supplementary factors related to causes of morbidity and mortality.

We were aware of some concerns about the difficulties of accurate classification of UCoD for older people, particularly when they fall. This was one reason why the NZIPS indicators consider falls for people aged 0-74 years, and separately for people aged 75 and over. However, our concerns were subsequently heightened by the results produced as part of our recent project aimed at investigating enhancements to the International Classification of Diseases-based Injury Severity Score (ICISS). [1]

This ICISS project involved linking the Ministry of Health's National Minimum Dataset (NMDS) of hospital discharge data to the Ministry of Health's Mortality Collection (MC). The latter collection is based on the Medical Certificate of Death (MCoD), coroners' reports, etc. This work exposed apparent contradictions between hospital discharge principal diagnosis (PDx) and Mortality Collection UCoD. For many of the 'injury' cases that die in hospital, there was a gross mismatch (ie. at the ICD10 chapter level) between hospital PDx and the MC UCoD – many UCoD being recorded to a medical cause of death. Only 48% had an UCoD coded to an external cause of injury. This is consistent with a number of studies including those from Australia and from Sweden. [2,3] This problem is particularly large for older people.

In this current paper, we have characterized the mismatch by answering the questions – for which subgroups were the mismatches small; and similarly, for which subgroups (as well as older people) were the mismatches large?

In the above situation, for a given death that was preceded by an injury event, the appropriate choice for UCoD was either:

1) an external cause of injury (ie. UCoD was incorrectly coded), or
2) a medical UCoD

Kreisfeld and Harrison [2] give a typical scenario that illustrates a situation where a hospital PDx is an injury diagnosis, but where (external cause of) injury is often not classified as the UCoD, sometimes in error:

> *"A serious fall can precipitate an acute medical event associated with another condition such as ischaemic heart disease which may otherwise not have proved life threatening in the short term. In such an eventuality, it could be argued that it was the fall that set in train the events which led to death. Under the rules of the ICD-10, following this logic would require that the fall be regarded as the underlying cause of death. This logic is, however, contrary to practice."*

In regard to (1) above, there have been a number of studies in which the accuracy of UCoD has been investigated. These inaccuracies have been introduced by medical practitioners, coroners or coders. [4-9] There have been calls, over a number of decades, to improve the accuracy of death certification, and the classification of UCoD, to little effect. [10-12] **Carrying out a further study of the accuracy of death certification and the UCoD was <u>NOT</u> the focus of this report**.

If the appropriate choice of UCoD is a medical cause (ie option (2) above), it is also conceivable that the injury, and the external cause before it, either:

a) initiated an alternative sequence resulting in the death, or
b) was an intermediate step in the causal pathway, without which death would not have occurred when it did.

For example: A person who had a motor vehicle traffic crash (MVTC), sustained a fractured sternum, and was admitted to hospital. The person was discharged dead 9 weeks after their MVTC with the following diagnoses: fractured sternum, coma, cerebrovascular disease / stroke (CVD), pneumonia. The UCoD was classified to CVD. The MVTC was not listed on the death certificate. The stroke could have led to the MVTC. Whether or not that was the case, without the MVTC and the serious injuries that ensued, the death was unlikely to have occurred at that time.

As injury prevention researchers and practitioners, we are interested in preventing death by preventing injury. This leads to an interest in all cases where injury lies on a causal pathway to death, even if the external cause that resulted in the injury is not the UCoD. The challenge for this project and report was to identify a theoretical definition of injury death, and an operational definition of injury death that was consistent with this theoretical definition, since the current methods for identifying injury deaths result in an undercount and potentially lost opportunities for prevention.

Purpose

The **overall purpose** of this work was:

1) To inform NZIPS regarding potential sources of bias when
    a) estimating the size, nature and burden of fatal injury,
    b) calculating the NZIPS injury indicators, used for policy making and priority setting.[1]

2) To propose a method for identifying cases of fatal injury that is more consistent with definitions of injury death (explicitly or implicitly) that is useful to injury prevention researchers, practitioners and policy makers.

Aims:

(1) To characterize the subgroups where there were discrepancies between the NMDS principal diagnosis coded to injury, and the MC's UCoD coded to other than an external cause.
(2) To describe any lack of correspondence between data captured in both the MC and the NMDS (ie. age, gender, external cause) in order to highlight any potential concerns regarding the validity of the NZIPS fatal injury indicators.
(3) Taking cognisance of :
- WHO coding rules for mortality data,
- theoretical and operational definitions of injury death pertinent to injury prevention researchers, practitioners and policy makers,

[1] If biases exist, the specification of these NZIPS chartbook indicators should be reviewed.

- previously identified discrepancies between hospital discharge and UCoD data, and methods used to “adjust” the numbers of cases of injury death,

propose a new and improved method for identifying injury deaths from the MC.

Cause of injury death

Volume 1 of the World Health Organization’s (WHO’s) ICD-10 manual describes the underlying cause of death (UCoD) as:

> *“(a) the disease or injury which initiated the train of events leading directly to death, or (b) the circumstances of the accident or violence which produced the fatal injury”.*

The WHO indicate that the purpose of coding the UCoD, from a public health perspective, is to prevent the precipitating cause from operating (i.e. identifying the primary cause of the death in order to prevent/reduce the occurrence in future). [13] This represents a simplistic, unrealistic and misleading concept of cause. Intervening at any point on any causal pathway can prevent disease and death. One of the purposes of this paper is to show that the WHO approach is not very helpful for injury prevention researchers, practitioners and policy makers.

The following is an example of why that is the case. On 13 July 1967, during one of the later stages of the Tour de France cycle race, Tom Simpson, who was cycling up Mount Ventoux in the very hot sun, collapsed and died. The autopsy report stated that:

> *“Death was due to cardiac collapse which may be put down to exhaustion in which unfavourable weather conditions, an excessive workload, and use of medicines of the type discovered on the victim may have played a part. The dose of amphetamines ingested by Simpson could not have led to his death on its own; but on the other hand it could have led him to go beyond the limit of his strength and thus bring on the appearance of certain troubles linked to his exhaustion.” (Fotheringham, 2003, p178)* [14]

However, this does not tell the whole story. An expanded list of factors that appear to be associated with Simpson’s death were as follows:

- Amphetamine use
- Alcohol use
- Unfavourable weather conditions, ie. very hot temperatures
- “Excessive” exercise
- Dehydration
    - Contemporary belief that to starve oneself of liquid enhances performance during big races
    - Tour de France rules, in operation at the time, did not allow riders to take liquid from support cars
    - Diarrhoea for 3 days before
- Hypoglycaemic
    - Diarrhoea for 3 days before

- Unable to eat for 3 days before death.

It is likely that all of these contributed to the death of Tom Simpson. The concept of an UCoD is unhelpful, since to intervene and remove / reduce any one of these contributing factors would have prevented the death. In this, and in many other examples, there is not just one cause of death, but several –many of which are of interest to injury prevention researchers, practitioners, and policy makers.

More useful than the concept of UCoD, is the WHO's theoretical definition of cause of death, which is:

> *"all those diseases, morbid conditions or injuries which either resulted in or contributed to death and the circumstances of the accident or violence which produced such injuries".*

This can be likened to the definition of "necessary cause"[2]. In the 'Dictionary of Epidemiology', Last has defined a "necessary cause" as follows:

> *"a causal factor whose presence is required for the occurrence of the effect".* [22]

Translating this to injury deaths, injury is a necessary cause of death if injury is required for the occurrence of death. However, we all die sometime; the issue is when we die. So we propose the following theoretical definition of <u>injury death</u>:

> *An injury death is one in which the injury resulted in premature death.*

That is, if the injury had not occurred, the death would not have occurred, or death would have occurred later.

This theoretical definition of injury death is in contrast to the UCoD. The WHO coding rules force the coder to choose one UCoD when there may be several causes, each contributing to the death. Typically, UCoD is used by government agencies in producing mortality statistics, including in New Zealand. Such practice results in an undercount of injury deaths. [2]

Having established a theoretical definition of injury death, the challenge for this project was to identify an operational definition of injury death that was consistent with this theoretical definition, since the current methods for identifying injury deaths result in an undercount and, potentially, lost opportunities for prevention.

Methods

Aim 1: To characterize the subgroups where there was a discrepancy between the NMDS principal diagnosis coded to injury, and the MC's UCoD coded to other than an external cause.

[2] Some have referred to this as a "component cause". [15]

In our investigations, we considered 3 follow-up periods from injury to death: <7 days, <3 months, and <12 months.

We focused on people who had been injured in 2000-2004, who were admitted to hospital for treatment of their injury (ie. they had a primary diagnosis [PDx] of injury). For this population, we linked their NMDS record to the MC data using the National Health Index (NHI), a unique person identifier in NMDS and MC. This resulted in 10,234 people with a PDx of injury who died within 12 months of their injury.

Aim 2: To describe any lack of correspondence between data captured in both the MC and the NMDS in order to highlight any potential concerns regarding the validity of the NZIPS fatal injury indicators

Investigated was the correspondence of age, sex, cause (falls, MVTC, drowning, poisoning, other specified) and intent (unintentional, assault, intentional self-harm, other specified) between data captured by NMDS and MC, for people who died within 7 days of their injury.

Aim 3: To propose a new and improved method for identifying injury deaths from the MC.

Developing an optimal method of identifying cases of injury death involved two main methods. We carried out a review of the literature to investigate what theoretical and operational definitions of injury other authors had used, as well as to identify previous investigations of accuracy of vital statistics data. Secondly, we carried out a review of a sample of 70 records for which there had been a mismatch between PDx of injury recorded on the NMDS and an UCoD of non-injury recorded on the MC. The purpose of this was to get insight into whether these deaths were consistent with our theoretical definition of injury death.

Results

Aim 1

1,713 died within 7 days of their injury, of which 39% had an UCoD of non-injury.
5,900 died within 3 months of their injury, of which 66% had an UCoD of non-injury.
10,234 died within 12 months of their injury, of which 77% had an UCoD of non-injury.

The percentage non-injury (%NI) was higher for females and for older ages.
Falls had the highest %NI of the external cause groups.

The following groups were found to have low %NI:

- People aged less than 30 years of age, who died within 3 months
- MVTCs, where death occurred within 3 months

- Assaults and self-harm, where death occurred within 3 months
- People with traumatic brain injury (TBI), who died within 7 days
- People with very serious injury, who died within 7 days.

Aim 2

Of the 1713 people who died within 7 days of their injury:

- Sex was identical for all but 6 cases (with lack of correspondence due to misclassification on the MC);
- Age was within 1 year for 99% of cases;
- There was 92% agreement for external cause group;
- There was 94% agreement for intent group.

The results were similar for the group of people who died <3 months and <12 months after their injury.

Aim 3

There is a good theoretical reason for some of the discrepancies between the NMDS PDx and the UCoD. The NMDS PDx is:

> *"...the diagnosis established after study to be chiefly responsible for occasioning the patient's episode of care in hospital (or attendance at the health care facility)"*[3].

The UCoD is defined as:

> *"(a) the disease or injury which initiated the chain of morbid events leading directly to death, or (b) the circumstances of the accident or violence which produced the fatal injury".*

For the sample of deaths chosen (NMDS PDx classified to injury and MC UCoD classified to non-injury), the results suggest the following:

- For people aged 70 and over, for most of the sampled cases injury was not or was unlikely to be a necessary cause, no matter what time interval between injury and death was considered. This was also the case for people aged 30 to 44 years.
- For people aged 45 to 69 years, this was again the case; however, for the death that occurred the same day as the injury event, injury was judged to be a necessary cause.
- For people aged less than 30 years, all the cases sampled - for which the time between injury event and death was less than 90 days (n=5) - injury was judged to be a necessary cause; either unequivocally, or using a balance of probability argument.
- For assault and self-harm, only three out of the seven sampled deaths were reassessed. For two out of the three, injury was regarded as either not, or unlikely, to be a necessary cause.
- For falls, the two deaths sampled with a time to death of less than 7 days, were classified as having injury as a probable necessary cause.

---

[3] National Health Data Dictionary, Version 8.0, AIHW, 1999 and ICD-10-AM, Volume 5, NCCH, 2000

- For fractured neck of femur (FNOF), 3 of the 7 deaths were classified as having injury as a probable or definite necessary cause.
- For TBI, 5 of the 7 deaths were classified as having injury as a probable or definite necessary cause.
- For all deaths where injury or external cause of injury was mentioned anywhere on the MCoD (n=5), they were classified as having injury as a definite necessary cause, except for one instance where injury was classified as a probable necessary cause.
- Finally, for deaths where no non-injury co-morbid condition was mentioned on the NMDS records, only 1 of the 7 sampled deaths (where death occurred on the same day as the injury event) was classified as having injury as a probable or definite necessary cause.

Two contrasting examples illustrate the judgement that went into the classification of necessary cause for the sample of 70 deaths:

Example 1: "This person fell and was admitted to hospital with a traumatic subdural haemorrhage. This was confirmed on a CT scan. They died 2 months later; they were discharged 2 days before death. The UCoD was coded to myocardial infarction (MI). Their injury was listed in Part II of the death certificate[4]. They were readmitted the same day as the death; for this admission, only CVD was listed on the NMDS record."

Example 2: "This person fell, fractured their humerus and was admitted to hospital. They were discharged after 1 day. They died within a week. The UCoD was coded to chronic obstructive pulmonary disease (COPD). Osteoporosis was listed in Part II of the death certificate. For this person, there were multiple admissions for COPD identified in the NMDS for the previous 10 years."

The first of these examples suggests that injury was a necessary cause. The second suggests that injury was not a necessary cause of death. We cannot be 100% certain for either, however. These assessments of injury as a necessary cause depend on balance of probability arguments.

Discussion

Injury prevention researchers, practitioners, and policy makers are interested in preventing death by preventing injury. So, we are interested in all cases where the injury lies on the causal pathway to death, even if the UCoD is not classified to an external cause of injury.

Firstly, we needed to agree on a theoretical definition of injury death. We proposed a definition based on "necessary cause":

An injury death is one in which the injury resulted in premature death.

[4] In Part II of the MCoD is listed: "Other significant conditions contributing to death, but not related to the disease or condition causing it."

In other words, an injury death is one in which, if the injury had not occurred, the death would not have occurred, or would have occurred later.

We also needed to expand our operational definition of injury death. The question was: how? Based on our findings, we tentatively proposed the following:

that a death be counted as a case of injury death if it satisfies one or more of the following:

- *it has an UCoD of an external cause of injury*
- *it has an injury or external cause recorded anywhere on the MCoD and the person died within 1 year of the injury event*
- *the person is aged less than 30 and died within 90 days of the injury event*
- *the person was injured from MVTCs or drowning and died within T5 days of the injury event*
- *the person fell and died within 7 days of the injury event*
- *the person sustained an FNOF and died within 90 days of the injury event*
- *the person was injured as a result of assault or self-harm and died within T8 days of the injury event*
- *the person sustained a TBI and died within 180 days of the injury event*

Here, T5 and T8 are time thresholds yet to be identified. Whatever new operational definition of injury death is used, if structured similar to the above, it will result in the ascertainment of many more cases of injury deaths than currently, ie. when using UCoD alone. This will have the most impact on the counts of falls injury deaths amongst the NZIPS priority areas (ie. assault, self-harm, work-related, falls, motor vehicle traffic crashes, and drowning).

No operational definition is 100% accurate in identifying cases of injury death consistent with our theoretical definition. Associated with any operational definition will be a false positive (FP) and false negative (FN) error rate. The current operational definition of injury death based on UCoD alone is likely to have a very low FP error rate, but a significant FN error rate. The proposed operational definition is a starting point for further investigations to identify a new operational definition that will have substantially reduced FN error rate with the expectation of only a small increase in FP error rate.

Recommendations

A further study, with a greater sample size, is needed to investigate and finalise the proposed operational definition. This further study could be conceptualised in terms of screening, with the proposed operational definition being equivalent to a screening tool, and the use of a panel of expert assessors to provide a confirmatory classification, ie. a definitive assessment of whether a particular death is a "true" injury death or not. Such work would require a significant sample for each of the seven (out of eight) elements that currently make up the proposed operational definition.

The process of identification of one or more alternative operational definitions was informed by the results of our current work. It should also be informed by a literature review of studies aimed at identifying *excess mortality*, ie. increased likelihood of death following injury. For example, the current work indicates an undercount for fractured neck of femur (FNOF) deaths. Previous work has found an excess mortality for people sustaining FNOF in the first year after the fracture [16]; others found that this excess mortality persisted for up to 10 years [17]. Excess mortality is likely to be dependent on diagnosis and external cause (including intent) of injury and time between the injury event and death. Knowledge of that excess mortality will not only further inform the operational definition, but will also allow the qualification of indicator counts in terms of additional cases that are likely to remain uncounted by any new operational definition.

Kreisfeld & Harrison (Flinders) authored an Australian Institute of Health and Welfare report [2] in which they used the concept of “additional injury deaths” that were those identified with a medical UCoD, but where an injury code appeared anywhere on the death certificate. As an interim, until the recommended further work is completed, we recommend that this approach be used in New Zealand, alongside the current approach.

Recommendation

> That for the NZIPS indicators, cases of injury death be defined and presented in two ways: (1) using the current operational definition of injury death based on underlying cause of death, but including sequelae of injury, (2) using the current operational definition plus “additional injury deaths”, which are those identified with a medical UCoD, but where an injury or external cause code appears anywhere on the medical certificate of death.

Those interested in injury prevention need to be mindful that any injury mortality statistics which have been derived in the traditional manner (i.e. using only UCoD) are likely to underestimate the number of deaths which are of interest to them. The underestimate is likely to be substantial in some cases (e.g. injury deaths among older people).

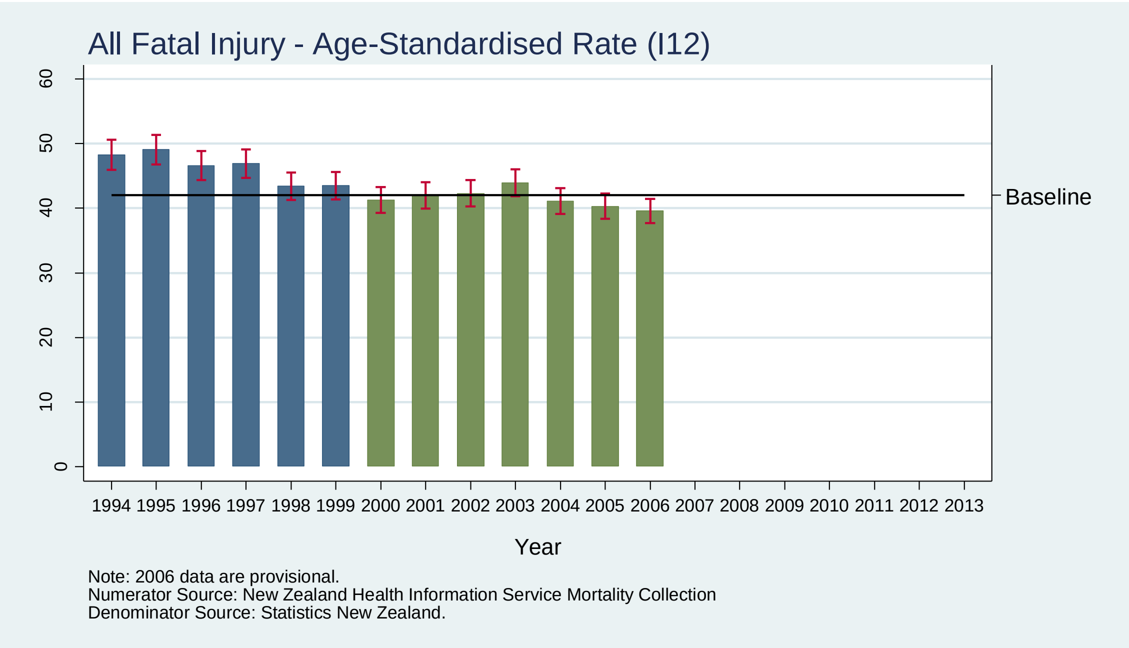
NZIPS indicators of injury death: Are we counting all the cases?

Introduction:

The New Zealand Injury Prevention Strategy (NZIPS) was established in 2003. There was a desire to measure improvements in injury incidence since its introduction. This led to the development of injury outcome indicators: for fatal and serious non-fatal injury. [18,19]

An example of a fatal injury indicator is shown in Figure 1: “All Fatal Injury – Age-Standardised Rate (I12)”. This figure shows a decline in the rate in 2006 compared to the baseline (based on the data for 2001 to 2003). [20]

Figure 1: Trend in the NZIPS all fatal injury rate.



The operational definition of injury death, used in these NZIPS fatal injury indicators, is an underlying cause of death (UCoD) in the ICD10 range V01-Y36. That is, any external cause of injury code excluding:

- Complications of surgical and medical care
- Sequelae of external causes of morbidity and mortality
- Supplementary factors related to causes of morbidity and mortality.

We were aware of some concerns about the difficulties of accurate classification of UCoD for older people, particularly when they fall. This was one reason why the NZIPS indicators consider falls for people aged 0-74 years, and separately for people aged 75 and over. However, our concerns were very much heightened by the results produced as part of our recent project aimed at investigating enhancements to the International Classification of Diseases-based Injury Severity Score (ICISS). [1]

That project involved linking hospital discharge data (NMDS) to the Ministry of Health's Mortality Collection. The latter collection is based on the Medical Certificate of Death (MCoDs), Coroners' reports, etc. This work exposed apparent contradictions between hospital and Mortality Collection diagnostic data. For many of the 'injury' cases that die in hospital, there was a gross mismatch (ie. at the ICD chapter level) between hospital principal diagnosis (PDx) and underlying cause of death (UCoD) recorded on the Mortality Collection (MC) – many being recorded to a medical cause of death. [1] This is consistent with a number of studies including those from Australia and from Sweden. [2,3] This problem is particularly large for older people.

In this report, we propose to characterize the mismatch by answering the questions – for which subgroups are the mismatches small; and similarly, for which subgroups (other than older people) are the mismatches large?

In the above situation, for a given death that was preceded by an injury event, the appropriate choice for UCoD was either:

1) an external cause of injury (ie. UCoD was incorrectly coded), or
2) a medical UCoD

Kreisfeld and Harrison [2] give a typical scenario that illustrates a situation where a hospital PDx is an injury diagnosis, but where (external cause of) injury is often not classified as the UCoD, sometimes in error:

> *"A serious fall can precipitate an acute medical event associated with another condition such as ischaemic heart disease which may otherwise not have proved life threatening in the short term. In such an eventuality, it could be argued that it was the fall that set in train the events which led to death. Under the rules of the ICD-10, following this logic would require that the fall be regarded as the underlying cause of death. This logic is, however, contrary to practice."*

In regard to (1) above, there have been a number of studies in which the accuracy of UCoD has been investigated. These inaccuracies have been introduced by medical practitioners, coroners or coders. [4-9] There have been calls, over a number of decades, to improve the accuracy of death certification, and the classification of UCoD, to little effect. [10-12] **Carrying out a further study of the accuracy of death certification and the UCoD was <u>NOT</u> the focus of this report**

If the appropriate choice of UCoD is a medical cause (ie option (2) above), it is also conceivable that the injury, and the external cause before it, either:

a) initiated an alternative sequence resulting in the death, or
b) was an intermediate step in the causal pathway, without which death would not have occurred when it did.

For example: A person who had a motor vehicle traffic crash (MVTC), sustained a fractured sternum, and was admitted to hospital. The person was discharged dead 9 weeks after their MVTC with the following diagnoses: fractured sternum, coma, cerebrovascular disease / stroke (CVD), pneumonia. The UCoD was classified to CVD. The MVTC was not listed on the death certificate. The stroke could have led to the MVTC. Whether or not that was the case, without the MVTC and the serious injuries that ensued, the death was unlikely to have occurred at that time.

As injury prevention researchers and practitioners, we are interested in preventing death by preventing injury. This leads to an interest in all cases where injury lies on a causal pathway to death, even if the external cause that resulted in the injury is not the UCoD. The challenge for this project and report was to identify a theoretical definition of injury death, and an operational definition of injury death that was consistent with this theoretical definition, since the current methods for identifying injury deaths result in an undercount and potentially lost opportunities for prevention.

Finally, recent work by Henley and Harrison in Australia has raised the other potential problem of lack of concordance between certain data captured in hospital (eg. external cause of injury), and those data captured on the Medical Certificate of Causes of Death (MCoD) based collections. [21] Consequently, in this proposed work, we will describe the correspondence between key data recorded both on the National Minimum Dataset (NMDS) of hospital discharges and the MC.

Purpose

The **overall purpose** of this work was:

1) To inform NZIPS regarding potential sources of bias when
   a) estimating the size, nature and burden of fatal injury,
   b) calculating the NZIPS injury indicators, used for policy making and priority setting.

2) To propose a method for identifying cases of fatal injury that is more consistent with definitions of injury death (explicitly or implicitly) that is useful to injury prevention researchers, practitioners and policy makers.

Aims:

(1) To characterize the subgroups where there were discrepancies between the NMDS principal diagnosis coded to injury, and the MC's UCoD coded to other than an external cause.

(2) To describe any lack of correspondence between data captured in both the MC and the NMDS (ie. age, gender, external cause) in order to highlight any potential concerns regarding the validity of the NZIPS fatal injury indicators.

(3) Taking cognisance of :

- WHO coding rules for mortality data,
- theoretical and operational definitions of injury death pertinent to injury prevention researchers, practitioners and policy makers,
- previously identified discrepancies between hospital discharge and UCoD data, and methods used to "adjust" the numbers of cases of injury death,

propose a new and improved method for identifying injury deaths from the MC.

The following section considers the theoretical definition of injury death.

Theoretical definition of injury death

Volume 1 of the World Health Organization's (WHO's) ICD10 manual describes the underlying cause of death (UCoD) as:

> *"(a) the disease or injury which initiated the train of events leading directly to death, or (b) the circumstances of the accident or violence which produced the fatal injury".*

The WHO indicated that the purpose of coding the UCoD, from a public health perspective, is to prevent the precipitating cause from operating (i.e. identifying the primary cause of the death in order to prevent/reduce the occurrence in future). [13] This represents a simplistic, unrealistic and misleading concept of cause. Intervening at any point on any causal pathway can prevent disease and death. One of the purposes of this paper is to show that the WHO approach is not very helpful for injury prevention researchers, practitioners and policy makers.

The following is an example of why that is the case. On 13 July 1967, during one of the later stages of the Tour de France cycle race, Tom Simpson, who was cycling up Mount Ventoux in the very hot sun, collapsed and died. The autopsy report stated that:

> *"Death was due to cardiac collapse which may be put down to exhaustion in which unfavourable weather conditions, an excessive workload, and use of medicines of the type discovered on the victim may have played a part. The dose of amphetamines ingested by Simpson could not have led to his death on its own; but on the other hand it could have led him to go beyond the limit of his strength and thus bring on the appearance of certain troubles linked to his exhaustion." (Fotheringham, 2003, p178)* [14]

However, this does not tell the whole story. An expanded list of factors that appear to be associated with Simpson's death were as follows:

- Amphetamine use
- Alcohol use
- Unfavourable weather conditions, ie. very hot temperatures
- "Excessive" exercise
- Dehydration
    - Contemporary belief that to starve oneself of liquid enhances performance during big races
    - Tour de France rules, in operation at the time, did not allow riders to take liquid from support cars
    - Diarrhoea for 3 days before
- Hypoglycaemic
    - Diarrhoea for 3 days before

- Unable to eat for 3 days before death.

It is likely that all of these contributed to the death of Tom Simpson. The concept of an UCoD is unhelpful, since to intervene and remove / reduce any one of these contributing factors could have prevented the death. In this, and in many other examples, there is not just one cause of death, but several –many of which are of interest to injury prevention researchers, practitioners, and policy makers.

More useful than the concept of UCoD, is the WHO's theoretical definition of cause of death, which is:

> *"all those diseases, morbid conditions or injuries which either resulted in or contributed to death and the circumstances of the accident or violence which produced such injuries".*

This can be likened to the definition of "necessary cause"[5]. In the 'Dictionary of Epidemiology', Last has defined a "necessary cause" as follows:

> *"a causal factor whose presence is required for the occurrence of the effect".* [22]

Translating this to injury deaths, injury is a necessary cause of death if injury is required for the occurrence of death. However, we all die sometime; the issue is when we die. So we propose the following theoretical definition of injury death:

> *An injury death is one in which the injury resulted in premature death.*

That is, if the injury had not occurred, the death would not have occurred, or death would have occurred later.

This theoretical definition of injury death is in contrast to the UCoD. The WHO coding rules force the coder to choose one UCoD when there may be several causes, each contributing to the death. Typically, UCoD is used by government agencies in producing mortality statistics, including in New Zealand. Such practice results in an undercount of injury deaths [2] and, potentially, lost opportunities for prevention.

Having established a theoretical definition of injury death, the challenge for this project was to identify an operational definition of injury death that was consistent with this theoretical definition.

---

[5] Some have referred to this as a "component cause". [15]

Methods

Aim 1: To characterize the subgroups where there is a discrepancy

Population

The population was people who were injured in the period 2000-2004 and were admitted to hospital with a principal diagnosis (PDx) of injury, and who died within 12 months of the date of injury. (12 months was an arbitrary choice. It was our expectation that most deaths, for which injury was a necessary cause, would occur within 12 months.)

Sources of data

The first source was the NZ public hospital discharges (NMDS) from 2000-2005, with an external cause of injury code on the record. NMDS is a hospital discharge-based data set. People who were injured in 2004, for example, could have been admitted to hospital in 2004 but discharged in 2005. Hence the need to consider this expanded period.

The second source was the MC data - all UCoDs - for the period 2000-2005. People who were injured in 2004, but died 12 months later would be captured in the MC in 2005; hence the need to consider MC data for the 2000-2005 period.

Linkage of NMDS to MC

The NMDS data was linked to the MC data using the National Health Index (NHI).[6] For a particular NHI, only one case exists in the MC. However, in the NMDS, it is possible to have hospital discharges relating to more than one injury event. This would cause many-to-one linkages. To avoid that, we selected NMDS discharges from the last injury event before death.

Even with this restriction, a single record in the MC could still be linked to many discharge events from NMDS, in situations where there were multiple admissions and / or transfers following the injury event. The linkage was made one-to-one by selecting only the NMDS cases related to the first

[6] Records for individuals in the NMDS and the Mortality Collection may have both a Master NHI and an Event NHI. This is because one person may have more than one NHI. One of the main tasks of the NZHIS Data Quality team is to identify and link records such as these. In these situations both NHIs remain valid and attached to the person's details but the earlier NHI is referred to as the Master NHI and is the preferred one for future use. Instances where 2 people are using the exact same NHI are extraordinarily rare and are resolved by the creation of a new Master NHI.

discharge following the last injury event. All diagnoses and E-codes in subsequent discharges (for the same injury event) were extracted to the same row, with tags to identify diagnoses and E-codes in the first discharge after injury, and last discharge before death.

Operational definitions of injury

NMDS

The operational definition of injury applied to the NMDS was a PDx in the range S00-T78 (ICD-10). This is consistent with the NZIPS indicators. The International Collaborative Effort (ICE) on Injury Statistics recommended that “medical injury” be tabulated separately from other injuries. We have excluded these injuries from consideration. Also, sequelae of injuries have been excluded, as these relate to the late consequences of an injury, rather than the injury itself.

We only retained those linked cases where:

- the date of death was less than or equal to 12 months after the date of injury, and
- NMDS PDx was in the range S00-T78.

Mortality Collection

For the MC and for the investigation of Aim 1 and Aim 2, the UCoD was called an “injury” if the UCoD was an E-code in the range V01-Y36, or Y85-Y89. The former range is consistent with the NZIPS indicators. The deaths in the range Y85-Y89 (n=17) have been included also. These are deaths due to sequelae of injury. Although excluded from the operational definition based on morbidity data, sequelae of injury as an UCoD are relevant to our consideration – since they were initiated by an injury event.

Choice of ‘time to death’ threshold

We investigated three ‘time to death’ thresholds: 1 week, 3 months and 1 year. The first was chosen since, *a priori*, we expected that almost all deaths occurring within 1 week of the injury would be injury deaths (ie. be consistent with our theoretical definition of injury death). The last (ie. the 1 year threshold) was chosen since we expected all but a few deaths related to the injury event for which they were hospitalized to occur within 12 months of injury. 3 months was an intermediate threshold, one for which the non-injury UCoD rate (amongst deaths where the PDx of the first discharge record of the last injury event before death was an injury) appeared to stabilize to a constant value – see results (page 34).

Description of the mismatch by selected variables

We described the mismatches between injury cases identified using NMDS PDx and MC UCoD, for each threshold and by selected variables: age, sex, external cause (including by NZIPS priority areas), injury diagnosis (based on most frequent cells within the Barell matrix) [23], whether died in hospital, and comorbid conditions. NMDS variables were used to characterize the mismatches. That is, the variable used to tabulate the linked data were all taken from NMDS.

Aim 2: To describe any lack of correspondence between data captured in NMDS and MC.

Statistical method

The same data, that were used for Aim 1, were used to address Aim 2. The correspondences between data captured by the NMDS and by the MC were assessed using tabulation, the Kappa statistic, or the Bland-Altman method [24], for:

- (i) Age
- (ii) Sex
- (iii) External cause at a broad level (eg. NZIPS priority areas: MVTC, Falls, Drowning etc.)
- (iv) Intent (assault, self-harm, unintentional, unspecified)

Also, this analysis was carried out for selected time to death strata (eg. <7 days, <3 months, <1 year). Missing values were excluded when estimating Kappa or the Bland-Altman statistics.

Aim 3: Identify an optimal method of identifying injury deaths from the Mortality Collection

Process of capture of mortality diagnoses

The description of the process for the capture of mortality diagnoses, including the underlying cause of death and the external cause of injury, was developed from verbal and documented descriptions provided by one of the authors (CF – Ministry of Health (MoH) Sector Services). Additionally, a synopsis of the World Health Organization's (WHO) mortality coding rules was obtained from the second volume of the WHO ICD-10 classification.

Literature review

Systematic reviews of the literature were carried out:

a) relating to the theoretical and operational definitions of injury death used by the injury research community, and
b) of work to identify discrepancies between hospital discharge and mortality data and methods used to "adjust" the numbers of cases of injury death.

Definition of injury mortality

The OVID (Embase and Medline) and CINAHL article databases were searched for articles relating to a theoretical or operational definition of injury death using the following search terms:

("Injury" + "death") + "definition"

("Trauma" + "mortality") + "definition"

(("injury" or "trauma") + ("death" or "mortality")) + "definition"

Investigations of the discrepancy between hospital and mortality records

Initial exploration of the literature was conducted using the Science Citation Index search engine from ISI Web of Knowledge. A frequently cited article by Goldacre (1993) was used as a basis for the search. All articles that had cited this article were reviewed, as were articles that had been referenced by Goldacre [25]. From this list, articles considered relevant to the review were identified and were used as a basis to identify additional articles, firstly by reviewing those that cited these additional articles and then by reviewing the articles that had been included on the reference lists. This process continued until no additional relevant articles were identified.

Following the search of the Science Citation Index, the OVID and CINAHL search engines were used. The following keywords were used in the search strategy:

1. ("Death certificates" or "death registration") + ((discharge + data) + records) + (review + comparison)
2. ("Death certificates" or "cause of death" or "death registration") + ("underreported" or "underestimated" or "under rated" or "under report" or "over report")

Methods to adjust the number of cases of injury death

Similar methods to those described above were used to identify references describing methods to adjust for the number of cases of injury death. An article by Rossignol (1994) [26] was used as the basis for the exploration using the Science Citation Index. This article was selected as it was the first reference identified to describe a method of adjusting for the number of cases of injury death estimated. The following keywords were used to search the OVID and CINAHL article databases:

("Injury" or "trauma") + ("death" or "mortality") + ("adjust" or "capture-recapture")

In addition to the above, a search of the "Google" internet based search engine was conducted using the following terms: "Discrepancies between hospitalisation and death data" and "Methods to adjust the numbers of cases of injury death". Finally, the injury reference list "SafetyLit" was searched for articles relevant to definition of injury mortality, investigations of the discrepancy between hospital and mortality records, and methods to adjust the number of cases of injury death.

A total of 45 references were identified using the above strategies. Each reference was reviewed to determine relevance to the two strands. A revised list of 21 references was produced; the articles selected as belonging to one of the two strands. A draft of this review was critiqued by two experts in this area, who recommended an additional 20 references and expanded search terms, which were incorporated into the search strategy described above. Eight additional articles were considered relevant to the current review.

Only English language articles were retained and reviewed.

Theoretical and operational definitions of injury death

The reviews were used to inform our proposed theoretical and operational definitions of injury.

Mismatch between WHO coding rules and the theoretical definition of injury death

We described the mismatch, at a theoretical level, between the WHO coding rules for UCoD and the chosen theoretical definition of injury death.

Description of the likely differences in case ascertainment at a theoretical level.

The project team also made an assessment of the likely misclassification, at a theoretical level, between the method used to define a case of injury death, described in the NZIPS indicators specifications [19], and the proposed operational definition of injury, based primarily on the results of the empirical work carried out as part of this project. The proposed operational definition can be found in the section starting on page 42.

Review of a sample of records

We reviewed a sample of 70 records for which there was a mismatch between NMDS (PDx=injury), and the Mortality Collection (UCoD=non-injury). These were used:

(i) to illustrate the differences in coding rules / conventions between NMDS (and ICD coding rules within hospitals) and the MC (and the WHO coding rules that are applied)

(ii) to illustrate the discrepancies between WHO coding rules for mortality data, and the theoretical and operational definitions of injury

(iii) to inform recommendations regarding enhanced data capture within the MC

(iv) to inform recommendations regarding a modified case definition of injury death for the NZIPS injury mortality indicators.

We created a matrix of subgroups (rows) against time to death (columns) – see **Table 1**. In each cell of **Table 1** is shown the number of people with an NMDS PDx of injury, who died and were assigned a medical UCoD, amongst those injured in the period 2000 to 2004.

The subgroups were defined in terms of age, circumstance of injury, diagnosis, whether nature or circumstance of injury were recorded anywhere on the death certificate, and whether comorbid conditions were recorded on the NMDS record. The rationale for the choice of rows was informed by the results described under Aim 1 (see page 34), and that rationale was as follows.

- We hypothesised that the certainty with which a given death can be classified depends on age, and time to death within age group. Relatively few younger people, who were admitted to hospital with a PDx of injury and who subsequently died, were assigned a medical UCoD. The converse is true for older people.
- Given a death had occurred, people were most likely to be assigned an UCoD of external cause of injury if they sustained an injury whose NMDS external cause was:
    1. MVTC,
    2. Drowning,
    3. Assault,
    4. Self-harm,

or for which the diagnosis was of traumatic brain injury (TBI)

- Amongst people who died and were assigned a medical UCoD, falls and fractured neck of femur (FNOF) were the most common NMDS external cause / PDx codes, and so these groupings provided the greatest potential for identifying additional cases.
- If nature of injury or external cause was recorded anywhere on the death certificate, previous work has classified these as injury deaths. [2]
- If no comorbidity had been recorded on the NMDS record, we hypothesised that the plausibility of a death being due to other causes was less.

Table 1: The number of people with an NMDS PDx who died and were assigned a medical UCoD, by subgroup and time to death.

	Time from injury to death (Days)						
	0	**1-6**	**7-29**	**30-59**	**60-89**	**90-179**	**180+**
People aged 70+	36	544	1124	1032	751	1516	2086
People aged 45-69	7	54	111	93	55	137	223
People aged 30-44	3	11	13	7	7	12	36
People aged <30	5	7	7	1	3	6	18
MVTCs or Drowning	2	15	15	27	16	47	160
Assault or self-harm	3	8	21	14	14	25	45
Fall	32	509	1062	955	692	1375	1896
FNOF	10	156	274	243	190	370	459
TBI[a] (NMDS PDx, or MC contributing cause)	6	37	41	27	21	49	64
Injury / Ext cause mentioned anywhere on death cert	1	3	2	1	1	1	1
No comorbidity recorded on NMDS records	3	35	72	88	79	171	273

a. TBI = Traumatic brain injury

Amongst the cases with an NMDS PDx of injury and UCoD of non-injury, we selected at random an example death (from the group of known mismatches) from each cell of the matrix described above (n=70). For each example we:

- Inspected all information that was available to the MoH Information Directorate relating to the example, eg. from
  - MC record
  - NMDS records
  - MCoD
  - Coroner's report
  - Inquest
  - Post-mortem report
- Two investigators (CF/PG) made a judgement whether the example was :
  - A definite case of injury (code 1)
  - A probable case of injury (code 2) – ie. subjective probability of injury >0.5

- A possible case of injury (code 3) - ie. subjective probability of injury <0.5, but >0
- A definite case of non-injury (code 4).

Our hypothesis was that: from the patterns of these codes in the resultant matrix, we would be able to hypothesise a time to death threshold for each row, in order to posit an operational definition of injury death, consistent with our proposed theoretical definition of injury, based on “necessary cause”.

Also, as part of this review, we explored what could be captured relatively easily if we wanted to carry out a follow-up study to investigate a proposed operational definition of injury death.

Three weeks before the review, investigator PG sent CF (MoH Sector Services) a list of NHIs of the relevant deaths for review. CF put a request to the archives of the MoH and Coronial Services Unit to release paper copies of the notes of all the NHIs listed. As all of the deaths had been classified with a medical UCoD, most were not coroners’ cases and so coroners’ reports and post-mortem reports were often absent.

For the review, the MC case notes were available as a ‘hard copy’. The exceptions to this were the NMDS records of the case. In order to review cases prior to coding, the MC staff had access to the electronic version of the NMDS, including all NMDS records for a specific NHI. To make a judgment on the likelihood of each example being a case of injury death, CF/PG reviewed recent NMDS records. Frequently, the reason for mismatch did not relate to the most recent hospital discharge and CF/PG were required to search all relevant NMDS records to determine the hospital admission of interest.

Typically, the process of assessment was as follows. PG/CF identified the death on the MC, ascertained the UCoD from the MCoD, and investigated whether the injury event was listed anywhere on the MCoD. They then searched the NMDS for the individual to identify how the injury fitted into the chain of events leading to the death. Where a coroner’s report and/or a post mortem report existed, these were reviewed to determine if there was mention of the injury event in the investigation. All salient information was recorded.

Results

Aim 1: To characterize the subgroups where there is a discrepancy

Linkage of NMDS to MC

The number of linked records was 63,056. These records corresponded to 63,056 persons. For 10 individuals for which date of injury was missing, injury was assumed to have occurred on the admission date.

Out of these 63,056, the following were then excluded:

- 44,362 people with a PDx outside the ICD-10 diagnosis code range S00-T78 (see Operational Definition of Injury – NMDS);
- 82 people who were injured prior to 1 Jan 2000 and died after 1 Jan 2000.
- 1,454 people who were injured after 31 Dec 2004 and died within 2005
- 6,924 people who were injured during 2000 to 2004 and who died after 365 days following injury. (Note: only 386 had an UCoD of external cause of injury)

The resultant dataset included 10,234 eligible people.

Description of the mismatch by selected variables

Amongst the 10,234 eligible people, 7,905 (77%) had an UCoD of non-injury.

The investigation of the mismatches by selected variables was carried out for 3 time-to-death thresholds: <7 days, <3 months and <12 months. Table 2 shows that the percentage with an UCoD of non-injury (NI) was 39% (<7 days), 66% (<3 months) and 77% (<1 year). For each threshold, the %NI was greater for females than males. It was lowest for younger ages, and highest for older ages. For the <7 days threshold it was low until age 50, moderately low from age 50 to 59, moderately high from 60-79, and high from 80 onwards[7]. For the <3 months threshold, it was low from age 5 up to age 35, moderately low for ages 0 to 4 and 35 to 49, moderately high from 50-59, and high from 60 onwards. For the <1 year threshold, it was low from age 10 to 29, moderately low from 0 to 9 and 30 to 44, and moderately high from 45 to 54, and high from age 55 onwards (Table 2).

Falls had the highest %NI for each threshold amongst the external cause groups considered (Table 3). %NI was low for MVTCs for the <7 days and the <3 months thresholds; it was moderately low for the <1 year threshold. %NI remained low for any threshold for drowning. For poisoning, %NI was moderately low for the <7 days threshold but moderately high for the <3 months and <1 year thresholds.

Unintentional injury had higher %NI than intentional injury for each threshold (Table 3). %NI was low for assault and self-harm for the <7 days threshold, and it was moderately low for the <3 months and <1 year thresholds.

The %NI for principal diagnosis for the first discharge after the injury – PDx(1st) - is shown in Table 3. Only the most frequent nature and body site of injury combinations were tabulated. Relatively high %NI's throughout were found for fractures of the hip, other lower extremities, upper extremities, vertebrae, and pelvis / lower back. TBI, where a skull fracture was involved, had low %NI for all time to death thresholds, and TBI without skull fracture showed low %NI for the <7 days threshold, and it was moderately low for the <3 months and <1 year thresholds. The %NI was low for spinal cord injury for the <7 days threshold, and was moderately low for the <3 month and <1 Year thresholds. Like spinal cord injury, the %NI was low for internal injury of the organs of the abdomen for the <7 days

[7] We have used the following terms to represent ranges of %s as described below:

- "Low" – <15%
- "Moderately low" – 15-39%
- "Moderately high" - 40-59%
- "High" – ≥60%.

We have used them with a small degree of flexibility, however (eg. 15% has been described as low in some instances).

threshold, and was moderately low for the <3 month and <1 Year thresholds. The %NI was low for internal injury of the organs of the thorax for the <7 days threshold, and was moderately high for the <3 month and for the <1 Year thresholds. For system-wide effects (eg. poisoning), the %NI was moderately low for the <7 days threshold but was moderately high for the <3 and <12 months thresholds.

When considering the principal diagnosis for the last discharge before death – PDx(last) – the patterns of %NI by diagnosis and time to death threshold were very similar (Table 4). For deaths where the PDx(last) was not an injury, the %NIs were large for each threshold. The majority of the deaths with PDx(last) of non-injury had a PDx (1st) of hip fracture.

When considering threat to life severity of injury (ICISS) strata, the %NI was high for ICISS>0.920. For 0.90<ICISS<=0.92, %NI was moderately low for the <7 days threshold, and high for the <3 and <1 year thresholds. For ICISS<=0.90, %NI was low for the <7 days threshold, moderately low for the <3 months, and moderately high for the <1 year threshold. The %NI was much larger for people who died outside hospital than for those who died in hospital (Table 4).

Where there existed disease co-morbidities on the first discharge record after the injury, the %NI was moderately high or high. Where only injury or external cause codes were recorded, %NI was low for the <7 days threshold, and moderately high for the <3months and <1 year thresholds.

		Time from injury to death < 7 days				Time from injury to death < 3 months				Time from injury to death < 1 year			
		Number				Number				Number			
Variable	Category	Deaths	UCoD= Injury	UCoD= Non-Injury	% Non-injury	Deaths	UCoD= Injury	UCoD= Non-Injury	% Non-injury	Deaths	UCoD= Injury	UCoD= Non-Injury	% Non-injury
All deaths		1713	1046	667	39	5900	1998	3902	66	10234	2329	7905	77
Gender	Male	923	631	292	32	2623	1081	1542	59	4272	1297	2975	70
	Female	789	414	375	48	3276	916	2360	72	5961	1031	4930	83
Age	0-4	35	30	5	14	44	35	9	20	49	35	14	29
	5-9	17	17	0	0	21	21	0	0	27	22	5	19
	10-14	31	30	1	3	37	33	4	11	46	40	6	13
	15-19	99	98	1	1	121	120	1	1	151	147	4	3
	20-24	69	67	2	3	103	98	5	5	129	119	10	8
	25-29	59	56	3	5	80	76	4	5	111	102	9	8
	30-34	66	62	4	6	95	86	9	9	142	118	24	17
	35-39	49	45	4	8	87	74	13	15	133	106	27	20
	40-44	55	49	6	11	89	70	19	21	138	99	39	28
	45-49	35	32	3	9	96	65	31	32	147	84	63	43
	50-54	46	37	9	20	101	59	42	42	160	70	90	56
	55-55	49	38	11	22	103	54	49	48	178	66	112	63
	60-64	39	23	16	41	115	43	72	63	224	50	174	78
	65-69	58	36	22	38	188	58	130	69	325	66	259	80
	70-74	109	56	53	49	403	97	306	76	707	106	601	85
	75-79	156	69	87	56	675	154	521	77	1286	167	1119	87
	80-84	228	86	142	62	1005	208	797	79	1822	225	1597	88
	85-89	284	128	156	55	1289	328	961	75	2262	357	1905	84
	90+	229	87	142	62	1248	319	929	74	2197	350	1847	84

Table 2: The mismatch between NMDS and MC by gender and age.

Table 3: The mismatch between NMDS and MC by external cause, intent and principal diagnosis of the first hospital discharge after injury.

		Time from injury to death < 7 days				Time from injury to death < 3 months				Time from injury to death < 1 year			
		Number				Number				Number			
Variable	Category	Deaths	UCoD= Injury	UCoD= Non-Injury	% Non-injury	Deaths	UCoD= Injury	UCoD= Non-Injury	% Non-injury	Deaths	UCoD= Injury	UCoD= Non-Injury	% Non-injury
E-code	Falls	920	379	541	59	4285	1010	3275	76	7647	1126	6521	85
Group	MVTC	327	313	14	4	489	417	72	15	625	446	179	29
	Drowning	19	16	3	16	21	18	3	14	22	19	3	14
	Poisoning	88	72	16	18	268	155	113	42	454	242	212	47
	Other specified	309	235	74	24	689	346	343	50	1228	437	791	64
	Unspecified	50	31	19	38	148	52	96	65	258	59	199	77
Intent	Unintentional	1506	858	648	43	5483	1692	3791	69	9585	1917	7668	80
	Assault	58	54	4	7	87	76	11	13	131	96	35	27
	Self-harm	131	124	7	5	262	212	50	19	390	295	95	24
	Other specified	11	6	5	45	53	10	43	81	108	12	96	89
	Unspecified	7	4	3	43	15	8	7	47	20	9	11	55
PDx	Fracture - hip	433	139	294	68	2239	559	1680	75	3828	615	3213	84
1st Discharge	Fracture - other lower extrem.	66	27	39	59	279	76	203	73	558	100	458	82
after injury	Fracture - upper extremity	47	7	40	85	285	34	251	88	613	46	567	92
	Fracture - TBI	162	157	5	3	217	201	16	7	232	201	31	13
	Fracture - vertebral column	29	14	15	52	151	34	117	77	243	40	203	84
	Fracture - pelvis and lower bacl	47	23	24	51	243	63	180	74	436	69	367	84
	Fracture - thorax	43	27	16	37	141	55	86	61	228	65	163	71
	Internal organ - TBI	361	318	43	12	568	436	132	23	702	457	245	35
	Internal organ - Spinal cord	21	18	3	14	30	24	6	20	37	26	11	30
	Internal organ - Abdomen	46	44	2	4	62	49	13	21	67	51	16	24
	Internal organ - thorax	26	24	2	8	51	30	21	41	69	33	36	52
	System-wide - poisoning	66	51	15	23	229	118	111	48	402	195	207	51
	System-wide - toxic effect	27	24	3	11	58	40	18	31	94	55	39	41
	System- wide - other	78	56	22	28	110	63	47	43	134	65	69	51

Table 4: The mismatch between NMDS and MC by principal diagnosis of the last hospital discharge before death, severity of injury, comorbid conditions and whether the person died in hospital.

		Time from injury to death < 7 days				Time from injury to death < 3 months				Time from injury to death < 1 year			
		Number				Number				Number			
Variable	Category	Deaths	UCoD= Injury	UCoD= Non-Injury	% Non-injury	Deaths	UCoD= Injury	UCoD= Non-Injury	% Non-injury	Deaths	UCoD= Injury	UCoD= Non-Injury	% Non-injury
PDx	Fracture - hip	429	137	292	68	1492	405	1087	73	2172	425	1747	80
Last discharge	Fracture - other lower extrem.	64	27	37	58	215	66	149	69	391	85	306	78
before death	Fracture - upper extremity	44	7	37	84	200	25	175	88	424	37	387	91
	Fracture - TBI	156	151	5	3	195	185	10	5	205	186	19	9
	Fracture - vertebral column	30	15	15	50	151	34	117	77	166	29	137	83
	Fracture - pelvis and lower bacl	44	23	21	48	163	47	116	71	253	51	202	80
	Fracture - thorax	38	26	12	32	111	47	64	58	172	54	118	69
	Internal organ - TBI	370	327	43	12	550	443	107	19	664	461	203	31
	Internal organ - Spinal cord	20	17	3	15	30	24	6	20	33	26	7	21
	Internal organ - Abdomen	46	44	2	4	60	50	10	17	64	52	12	19
	Internal organ - thorax	26	24	2	8	50	31	19	38	67	34	33	49
	System-wide - poisoning	64	49	15	23	212	107	105	50	372	176	196	53
	System-wide - toxic effect	26	23	3	12	52	37	15	29	86	52	34	40
	System- wide - other	77	56	21	27	105	63	42	40	126	64	62	49
	Non-injury	30	10	20	67	1274	233	1041	82	2791	291	2500	90
ICISS	<=0.90	869	730	139	16	1516	1040	476	31	1858	1073	785	42
	0.901-0.920	87	53	34	39	316	101	215	68	498	116	382	77
	0.921-0.940	193	62	131	68	1106	263	843	76	1940	304	1636	84
	0.941-0.960	225	81	144	64	1120	280	840	75	2032	319	1713	84
	0.961-0.980	124	40	84	68	705	114	591	84	1334	157	1177	88
	0.981-1.000	215	80	135	63	1137	200	937	82	2572	360	2212	86
Died in	Yes	1530	959	571	37	2874	1510	1364	47	2973	1538	1435	48
hospital	No	183	87	96	52	3026	488	2538	84	7261	791	6470	89
Comorbid	No (injury only)	291	253	38	13	600	322	278	46	1109	393	716	65
condition	Disease	1152	614	538	47	4410	1347	3063	69	7420	1515	5905	80
on NMDS 1st	Abnormal symptoms and signs	123	73	50	41	438	137	301	69	851	189	662	78
discharge	Factors infl. health status	147	106	41	28	452	192	260	58	854	232	622	73
	and contact with services												

Aim 2: To describe any lack of correspondence between data captured on the NMDS and the MC.

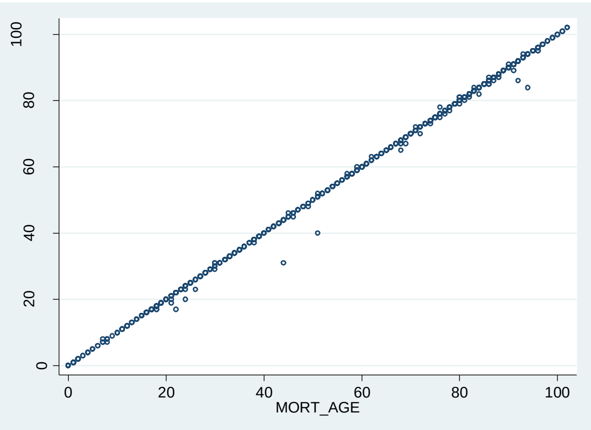
Correspondence by age, sex, cause and intent.

The results presented here are based on the subgroup of people who died within 7 days of their injury. Similar results were obtained for people who died within 90 days and 1 year.

Amongst the 1,713 people who died within 7 days, for all but 6 people (0.35%) the gender was recorded identically in the NMDS and MC. These 6 were due to misclassification on the MC.

For age, Figure 2 shows the correspondence between age on NMDS (“MORB_AGE”) and on the MC (MORT_AGE”). Most ages were identical. For 99% of people, the recorded age was identical or was within 1 year. The largest deviation was 13 years.

Figure 2: Correspondence between age as recorded on NMDS and age as recorded on MC.



The analysis by external cause (E-code group and intent) was restricted to the 1,046 people who had an UCoD of injury, and is based on the E-code from PDx(1st).

Table 5 shows the correspondence between the data captured by NMDS and MC for E-code group. Although it shows some discrepancy, there was 92% agreement (Kappa = 0.88). This is regarded as a high agreement. [27] There was less agreement for data captured using the <1 year threshold, namely 85% (Kappa=0.78).

Table 5: Correspondence between the data captured by NMDS and MC for E-code group

	Mortality Collection						
NMDS	Fall	MVTC	Drowning	Poisoning	Other spec	Unspec.	Total
Fall	372	0	0	0	7	0	379
MVTC	2	296	0	0	15	0	313
Drowning	1	0	13	0	2	0	16
Poisoning	1	0	1	63	6	1	72
Other specified	17	10	1	3	203	1	235
Unspecified	9	0	0	0	11	11	31
Total	402	306	15	66	244	13	1,046

Table 6 shows the correspondence between the data captured by NMDS and MC for Intent. Although it shows some discrepancy, there was 94% agreement (Kappa = 0.84). Again, this is regarded as a high agreement. [27] There was less agreement for data captured using the <1 year threshold, namely 91% (Kappa=0.72).

Table 6: Correspondence between the data captured by NMDS and MC for Intent.

	Mortality Collection					
NMDS	Unintentional	Assault	Self-harm	Other spec.	Undeterm.	Total
Unintentional	834	9	9	1	5	858
Assault	3	47	3	1	0	54
Self-harm	7	1	111	0	5	124
Other specified	6	0	0	0	0	6
Undetermined	0	1	3	0	0	4
Total	850	58	126	2	10	1,046

Aim 3: Identify an optimal method of identifying injury deaths from the Mortality Collection

Process of capture of mortality diagnoses on the MC

The primary person responsible for completing the Medical Certificate of Death (MCoD) is the doctor who last attended the patient (where death occurred in the hospital) or the individual's usual doctor (GP) in cases where the death occurred out of hospital. Where the death was 'expected' (i.e. the medical history of the individual indicated that death may be imminent), the GP will often be confident enough to complete the medical cause of death. Where the death was unexpected, it should be referred to a coroner.

Deaths in hospital in New Zealand are often not referred to a coroner. In addition, a coroner's report is not required if the deceased is "≥ 70 years and the injury is caused by an accident that resulted from infirmities of old age" (e.g. arthritis, poor balance, postural hypotension)[8]. In these cases the GP/attending doctor is able to certify cause of death. The new MCoD has a tick box to indicate 'discussed with coroner'.

When a death is referred to a coroner, the coroner will usually order an autopsy and gather information from relevant and various sources including

- the police (who provide a 1 page summary of the facts surrounding the event),
- hospital notes,
- Child, Youth and Family notes, and
- various other sources.

Once the coronial inquiry into a death is completed the coroner completes a coronial 'Certificate of Findings' detailing the cause of death and the circumstances surrounding the injury that caused the death (motor vehicle accident, suicide etc). This certificate is issued instead of a medical certificate of cause of death. The coroner will then provide this summary of the cause of death, which is available to the MC team.

Two fields in the summary (1-2 pages), that is submitted to MC team, are of interest: 'Cause of death' (what was the direct cause of death, eg. ruptured spleen) and 'As a result of' (ie. the circumstances surrounding the event). There is often insufficient information contained within these fields to accurately determine the underlying cause of death, at which time the MC team seeks further information from the following sources:

- the complete coronial file,

[8] Births Deaths and Marriages Registration Act, 1995, page 13

- Land Transport New Zealand (LTNZ) data (re: MVTC-related deaths, based on Traffic Crash Reports),
- DrownBase[9],
- the media, or
- NMDS (if the deceased died in hospital)

The primary source of information is the coronial file. The MC team often receive a postmortem report; and if they do, the findings on it are routinely read in conjunction with the coroner's report to ascertain the cause of death. However, if the reports contain too little information, or if conflicting information is obtained from an alternative source (eg. DrownBase), further information is obtained from other sources. In the past, MC staff members have gone to Coronial Services at the Ministry of Justice to access the full coronial file to find the additional information required to code the underlying cause of death. Since July 2007, when the Coroners Act 2006 came into force, MC staff have received coroners' and postmortem reports from the district coroners' offices. MC staff will soon be able to access more detailed electronic information from the Coroners Information System for cases that are closed.

Literature review

This is described in Attachment 2. The findings of this review have been incorporated into this report in the appropriate sections.

Theoretical and proposed operational definitions of injury death

Theoretical definition.

The WHO definition of cause of death is:

> *"all those diseases, morbid conditions or injuries which either resulted in or contributed to death and the circumstances of the accident or violence which produced such injuries".*

This can be likened to the definition of "necessary cause". This definition, stated in terms of injury death (see section 2), is:

> *An injury death is one in which the injury resulted in premature death.*

That is, if the injury had not occurred, the death would not have occurred, or would have occurred later.

[9] Water Safety New Zealand initially collects drowning data from media releases and police reports. (Their focus is drowning, and so they do not include near drowning.) Final verification of a drowning occurs after the inquest, from Coroners' reports from the Department of the Courts. The drowning database collated in this way is called "DrownBase".

Operational definition

It is usual, for statistical purposes, to identify cases of injury death using the UCoD – and so this has been the common operational definition of injury death used by injury researchers – Eg. Moyer 1989. [10]

Calder and Parker identified possible cases of death from hip fracture (implicit operational definition) as patients who were admitted to hospital with a hip fracture (hospital diagnosis code), who then died within 28 days of admission. [6,7] Note that these authors did not use UCoD as their definition.

The development of a new surveillance system for the Lazio region in Italy provided the opportunity to investigate three operational definitions: (1) mortality within 30 days of Emergency Department visit; (2) in-hospital mortality; (3) mortality based on specific E-codes from the Mortality Register. [28]

Kreisfeld and Harrison provide one of the more detailed operational definitions of injury death in the literature relevant to this investigation. [2] Their definition is an adaptation of the State and Territorial Injury Prevention Directors Association (STIPDA) agreement regarding the ICD codes for inclusion and exclusion in the case definition. [29] The scheme was originally produced for ICD-9 and Kreisfeld and Harrison mapped the scheme to ICD-10 and applied it to their death data. [2] The ICD-10-AM codes used to define cases were S00-S99, T00-T75, T78.8, T79, T90-T97, T98.0-T98.2 and excluded 'complications of surgical and medical care' (T80-88, T98.3), 'sequelae', and 'adverse reactions to food' (T78.0-78.4) Their operational definition also included 'additional' cases. When capturing the 'additional' cases, they searched for cases whose UCoD was not an external cause, but for which an external cause or an injury diagnosis code, in the code ranges listed above, was present among the multiple causes of death listed.

From the results obtained when investigating the characteristics of the mismatches between NMDS PDx of injury and MC UCoD, we hypothesised that the operational definition might have some of the following elements - namely people satisfying one or more of the following (where T1, T2, etc are times measured from the injury event);

- with an UCoD of injury
- aged 70 and over who die within T1 days of the injury event
- aged 45-69 who die within T2 days of the injury event
- aged 30-44 who die within T3 days of the injury event
- aged less than 30 who die within T4 days of the injury event
- injured from MVTCs or drowning who die within T5 days of the injury event
- who fall and who die within T6 days of the injury event
- who sustain a fractured neck of femur who die within T7 days of the injury event
- who sustain a TBI who die within T8 days of the injury event

- who have an injury or external cause recorded anywhere on the MCoD who die within T9 days of the injury event
- who had no medical comorbid conditions recorded on their hospital (NMDS) records who died within T10 days of their injury event.

Here, T1, T2, T3, etc. stand for time thresholds not yet fully specified. These time thresholds were considered, and firm thresholds proposed, in the Results and Discussion below.

The elements included in this operational definition were based on those characteristics of the group of people discharged from hospital with a PDx of injury, and who died, that had a either a high proportion with low percentage UCoD of non-injury, or a high proportion.

The structure of each line of this proposed operational definition is similar to that of Calder and Parker. [6,7] The findings reported below (page 45) provides an initial investigation of those elements.

Mismatch between WHO coding rules and the theoretical definition of injury death

The general principle stated as part of the WHO coding rules for classifying UCoD are as follows:

> *"When more than one condition is entered on the certificate, the condition entered alone on the lowest used line of Part I should be selected only if it could have given rise to all the conditions entered above it."*

Contrast this with the proposed theoretical definition of injury death (as a necessary cause), which is of relevance to epidemiologists:

> *"An injury death is one in which the injury resulted in premature death."*

It is clear that if UCoD is an external cause leading to injury and subsequent death, that injury is a necessary cause. It is also clear that, in the presence of a medical UCoD, an external cause or injury diagnosis mentioned anywhere else on the MCoD could be a necessary cause of death. For example, someone has underlying Ischaemic Heart Disease (IHD). They fall and fracture their femur. They are operated on within 24 hours of their fall under general anaesthetic, and they fail to recover from the operation. On the MCoD, IHD is assigned as the UCoD. It is clear, in this example, that the death would have occurred days or even months later if the person had not fallen and fractured their femur. In this case, even though UCoD is IHD, fractured femur is a necessary cause of death. As epidemiologists, we are interested in counting these cases as injury deaths. There are many other examples of competing causes where a medical UCoD is assigned but injury is a necessary cause. Some of these are illustrated beginning on page 46.

It is clear from the above, that UCoD will only capture a subset of injury deaths. The question is: how do we capture the missing injury deaths? We endeavour to address this in the following sections.

Results of the review of a sample of records

The results of the review of MoH Information Directorate records are shown in Table 7. As indicated in the methods, the coding scheme used, when applying our theoretical definition of injury death, was:

- A definite case of injury death (code 1)
- A probable case of injury death (code 2) – ie. subjective probability of injury >0.5
- A possible case of injury death (code 3) - ie. subjective probability of injury <0.5, but >0
- A definite case of non-injury death (code 4).

There were 12 (out of 70) deaths, represented in Table 7, where it was apparent that the injury event was a necessary cause of death. Five of these were the result of drug or alcohol poisoning. There were four cases (highlighted in Table 7) where there was insufficient or inaccurate information provided by the coroner or other recorders, which resulted in the death being given an inaccurate UCoD.

For the sample of deaths chosen (NMDS PDx classified to injury and MC UCoD classified to non-injury), the results suggest the following:

- For people aged 70 and over, for most of the sampled cases injury was not or was unlikely to be a necessary cause, no matter what time interval between injury and death was considered. This was also the case for people aged 30 to 44 years.
- For people aged 45 to 69 years, this was again the case; however, for the death that occurred the same day as the injury event, injury was judged to be a necessary cause.
- For people aged less than 30 years, all the cases sampled - for which the time between injury event and death was less than 90 days (n=5) - injury was judged to be a necessary cause; either unequivocally, or using a balance of probability argument.
- For assault and self-harm, only three out of the seven sampled deaths were reassessed. For two out of the three, injury was regarded as either not, or unlikely, to be a necessary cause.
- For falls, the two deaths sampled with a time to death of less than 7 days, were classified as having injury as a probable necessary cause.
- For FNOF, 3 of the 7 deaths were classified as having injury as a probable or definite necessary cause.
- For TBI, 5 of the 7 deaths were classified as having injury as a probable or definite necessary cause.

- For all deaths where injury or external cause of injury was mentioned anywhere on the MCoD (n=5), they were classified as having injury as a definite necessary cause, except for one instance where injury was classified as a probable necessary cause.
- Finally, for deaths where no non-injury co-morbid condition was mentioned on the NMDS records, only 1 of the 7 sampled deaths (where death occurred on the same day as the injury event) was classified as having injury as a probable or definite necessary cause.

Table 7: Results of the review of a sample of records: codes showing the likelihood that injury was a necessary cause of death (1&2 = likely; 3&4 = unlikely).

	Time from injury to death						
	0	1-6	7-29	30-59	60-89	90-179	180+
People aged 70+	4	3	3	2	4		4
People aged 45-69	1	3	4	3	3	3	4
People aged 30-44	3	4	4	3	3	4	4
People aged <30	1	1	2	2	1	3	4
MVTCs or Drowning	2	4	3	3	2	2	4
Assault or self-harm		3	4	1			
Fall	2	2	4	4	2	4	4
FNOF	4	1	2	4	2	4	3
TBI (NMDS PDx, or MC contributing cause)	2	3	1	2	2	2	4
Injury / Ext cause mentioned anywhere on death cert		1	1	2		1	1
No Comorbidity	1	4	4	3	4	4	3

Illustration of the discrepancies between NMDS and MC

There are good reasons why the PDx and UCoD may be different, For hospital discharge data, the PDx is: *"...the diagnosis established after study to be chiefly responsible for occasioning the patient's episode of care in hospital (or attendance at the health care facility)"*[10]. In comparison, the underlying cause of death is defined as: *"(a) the disease or injury which initiated the chain of morbid events leading directly to death, or (b) the circumstances of the accident or violence which produced the fatal injury".* [13]

Nevertheless, descriptions of cases where PDx is an injury and UCoD coded to NI can give insights into what cases we would want to count when applying the necessary cause definition, and what we do not.

[10] National Health Data Dictionary, Version 8.0, AIHW, 1999 and ICD-10-AM, Volume 5, NCCH, 2000

Case Scenarios

Aged 70+

Necessary cause of death (likely to be) injury

A person had a fall, sustained a FNOF, and was admitted to hospital. They died 6 weeks after their fall. The UCoD was classified to Alzheimer's disease. The fracture was listed on Part II of the death certificate, as was bronchopneumonia. The person was discharged 3 weeks prior to death.

Necessary cause of death unlikely to be / not injury

A person had a fall, sustained an injured right ankle and was admitted to hospital. They died on the same day as their fall. The UCoD was classified to liver cancer. The fracture was not listed on the death certificate. This was classified to non-injury death, since a minor injury such as an ankle injury is unlikely to be part of a causal pathway to death.

Aged 45-69

Necessary cause of death (likely to be) injury

This person was admitted to hospital with a PDx of toxic effects of methanol. They died on the same day as their admission. The UCoD was classified as "Mental / behavioural disorder relating to substance use". The coroner's findings indicated a long history of alcohol abuse.

Necessary cause of death unlikely to be / not injury

This person fell, sustained a (complex) fractured wrist and was admitted to hospital. They died within a week of the fall. The UCoD was classified to stroke. There had been 4 admissions for serious respiratory problems in the 3 years prior to death. The wrist fracture was listed in Part II of the death certificate. Using a balance of probability argument, this case was judged not to be an injury death, since fractured wrists are unlikely to be a necessary cause of injury death.

Aged 30-44

Necessary cause of death (likely to be) injury

None identified.

Necessary cause of death unlikely to be / not injury

This person fell and was admitted to hospital with a PDx of "Unspecified head injury". The notes indicated that head injury was "minor". They died 2½ weeks following the injury event. The UCoD was classified to HIV. AIDS dementia was recorded in Part II of the death certificate.

Aged less than 30

Necessary cause of death (likely to be) injury

This person was admitted to hospital with a partial thickness burn. They died 7 weeks later. The UCoD was septicemia. There was no mention of a burn on the discharge record immediately prior to death. The death was due to a streptococcus infection. This could have been as a result of the burn.

Necessary cause of death unlikely to be / not injury

This person fell from their wheelchair, fractured their nasal bones and was admitted to hospital. They died 10 months after the fall. The UCoD was classified to birth asphyxia. The notes indicated that the person had cerebral palsy, recurrent chest infections and spastic quadriplegia.

MVTC

Necessary cause of death (likely to be) injury

A person had a MVTC, sustained a fractured sternum, and was admitted to hospital. They died 9 weeks after their MVTC. The UCoD was classified to CVD – cerebrovascular disease. The MVTC was not listed on the death certificate. The person was discharged dead with the following diagnoses: Fractured sternum, coma, CVD, pneumonia. There were no previous admissions where CVD had been mentioned. CF/PG assessed that the stroke could have led to the MVTC. Whether or not that is the case, without the MVTC and the serious injuries that ensued, the death was unlikely to have occurred at that time.

Necessary cause of death unlikely to be / not injury

A person had a MVTC, sustained a head injury and multiple rib fractures, and was admitted to hospital. They died 2 weeks after the injury event. The UCoD was classified to end-stage renal disease. MVTC, head injury and multiple rib fractures were not listed on the death certificate. Given that acute renal failure had been listed on all NMDS records during the last year of life, CF/PG judged that the MVTC and the resulting injuries were not a necessary cause of death.

Drowning

Necessary cause of death (likely to be) injury

No example was included in our sample of deaths.

Necessary cause of death is equivocal

This adult was admitted to hospital for a cardiac event. Within a week of admission, they were found dead with their head in less than 10cm of water. The UCoD was classified to type II diabetes. There was no mention of drowning on the death certificate. This case was not sent to a coroner.

Necessary cause of death unlikely to be/ not injury

No example was included in our sample of deaths.

Assault

Necessary cause of death (likely to be) injury

No example was included in our sample of deaths.

Necessary cause of death unlikely to be / not injury

This person was admitted to hospital for fracture of the lower end of the radius (wrist fracture) as the result of an assault. They were discharged on the same day as the assault event. They died 6 weeks later. The UCoD was tubule nephritis. On the death certificate they were recorded as dehydrated within a week of death, and having acute renal failure 1 day prior.

Self-harm

Necessary cause of death (likely to be) injury

No example was included in our sample of deaths.

Necessary cause of death equivocal

This person was admitted to hospital as a result of intentional self poisoning by morphine. They died within 1 month of the poisoning. The UCoD was classified to acute MI. There was no mention of self-harm or depression on the death certificate. They were discharged to a psychiatric ward immediately after treatment for the poisoning and the heart attack occurred while they were in the psychiatric ward They had a history of angina.

Necessary cause of death unlikely to be / not injury

No example was included in our sample of deaths.

Fall

Necessary cause of death (likely to be) injury

This person fell and was admitted to hospital with a FNOF. They died 11 weeks after their fracture. The UCoD was classified to pneumonia. They had been transferred between inpatient and rehabilitation units between the time of the fall and death. The fall was not listed on the death certificate.

Necessary cause of death unlikely to be / not injury

This person fell and was admitted to hospital with a FNOF. They died 2½ weeks after their fracture. The UCoD was classified to lung cancer. There was a history of admissions for bronchopneumonia resulting from the cancer.

FNOF

Necessary cause of death (likely to be) injury

This person fell, fractured their femur, and was admitted to hospital. The person died 2 days after their fall, and was classified with an UCoD of Acute MI. There had been no prior mention of IHD – ischaemic heart disease – on prior NMDS records. CF indicated that if the fracture had been entered in Part I of the death certificate, it would have been coded as the UCoD.

Necessary cause of death unlikely to be / not injury

This person fell (same level) and was admitted to hospital with PDx of FNOF. They died 4 months later. Their UCoD was coded to breast cancer. There was no record of cancer treatment on NMDS records, although treatment could have occurred privately. There was no record of a health event once discharged after the fall. It is unusual not to receive treatment / care following FNOF - so they could have been transferred to a private hospital.

TBI

Necessary cause of death (likely to be) injury

This person fell and was admitted to hospital with a traumatic subdural haemorrhage. This was confirmed on a CT scan. They died 2 months later; they were discharged 2 days before death. The UCoD was coded to MI. Their injury was listed in Part II of the death certificate. They were admitted the same day as the death; only CVD was listed on the NMDS record.

Necessary cause of death equivocal

This person fell (same level) and was admitted for a closed head injury with brief loss of consciousness. They died 3 days after the injury. The UCoD was classified to Acute MI. The fall was included on the death certificate. There was haemorrhaging due to the anticoagulant given for the circulatory problems.

Necessary cause of death unlikely to be / not injury

This person fell from their bed and was admitted for concussion. They died 11 months after the injury. The UCoD was classified to CVA (stroke). There was cellulitis of the leg recorded 1 month prior to death. Alzheimer’s Disease was listed as contributing cause of death.

Injury / external cause mentioned anywhere on death certificate

Necessary cause of death (likely to be) injury

This person was admitted to hospital following self-harm (poisoning) with tricyclic or tetracyclic medicines. They died within 2 months. The UCoD was classified as IHD. They had had 9 admissions in the 5 months prior to death for diabetes or depression treatment. The coroner’s files indicated acute coronary insufficiency. The post-mortem indicated chronic IHD. The pathologist’s clinical notes indicated toxic levels of citalopram.

Necessary cause of death unlikely to be / not injury

No example was included in our sample of deaths.

No non-injury comorbidity mentioned on the NMDS records.

Necessary cause of death (likely to be) injury

No example was included in our sample of deaths.

Necessary cause of death unlikely to be / not injury

This person fell, fractured their humerus and was admitted to hospital. They were discharged after 1 day. They died within a week. The UCoD was coded to chronic obstructive pulmonary disease (COPD). Osteoporosis was listed in Part II of the death certificate. For this person, there were multiple admissions for COPD identified in the NMDS for the previous 10 years.

Discussion

Theoretical definition of injury death

It is usual, for the publication of government statistics, to identify cases of injury death using the UCoD. This has also been the common operational definition of injury death used by injury researchers. [10] We have argued here that this is a problem, from an epidemiological and injury prevention perspective. Epidemiologists recognise that, for any given adverse health outcome (including death), typically there is a web of causation that leads to that outcome. The UCoD should be close to the start of a given causal pathway, and can be legitimately considered a cause of death; however, so can any other factor that is part of the causal pathway that includes the UCoD, as well as "parallel" causal pathways. The examples that we have given illustrate this (see from page 46).

Since it is over-simplistic to think that the WHO UCoD is the only cause that is of relevance, we needed to find an alternative way of defining injury death - firstly theoretically. We argued that the concept of a "necessary cause" was an important one, and based the theoretical definition of injury death on that concept. In his Dictionary of Epidemiology, Last defined a "necessary cause" of disease as:

> *"a causal factor whose presence is required for the occurrence of the effect".* [22]

In terms of injury death, we interpreted this as follows:

> *"An injury death is one in which the injury resulted in premature death."*

In other words, an injury death is one in which, if the injury had not occurred, the death would not have occurred, or death would have occurred later.

The essence of this project was an investigation to identify (or at least propose) an operational definition of injury consistent with that theoretical definition. The main elements of that investigation were:

- a characterisation of the subgroups where there is a discrepancy between the NMDS PDx coded to injury, and the MC's UCoD coded to other than an external cause;
- a literature review to identify what others have found and the approaches to this problem that they have taken, and
- an assessment of a sample of records where there is a mismatch between UCoD and NMDS PDx.

Patterns of discrepancy between NMDS PDx and MC UCoD

Results of our analyses

Amongst the population with an NMDS PDx of injury considered in this study, the percentage with an UCoD of NI was 39% (time from injury to death <7 days), 66% (<3 months) and 77% (<1 year). Major variations in %NI were found for

- age,
- circumstance of injury,
- intent,
- NMDS PDx – both on the first discharge record after injury, and the last discharge record before death,
- the threat to life severity of injury resulting in admission,
- the existence or not of disease co-morbidities on the NMDS record, and
- whether or not the person died outside of hospital.

Particularly high %NI levels were found for older people aged 70 and over, for falls, and for fractures of the upper and lower limbs. Some of these combinations were investigated and are shown in

Table 8 for deaths within 7 days of injury. %NI was high for people aged 70+ who were injured as a result of a fall. It was only moderately high for people aged 70+ injured by other mechanisms. [11] Falls are a marker of “frailty” amongst older people [30,31]; the results in

[11] As before, we have used the following terms to represent ranges of %s as described below:

- “Low” – <15%
- “Moderately low” – 15-39%
- “Moderately high” - 40-59%
- “High” – $\geq$60%.

We have used them with a small degree of flexibility, however (eg. 15% has been described as low in some instances)

Table 8 are consistent with this.

For those aged 0-69, the frequencies in a number of the groups formed by the cross-tabulation of (falls=Y/N)*(FNOF=Y/N) are small and so will not be commented on. People aged 0-69 who fell had moderately high levels of %NI, whereas those injured by other mechanisms, the %NI was low.

Table 8: Number and percentage of %UCoD=NI for deaths within 7 days of injury for older people, falls, FNOF and gender.

Age	Falls	FNOF	Gender	UCoD=NI	UCoD=I	Total	%NI
70+	Y	Y	M	112	48	160	70
70+	Y	Y	F	163	74	237	69
70+	Y	N	M	96	83	179	54
70+	Y	N	F	131	90	221	59
70+	N	Y	M	2	7	9	22
70+	N	Y	F	7	8	15	47
70+	N	N	M	31	59	90	34
70+	N	N	F	38	57	95	40
0-69	Y	Y	M	1	1	2	50
0-69	Y	Y	F	8	0	8	100
0-69	Y	N	M	15	63	78	19
0-69	Y	N	F	15	20	35	43
0-69	N	Y	M	0	0	0	
0-69	N	Y	F	1	1	2	50
0-69	N	N	M	35	370	405	9
0-69	N	N	F	12	164	176	7
0-69	N	N	unknown	0	1	1	0
				667	1046	1713	

In the results, we found particularly low %NI rates for:

- people aged less than 30 years;
- MVTCs and drowning (for MVTC: where the death occurred within 90 days of the injury);
- assault and self-harm – where death occurred within 90 days;
- TBI with or without skull fracture – in the latter case, where death occurred within 7 days;
- spinal cord injury - where death occurred within 7 days;
- other internal organ injury - where death occurred within 7 days;
- very serious injuries (ICISS<=0.90) who died within 7 days; or
- has no non-injury co-morbid conditions associated with their hospitalisation for injury - where death occurred within 7 days of injury.

It should be noted that some overdoses are not coded to an injury code in the MC. Rather, there was a tendency to classify the UCoD as a mental health condition, ie. codes to the ICD chapter “Mental / behavioural disorder relating to substance use”. This probably explains the moderately high %NI for poisoning. Note that there was a WHO directive, which took effect from January 2006, which states that certain deaths from poisonings should not be coded to this mental health and behavioural disorder chapter. That directive has now been implemented, and so, in the future, more cases involving poisoning will be coded to an external cause of injury UCoD code.

What others have found

What follows next is a synopsis of the literature that has considered mismatches between hospital PDx and UCoD.

For those with a main hospital diagnosis in the injury and poisoning chapter, who died within 4 weeks of hospital admission, Goldacre identified 40% with an external cause of injury UCoD on the death certificate. [25] For those with a main diagnosis in the injury and poisoning chapter who died within 1 year of discharge, Johansson and Westerling identified 46% of males and 54% of females with an external cause of injury UCoD. [3] Johansson and Westerling reported that discordance increased with time elapsed from hospital discharge. For hospital deaths, 28% of the main diagnoses were 'incompatible' (not within the same ICD chapter) with UCoD. This increased to around 43% at 15-30 days, and 47% for deaths occurring at least four months after discharge.

Goldacre highlighted fractured neck of femur (FNOF) as a condition that, although present as a main condition on hospital discharge records, was only recorded (anywhere) on the death certificate in a minority of cases (25%) for deaths that occurred within 4 weeks of hospital admission. [25]

When all hospital information (including main condition, additional conditions, data on injuries and surgery within four weeks of death) was added to the death certificate and this was re-analyzed by automatic coding software, Johansson and Westerling reported that there was a substantial increase in the number of deaths from falls (from 667 to 1051). [3] Both Goldacre, and Johansson and Westerling, concluded that morbidity information should be routinely considered when establishing the UCoD. [3,25]

In contrast to Goldacre, Koehler and colleagues started with deaths in two groups of individuals aged 65 years and over: those for whom an unintentional fall related external cause of injury code was recorded in hospital discharge data, and those for whom the coroners records contained an underlying cause of death recorded as a fall. [32] For each case identified, two forensic pathologists and a forensic epidemiologist reviewed hospital records, autopsy reports, toxicology reports, death certificates, and coroner's reports. Of 77 deaths identified, 34 had been recorded with an UCoD of non-injury. After forensic examination, 12 of these were re-classified to accidental deaths. In addition, there were 22 cases identified where the UCoD was assigned to a fall in which the individual had only a minor or superficial injury and where these injuries played no apparent role in the death, resulting – according to the authors - in an over-count of falls related injury death. [32]

There have been a number of studies in which the certification practices of physicians and coroners have been investigated to determine the impact of these practices on the UCoD recorded on death certificates. [4,6,7,9,12] Betz et al (2008) and Roberts et al (2000) surveyed physicians and coroners, respectively, on death certification practices. Both investigations involved physicians / coroners reading clinical scenarios and then either completing a death certificate [9] or providing a verdict, with explanation [12]. For example, the physicians were presented with a case of an elderly patient who died from intracranial bleeding after a fall. Only 35% of survey respondents reported injury as a contributing cause of death. 51% reported a high level of confidence in their ability to complete a death certificate accurately. [9] In the work of Roberts and colleagues, the coroners were provided with 16 scenarios grouped as (1) post-operative, (2) a combination of trauma and natural disease, and (3) infectious disease. For scenarios that were a combination of trauma and natural disease, there was no significant agreement between the responding coroners. Roberts and colleagues suggested that the variation in whether to hold an inquest or not reflected the lack of definition for natural causes and the personal attitudes of each coroner, and concluded that national consensus on such issues needed to be reached in order to ensure consistent coding of 'borderline' cases. [12]

Calder and colleagues (1996), Parker (1996) and Pemberton (1988) have conducted case-series analyses of patients admitted to hospital with proximal femoral and hip fracture in order to determine the influence of coronial practices on the death rates from these injuries. [4,6,7] Calder and colleagues reported that none of the 92 patients who died within 28 days of being admitted with proximal femoral fracture to Leicester Royal Infirmary had the fracture listed as a direct cause of death. [6] Of the 22 referred for an inquest, all had the fracture listed as a contributing factor to the death, while only one of the remaining 70 not referred for an inquest had the fracture recorded as contributing. [6]

In a subsequent letter to the editor, Parker reported that the findings of Calder and colleagues were supported by data from Peterborough. Of the 15 cases of hip fracture that died within 28 days of being admitted to Peterborough District Hospital, the coroner allowed the death certificate to be issued in 14 cases because *"other medical conditions were thought to be more pertinent as a cause of death"*. [7] In all of these cases, the hip fracture was mentioned in Part II of the death certificate. He concluded that the practice of holding inquests into most deaths after hip fractures *"results in considerable distress to relatives and additional cost…Most deaths due to hip fracture, even when the fracture was due to a fall, are deaths due to natural causes."* [7]

In 1971, a policy was introduced by the coroner in Sheffield and Barnsley that the UCoD for most hip fractures in older people was osteoporosis, and death certificates should be completed to reflect this fact. The outcome of this policy was that these health districts had unusually high death rates attributable to osteoporosis and a low death rate due to hip fracture. [33]

In a further study, published in 1988, coroners in Nottingham reviewed 73 out of 94 FNOF deaths. For 60 of these cases, the fracture was entered in part II of the death certificate. The most frequently listed UCoD were recorded as ischemic heart disease, deep vein thrombosis, bronchopneumonia or cerebral vascular disease. For 35 fractured neck of femur deaths in North Derbyshire (30 of which were subject to an inquest), the fracture was listed as the UCoD in 28% of cases, it was mentioned in

Part II in 56% of cases, and was not mentioned at all in 16% of cases. [4] Pemberton concluded that the differences in death rates between health districts reflected the policy and views of the coroners and that death rates based on hospital data may more accurately reflect hip fracture death rate than that recorded in national statistics. [4]

Implications for the operational definition of injury

Our results suggest that certain subgroups, who are injured and die within a given threshold of time and which have a low %NI, could be identified as markers of injury death (ie. where injury is a necessary cause of death). This led to an initial proposed operational definition of injury death, which was examined in some preliminary work as part of this project. Even without further examination, this proposed operational definition could have more favourable properties than using UCoD alone. **It should be noted that no operational definition of injury will be 100% accurate in identifying cases satisfying our (or any) theoretical definition of injury.** Associated with any operational definition will be a false positive (FP) and a false negative (FN) error rate. The current operational definition based on UCoD alone is likely to have a very low FP error rate, but significant FN error rate. The proposed operational definition (below) is a starting point for further investigations to identify a new operational definition. We expect that, following further investigation, an operational definition will be found, which has substantially reduced FN error rate with only a small increase in the FP error rate.

On the back of our analysis, we proposed on page 42 the following partially specified operational definition of injury death, namely people satisfying one or more of the following:

- with an UCoD of external cause of injury
- aged 70 and over who die within T1 days of the injury event
- aged 45-69 who die within T2 days of the injury event
- aged 30-44 who die within T3 days of the injury event
- aged less than 30 who die within T4 days of the injury event
- injured from MVTCs or drowning who die within T5 days of the injury event
- who fall who and die within T6 days of the injury event
- who sustain a fractured neck of femur who die within T7 days of the injury event
- who sustain a TBI who die within T8 days of the injury event
- who have an injury or external cause recorded anywhere on the MCoD who die within T9 days of the injury event
- who had no medical comorbid conditions recorded on their hospital (NMDS) records who died within T10 days of their injury event.

In the above bullet points, T1, T2, …, T10 are the times between the injury event and death. This partially specified operational definition was modified in light of the assessment of a sample of records – next section.

Discussion of the review of a sample of records and their implications for the partially specified proposed operational definition of injury death

The results of the review of a sample of death records tentatively suggest the following:

- For people aged under 30 years, not only are the %UCoD=NI low, but also there is evidence that injury was a necessary cause for most of the cases with UCoD coded to NI.

- For people aged 30 years and over, if the UCoD is coded to NI, then no matter what the time between injury event and death, the results suggest that many of these may be regarded as legitimate NI cases.

- On the other hand, many of the deaths that occurred following FNOF were found on inspection to be likely injury deaths using our necessary cause definition. Many FNOFs occur in older people. An exception to the previous bullet may be, therefore, that for older people (eg. aged 70 and over), if they have been admitted for FNOF and die within 90 days, the case should be classified to an injury death. With such a threshold many more injury deaths would be captured.

- Falls had the highest %NI for each threshold amongst the external cause groups considered. When the sample of UCoD=NI for falls was investigated, deaths on the same day and within 7 days appeared likely to have injury as a necessary cause. If a threshold of 7days could be used for falls, this would be important since falls are the most common circumstance of injury discharge from hospital, amongst those that are subsequently classified with an UCoD of NI. So with such a threshold many more injury deaths would be captured.

- Relatively few people who were injured as a result of a MVTC or drowning were assigned an UCoD of NI. For those that were, the review of these UCoD=NI deaths showed equivocal results. It is unclear what time threshold can be proposed for MVTCs and Drowning in the above operational definition.

- Assault and self-harm had low %NI for the <7 days threshold, and it was moderately low for the <3 months and <12 months thresholds. A conservative approach would be to propose that cases be captured if they have NMDS PDx of assault or self-harm, and die within 7 days of the injury event. The investigation of individual assault and self-harm UCoD=NI deaths was incomplete, so provides limited additional insight.

- TBI where skull fracture was involved showed low %NI for all thresholds, and TBI without skull fracture showed low %NI for the <7 days threshold and moderately low %NI for the <3 and <12 months thresholds. The investigation of the sample of cases suggests that many of the UCoD=NI deaths could have injury as a necessary cause – for a threshold of up to 6 months. One would expect that these (and other) serious injuries would often be necessary causes of death, even where UCoD is classified to NI on the MC.

- For cases for which an injury or external cause of injury was present anywhere on the MCoD, our assessment of the sample of deaths was that in all cases injury was assessed as a necessary cause of death, and so the presence of an injury or external cause of injury on the MCoD is a marker of injury as a necessary cause of death.

- For hospital discharges with a PDx of injury, and where only injury diagnoses or external cause codes were recorded on the NMDS record (ie. no non-injury co-morbid conditions), the %UCoD=NI was low for the <7 days to death threshold. The findings from the investigation of a sample of UCoD=NI cases for this subgroup showed that all the deaths classified to UCoD=NI were judged not to have injury as a necessary cause. This result was counterintuitive. If it is real, the existence of no comorbid conditions on the NMDS cannot be used as a criterion within the operational definition of injury death.

This leads to the modified provisional operational definition of injury death.

Proposed provisional operational definition of injury death.

This leads to the modified provisional operational definition of injury death, namely people satisfying one or more of the following:

- with an UCoD of an external cause of injury
- with an injury or external cause recorded anywhere on the MCoD who die within 1 year of the injury event
- aged less than 30 and who die within 90 days of the injury event
- injured from MVTCs or drowning and who die within T5 days of the injury event
- who fall and die within 7 days of the injury event
- who sustain a fractured neck of femur and who die within 90 days of the injury event
- who are injured from assault or self-harm and who die within T8 days of the injury event
- who sustain a TBI and who die within 180 days of the injury event

Note that,

i. for TBI, concussion without brain injury is excluded.
ii. that the second bullet is similar to the approach investigated by Kreisfeld and Harrison. [2]
iii. the time threshold between injury and death is yet to be specified (shown as 'T5' and 'T8') in the 4th and 7th bullet point.

This provisional operational definition is a starting point for further investigations to confirm, or otherwise, a new operational definition. This new operational definition is likely to reduce FNs, but increase FPs. We are confident that, for a carefully chosen new operational definition, based on the above, the reduction in FNs will markedly outweigh the increase in FPs.

If this definition is applied to the NZIPS indicators, the additional number of cases for all injury, and for each priority area in the period 2001-2005 was 3,134 (37% increase in injury deaths compared with the NZIPS fatal injury definition). Note that this will underestimate the effect of the new definition since the Ministry of Health only commenced capturing secondary causes of injury systematically in 2007.

What needs to be done to finalise the new operational definition?

This definition (and perhaps others like it) needs to be investigated with a bigger sample than we employed, using a range of times to death, and using appropriate experts to come to a judgement about whether injury was a necessary cause of death or not. For this current work, we took a small systematic sample to:

(i) illustrate the discrepancies between NMDS and the MC
(ii) illustrate the discrepancies between WHO coding rules for mortality data, and the theoretical and operational definitions of injury
(iii) inform recommendations regarding enhanced data capture within the MC
(iv) inform recommendations regarding a modified operational definition of injury death for the NZIPS injury mortality indicators.

Future work needs to focus on investigating and finalising the operational definition. This would require a significant sample for each of the seven (out of eight) elements that currently make up the operational definition.

The process of identification of the proposed operational definitions was informed by the results of our current work. It should also be qualified by a literature review of studies aimed at identifying *excess mortality* associated with injury, which we recommend be carried out as one of the next steps, following this work. That excess mortality is likely to be dependent on diagnosis and external cause (including intent) of injury, and by time between the injury event and death. The diagnoses and external causes that should be the focus of the literature review should be informed by the current empirical work. For example, the current work indicates an undercount for FNOF injury deaths.

Previous work has found an excess mortality for people sustaining FNOF in the first year after the fracture [16]; others found that this excess mortality persisted for up to 10 years [17]. As well as informing the operational definition, it would also provide an indication of the likely undercount associated with any operational definition.

Such a literature review should be limited to analytical epidemiological studies based on primary data sources. (Papers considered in the current review suggest that uncontrolled confounding can be overwhelming in studies based on secondary data only.)

Correspondence of NMDS and MC data

With 6 exceptions, the gender recorded on the MC was identical to that recorded on NMDS. These were found to be classification errors on the MC. Almost all of the ages were similar between NMDS and MC; 99% were within 1 year of one another. For circumstance of injury (falls, MVTC, Drowning, Poisoning, Other specified, and Unspecified), there was 94% agreement between the MC data and NMDS. For the subset of people with an NMDS PDx of injury, and UCoD of external cause of injury:

- Of the people classified to falls on NMDS, 98% of these were identified as falls in the MC. There were 6% more external causes classified to falls on the MC compared with NMDS.
- Of the people classified to MVTC on NMDS, 95% of these were identified as MVTCs in the MC. There were 2% fewer external causes classified to MVTCs on the MC compared with NMDS.
- Of the people classified to drowning on NMDS, 81% of these were identified as drowning in the MC. There were 6% fewer external causes classified to drowning on the MC compared with NMDS. These findings were based on very small numbers.
- Of the people classified to poisoning on NMDS, 88% of these were identified as poisoning in the MC. There were 8% fewer external causes classified to poisoning on the MC compared with NMDS.

For the NZIPS priority groups of falls and MVTCs, the above results show good correspondence.

The data captured by the NMDS and MC for “intent” shows some discrepancy; however, there was 94% agreement (Kappa = 0.84). This is regarded as a high agreement. Given that the majority of these injury deaths, with the exception of deaths in older people, would have been investigated by a coroner, it is the MC data that represents the “gold standard” in this instance. Incidentally, in terms of the NZIPS serious non-fatal injury indicators for assault and for self-harm, it is reassuring that the level of agreement is so high.

In a USA study of male Viet Nam veteran’s, who had been enlisted in the army for a single term and who were discharged from the army alive, and for deaths occurring over an 18 year follow-up period since discharge, the UCoD E-code was compared with the independent findings of a medical review panel. They found that the broad classification of MVTC deaths was excellent, with 97% being identified from the UCoD. For self-harm deaths, 90% were classified as such as the UCoD; for assault it was 96%; but for unintentional poisoning it was 50%. Falls were not examined as a category. [10] These results are similar to those that we found, with the exception of poisoning.

Strengths and Limitations

Strengths

This is the first systematic examination to identify an operational definition of injury death consistent with a theoretical definition of injury death based on "necessary cause". A multi-faceted provisional operational definition has been constructed, in the light of the results of this work. That definition goes far beyond that of other investigations.

Limitations

This study was limited to deaths that occurred within 12 months of the injury event. There were 6,924 people injured during 2000 to 2004 who died after the 365 days injury threshold used in this study (as opposed to 10,234 that died within 12 months). However, relatively few (486 of these 6,924) had a UCoD of injury. Nevertheless, it is clear that some injury deaths occurred beyond this 12 month limit that we arbitrarily imposed. Since there were less than 5% of deaths with an UCoD of injury, our expectation is that this arbitrary threshold will have minimal effect on our results.

We investigated a limited sample of NI cases from the MC:

(i) to illustrate the discrepancies between WHO coding rules for mortality data, and the theoretical and operational definitions of injury death

(ii) to inform recommendations regarding enhanced data capture within the MC

(iii) to inform recommendations regarding a modified case definition of injury death for the NZIPS injury mortality indicators.

Further work is now needed to investigate our provisional operational definition, with a bigger sample size (see Recommendations). So although the size of the sample we used was fit for the purposes originally proposed and listed above (and so was not strictly a limitation), it does represent a limitation in terms of verifying the operational definition of injury death.

Conclusions

Using theoretical arguments, counting cases of injury death using underlying cause of death from the MC alone will not count all cases, where injury is defined in terms of a "necessary" cause of death.

As a result of this work we proposed a theoretical definition of injury death as follows:

An injury death is one in which the injury resulted in premature death.

In other words, an injury death is one in which, if the injury had not occurred, the death would not have occurred, or would have occurred later.

We also produced a provisional operational definition of injury. It is proposed that a death be counted as a case of injury death if it satisfies one or more of the following:

- it has an UCoD of an external cause of injury
- it has an injury or external cause recorded anywhere on the MCoD and the person died within 1 year of the injury event
- the person is aged less than 30 and died within 90 days of the injury event
- they were injured from MVTCs or drowning and died within T5 days of the injury event
- they fell and died within 7 days of the injury event
- they sustained a fractured neck of femur and died within 90 days of the injury event
- they were injured as a result of assault or self-harm and died within T8 days of the injury event
- they sustained a TBI and died within 180 days of the injury event

Here, T5 and T8 are time thresholds yet to be identified. Whatever new operational definition of injury death is used, if structured similar to the above, it will result in the ascertainment of many more cases of injury deaths than currently, ie. than when using UCoD alone. Amongst the NZIPS priority areas, this will have the most impact on the counts of falls injury deaths

This definition needs to be investigated in a further study – see Recommendations. Whatever operational definition of injury is used, it will not capture all cases of injury death. Work needs to be done to describe the extent of the missing cases, from a literature review, using "excess mortality" arguments.

Age, gender, external cause of injury and intent of injury captured on the MC were similar to those captured in the NMDS. The levels of any inaccuracies associated with these fields are unlikely to compromise the validity of the NZIPS fatal injury indicators.

Recommendations

Enhanced data capture within the Mortality Collection

For 2007 onwards, MC staff have been coding all injuries documented on the MCoD and this data will be available on the MC. Currently, they are not coding E-codes that appear on the MCoDs where the UCoD is non-injury. E-codes are required to be able to classify additional injury deaths cases to priority area (eg. falls, MVTC, assault, self-harm). We recommend that this be implemented.

Recommendation 1

> Where an external cause or the nature of injury is recorded on the medical certificate of cause of death, we recommend that this be captured on the Mortality Collection, even in the presence of a non-injury underlying cause of death.

In order to implement our proposed operational definition of injury death, the date of the injury event is needed.

Recommendation 2

> We recommend that the date of the injury event is recorded on the Mortality Collection in all instances where an injury or an external cause of injury is recorded on the medical certificates of cause of death.

The World Health Organization (WHO) has recommended that deaths due to certain poisonings should no longer be assigned underlying cause of death codes F10-F19 from the Mental and Behavioural Disorders chapter of the International Classification of Diseases.

Recommendation 3

> We recommend that the change URC0117 described in the WHO List of Official ICD-10 Updates, which recommends that deaths due to certain poisoning should no longer be assigned an underlying cause of death code in the F10-F19 from the Mental and Behavioural Disorders chapter of ICD10, be implemented.

For the years when this recommendation is not implemented, it is recommended that the current operational definition be adjusted as follows:

Recommendation 3.1

We recommend that, if for a particular person the principal diagnosis captured on NMDS is classified to poisoning (X40-X49, X60-X96, X85-X90 or Y10-Y19), and the UCoD is coded to the range F10-F19, this person be counted as a case of injury death.

A modified case definition of injury death for the NZIPS fatal injury indicators.

Renate Kreisfeld and James Harrison (Flinders) authored an Australian Institute of Health and Welfare report [2] in which they used the concept of “additional injury deaths” which were those identified with a medical UCoD, but where an injury code appeared anywhere on the death certificate. As an interim, until the recommended further work is completed, we recommend that this approach be used in New Zealand, alongside the current approach which uses a definition based solely on UCoD.

Recommendation 4

That for the NZIPS indicators, cases of injury death be defined and presented in two ways: (1) using the current operational definition of injury death based on underlying cause of death, but including sequelae of injury, (2) using the current operational definition plus “additional injury deaths”, which are those identified with a medical UCoD, but where an injury or external cause code appears anywhere on the medical certificate of death.

Further Work

Literature Review of studies to identify excess mortality

The process of identification of one or more alternative operational definitions is informed by the results of our current work. It should also be informed by a literature review of studies aimed at identifying *excess mortality.* That excess mortality is likely to be dependent on diagnosis and external cause (including intent) of injury and time between the injury event and death. The diagnoses and external causes that should be the focus of the literature review should be informed by the current empirical work. The proposed literature review will inform the period during which excess mortality exists, which itself is dependent on diagnosis and external cause. Knowledge of that excess mortality will not only inform the operational definition, but will also allow the qualification of indicator counts in terms of additional cases that are likely to remain uncounted by any new operational definition.

Such a literature review should be limited to analytical epidemiological studies based on primary data sources. (Papers identified in the current review suggest that uncontrolled confounding can be overwhelming in studies based on secondary data only.)

Recommendation 5

That a systematic review of the literature be funded, aimed at characterising excess mortality following injury. Such a literature review should aim to describe that excess mortality by diagnosis and external cause (including intent) of injury and time between the injury event and death.

A further investigation of operational definition.

A further study, with a greater sample size, is needed to investigate and finalise the proposed operational definition. The further study could be formulated in terms of screening, with the proposed operational definition being equivalent to a screening tool, and using a panel of expert assessors to provide a confirmatory classification, ie. a definitive assessment of whether a particular death is a "true" injury death or not. Such work would require a significant sample for each of the seven (out of eight) elements that currently make up the provisional operational definition.

Expanding a little further, the proposed method to identify the "true" status of the death (injury death or not) would include expert assessors (eg. forensic pathologist, etc) being asked to carry out "thought experiments" for a sample of deaths (blind to the proposed operational definition(s) and the classification of individual deaths using these operational definition(s)) to classify cases into injury-related and not injury-related deaths.

a. These "thought experiments" would be along the lines of, given all of the information available from MC, NMDS, MCoD, coroners' report, etc., and using a balance of probability argument, would the occurrence of an injury have shortened life, or not?
b. The consensus of these thought experiments could be regarded as a "gold standard" in a screening-related approach to assessing alternative operational definitions.

That screening approach could, for each operational definition (eg. generated by varying the time to death thresholds for each subpart of the operational definition), be used to work out sensitivities, specificities, positive predictive values and negative predictive values – and these used to decide on the best operational definition.

Recommendation 6

That a further study, with a greater sample size, be funded to investigate and finalise the proposed operational definition.

Coding of self-harm injury death

Someone admitted to hospital due to self-harm, (and so coded on NMDS with an E-code of self-harm), may be classified as an unintentional injury death in certain circumstances. If the coroner states that the death was self-inflicted but he is unable to determine whether or not the deceased intended to kill him/herself, then MC staff would use an undetermined intent code (Y10-Y34). If the coroner clearly states that the deceased did not intend to kill him/herself, even though the injury that led to death was self-inflicted, then MC staff code such a case to an unintentional injury death code. It implies that there will be contradictory cases classified on NMDS relative to the MC. For example, if someone clearly self-harms, and clearly did not intend to kill themselves, but they die in hospital of their self-harm injuries, then NMDS would code to self-harm, but MC would have the case coded to an unintentional injury. The extent of this mismatch deserves further investigation.

Recommendation 7

> As part of the study proposed in Recommendation 5, that the mismatch (and the reason for the mismatch) between injury coded to self-harm in the NMDS, and the subsequent death coded to unintentional injury on the MC, be investigated in order to estimate the size of the problem of self-harming that resulted in unintended death.

References

1. Davie G, Cryer C, Langley J. Improving the predictive ability of the ICD-based Injury Severity Score. *Injury Prevention* 2008;14:250-5.
2. Kreisfeld R, Harrison JE. Use of multiple causes of death data for identifying and reporting injury mortality. . *Injury technical paper series no.9 (AIHW cat. No. INJCAT 98).* Canberra: AIHW, 2007.
3. Johansson LA, Westerling R. Comparing hospital discharge records with death certificates: can the differences be explained? *Journal of Epidemiology and Community Health* 2002;56:301-8.
4. Pemberton J. Are hip fractures underestimated as a cause of death? The influence of coroners and pathologists on the death rate. *Community Medicine* 1988;10:117-23.
5. Lapidus G, M B, Schwartz R, Banco L, Jacobs L. Accuracy of fatal motorcycle injury reporting on death certificates. *Accident Analysis and Prevention* 1994;26:535-42.
6. Calder SJ, Anderson GH, Gregg PJ. Certification of cause of death in patients dying soon after proximal femoral fracture. *British Medical Journal* 1996;312:1515.
7. Parker MJ. Mortality inferred from death certificates reflects coroners' practice, not the true mortality. *British Medical Journal* 1996;313:879.
8. Rodriguez SR, Mallonee S, Archer P, Gofton J. Evaluation of death certificate-based surveillance for traumatic brain injury - Oklahoma 2002. *Public Health Reports* 2006;121:282-9.
9. Betz ME, Kelly SP, Fisher J. Death certificate inaccuracy and underreporting of injury in elderly people. *Journal of the American Geriatric Society* 2008;56:2267-72.
10. Moyer LA, Boyle CA, Pollock DA. Validity of death certificates for injury-related causes of death. *American Journal of Epidemiology* 1989;130:1024-32.
11. Langlois JA, Smith GS, Baker SP, Langley JD. International comparisons of injury mortality in the elderly - issues and differences between New Zealand and the United States. *International Journal of Epidemiology* 1995;24:136-43.
12. Roberts ISD, Borodkin LM, Benbow EW. What is a natural cause of death? A survey of how coroners in England and Wales approach borderline cases. *Journal of Clinical Pathology* 2000;53:367-73.
13. World Health Organization. *International Statistical Classification of Diseases and Related Health Problems,* Tenth Revision, Volume 2, Second Edition. Geneva: World Health Organization, 2004.
14. Fotheringham W. *Put me back on my bike. In search of Tom Simpson.* London: Yellow Jersey Press, 2003.
15. Rothman KJ, Greenland S, Lash TL. *Modern Epidemiology, 3rd Edition*. Philadelphia: Lippincott, Williams & Wilkins, 2008.
16. Hindmarsh DM, Hayen A, Finch CF, Close JCT. Relative survival after hospitalisation for hip fracture in older people in New South Wales, Australia. *Osteoporosis International* 2009;20:221-9.

17. Bliuc D, Nguyen ND, Milch VE, Nguyen TV, Eisman JA, Center JR. Mortality Risk Associated With Low-Trauma Osteoporotic Fracture and Subsequent Fracture in Men and Women. *Journal of the American Medical Association* 2009;301(5):513-21.
18. Cryer C, Langley J, Stephenson S. Developing Valid Injury Outcome Indicators: A report for the New Zealand Injury Prevention Strategy. Dunedin: University of Otago, 2004:1-141.
19. Cryer C, Langley JD. Developing valid indicators of injury incidence for "all injury". *Injury Prevention* 2006;12:202-7.
20. Gulliver P, Cryer C, Davie G. A Chartbook of the New Zealand Injury Prevention Strategy Serious Injury Outcome: 1994 – 2008. *Injury Prevention Research Unit (University of Otago) Occasional Reports OR081*. Wellington: New Zealand Injury Prevention Strategy Secretariat, ACC, 2009.
21. Henley G, Harrison J. *Causes of injury mortality: managing misclassification*. Flinders University, Australia: AIHW National Injury Surveillance Unit, 2006.
22. Last JM. *A dictionary of epidemiology.* Third Edition ed. New York: Oxford University Press, 1995.
23. Barell V, Aharonson-Daniel L, et al. An introduction to the Barell body region by nature of injury diagnosis matrix. *Injury Prevention* 2002;8:91-96.
24. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* 1986;i:307-10.
25. Goldacre MJ. Cause-specific mortality - understanding uncertain tips of the disease iceberg. *Journal of Epidemiology and Community Health* 1993;47:491-6.
26. Rossignol M. Completeness of provincial workers compensation files to identify fatal occupational injuries. *Canadian Journal of Public Health* 1994;85:244-7.
27. Landis RJ, Koch GG. The measurement of observer agreement for categorical data. *Biometrics* 1977;33:159-74.
28. Farchi S, Camilloni L, Rossi PG, Chini F, Borgia P, Guasticchi G. Home injuries mortality: sensitivity and specificity analysis of different data sources and operative definitions. *Accident Analysis and Prevention* 2007;39:716-20.
29. Injury Surveillance Workgroup. *Consensus recommendations for using hospital discharge data for injury surveillance.* State and Territory Injury Prevention Directors Association, 2003.
30. Cryer C, Patel S. *Falls, Fragility and Fractures. National Service Framework or older people: The case for strategies to implement a joint Health Improvement and Modernisation Plan for falls and osteoporosis.* The Alliance for Better Bone Health, 2001.
31. UK Accidental Injury Task Force's Working Group on Older People. *Priorities for prevention*. Canterbury: Centre for Health Services Studies, University of Kent., 2001.
32. Koehler SA, Weiss HB, Shakir A, Shaeffer S, Ladham S, Rozin L, et al. Accurately assessing elderly fall deaths using hospital discharge and vital statistics data. *Am J Forensic Med Pathol* 2006;27:30-5.
33. Pemberton J, Cust G. An epidemic of osteoporosis? *Community Medicine* 1986;8:322-8.

Attachment 1: The capture of mortality data

Preface

This attachment provides a précis of the ICD-10 coding rules for coding mortality data and a description of the capture of mortality data in New Zealand. In order to reduce the likelihood of misrepresentation of the coding rules, rules have been transcribed rather than described. For reference, excerpts have been pasted from Ministry of Health coding documents as well as relevant New Zealand legislation. A diagrammatic representation of the capture of mortality data in New Zealand (as presented by Christine Fowler in December 2008) is also included.

World Health Organisation Rules for coding Injury Related mortality

Definitions

Taken from: World Health Organisation (1992) International statistical classification of diseases and health related problems – 10th revision. Volume 1, Geneva.

Causes of death: “all those diseases, morbid conditions or injuries which either resulted in or contributed to death and the circumstances of the accident or violence which produced such injuries”.

Underlying cause of death “(a) the disease or injury which initiated the train of events leading directly to death, or (b) the circumstances of the accident or violence which produced the fatal injury”.

Rules and guidelines for mortality coding

Taken from: World Health Organisation (1992) International statistical classification of diseases and health related problems – 10th revision. Volume 2, Geneva.

The purpose of the above definition of ‘cause of death’ is to ensure that all relevant information is recorded and that the certifier does not select some conditions for entry and reject others. The definition does not include symptoms and modes of dying such as heart failure or respiratory failure.

International form of medical certificate of death:

Part I is for diseases related to the train of events leading directly to death, part II is for unrelated but contributory conditions.

The condition recorded on the lowest used line of Part I of the certificate is usually the underlying cause of death used for tabulation.

Indirect causes should be included on the certificate. For example, where an antecedent condition has predisposed to the direct cause by damage to tissues or impairment of function, even after a long interval.

Procedures for selection of the underlying cause of death for mortality tabulation

When more than one cause of death is recorded:

General principle

When more than one condition is entered on the certificate, the condition entered alone on the lowest used line of Part I should be selected only if it could have given rise to all the conditions entered above it.

Selection rules

1. If the General Principle does not apply and there is a reported sequence terminating in the condition first entered on the certificate, select the originating cause of this sequence. If there is more than one sequence terminating in the condition mentioned first, select the originating cause of the first mentioned sequence.
2. If there is no reported sequence terminating in the condition first entered on the certificate, select the first mentioned condition.
3. If the condition selected by the General Principle or by Rule 1 or Rule 2 is obviously a direct consequence of another reported condition, whether in Part I or Part II, select this primary condition.

In some circumstances the ICD allows the originating cause to be superseded by one more suitable for expressing the underlying cause in tabulation (see 'Modification rules' (this page) and 'Specific rules relating to Injury' (page 6)). There are some categories for combinations of conditions, or there may be over-riding epidemiological reasons for giving precedence to other conditions on the certificate.

Where the originating antecedent cause is an injury or other effect of an external cause classified to Chapter XIX, the circumstances that gave rise to that condition should be selected as the underlying cause for tabulation and coded to V01-Y89. The code for the injury or effect may be used as an additional code.

Where the General Principle cannot be applied, clarification of the certificate should be sought from the certifier wherever possible. Where further clarification cannot be obtained, the selection rules must be applied. Rule 1 is applicable only if there is a reported sequence, terminating in the condition first entered on the certificate. If such a sequence is not found, Rule 2 applies and the first entered condition is selected.

The condition selected by the above rules may, however, be an obvious consequence of another condition that was not reported in a correct causal relationship with it, e.g. in Part II or on the same line in Part I. If so, Rule 3 applies and the originating primary condition is selected. It applies, however, only when there is no doubt about the causal relationship between the two conditions; it is not sufficient that a causal relationship between them would have been accepted if the certifier had reported it.

Modification rules

These are intended to improve the usefulness and precision of mortality data and should be applied after selection of the originating antecedent cause.

Rule A: Senility and other ill-defined conditions.

Where the selected cause is ill-defined and a condition classified elsewhere is reported on the certificate, reselect the cause of death as if the ill-defined condition had not been reported, except to take account of that condition if it modifies the coding. Ill defined conditions: I46.9 (cardiac arrest, unspec), J95.9 (hypotension, unspec); I99 (other and unspec disorders of circulatory system); J96.0 (acute respiratory failure); J96.9 (respiratory failure, unspec); P28.5 (resp failure of newborn); R00-R94 and R96-R99 (Symptoms signs and abnormal clinical and laboratory findings, nec).

Rule B: Trivial conditions

Where the selected cause is a trivial condition unlikely to cause death and a more serious condition is reported, reselect the underlying cause as if the trivial condition had not been reported. If the death was the result of an adverse reaction to treatment of a trivial condition, select the adverse reaction.

Rule C: Linkage

Where the selected cause is linked by a provision in the classification or in the notes for use in underlying cause mortality coding with one or more of the other conditions on the certificate, code the combination. Where the linkage provision is only for the combination of one condition specified as due to another, code the combination only when the correct causual relationship is stated or can be inferred from application of the selection rules. Where a conflict in linkage occurs, link with the condition that would have been selected if the cause initially selected had not been reported.

Accidents with mention of A35 (Tetanus) should be coded to A35

Accidents resulting from G40-G41 (Epilepsy), code to G40-G41

Rule D: Specificity

Where the selected cause describes a condition in general terms and a term that provides more precise information about the site or nature of this condition is reported on the certificate, prefer the more informative term.

Rule E: Early and late stages of disease

Where the selected cause is an early stage of a disease and a more advanced stage of the same disease is reported on the certificate, code to the more advanced stage. This rule does not apply to a chronic form as due to an acute form unless the classification gives special instructions to that effect.

Rule F: Sequelae

Where the selected cause is an early form of a condition for which the classification provides a separate “Sequelae of…” category, and there is evidence that death occurred from residual effects of this condition rather than from those of its active phase, code to the appropriate “Sequelae of…” category.

Specific rules relating to Injury

It is recommended that a code from Chapter XIX (S00-T98) should be used in addition in order to identify the nature of the injury and permit relevant tabulations.

Where more than one kind of injury to a single body region S00-S99, T08-T35, T66-T79, is mentioned and there is no clear indication as to which cause death, the General Principle and the Selection Rules should be applied in the normal way.

When combinations of medicinal agents classified differently are involved, proceed as follows: if one component of the combination is specified as cause of death, code to that component; if no component is specified, code to the category provided for the combination (e.g. mixed antiepileptics (T42.5)). Otherwise, if the components are classified to the same three character category, code to the appropriate category for "Other" if not, code to T50.9.

Combinations of medicinal agents with alcohol should not be coded to the medicinal agent.

External Causes

The codes for external causes (V01-Y89) should be used as the primary codes for single condition coding and tabulation of the underlying cause when, and only when, the morbid condition is classifiable to chapter XIX (Injury, poisoning and other consequences of external causes).

When the morbid condition is classified to Chapters I-XVIII, the morbid condition itself should be coded as the underlying cause and categories from the chapter for external causes may be used, if desired, as supplementary codes.

MoH Information Directorate process for recording injury deaths

(As described by Christine Fowler, 12 March 2009)

The primary person responsible for completing the Medical Certificate of Death is the doctor who last attended the patient (where death occurred in the hospital) or the individual's usual doctor (GP) in cases where the death occurred out of hospital. Where the death was 'expected' (i.e. the medical history of the individual indicated that death may be imminent), the GP will often be confident enough to complete the MCoD. Where the death was unexpected, it will be referred to the coroner.

Deaths in hospital are often not referred to the coroner. This can be identified by checking the 'facility' and 'post-mortem' codes in the Mortality Collection. The 'facility' code identifies where the death occurred. In addition, a coroners report is not required if the deceased is "≥ 70 years and the injury is caused by an accident that resulted from infirmities of old age" (e.g. arthritis, poor balance, postural hypertension) – refer excerpt from Births Deaths and Marriages Registration Act, 1995, page 13 of this document. In these cases the GP/attending doctor is able to certify MCoD. It is also possible that long term patients may not be referred to the coroner (the doctor may forget about the necessity to do so). The MoH Information Directorate team has recently begun doing a keyword search on files as they are submitted to identify those that haven't been forwarded to the coroner, but that should have been. The new MCoD form has a tick box to indicate 'discussed with coroner'.

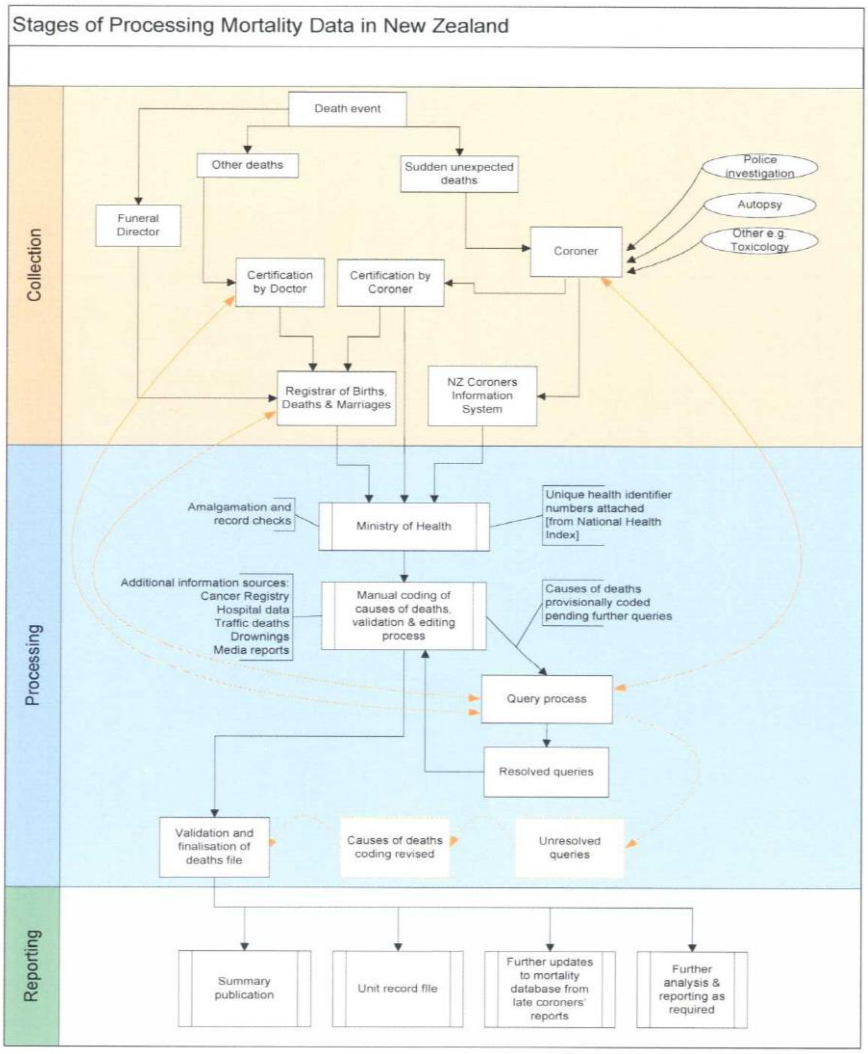
Where the coroner becomes involved, they will usually order an autopsy and gather information from the police (who provide a 1 page summary of the facts surrounding the event), hospital notes, CYF notes etc. Once the coronial inquiry into a death is completed the coroner completes a coronial 'Certificate of Findings' detailing the cause of death and the circumstances surrounding the accident or injury that caused the death (motor vehicle accident, suicide etc). This certificate is issued instead of a medical certificate of cause of death. The coroner will then provide a summary of the cause of death to the Mortality Collection.

Two fields are of interest in the summary file (1-2 pages) submitted to the MC: 'Cause of death' (what was the direct cause of death, i.e. ruptured spleen) and 'As a result of' (the circumstances surrounding the event). There is often insufficient information contained within these fields to accurately determine the underlying cause of death, at which time the MC seeks further information from the complete coronial file, LTSA data, Drownbase or the media. "LTSA data is very helpful in MVTC related deaths. It provides additional detail allowing the classification of the circumstances associated with the death".

In the past, MC staff have gone to coronial services to access the additional information required to code the underlying cause of death. As at July 2007, this is no longer permitted, however they will soon be able to access electronic information (Refer new coronial services Bill).

The primary source of information is the coronial file. However if this doesn't make sense or if conflicting information is obtained from an alternative source (i.e. Drownbase) further information is obtained from (for example) post-mortem reports. NMDS data may also be used if coroners reports are too vague. The MC does not have access to inpatient data, only discharge data.

Processing mortality data



Excerpts from "A guide to certifying causes of death" NZHIS (2001)

Page 8:

The New Zealand Medical Certificate has been designed in accordance with the International Death Certificate recommended by WHO to ensure that the questions asked on death certificates are uniform throughout the world. The directions for filling in the Medical Certificate of Causes of Death are set out on the front cover of each book of medical certificates.

Reporting of deaths to a coroner

In general, the doctor attending a patient during any final illness signs a medical certificate of cause of death if satisfied as to probable cause. There are occasions, however, when a doctor is required to report a death to a coroner. Deaths without known cause, apparent suicides and deaths arising from violent or unnatural events, or occurring in circumstances as stated in section 4 of the Coroners Act 1988, must always be reported to the coroner (see page 54). On occasion the coroner may direct that a medical certificate can be issued by the doctor in charge of the patient, for instance when an elderly person has died following a fractured neck of femur (see page 55). In such cases it is helpful to NZHIS if the doctor writes "as discussed with coroner" on the medical certificate.

In other cases, however, the coroner may assume jurisdiction and issue a Finding – such a Finding may be issued 'on the papers' (after studying the postmortem report and/or doctor's certificate), or after sitting at inquest.

Appendix 2: Extracts from Legislation

Extract from the Coroners Act 1988 (pg 54)

4. Deaths that must be reported—
(1) The following deaths shall be reported:
(a) Every death that appears to have been:
(i) Without known cause; or
(ii) Suicide; or
(iii) Unnatural or violent.
(b) Every death in respect of which no doctor has given a certificate under Section 25 of the Births and Deaths Registration Act 1951:
(c) Every death:
(i) That occurred while the person concerned was undergoing a medical, surgical, or dental operation or procedure or some similar operation or procedure; or
(ii) That appears to have been a result of any such operation or procedure; or
(iii) That occurred while the person was affected by an anaesthetic; or
(iv) That appears to have been a result of the administration to the person of an anaesthetic:
(d) The death of any patient detained in an institution pursuant to an order under Section 9 of the Alcoholism and Drug Addiction Act 1966.
(e) The death of any child or young person in a residence established under Section 364 of the Children, Young Persons, and Their Families Act 1989:
(f) The death of any child or young person while that child or young person—
(i) Is in the custody or care of an Iwi Authority or a Cultural Authority, or the Director of a Child and Family Support Service, pursuant to Section 43 or Section 78 or Section 110 or Section 139 or Section 140 or Section 141 or Section 234 or Section 238 or Section 345 of the Children, Young Persons, and Their Families Act 1989; or
(ii) Is in the charge of any person or organisation pursuant to Section 362 of the Act.
(g) The death of any special or committed patient (within the

meaning of the Mental Health
Act 1969) in a hospital.
(h) The death of any inmate (within the meaning of the Penal Institutions Act 1954).
(i) The death of any person in the custody of the Police.
(j) The death of any person in such circumstances that an enactment other than this Act requires the holding of an inquest.
(2) Paragraphs (d) to (h) of subsection (1) of this section apply to a death whether or not it occurred in the institution, residence, hospital, or penal institution concerned.

Extract from the Births, Deaths and Marriages Registration Act 1995 (as amended by the Births, Deaths and Marriages Registration Amendment Act 2000) (pg 55)

38. Medical certificates in relation to accidents to elderly persons—
(1) Notwithstanding that a death may have been reported to the Police under section 4 of the Coroners Act 1988, a doctor may give a doctor's certificate for
56 A Guide to Certifying Causes of Death
the death of a person if the person had attained the age of 70 years and, in the opinion of the doctor,—
(a) The death was caused by injuries, or injuries contributed substantially to it; and
(b) The injuries were caused by an accident; and
(c) The injuries, the accident, or both, arose principally by virtue of infirmities that were attributes of the person's age; and
(d) The accident was not suspicious or unusual; and
(e) The accident was not caused by an act or omission of any other person; and
(f) Except to the extent that the death involved injury by accident, it was not violent, unnatural, or in some way a death in respect of which the Coroners Act 1988 requires an inquest to be held.
(2) If a doctor is aware that a death has been reported under section 4 of the Coroners Act 1988, the doctor must not give a doctor's certificate under subsection (1) without first obtaining the agreement of the Coroner to whom the death has been reported.

[*Note from NZHIS: Section 38 is meant to apply mainly to those cases where an elderly person falls and fractures a neck of femur. It is not envisaged that this clause covers such events as motor vehicle crashes or where a third party is involved.*]

Attachment 2: Systematic Literature Review

Pauline Gulliver, Colin Cryer, Ari Samaranayaka, Gabrielle Davie, John Langley

List of abbreviations

ACC	Accident Compensation Corporation
ICD	International Classification of Diseases
ICD-9	Nine version of the ICD coding scheme
ICD-10	Tenth version of the ICD coding scheme
ICD-10-AM	Australian modification of ICD-10
ICISS	International Classification of Diseases-based Injury Severity Score
E-codes	External cause of injury codes from the ICD coding scheme
EIS	Emergency Information Service
HD	Hospital discharge records
MR	Mortality registry
NCIS	Australian National Coronial Information Service
NZIPS	New Zealand Injury Prevention Strategy
STIPDA	State and Territorial Injury Prevention Directors Association
TBI	Traumatic brain injury
UCoD	Underlying Cause of Death
WHO	World Health Organisation

Introduction

Many of the New Zealand Injury Prevention Strategy (NZIPS) fatal injury indicators are derived from the underlying cause of death as captured in the Mortality Collection [1]. The other potential source of injury deaths data for the NZIPS indicators, the Accident Compensation Corporation (ACC) claims data, have missing injury deaths, and so they need to rely on other sources for more complete enumeration of the burden of fatal injury – the Mortality Collection being a primary source [2]. Recent work to enhance the International Classification of Diseases-based Injury Severity Score (ICISS) has exposed apparent contradictions in the diagnostic data: for many of the ‘injury’ cases that die in hospital, there was a gross mismatch between hospital principal diagnosis and underlying cause of death recorded on the Mortality Collection [3]. This is consistent with a number of studies including those from Sweden and Australia [4 5].

The objective of this literature review is to provide a theoretical basis for a revised definition of an injury death. Two strands of literature have been reviewed:

c) theoretical definitions of injury death used by the injury research community; and
d) research to identify discrepancies and methods used to “adjust” the numbers of cases of injury death.

This document provides a description of the methods used to conduct the systematic review as well as the findings of the review.

Methods

For each of the categories described below, articles specifically related to the reliability of injury death data were identified. Articles were rejected on the basis that they did not focus specifically on injury deaths, the end point was hospitalization rather than death, or that the focus of the article was on ICD rule changes or on the effect of coding discrepancies on resource allocation over time. Only English language articles were reviewed and retained.

Definition of injury mortality

The OVID (Embase and Medline) and CINAHL article databases were searched for articles relating to a theoretical or operational definition of injury death:

(“Injury” + “death”) + “definition”

(“Trauma” + “mortality”) + “definition”

((“injury” or “trauma”) + (“death” or “mortality”)) + “definition”

Investigations of the discrepancy between hospital and mortality records

Initial exploration of the literature was conducted using the Science Citation Index search engine from ISI Web of Knowledge. A frequently cited article by Goldacre (1993) was used as a basis for the search. All articles that had cited this article were reviewed, as were articles that had been referenced by Goldacre [6]. From this list, articles considered relevant to the review were identified and were used as a basis to identify additional articles, firstly by reviewing those that cited these additional articles and then by reviewing the articles that had been included on the reference lists. This process continued until no additional relevant articles were identified.

Following the search of the Science Citation Index, the OVID and CINAHL search engines were used. The following keywords were used in the search strategy:

3. (“Death certificates” or “death registration”) + ((discharge + data) + records) + (review + comparison)
4. (“Death certificates” or “cause of death” or “death registration”) + (“underreported” or “underestimated” or “under rated” or “under report” or “over report”)

Methods to adjust the number of cases of injury death

Similar methods to those described above were used to identify references describing methods to adjust for the number of cases of injury death. An article by Rossignol (1994) [7] was used as the basis of the exploration using the Science Citation Index. This article was selected as it was the first reference identified to describe a method of adjusting for the number of cases of injury death estimated. The following keywords were used to search the OVID and CINAHL article databases:

(“Injury” or “trauma”) + (“death” or “mortality”) + (“adjust” or “capture-recapture”)

Additional searches

In addition to the above, a search of the “Google” internet based search engine was conducted using the following terms: “Discrepancies between hospitalisation and death data” and “Methods to adjust the numbers of cases of injury death”. Finally, the injury reference list “Safetylit” was searched for articles relevant to definition of injury mortality, investigations of the discrepancy between hospital and mortality records, and methods to adjust the number of cases of injury death.

Results

A total of 45 references were identified using the above strategies. Each reference was reviewed to determine relevance to the two strands. A revised list of 21 references were identified as belonging to one of the two strands. A draft of this review was critiqued by two experts in this area, who recommended an additional 20 references (total of 64 reviewed) and expanded search terms, which were incorporated into the search strategy described above. Eight additional articles (total of 29) were considered relevant to the current review.

Definition of injury mortality

The current WHO definitions of death include:

> Causes of death: "all those diseases, morbid conditions or injuries which either resulted in or contributed to death and the circumstances of the accident or violence which produced such injuries".
>
> Underlying cause of death (UCoD) "(a) the disease or injury which initiated the train of events leading directly to death, or (b) the circumstances of the accident or violence which produced the fatal injury" [8].

It is usual, for statistical purposes, to identify cases of injury death using the UCoD – and so this is the common operational definition of injury death used. For example, some of the references reviewed for the current investigation defined injury death as those cases in which an injury event (an event is assigned with an external cause of injury ICD code) was identified as the underlying cause of death [9]. Other investigations which also consider the UCoD as the operational definition of injury death selected cases according to individual ICD external cause code blocks (such as suicide: ICD-10 X60 – X84 [10]). The United States National Violent Death Reporting System uses ICD-10 codes recorded as the UCoD as the basis of selecting cases of violent death defined as *"the intentional use of physical force or power against one-self, another person, or a group or community"* [ie. suicide (ICD-10 codes X60-X84), homicide (ICD-10 codes X85-Y08), legal intervention (ICD-10 code Y35), terrorism (ICD-10 codes U01, U03)) as well as unintentional firearms injury deaths (ICD-10 codes W32-W34)] [11]. In order to ensure complete case identification, additional ICD-10 codes are used if death occurs more than a year after the injury event. These Y87(.0-.2), Y89(.0 and .9) and Y86 codes (specifically related to firearms incidents) describe the sequelae of 'other accidents', 'intentional self harm, assault and events of un-determined intent' and ‘legal intervention’ or ‘unspecified external cause’ [12]. This definition was also employed by Comstock et al (2005). [39]

When investigating the accuracy of injury death data, alternative definitions for injury death to those outlined by WHO have been described. For example, Pemberton selected cases on the basis of hospital admission for a fractured neck of the femur (i.e. hospital diagnosis codes) [13] who died subsequent to admission. While Calder and Parker identified possible cases of death from hip fracture as patients who were admitted to hospital with a hip fracture (hospital diagnosis code), who then died within 28 days of admission [14 15]. Hindmarsh and colleagues provided more specificity in their case definition, requiring a principal hospital diagnosis of a hip fracture, associated with an unintentional fall in the first external cause field [16]. Lu and colleagues also based their case definition on hospital diagnosis codes. In order to increase the likelihood that a hospital discharge was related to an injury death, only those cases who died within 3 days of discharge were included in their investigation [17].

Carr and colleagues [18], when investigating the accuracy of military cause of death classification, used a criteria defined by Brent and colleagues in 1987 to evaluate if an accidental or undetermined death (as defined by a military classification scheme) was suspicious of suicide – that there was specific evidence of past psychiatric history or evidence of intent communicated verbally or in writing [19]. In order to identify work related fatalities, Russell and Conroy first identified cases through ICD-9 external cause codes as recorded on the death certificate (although from the publication we were unable to determine where on the death certificate this information was recorded), and then through an ‘injury-at-work’ flag, acquired from the Office of Vital Statistics [20].

Kreisfeld and Harrison provide one of the more detailed operational definitions of injury death in the literature relevant to this investigation [5]. The definition of injury death is an adaptation of the US State and Territorial Injury Prevention Directors Association (STIPDA) scheme of ICD codes for injury hospitalizations (originally produced for ICD-9) [21], mapped to ICD-10 and applied to death data [5]. As described in the Kriesfeld and Harrison report, the ICD-10-AM codes, recorded in either the UCoD field or Part II (contributing causes), used to define injury death cases were S00-S99, T00-T75, T78.8, T79, T90-T97, T98.0-T98.2 and excluded cases whose only codes from the Injury and Poisoning chapter of ICD-10 were for ‘complications of surgical and medical care’, ‘sequelae’, and ‘adverse reactions to food’ [5]. ‘Additional’ injury deaths were identified as those attributed (UCoD) to natural causes, but where an injury diagnosis or external cause code was present among the multiple causes of death [5].

Three references were identified in the international academic literature that compared different operational definitions of injury mortality [22-24]. In the first, the development of a new surveillance system for the Lazio region in Italy provided the opportunity to devise what the authors described as a “gold standard" for recording fatal home injuries and allowed the comparison of three operational definitions: (1) mortality within 30 days of Emergency Department visit; (2) in-hospital mortality; (3) mortality based on specific E-codes from the Mortality Register [22].

The "gold standard" was devised by:

1. Identifying all emergency department visits from the Emergency Information System (EIS) in 2000 where home was reported as the place of the trauma. Cases were excluded if they were (a) late effects of trauma or poisoning, or (b) if they were a subsequent visit within 48 hours of the previous visit.
2. The emergency department records were linked with hospital discharge (HD) records for the period 2000-2001 (EIS-HD data set).
3. The mortality registry (MR) was then searched for each person present in the EIS-HD data set. Criteria for defining a home accident related death were
    a. reported deceased in either EIS-HD database or the MR with the date of discharge = date of death;
    b. erroneously listed as discharged in EIS-HD database, but reported in the MR with a date of death = date of discharge;
    c. listed as discharged in the EIS-HD database but found in the MR within 9 months with a diagnosis related to the discharge diagnosis (i.e. at least the same body region affected according to a nine modality Barell classification [25]) – as with Russel and Controy above, we were unable to determine from where on the death certificate this information was obtained;
    d. trauma deaths of persons not linked to EIS-HD database but present in the mortality registry with external causes not attributable to road (E: 850-58; 860; 861; 864; 865; 867; 868.3; 869; 880-901; 905-908; 910-918; 920-925; 927; 928.9; 929-949; 988.9) [22].

The sensitivity, specificity and positive predictive values for the three operational definitions were compared with this "gold standard".

The definition with the best performance in terms of sensitivity and positive predictive value was in-hospital mortality (sensitivity 63.4%, positive predictive value 78.1%), while mortality based on E-codes reported in the death certificate scored poorly (sensitivity 59.4%, positive predictive value 100%). However, in-hospital deaths over-estimated those who were younger and who died during transport. The majority of misclassified death certificates, as compared with the "gold standard" operational definition, had trauma as the reported cause of death, but did not include an E-code. None of the operational definitions worked perfectly leading the authors to conclude that *"In order to measure the real burden of home injuries, hospital and mortality data must be integrated"* [22].

Goldacre and colleagues analysed fractured neck of the femur case fatality rates per 100 admissions for (a) fractured neck of the femur in any position on the death certificate, and (b) all causes of death, for eight Oxford NHS hospital trusts. Four different injury death definitions were tested: (i) in-hospital deaths within 30 days of admission; and deaths anywhere within (ii) 30 days; (iii) 90 days; and (iv) 180 days of admission [23]. For each NHS hospital trust, age standardized deaths rate were affected by whether death registration data was included, whether time intervals extended beyond 30 days of admission and whether deaths not certified as fractured neck of the femur were included. Goldacre and colleagues concluded that all causes of mortality should be considered when investigating death rates after fractured neck of the femur admission [23].

The third study to compare different definitions of hospital mortality was conducted by Skaga and colleagues, who tested three ways of defining trauma death: (1) death during acute care, (2) death by the end of somatic care (i.e. discharged from the last domestic or foreign [i.e. another country] acute care facility) and (3) death within or <=30 days after injury. All patients with an ISS score greater than or equal to 10, admitted to Ulleval University Hospital (UUH) in Oslo, Norway were included in the investigation, as were patients with 'trauma team activation'. Penetrating injuries to the torso or extremities proximal to the elbow or knee were included irrespective of their ISS score [24].

'Status' (dead or alive) was collected at discharge from UUH for the first end-point, during acute care. For the second end-point, the end of somatic care, patients were tracked through other acute care facilities until discharge. For the third end-point, 30 days after injury, survival status irrespective of whether they were still in acute care was determined from patient records and the Norwegian Population Registry. The results of this study showed that, irrespective of the definition of trauma death used ((1), (2), or (3) as described above), injury related mortality was highest during the first 5 days after injury, reaching a plateau approximately 18 days after injury. Severe co-morbidity and advancing age were associated with higher mortality rates and late mortality. Only 4.6% of blunt trauma deaths occurred more than 30 days post-injury while still in somatic care (i.e. survival status for the third end point after 30 days), leading the authors to conclude that *"the validity of performance studies in trauma should improve if mortality occurring within 30 days of injury is adopted as the universally accepted fixed end-point"* [24]. Although the hazard functions presented in the paper support these findings to the extent that a substantial proportion of the study sample died within 20 days of the trauma event, no analysis was presented on how these deaths were otherwise coded in the population register (i.e. were they listed as injury deaths). Therefore, it is difficult to determine if the definitions presented improve the capture of injury death cases above current definitions.

Investigations of the discrepancy between hospital and mortality records

The predominant area of published research activity for the reliability of injury death data relates the discrepancies between hospital discharge and death certificate records. Literature relevant to this area has been summarized in the section below under four headings:

(1) methodological reviews: studies that review the method of investigations for injury related mortality have been summarized in this section;

(2) coding: this section provides a description of the impact of coding decisions;

(3) comparison studies: where studies describing the differences in cause of death derived from different data sources have been summarized; and

(4) investigating discrepancies: these studies provide some insight into the reasons for the differences between different sources of cause of death data.

Methodological reviews

In 2006, Johansson, Westerling and Rosenberg conducted a review of investigations into the accuracy of cause of death statistics. Investigations involving a panel of experts reviewing causes of death reported to an official statistics agency [26]. Data collection methods, review procedures and how the authors arrived at the underlying cause of death, as well as the reproducibility of the study, were evaluated. In order for the investigation to be considered reproducible, Johansson and colleagues required that there was a description of the composition of the review panel, an explicit strategy for dealing with competing causes of death and explicit diagnostic criteria [26]. In a summary of their results, the authors stated that "Of 16 [studies] that discussed the difference between dying "with" and dying "from" a condition, eight described how competing causes had been handled. For these eight, the selection of the principal cause was reproducible, but in three the selection strategy conflicted with the instructions issued by the World Health Organisation" [26]. None of the authors of these studies pointed out that they were deviating from international standards or provided reasons why they had done so. Johansson, Westerling and Rosenberg concluded that *"Explicit descriptions of methods and criteria would contribute to methodologic improvement and would allow readers to assess the generalizability of the conclusions"* [26].

Coding

The coding of hospital discharge and death data is central to the arguments presented in the comparison studies section below. In order to fully understand the discrepancies between data sources of cause of death information, McKenzie and colleagues suggest that definitions of the fields being compared and the primary purpose of each of the opposing data sources must be clearly articulated in the description of the investigation [27].

For hospital discharge data, the “main condition” treated or investigated during an episode of health care is *“the condition, diagnosed at the end of the episode of health care, primarily responsible for the patient’s need for treatment or investigation”* [8]. In comparison, the underlying cause of death is defined as *“(a) the disease or injury which initiated the chain of morbid events leading directly to death, or (b) the circumstances of the accident or violence which produced the fatal injury”* (Six Decennial International Revision Conference, quoted in [8]).

The purpose of coding the underlying cause of death, from a public health perspective, is to prevent the precipitating cause from operating (i.e. identifying the primary cause of the death in order to prevent/reduce the occurrence in future) [8], while the primary purpose of hospital records is in-patient care. Comparing information in hospital and mortality records assumes a degree of concordance concerning their purpose, and additionally overlooks the fact that they contain varying amounts of information, some of which is not relevant to describing the underlying cause of death. In addition, all of the information needed for the reconstruction of the mortality record may not be recorded for use in reviews of patient files [28]. For example, in the case of Moyer et al (see *Comparison Studies* section below), a summary of the patient records was provided to the medical review panel, rather than the complete case notes. It is possible that this process presented only part of the picture for the review panel.

Walker and colleagues have provided a description of the Australian Bureau of Statistics (ABS) coding rules and the impact that these and differing coroners practices in Australian jurisdictions have on the likelihood of suicide being recorded in Australia. There are three main reasons provided by the authors for a likely under-reporting of suicide in Australia. First, the ABS requires medical or legal documentation as evidence of intent. Secondly the ABS has a cut-off date of 12-15 months after the reference period for filing the underlying cause of death. Cases that remain open after this time are coded to X59 (exposure to unspecified factor) or to the default accident block depending on information available. For the period 2000-2003, Irwin et al (2008) estimated that at least 31% of fatal injury cases would have remained open at the time the ABS coded underlying cause of death [29]. Thirdly, the ABS does not up-date data, even if is established to be incorrect [30]. Added to these factors (within the ABS) are external influences, such as variable documentation and reporting from coroners and police between Australian jurisdictions and sensitivities on the part of the coroners that prevent the accurate recording of suicides [30].

Given that the ABS sources cause of death data from the Australian National Coronial Information Service (NCIS), limitations in NCIS data will flow through to ABS data. In a review of NCIS data, Irwin and colleagues found that NCIS was unlikely to capture fatal injuries of people aged over 65 years, particularly if the nature of the injury was related *"to the age of the person"*. This became apparent in the case of deaths related to suffocation, falls, and complications of care, where less than 50% of deaths were coroner certified, and for deaths due to exposure and other unspecified factors, where less than 15% of deaths were coroner certified [29].

In 1995, Langlois and colleagues provided a description of the effects of different recording practices on the age and sex adjusted death rates from falls related injury deaths in New Zealand and the United States [31]. Although overall injury death rates, as recorded in vital statistics data, in younger age groups in New Zealand the US were similar in the 1980's, they were markedly higher among older people living in New Zealand [32]. Age and sex adjusted death rates (from vital statistics data) for suicide, motor vehicle traffic crashes and homicide were reported as similar between the two countries. Age adjusted fall hospitalization rates between the two countries were estimated to be similar for adults 65 years of age and over. However, the biggest difference between the two countries was in the age adjusted in-hospital death rates for falls. The age adjusted death rate in New Zealand was reported as almost three times higher than that in the US.

The authors hypothesized that variations in in-hospital falls-related deaths between the US and New Zealand highlighted differences in length of stay between the two countries. As deaths from falls were usually the result of comorbid conditions or conditions that develop as a result of the injury sustained during the fall, it was possible that the US physicians were more likely to code the other condition as the underlying cause of death, rather than the fall (falls were more likely to be listed in part II of the death certificate in the US). In addition, it was reported that supplementary information was more likely to be considered when coding death in New Zealand, resulting in improved accuracy. Langlois et al suggested that the reasons for similar death rates for motor vehicle traffic crashes, suicides and homicides between the two countries was that death usually occurred soon after the event, reducing the likelihood of inaccurate coding [31].

Increasingly, there have been calls for the recording of multiple causes of death to allow for competing causes to hold the same weight in mortality statistics [6]. Since 1997, the ABS has recorded up to 20 multiple causes of death [5]. In 2007, Kreisfeld and Harrison produced a report in which the potential use of multiple causes of death in injury death reporting was assessed [5].

As highlighted in the above *Definition of injury mortality* section, the operational definition of injury death used for the Kreisfeld and Harrisons investigation was adapted from the STIPDA workgroup recommendations for injury hospitalizations [21], mapped to ICD-10 and applied to death data [5]. 'Additional' injury deaths were identified as those attributed (UCoD) to natural causes, but where an injury diagnosis or external cause code was present among the multiple causes of death [5].

The ‘additional’ injury deaths were highly concentrated in older age groups. A total of 80% of ‘additional’ injury deaths were certified by a medical practitioner only. In contrast, 80% of conventional injury deaths were certified by a coroner. The predominant causes of death for ‘additional’ injury deaths were either falls or poisoning by drugs or other substances.

Because of the preponderance of falls in the ‘additional’ category, these were further investigated using data from the National Coronial Information System (NCIS). A total of 136 NCIS falls cases were reviewed. For these deaths, 58% were ascribed an UCoD as a disease of the circulatory or respiratory system by the coroner. From a separate data source, linked injury hospitalizations and deaths that occurred in Western Australia from 1 July 2000-30 June 2001, less information was contained in the death record than hospital discharge records for falls related deaths. Death data contained fewer ICD codes relative to hospital data, in terms of the total number assigned as well as the comparative number from ICD 10 diagnosis codes from the XIX and XX (‘S’ and ‘T’ diagnosis codes, and external cause of injury and poisoning codes) chapters [5].

A total of 89% of the ‘additional’ poisoning by drugs or other substances cases were certified by the coroner, of which 69% were coded to ‘mental/ behavioural disorder due to psychoactive substance’. Kreisfeld and Harrison indicated that this situation is unlikely to occur in the future as a World Health Organisation directive, which took effect in January 2006, prevents deaths from poisoning to be coded to the mental/behavioural disorders chapter [5].

Kreisfeld and Harrison concluded that the results of their investigation highlighted the need to up-grade the certification skills of medical practitioners. In addition they reported a need to investigate the extent to which the current practice of treating fractured neck of the femur differently from other injury deaths has lead to an underestimation of fall-related mortality [5].

Comparison studies

In order to provide an account of the reliability of injury related death data, there have been a number of investigations in which the UCoD on death certificates or mortality registers have been compared with the main diagnosis on hospital records or other casualty data sets to determine the difference in cause of death as specified in each data set (see Table 1 for a summary of the studies).

In the well referenced study of Goldacre (1993), comparisons were made between the main diagnosis on hospital discharge records and data recorded on the death record to determine the extent to which the main diagnosis was evident as a cause of death [6]. A similar study was also conducted by Johansson and Westerling, with a secondary aim of determining the importance of hospital discharge information not recorded on the death certificate [4]. Goldacre created ‘cohorts’ of main hospital diagnoses for the period 1979-1986 by using only the first diagnosis for individuals admitted more than once for the same main diagnosis, or using all main diagnoses for individuals admitted more than once for multiple main diagnoses and linking these records with death certificate data for 1987. Concordance in two main time periods was then investigated – deaths within four weeks and within one year of hospital admission [6]. Johansson and Westerling compared the final main diagnosis for individuals hospitalized in the final year of life with the underlying cause of death recorded on the death certificate. In order to determine the importance of the main diagnosis and additional diagnoses contained within the hospital file, Johansson and Westerling also added additional diagnoses from the hospital records to the second part of the death certificate. The death certificate was then reanalyzed by the ACME software used to code UCoD [4].

Despite the differences in the ways the studies were conducted, both Goldacre, and Johansson and Westerling had similar results. For those with a main diagnosis in the injury and poisoning chapter who died within 4 weeks of hospital admission, Goldacre identified 40% with an UCoD from the same chapter on the death certificate (i.e the chapter of the UCoD was also recorded as ‘Injury and Poisoning’) [6]. For those with a main diagnosis in the injury and poisoning chapter who died within 1 year of discharge, Johansson and Westerling identified 46% of males and 54% of females with an UCoD also from the ‘Injury and Poisoning’ chapter [4]. Johansson and Westerling reported that discordance increased with time elapsed from hospital discharge. For hospital deaths, 28% of the main diagnoses were ‘incompatible’ (not within the same ICD chapter) with UCoD. This increased to around 43% at 15-30 days, and 47% for deaths occurring at least four months after discharge.

Goldacre highlighted fractured neck of the femur as a condition that, although present as a main condition on hospital discharge records, was only recorded (anywhere) on the death certificate in a minority of cases (25%) [6]. When all hospital information (including main condition, additional conditions, data on injuries and surgery within four weeks of death) was added to the death certificate and this was re-analyzed by ACME, Johansson and Westerling reported that there was a 57.6% increased in the number of deaths from falls (from 667 to 1051) [4]. Both authors concluded that morbidity information should be routinely considered when establishing the UCoD.

The results from each of the above studies have shown an undercount of injury related deaths in death records, a result which may be a bi-product of how possible discrepancies were investigated. In general, each of these investigations started with hospital data with a main diagnosis of injury and sought to determine if that diagnosis was represented in the death record. In a deviation from this pattern, Koehler et al started with deaths in two groups of individuals aged 65 years and over: those for whom an unintentional fall related external cause of injury code was recorded in hospital discharge data, and those for whom the coroners records contained an underlying cause of death recorded as a fall [33]. The aim of this investigation was to determine how many of the elderly deaths containing a fall-associated hospital external cause of injury code were or should have been recorded in the death records as a fall.

For each case identified, two forensic pathologists and a forensic epidemiologist reviewed hospital records, autopsy reports, toxicology reports, death certificates and death investigation reports as prepared by the coroner. Of 77 deaths identified, there were 34 coded to natural deaths. After forensic examination, 12 of these were re-classified to accidental deaths. The remaining 22 natural causes of death had a fall associated external cause of injury code assigned in the hospital discharge data which related to minor or superficial injuries. The authors suggested that these injuries played no apparent role in the death, resulting in an 'over-count' of falls related injury death [33]. We argue that this would only be the case if external cause of injury codes were the only criteria for identifying falls cases from hospital discharge data. This would seldom be the case, as principal diagnosis codes taken from the ICD 'Injury and Poisoning' chapters would usually also be involved in screening for possible injury cases. For the 22 natural cases, no information was provided concerning the principal diagnosis as listed in the hospital discharge data. The authors recommended that, if hospital discharge data is to be used for to identify fatal falls, only those e-coded falls *"that demonstrate a serious concomitant traumatic injury…which ranked above a certain level of severity"* should be counted.

Table 1: Summary of comparison studies

Author(s)	Title	Description	Main findings
Goldacre (1993)	Cause-specific mortality – understanding uncertain tips of the disease iceberg	A disease may be present at the time of death but not recorded on the death certificate because (i) it may be unknown to the doctor who certifies death or (ii) it is not considered sufficiently relevant to merit recording on the death certificate. Made comparisons between main diagnosis on hospital records and data recorded on the death certificate to determine the extent to which the main diagnosis appeared as a cause of death. If individual had more than one record for the same main diagnosis, first admission was selected. An individual with multiple records and different main diagnoses had each main diagnosis selected. Cohorts of records for each main diagnosis were constructed. Analysed at 4 weeks and 1 yrs after admission. Allowed for diagnostic cross-over between similar conditions.	• Fractured neck of femur not commonly recorded as UCoD within 4 weeks of admission. • Of those with an injury poisoning main diagnosis on the hospital record, only 40% had an injury/poisoning UCoD code. • Patients may die soon after hospital care from causes wholly unrelated to admission. • Diagnostic information not available during hospital care may have become available after death. • Underestimation of the contribution of individual diseases to mortality is an inevitable consequence of single cause analysis of mortality when multiple pathology is present.
Johansson and Westerling (2006)	Comparing hospital discharge records with death certificates: can the differences be explained?	Comparison of death certificate's underlying cause of death and the main condition from final hospital discharge record.	• Incompatibilities most common in 15-44 yr age group. • Increased incompatibility with increased time from death. • For incompatible records, original underlying UCoD was often symptoms and other ill-defined conditions.
Goldacre, Roberts and Yates, 2002	Mortality after admission to hospital with fractured neck of the femur: database study	Inpatient records were linked to death registration data in the former Oxford NHS health region (population 2.5 million) from 1994 to 1998	• In 22 of 92 cases an inquest was held and the fracture was recorded as a contributory cause of death. • For the remaining 70 cases where an inquest was not help was the fracture recorded as a contributing cause.
Koehler , Weiss, Shakir, Shaeffer, Ladham,, Rozam, Dominick, Lawrence, Miller, Wecht	Accurately assessing elderly falls using hospital discharge and vital statistics data	Retrospective forensic review of elderly (age 65 and over) fall-associated fatalities identified from hospital discharge and Vital Statistics Data, between 1997 and 1998. Cases were identified as those for whom an unintentional fall related external cause of injury code was recorded in hospital discharge data, and those for whom the coroners records contained an underlying cause of death recorded as a fall	• The manner of death should have been changed from natural to accidental in 28% of the 77 cases . • There was 22% of accidental cases where the fall did not contribute directly or sequentially to the cause of death.

Investigating discrepancies

There have been a number of studies in which the certification practices of physicians and coroners have been investigated to determine the impact of these practices on the UCoD recorded on death certificates [13-15 34 35]. Betz et al (2008) and Roberts et al (2000) surveyed physicians and coroners on death certification practices. Both investigations involved the study members reading clinical scenarios and then either completing a death certificate [34] or providing a verdict, with explanation [35]. For example, the physicians were presented with a case of an elderly patient who died from intracranial bleeding after a fall. Only 35% of survey respondents reported injury as a contributing cause of death, while 51% reported a high level of confidence in their ability to complete a death certificate accurately [34]. The coroners were provided with 16 scenarios grouped as (1) post-operative, (2) a combination of trauma and natural disease, and (3) infectious disease. For all three scenarios, which were a combination of trauma and natural disease, there was no significant agreement between the responding coroners. Roberts and colleagues suggested that the variation in whether to hold an inquest or not reflected the lack of definition for natural causes and the personal attitudes of each coroner, and concluded that national consensus on such issues needed to be reached in order to ensure consistent coding of 'borderline' cases [35].

Moyer and colleagues compared the UCoD recorded on the death certificate with that determined by a panel of physicians for a randomly selected cohort of US veterans of the Vietnam era who were discharged alive [9]. The panel was made up of two physicians and a registered nurse. The registered nurse was responsible for obtaining all medical and legal documentation relevant to each case and providing a concise summary of the information for review by the physicians. Each physician independently determined UCoD, results from each specialist was compared and, where consensus could not be reached, independent specialists were consulted. No information was provided concerning the number of cases in which consensus could not be reached or how many independent specialists were consulted. In addition, no information was provided about the experience of the registered nurse in coding or summarizing data relevant for coding UCoD. Of interest is that although some of the discordance is unexpected, what is surprising is that, from the nurses summaries, the medical review panel were not always able to determine UCoD. For example, of the unintentional poisonings, in 9 cases where there was disagreement between the death certificate and the medical review panel findings, the death certificate provided more detail about the death than the medical review panel was able to obtain in five of these cases. In each, the medical records (or the summary of the medical records) did not contain sufficient information to capture the nature and intentionality of the decedents drug involvement [9]. In this study, it appeared that the mortality data was more reliable than the summarized medical records for determining cause of death.

Using a study sample similar to Moyer et al., Carr and colleagues conducted a retrospective investigation comparing Department of Defense casualty records with medical mortality records for all active duty military deaths in the calendar years 1998 and 1999 [18]. The casualty records contained only basic information concerning a death – demographic information, date and location of death and a one or two line entry for the manner and cause of death. In contrast, the medical mortality register contained information for those deaths involving the medical examiners' office. Data from multiple sources were drawn upon for the medical mortality register including death certificates, autopsy reports, reports from the Armed Forces Medical Examiner, toxicology reports, investigative agency reports, medical records and personnel records. The focus of the investigation was to identify suicides that may not have been reported to the official agency or were classified as accidental or undetermined. In order to identify a potential suicide, the authors required specific evidence of past psychiatric history, or evidence of intent communicated verbally or in writing (in line with Centre of Disease Control definition of suicide). As shown in Table 1, an under-reporting of suicide was identified in the casualty records. The authors concluded that problems of reporting suicide lay in variable reporting methods and failure to up-date official records [18], reinforcing the message from Walker et al concerning the importance of up-dating official data sources when more information comes to light [30].

Calder and colleagues (1996), Parker (1996) and Pemberton (1988) have conducted case-series analyses of patients admitted to hospital with proximal femoral and hip fracture in order to determine the influence of coroner practices on the death rates from these injuries. Calder et al reported that none of the 92 patients who died within 28 days of being admitted with proximal femoral fracture to Leicester Royal Infirmary had the fracture listed as a direct cause of death [14]. Of the 22 referred for an inquest, all had the fracture listed as a contributing factor to the death, while only one of the remaining 70 not referred for an inquest had the fracture recorded as contributing [14].

In a subsequent letter to the editor of BMJ, Parker reported that the findings of Calder and colleagues were supported by data from Peterborough. Of the 15 cases of hip fracture that died within 28 days of being admitted to Peterborough District Hospital, the coroner allowed the death certificate to be issued in 14 cases because *"other medical conditions were thought to be more pertinent as a cause of death"* [15]. In all of these cases, the hip fracture was mentioned in section II of the death certificate. Parker, in his role as an orthopaedic research fellow, concluded that the practice of holding inquests into most deaths after hip fractures *"results in considerable distress to relatives and additional costs…Most deaths due to hip fracture, even when the fracture was due to a fall, are deaths due to natural causes."* [15]

In 1971, a policy was introduced by the coroner in Sheffield and Barnsley that the underlying cause of death for most hip fractures in the elderly was osteoporosis, and death certificates should be completed to reflect this fact. The outcome of this policy was that these health districts had unusually high death rates attributable to osteoporosis and a low death rate due to hip fracture [36]. In a study investigating the influence of this decree on cause-specific death rates, death rates in Nottingham and North Derbyshire were investigated. These two health districts were selected because either there were large differences between hospital and national death rates (Nottingham) or the death rates from hospital and national data sets were closer to each other than for other districts in Trent (North Derbyshire). The investigation revealed that coroners in Nottingham reviewed 73 out of 94 fractured neck of femur deaths. For 60 of these cases, the fracture was entered in part II of the death certificate. The most frequently listed UCoD were recorded as ischemic heart disease, deep vein thrombosis, bronchopneumonia or cerebral vascular disease. For the 35 investigated fractured neck of femur deaths in North Derbyshire (30 of which were subject to an inquest), the fracture was listed as the UCoD in 28% of cases, it was mentioned in section II in 56% of cases and was not mentioned at all in 16% of cases [13]. Pemberton concluded that the differences in death rates between health districts reflected the policy and views of the coroners and that death rates based on hospital death data may more accurately reflect hip fracture death rate than that recorded in the national data.

Hindmarsh et al [16] used the New South Wales Admitted Hospital Patient Data Collection (2000-2003) to identify people aged 65 years and over, admitted to hospital with a principal diagnosis of a hip fracture, associated with an unintentional fall, in order to determine the effect of this event on relative survival. Relative survival was calculated as the ratio of observed to expected, where expected survival was estimated from a population matched for age, sex, and calendar period. For the study sample, where cause of death information was available, fewer than 2% had a fall as UCoD, while only 21% had the hip fracture recorded as a contributing cause of death. When the time period for follow-up was reduced to 28 days, 53% of deaths had the hip fracture recorded as a contributing cause. Given these results, it is of interest that 35% of deaths in men and 28% of deaths in women which occurred within 3 months of admission for a fall related hip fracture, occurred during the hip fracture hospital admission. Both men and women over 85 years had substantially lower relative survival than the younger age groups in the first three months following the hip fracture. Hindmarsh et al concluded that the full impact of falls in older people on mortality rates is underestimated when based on the underlying cause of death alone [16].

It is likely that hip fracture is not the only fatal injury diagnosis to be underestimated for those aged 65 years and over. In an evaluation of death certificate-based traumatic brain injury (TBI) reporting, where Oklahoma multiple cause of death vital statistics data was compared with the Oklahoma Injury Surveillance System, case characteristics of those with a TBI according to the surveillance system whose death certificate did not contain relevant ICD-10 coding for TBI were examined [37]. To be included in the Injury Surveillance System, there was either a medical examiner report that described a TBI or a hospital medical record that contained one or more ICD-9-CM hospital discharge codes indicating Centres for Disease Control (CDC) defined TBI in a person who died. Sensitivity and Predictive Value Positive were calculated for each data set by comparing the two. After linking the data sets, discordant records were examined manually to determine if the record contained TBI information in any cause of death field that would have met CDC ICD-10 code case definition. Death certificate surveillance (TBI diagnosis listed as one diagnoses from multiple cause of death data) was most likely to miss TBI-related deaths among traffic crashes, falls and persons aged 65 or over [37].

Through a survey of Ontario coroners (all of whom are governed by a common Act of Parliament and legal ruling), Parai et al. reported that the likelihood of recording a death as suicide was dependent on the manner of death as well as the level of evidence of intent [38]. The coroners responded to a self administered questionnaire in which 14 fictitious suicide events were described. The coroners were more likely to record hanging and gas as suicide than poisoning and drowning, potentially due to less implied intent. The presence of a non-specific diagnosis of depression was insufficient for a suicide diagnosis on the survey.

A secondary aim of the investigation by Koehler et al described above (*Comparison studies* section) was to investigate the main reasons for under- or over-counts in hospital discharge and vital statistics data [33]. The authors suggested that the reasons for the discrepancies were the different roles of the hospital discharge and vital statistics data. As highlighted in the *Coding* section of this review, the role of hospital discharge data is to code the circumstances of the events that brought the patient to the hospital. In contrast, the purpose of vital statistics data is to code the immediate cause of death as well as the sequence of events that played a direct role in the cause of death. Koehler et al suggested that this resulted in two problems. Firstly, if the patient is hospitalized for a relatively minor injury resulting from a fall, and dies from a pre-existing disease such as cancer, the fall would still be recorded on the hospital record while it would not appear on the vital statistics data. Secondly, if a patient develops a disease initiated by the fall, but which takes time to develop (such as pneumonia), hospital discharge data may continue to record the fall, while this case could be missed in vital statistics data [33].

In a study that compared the violent injury death reporting by a Statewide Medical Examiner and the Oklahoma State Department of Health Vital Statistics Office, Comstock et al also reported that deaths (in this case suicide, homicide, unintentional firearms and terrorism deaths) could be over as well as under-reported [39]. Miscoded deaths were those that: (1) did not meet the study definition[12]; (2) meeting study

---

[12] Suicide (ICD-10 codes X60-X84), homicide (ICD-10 codes X85-Y08), legal intervention (ICD-10 code Y35), terrorism (ICD-10 codes U01, U03)) as well as unintentional firearms injury deaths (ICD-10 codes W32-W34). In order to ensure complete case identification, additional ICD-10 codes are used if death occurs more than a year after the injury event. These Y87(.0-.2), Y89(.0 and .9) and Y86 codes

definition but not coded as a violent death; (3) coded as a violent death but miscoded as the cause of the death. The investigators also reviewed the movement of data through each of the surveillance systems to identify sources of error leading to miscoding. Reasons identified for reporting errors in either of the systems included data entry errors, amendments not being up-dated in the Vital Statistics system, coding differences between systems, incorrect coding and failure of data entry software to identify obvious errors. The authors suggested that Medical Examiner training in completing death certificates could improve the quality of death data coding, as could the standardization of definitions and coding systems [39].

Lapidus and colleagues described the accuracy of motorcycle injury reporting on death certificates in a study published in 1994 [40]. This study is of interest because many of the conclusions reached have not been observed (or reported) since the introduction of automated coding for cause of death data. In contrast to the other investigations reviewed, Lapidus et al evaluated the accuracy of the content of the death certificate information as well as the coding of the motorcycle deaths. Given that contextual information reported on a death certificate may be used to code the underlying cause of death, reviewing this contextual information may provide more insight into why there are coding discrepancies between data from different sources. It was found that death certificates under-reported motorcycle deaths by 38% when compared with Police Accident Reports. In addition, 40% of the reviewed certificates were missing some or all of the required information to code the death (including omitting the word ‘motorcycle’, no description of how the injury occurred and terminology that did not relate to the ICD-9 requirements for identifying a motorcyclist). The authors acknowledged that physicians had a central role in reporting, recording and transmitting accurate information. However, Lapidus et al also highlighted the finding that almost half of the inaccuracies were the fault of nosologists, the majority of which occurred for no apparent reason (i.e. they did not result from insufficient information being provided by the physicians) [40].

Methods to adjust the number of cases of injury death

Three investigations presenting methods for adjusting counts of injury deaths were identified from the literature [7 41 42]. Each of these investigations used the capture-recapture method of estimating the ‘true’ number of injury deaths. Methods used for capture-recapture range from the relatively simple two-sample model, whereby the estimated number is derived from the equation:

(specifically related to firearms incidents) describe the sequelae of ‘other accidents’, ‘intentional self harm, assault and events of un-determined intent’ and ‘legal intervention’ or ‘unspecified external cause’.

$$\text{Estimation of } n = \frac{(c1 + 1)(c2 + 1)}{m + 1} - 1$$

(where $c1$ and $c2$ are the numbers in the first and second capture samples, and m is the number in both (matches)),

to the more complicated log-linear model. (That method for deriving estimate is presented in the box below.)

Box 1: Fitting the log-linear model capture-recapture method (as quoted from [41])

Capture-recapture methods with log-linear models [43-45] were applied to estimate the number of fatal occupational injuries which had occurred but were not identified by the sources. The analyses were stratified according to the cause of injury (fall from elevation, machinery and electrocution) and separately by the industry type (agriculture, manufacture, construction, transportation, public administration, finance, and unspecified). The goodness-of-fit of a model is measured by the deviance G2, and a confidence interval of the estimate is computed using the method suggested by Cormack [43].

As with any multiple-regression-type model there are different criteria and strategies for finding the best model among the many available. With either three or four lists, the strategy adopted here is

Step 1: Fit the independence model.

Step 2: Fit the model with all pairwise interactions.

Step 3: Backward elimination-reduce the previous model sequentially by removing the least significant pairwise interaction, while some criterion is satisfied.

Step 4: If the final model in Step 3 includes any sets of all three pairwise interactions between three lists, add to that model the three-list interaction if it satisfies the same criterion. The criterion used is statistical significance at the nominal 10% level (i.e. a change of 2.71 in the residual G2), but could be an information criterion, such as Akaike's (AIC), a change of 2 in G2, or any Bayesian version (Bayesian Information Criterion, BIC). The selection was confirmed later by fitting all 113 possible models.

In an application of another version of the capture-recapture method, Rossignol used the maximum likelihood model for estimating the completeness of workers compensation files [7].

The capture-recapture method was first developed to estimate the size of closed animal populations. At it’s simplest, at one time, as many animals as possible are captured, tagged and released. At a later time this is repeated and the number of animals in each sample, and the number common to both, are used to estimate the number in the total population [46]. There are two main assumptions for capture-recapture methods – that the two (or more) samples are independent, or there is no dependency between the samples, and that all individuals have the same probability of being captured.

Tilling has suggested that it is unlikely that the underlying assumptions for these methods will hold in epidemiological studies. Cases captured by hospital discharge records are more likely to be also captured by mortality records. More severe cases are more likely to be admitted to hospital, diagnosed correctly and for that diagnosis to also be captured on the mortality records. They are also more likely to die [46]. Violations of these assumptions can lead to an under- or over-estimate of the true population [47].

References

1. Cryer C, Langley J, Stephenson S. *Developing Valid Injury Outcome Indicators: A report for the New Zealand Injury Prevention Strategy*. Dunedin: University of Otago, 2004:1-141.

2. Langley J, Gulliver P, Barson D. *What injury deaths is ACC missing?* Report to ACC. Dunedin: Injury Prevention Research Unit, University of Otago, 2006.

3. Davie G, Langley J, Samaranayaka A, Wetherspoon ME. Accuracy of injury coding under ICD-10-AM for New Zealand public hospital discharges. *Injury Prevention* 2008; 14: 319-323.

4. Johansson LA, Westerling R. Comparing hospital discharge records with death certificates: Can the differences be explained? *Journal of Epidemiology and Community Health* 2002;56(4):301-308.

5. Kreisfeld R, Harrison JE. *Use of multiple causes of death data for identifying and reporting injury mortality*. Injury Technical Papers. Canberra: Flinders University, 2007.

6. Goldacre MJ. Cause-specific mortality - understanding uncertain tips of the disease iceberg. *Journal of Epidemiology and Community Health* 1993;47(6):491-496.

7. Rossignol M. Completeness of provincial workers compensation files to identify fatal occupational injuries. *Canadian Journal of Public Health* 1994;85(4):244-247.

8. World Health Organisation. *International Statistical Classification of Diseases and Related Health Problems: tenth revision*. Second edition. Geneva: World Health Organisation, 2004.

9. Moyer LA, Boyle CA, Pollock DA. Validity of death certificates for injury-related causes of death. *American Journal of Epidemiology* 1989;130(5):1024-1032.

10. Elnour AA, Harrison J. Suicide decline in Australia: where did the cases go? *Australian and New Zealand Journal of Public Health* 2009;33(1):67-69.

11. Karch DL, Dahlberg LL, Patel N, Davis TW, Logan JE, Hill HA, et al. Surveillance for violent deaths - national violent death reporting system, 16 States, 2006. *Morbidity and Mortality Weekly Report* 2009;58(SS-1):1-44.

12. National Centres for Classification in Health. *The international statistical classification of diseases and health related problems, tenth revision, Australian modification (ICD-10-AM)*. Third ed. Sydney: National Centre for Classification in Health, 2002.

13. Pemberton J. Are hip fractures underestimated as a cause of death? The influence of coroners and pathologists on the death rate. *Community Medicine* 1988;10(2):117-123.

14. Calder SJ, Anderson GH, Gregg PJ. Certification of cause of death in patients dying soon after proximal femoral fracture. *BMJ* 1996;312:1515.

15. Parker MJ. Mortality inferred from death certificates reflects coroners' practice, not the true mortality. *BMJ* 1996;313:879.

16. Hindmarsh DM, Hayen A, Finch CF, Close JCT. Relative survival after hospitalisation for hip fracture in older people in New South Wales, Australia. *Osteoporosis International* 2009;20:221-229.

17. Lu TH, Shaw KP, Hsu PY, Chen LH, Huang SM. Non-referral of unnatural deaths to coroners and non-reporting of unnatural deaths on death certificates in Taiwan: implications of using mortality data to monitor quality and safety in health care. *International Journal for Quality in Health Care* 2008;20(3):200-205.
18. Suicide surveillance in the US military - Reporting and classification biases in rate calculations. 154th Annual Meeting of the American-Psychiatric-Association; 2001 May 05-10; New Orleans, La.
19. Brent DA, Perper JA, Allman CJ. Alcohol, firearms and suicide among youth. *Journal of the American Medical Association* 1987;257:3369-3372.
20. Russell J, Conroy C. Representativeness of death identified through the injury-at-work item on the death certificate: implications for surveillance. *American Journal of Public Health* 1991;81(12):1613-1618.
21. Injury Surveillance Workgroup. *Consensus recommendations for using hospital discharge data for injury surveillance:* State and Territory Injury Prevention Directors Association, 2003.
22. Farchi S, Camilloni L, Rossi PG, Chini F, Borgia P, Guasticchi G. Home injuries mortality: Sensitivity and specificity analysis of different data sources and operative definitions. *Accident Analysis and Prevention* 2007;39(4):716-720.
23. Goldacre MJ, Roberts SE, Yeates D. Mortality after admission to hospital with fractured neck of femur: database study. *BMJ* 2002;325(7369):868-869.
24. Skaga NO, Eken T, Jones JM, Steen PA. Different definitions of patient outcome: consequences for performance analysis in trauma. *Injury* 2008;39(5):612-622.
25. Barell V, Aharonson-Daniel L, et al.. An introduction to the Barell body region by nature of injury diagnosis matrix. *Injury Prevention* 2002; 8: 91-6.
26. Johansson LA, Westerling R, Rosenberg HM. Methodology of studies evaluating death certificate accuracy were flawed. *Journal of Clinical Epidemiology and Community Health* 2006;59:125-131.
27. McKenzie K, Walker S, Casey R. Some issues to consider when assessing concordance of death certificates with registry reports. *Australian and New Zealand Journal of Public Health* 2004;28(1):87.
28. Moriyama IM. Problems in measurement of accuracy of cause-of-death statistics. *American Journal of Public Health* 1989;79(10):1349-1350.
29. Irwin M, Hayen A, Finch C. *Methodological issues in using routinely collected electronic population mortality data: Guidelines for using the National Coroners Information System for fatal injury surveillance in NSW*. Sydney, Australia: NSW Injury Risk Management Research Centre, University of New South Wales, 2008.
30. Walker S, Chen LH, Madden R. Deaths due to suicide: the effect of certification and coding practices in Australia. *Australian and New Zealand Journal of Public Health* 2008;32(2):126-130.

31. Langlois JA, Smith GS, Baker SP, Langley JD. International comparisons of injury mortality in the elderly - issues and differences between new-zealand and the united-states. *International Journal of Epidemiology* 1995;24(1):136-143.
32. Rockett IRH, Smith GS. Injuries and the Australian mortality mosaic: a comparison with the United Kingdom and New Zealand. *Public Health* 1989;103:353-61.
33. Koehler SA, Weiss HB, Shakir A, et al.Accurately assessing elderly fall deaths using hospital discharge and vital statistics data*. Am J Forensic Med Pathol* 2006; 27: 30-5.
34. Betz ME, Kelly SP, Fisher J. Death certificate inaccuracy and underreporting of injury in elderly people. *Journal of the American Geriatric Society* 2008;56:2267-2272.
35. Roberts ISD, Gorodkin LM, Benbow EW. What is a natural cause of death? A survey of how coroners in England and Wales approach borderline cases. *Journal of Clinical Pathology* 2000;53:367-373.
36. Pemberton J, Cust G. An epidemic of osteoporosis? *Community Medicine* 1986;8(4):322-328.
37. Rodriguez SR, Mallonee S, Archer P, Gofton J. Evaluation of death certificate-based surveillance for traumatic brain injury - Oklahoma 2002. *Public Health Reports* 2006;121(3):282-289.
38. Parai JL, Kreiger N, Tomlinson G, Adlaf EM. The validity of the certification of manner of death by Ontario coroners. *AEP* 2006;16(11):805-811.
39. Comstock RD, Mallonee S, Jordan F. A comparison of two surveillance systems for deaths related to violent injury. *Injury Prevention* 2005;11:58-63.
40. Lapidus G, Braddock M, Schwartz R, Banco L, Jacobs L. Accuracy of fatal motorcycle-injury reporting on death certificates. *Accident Analysis and Prevention* 1994;26(4):535-542.
41. Cormack RM, Chang YF, Smith GS. Estimating deaths from industrial injury by capture-recapture: a cautionary tale. *International Journal of Epidemiology* 2000;29(6):1053-1059.
42. Razzak JA, Luby SP. Estimating deaths and injuries due to road traffic accidents in Karachi, Pakistan, through the capture-recapture method. *International Journal of Epidemiology* 1998;27(5):866-870.
43. Cormack RM. Log-linear models for capture-recapture. *Biometrics* 1989;45:395-413.
44. Fienberg SE. The multiple capture recapture consensus for closed populations and incomplete 2k contingency tables. *Biometrika* 1972;59:591-603.
45. International working group for disease monitoring and forecasting. Capture-recapture and multiple-record systems estimation I: History and theoretical development. *American Journal of Epidemiology* 1995;142:1047-58.
46. Tilling K. Capture-recapture methods - useful or misleading? *International Journal of Epidemiology* 2001;30:12-14.
47. Hook EB, Regal RR. Capture-recapture methods in epidemiology: methods and limitations. *Epidemiology review* 1995;17:243-264.