bulletin 105

Multiple causes of death

*An analysis of all natural and selected chronic disease causes
of death 1997–2007*

Contents

Acknowledgments

Abbreviations

ABS   Australian Bureau of Statistics

AIHW   Australian Institute of Health and Welfare

CHD   coronary heart disease

COPD   chronic obstructive pulmonary disease

NCIS   National Coroners Information System

ICD   International Classification of Diseases

RBDM   Registry of Births, Deaths and Marriages

WHO   World Health Organization

Symbols

. .   not applicable

Summary

Multiple causes of death data are useful for describing the role of all diseases involved in deaths due to natural causes. This bulletin is the first comprehensive application of multiple causes of death statistics to natural causes of death and specific chronic diseases of public health importance in Australia. It may be useful for guiding and improving policy for reducing deaths from these chronic diseases and for targeting future investment in health prevention. When describing patterns of causes of death using only the underlying cause, important cause information is overlooked. Analyses using multiple cause data complement routine descriptions of mortality that use only the underlying cause and offer broader insight into the disease processes occurring at the end of life.

Key findings about multiple causes of death include:

* During the period 1997 to 2007, there were 1,442,303 deaths in Australia, with 93% due to natural causes.

* Deaths due to natural causes were not always caused by a single disease; in 2007, only 1 in 5 deaths were reported as being caused by a single disease.

* The proportion of deaths reported as being caused by five or more diseases increased from 11% in 1997 to 21% in 2007.

* In 2007, on average, 3.1 diseases contributed to each death due to natural causes.

* For younger people (aged 30–59) and for very old people (aged 95 or more), on average, fewer diseases were involved in causing their deaths than for people aged 75–94.

Key findings about multiple causes for selected chronic disease deaths include:

* Cancer was usually reported as the underlying cause of death in deaths involving cancers—in 93% for lung, 91% for liver and 84% for colorectal.

* For deaths involving chronic and unspecified kidney failure, diabetes and asthma, 17%, 29% and 30% respectively were captured in the underlying cause information.

* Coronary heart disease (CHD) was a leading contributory cause for deaths involving selected chronic diseases. It contributed to 47% of deaths involving diabetes, 39% involving chronic and unspecified kidney failure, and 34% of deaths involving each of chronic obstructive pulmonary disease (COPD) and asthma.

* Hypertensive diseases featured as a leading contributor to deaths involving selected chronic diseases, in particular diabetes (30%), cerebrovascular diseases and asthma (each 25%), CHD (20%) and chronic and unspecified kidney failure (17%).

* Diabetes was a common contributory cause, in particular for deaths involving chronic and unspecified kidney failure (20%), CHD (16%) and asthma (16%).

* Cerebrovascular diseases commonly contributed to chronic disease deaths that also involved dementia and Alzheimer disease (23%), diabetes (20%) and CHD (13%).

1   Introduction

Patterns of cause of death are usually compiled using only one of the conditions reported on the death certificate—the underlying cause (that is, the disease or injury that initiated the train of events leading directly to death, or the circumstances of the accident or violence that produced the fatal injury). Analysis of the underlying cause of death is important as it is a point at which preventive interventions can be targeted (WHO 2009). However, in the majority of deaths, more than one disease is indicated as causing or significantly contributing to the death. Information about all the diseases that play a role in causing a death is referred to as multiple causes of death.

The use of multiple causes of death data to describe patterns of mortality is becoming more prominent (for examples, see ABS 2012; Desequelles et al. 2010, Gorina & Lentzner 2008; Redelings et al. 2006; Redelings et al. 2007). These data provide a more complete picture of all the conditions that contribute to deaths. These data can also expand the knowledge base for guiding health policy and funding activities, enhance other measures of population health that rely on cause of death data, such as burden of disease, and improve the comparability of data for international comparisons of mortality. Furthermore, descriptions of the diseases that commonly contribute to death and their association with specific other diseases can improve understanding of the joint role of diseases on death and provide insight for developing alternative interventions to enhance quality of life.

Chronic diseases are a major cause of morbidity and mortality in Australia and the prevalence of many chronic diseases is increasing (AIHW 2012). The nature of the leading causes of death has changed during the past century from infectious diseases to chronic diseases. People are also living longer and ageing of the population is associated with increasing co-morbidities, particularly when chronic diseases are present.

Assessments of all diseases that contribute to death are particularly relevant to chronic diseases deaths. This bulletin is the first comprehensive application of multiple causes of death statistics, including trends over time, to natural causes of death and chronic diseases of public health importance.

Both age and the condition selected as the underlying cause of death typically influence the number and types of multiple causes (Desequelles et al. 2010; Gorina & Lentzner 2008; Wilkins et al. 1997). In this bulletin these aspects of multiple causes of death are explored for broad categories of disease and for selected chronic disease causes of death (see Appendix for a list of the disease categories used in this bulletin).

Many deaths due to the chronic diseases reported in this bulletin are preventable and many of the deaths occur among people aged less than 75. In addition, chronic diseases often co-exist with other diseases and the likelihood of having one or more chronic diseases increases with age (AIHW 2012). Consequently, an assessment of the mortality caused by and associated with these chronic diseases is warranted.

The information gained through analysis of multiple causes of death data can facilitate an understanding of the common patterns of diseases that contribute to chronic diseases deaths, while also providing a basis for surveillance of emerging patterns over time.

An assessment of the variation in multiple causes of death by age, and by other sociodemographic characteristics, such as Indigenous status and remoteness and socioeconomic status, is also presented.

What are multiple causes of death?

Multiple causes of death occur when two or more diseases or conditions are recorded as contributing to death. A Medical Certificate of Cause of Death (death certificate) is used for documenting the diseases considered to be instrumental in causing a death. Usually a medical practitioner documents the diseases that caused the death on the death certificate, but for some deaths (in Australia) a coroner provides information about the causes.

The World Health Organization (WHO) recommends a standard format for death certificates that can be used for collating international statistics on causes of death (WHO 2009). The WHO recommendations for documenting the causes of death have been adopted throughout Australia.

The format of the death certificate enables a medical practitioner to document all medical conditions instrumental in causing the death, including the condition that led directly to death (the immediate cause), all the antecedent causes (that is, those that occurred as a result of the reported underlying cause and before the immediate cause) and all other significant conditions that contributed to the death but were not related to the disease or condition that caused it. The terminology to describe the different cause types used in this bulletin is presented in Box 1.

Multiple cause of death data represent all the diseases or conditions reported on a death certificate. The Australian Bureaus of Statistics (ABS) defines multiple cause coding as 'the coding of all morbid conditions, diseases and injuries entered on the death certificate, including those involved in the morbid train of events leading to the deaths which were classified as either the underlying cause, the immediate cause, or any intervening causes, and those conditions which contributed to death but were not related to the disease or condition causing death' (ABS 2012).

The information documented on death certificates is coded by the ABS to the international standard recommended by the WHO. The death certificate indicates each cause type (underlying, antecedent and other significant contributory causes) that should be documented. The coding process considers the sequence of occurrence of each disease or health condition, removes duplicate disease information and applies other logical rules to select the underlying and associated causes. This process is automated and results in a standardised output that can be used for statistical analyses of causes of death, at both a national and international level.

> **Box 1: Terminology used to describe cause of death types**
>
> **Causes of death**—defined (in 1967, by the World Health Assembly) as '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 any such injuries'. This definition aims to capture all the relevant information on the death certificate thereby reducing bias that might arise if, for example, the certifier selected some conditions for entry and rejected others. The causes of death, as documented on the death certificate, should not include symptoms or the mode of dying.
>
> **Underlying cause of death**—the disease or injury that initiated the train of events leading directly to death, or the circumstances of the accident or violence that produced the fatal injury. For each death only a single underlying cause is selected from among all the conditions reported. The underlying cause provides a logical point to target public health interventions aimed at preventing the precipitating cause from occurring—that is, by breaking the chain of events or providing a treatment or cure. The underlying cause of death refers to the health condition or event at the beginning of the chain of events leading to death.
>
> **Associated causes of death**—causes, other than the underlying cause, that were instrumental in causing death. They encompass conditions that intervened or significantly contributed to the death. Associated causes include:
>
> - the immediate (or direct) cause; that is, the condition that occurred immediately before death or closest to the time of death
> - all intermediate (or intervening) causes; that is, the conditions that occurred between the underlying and immediate causes
> - all significant contributing causes; that is, all significant conditions contributing to the death but which did not bring about the underlying cause, including significant pre-existing conditions.
>
> Associated causes of death are sometimes collectively referred to as contributing causes. In this bulletin, any disease or condition that is reported on the death certificate is considered as contributing to the death; that is multiple causes (see below) comprise all contributing causes.
>
> **Multiple causes of death**—all diseases or injuries reported on the death certificate; that is, any cause that contributed to the death. Multiple causes include the underlying and all associated causes.

What are the benefits of using multiple causes of death data?

Analyses using multiple causes of death data provide a more complete representation of all diseases and conditions that caused the death. Numerous authors have described the benefits of using multiple causes of death data; some recent accounts include ABS 2012; Desequelles et al. 2010; Gorina & Lentzner 2008; Redelings et al. 2006; Redelings et al. 2007. Some of the advantages of these data are:

- Deaths infrequently have a single cause. Therefore in describing patterns of mortality using only the underlying cause, important cause information is overlooked. The death certification process (in Australia) allows for up to 20 diseases to be reported as causing or contributing to a death. Analyses of multiple causes of death data complement routine analyses based on only the underlying cause and offer broader insight into the disease processes occurring at the end of life.

- In certifying the cause of death only one disease should be indicated as the underlying cause. In deaths involving multiple chronic diseases that are each potentially fatal, the decision about which disease to certify as the underlying cause can be arbitrary (Gorina & Lentzner 2008). Certification practices vary between practitioners and jurisdictions, which can also lead to inconsistency in the documentation of the underlying cause (Smith Sedhev & Hutchins 2001). Given the nature of chronic diseases, the tendency for these to occur jointly with other chronic diseases, and the complexity of selecting the underlying cause among the presence of multiple chronic diseases, analyses based on all the conditions influencing the death are highly applicable to chronic disease deaths.

- Multiple causes of death data facilitate understanding of the complexity of the morbid processes and the connection between diseases as they occur at the time of death. For example, an assessment of the joint role of diseases in contributing to death enables an understanding of the impact of specific co-morbidities at the time of death. These kinds of analyses can provide insight into other target points to, where possible, prevent death (Redelings et al. 2006) or enhance quality of life, and provide better information to contribute to debate around end of life care.

- Multiple causes of death data can improve the comparability of causes of death data presented in an international context. While many countries use an automated coding system to produce deaths statistics, there can be differences in certification practices (that is, in completing the death certificate). For example, countries may differ in the way that medical practitioners are trained to certify deaths, or some countries may have policies that influence certification practices. These differences can influence variation in statistics based on the underlying cause only, while estimates based on multiple causes of death data capture all mentions of the diseases involved in causing death and may be more comparable where certification practices differ.

- Levels of mortality in a population, for specific causes of death and among specific age groups, are a fundamental measure of public health and can be used to guide heath policy. However, routine reporting of information about the causes of death is usually based on the underlying cause only and the contribution of other important diseases is overlooked. Patterns of mortality derived from multiple cause data provide a more complete assessment of the contribution of all diseases to mortality in a population. This improves the information base for guiding health policy and funding activities as well as enhancing population health analyses that rely on cause of death information such as estimates of burden of disease.

Objectives of this bulletin

The objectives of this bulletin are to:

- describe and quantify the information that is overlooked in using only the underlying cause of death to describe patterns of mortality in the population
- provide a more complete description of chronic disease deaths by considering the contribution of multiple conditions to mortality
- explore patterns of diseases that are commonly associated with deaths due to selected chronic diseases.

Scope of this bulletin

In this bulletin, multiple causes of death data are used to describe patterns of mortality by considering all diseases recorded as contributing to deaths. Only deaths where the underlying cause was coded to a natural cause are included; that is, deaths due to external and ill-defined causes are excluded. The results describe the number of conditions typically contributing to deaths and the variation over time and between different age groups.

Patterns of multiple causes of death are assessed to determine any differences between different population groups, specifically between Indigenous and non-Indigenous Australians, and people living in different areas of remoteness and different areas of socioeconomic status.

The analyses in this bulletin provide complementary information about deaths due to leading chronic disease conditions as described in the *Key indicators of progress for chronic disease and associated determinants: technical report* (AIHW 2009); see the Appendix for the list of these chronic diseases.

Assessment of the strength of association between diseases that jointly contribute to death is important and useful for improving the knowledge of contributory causes of death. It can provide a useful foundation for understanding alternative health interventions. However, this assessment was out of scope for this bulletin.

2   Methods

Data sources

The data used for this bulletin come from the AIHW's National Mortality Database. This is a historical register of all deaths in Australia since 1964. The database comprises information about the causes of death and other characteristics about the person, such as sex, age at death, area of usual residence and Indigenous status. The cause of death data are sourced from the Registrars of Births, Deaths and Marriages (RBDMs) in each state and territory, the National Coroners Information System (NCIS) and the Australian Bureau of Statistics (ABS).

The ABS, using an automated process, codes the information about causes of death to an international standard—currently, the *International Statistical Classification of Disease and Related Health Problems 10th revision* (ICD-10) (WHO 2009). The coding process produces an underlying cause and where present, one or more associated causes. A single underlying cause of death is selected from all the cause information documented on the certificate, in accordance with the rules of the ICD-10.

Information on multiple causes of death is available in Australian mortality data from 1997 onwards. The analyses in this bulletin are based on deaths for the period 1997 to 2007. The data for 2006 and 2007 are preliminary versions and have been revised. At the time of writing this bulletin, the final versions of these data were not available to the AIHW. Similarly, deaths data for 2008, 2009 and 2010 have been produced by the RBDMs and the NCIS and coded by the ABS. However, these were only being released to the AIHW and other organisations at the time of writing.

Classification of causes of death

The analyses in this bulletin are based on deaths due to natural causes; that is, deaths with an external or ill-defined underlying cause are excluded.

External cause deaths are those due to intentional and unintentional accidents, injury and poisoning, and deaths where the intent was undetermined. The nature of these deaths and the utility of multiple cause data have been described elsewhere (Kreisfeld & Harrison 2007). Furthermore, in Australia, these deaths are usually certified by a coroner and the rules and processes used to code deaths due to external causes differ to those used to code natural causes of death.

The exclusion of deaths with ill-defined causes was made in accordance with the WHO recommendations (WHO 2009). These data do not add any information to the understanding of patterns of cause of death and they are also subject to specific coding rules. Ill-defined causes of death can also indicate poor quality of death certification. See Appendix Table A3 for a list of ill-defined causes that are excluded from the analyses.

This bulletin describes patterns of multiple causes of death using broad categories of disease based on selected ICD-10 chapters. The chapter groupings in ICD-10 are arranged according to the type of disease (for example, 'Certain infectious or parasitic diseases') or the body system affected by the disease (for example, 'Diseases of the circulatory system').

Chronic disease causes of death

This bulletin includes a special focus on selected chronic diseases. The chronic disease causes of death selected for these analyses are those reported in the indicator 'Deaths due to leading chronic diseases' in *Key indicators of progress for chronic disease and associated determinants: technical report* (AIHW 2009). Specifically these are: colorectal, liver, lung, breast and prostate cancers; Type 2 diabetes; dementia and Alzheimer disease; coronary (ischaemic) heart disease (CHD); cerebrovascular disease; chronic obstructive pulmonary disease (COPD); asthma and end-stage renal failure. Mortality from these conditions is monitored to evaluate how the prevention of chronic disease in Australia is progressing.

For this bulletin, some minor modifications to the chronic disease categories have been applied, as follows:

- all diabetes is reported (rather than only Type 2 diabetes) due to the difficulty in correctly identifying the type of diabetes in certification of cause of death (expert opinion, National Diabetes Data Working Group)
- COPD deaths include those involving bronchitis not specified as acute or chronic (this specific condition is excluded from the indicator for 'Deaths due to leading chronic diseases')
- end-stage renal failure is referred to as 'chronic and unspecified kidney failure' which includes end-stage renal failure; the ICD-10 codes remain the same as those used in AIHW (2009).

The ICD-10 codes used to indicate each of the cause of death categories in this bulletin are in the Appendix.

Analytical techniques

Patterns of multiple causes of death are described by age and sex and for specific groupings of underlying cause of death. For each death, only one cause can be coded as the underlying cause. However, in each death there can be more than one associated cause. There are several ways to analyse multiple causes of death data. For example, statistics based on the associated causes of death can be compared with those derived from the underlying cause of death data. Likewise, statistics based on multiple causes of death can be compared with those for the underlying cause. Using either method to describe patterns of mortality shows similar results.

In this bulletin the mortality profiles for specific diseases are based on comparisons of the multiple causes of death data to the underlying cause data, as the presentation of these results are more intuitive.

In these analyses using multiple causes per death, unless otherwise specified, the deaths are counted rather than the number of mentions of the condition. For example, if a death was coded as being caused by more than one of the conditions within the cause category, then the death was counted only once.

Patterns are also explored for various sociodemographic characteristics (such as Indigenous status, level of remoteness of area of residence and socioeconomic status of area of residence).

In this bulletin, age-standardised rates are used for describing trends over time and where different population groups are being compared. The frequency of diseases reported as the underlying cause is compared with the frequency of the same diseases reported as multiple causes using rate ratios. This method helps explain the extent to which the role of the disease is underestimated in overall mortality when only the underlying cause of death is used to measure mortality. The interpretation of the rate ratio is described in Box 2.

Box 2: Comparing underlying cause and multiple cause data

In this bulletin, mortality rate ratios are used to compare mortality due to specific diseases reported as the *underlying cause* to mortality due to the same disease reported as a *multiple cause*.

The rate ratio is calculated by dividing the mortality rate for deaths where the disease is reported as a multiple cause by the rate for deaths where the disease is reported as the underlying cause of death, as follows:

Rate ratio = (mortality rate due to disease as any cause of death) / (mortality rate due to disease as underlying cause of death)

The rate ratio can be used to describe the underestimation of the role played by a given cause of death or a group of causes when only the underlying cause is considered:

- A rate ratio of 1.0 indicates that in *all* deaths involving a specific disease, the disease was always reported as the underlying cause. Rate ratios that are less than 2.0 indicate that the disease is most often reported as the underlying cause; that is, analysis based on the underlying cause will capture the majority of deaths involving the disease.

- A rate ratio of 2.0 indicates that in all deaths involving a specific disease, the disease was reported as the underlying cause in *half* of the deaths. Consequently, only half of the mortality involving this condition is estimated in statistics based on the only the underlying cause of death.

- Rate ratios higher than 2.0 indicate that the disease is more likely to be reported as an associated cause than as the underlying cause. In this case, routine analyses based on the underlying cause will underestimate the role that the condition plays in overall mortality. For example, a rate ratio of 5.0 indicates that *one-fifth* of the mortality involving a disease is estimated using only the underlying cause of death.

Age-standardised or crude death rates can be used for the rate ratios.

3   Results

During the period 1997 to 2007, there were 1,442,303 deaths (Table 1). In each year, typically 93% of all deaths were due to a specified natural underlying cause. In 2007, of the remainder, 6% were due to an external underlying cause and less than 1% to ill-defined underlying causes. The results in this bulletin are based on the 1,342,378 deaths where the underlying cause was a specified natural cause.

For each of the deaths due to natural causes, other causes often contribute to the death. The total number of causes contributing to deaths (the underlying and the associated causes) during the period 1997 to 2007 is presented in Table 1 as multiple causes. The average number of conditions reported on death certificates has increased slightly over time, from 2.7 conditions in 1997 to 3.1 in 2007 (Table 1).

Table 1: Number of deaths due to specified natural causes by underlying and multiple causes, average number of causes contributing to deaths, total number of all cause deaths and proportion of natural cause deaths, 1997-2007

Year	Among deaths due to natural causes[a]			Deaths due to all causes	
	Number by underlying cause	Number by multiple causes[b]	Average number of causes	Number	Per cent natural
1997	120,650	330,764	2.7	129,350	93.3
1998	118,012	327,517	2.8	127,202	92.8
1999	118,730	330,958	2.8	128,102	92.7
2000	119,370	331,864	2.8	128,291	93.0
2001	120,062	337,102	2.8	128,544	93.4
2002	125,070	356,136	2.8	133,707	93.5
2003	123,568	372,303	3.0	132,292	93.4
2004	123,449	377,021	3.1	132,508	93.2
2005	121,618	376,345	3.1	130,714	93.0
2006	124,287	396,232	3.2	133,739	92.9
2007	127,562	401,628	3.1	137,854	92.5
Total 1997–2007	**1,342,378**	**3,937,870**	**2.9**	**1,442,303**	**93.1**

(a) In this bulletin, natural causes of death do not include deaths where the underlying cause of death was coded to an external cause or an ill-defined cause. See Appendix for a list of ill-defined causes excluded from these analyses.

(b) Number of multiple causes of death reported in this table refers to mentions of all diseases contributing to each death.
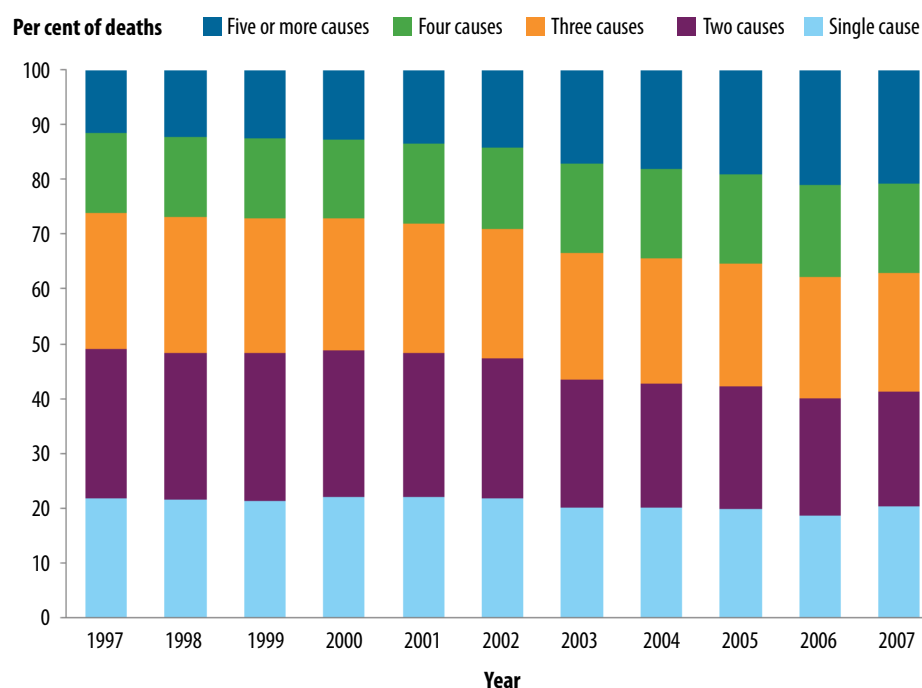
Note: Deaths data for 2006 and 2007 are preliminary data and are subject to revision.

Source: AIHW analysis of AIHW National Mortality Database.

In 2007, 20% of deaths were due to a single natural cause; for 21% of deaths, five or more causes contributed to the death. Over the period 1997 to 2007, the proportion of deaths caused by a single disease has remained steady, hovering between 19% and 22% (Figure 1). The proportion of deaths resulting from multiple diseases shows some variation over time. Specifically, over the period 1997 to 2007, there was:

• a decline in the proportion of deaths having two causes, from 27.2% to 20.8%

• a decline in the proportion of deaths having three causes, from 24.9% to 21.6%

• an increase in the proportion of deaths reporting four causes, from 14.8% to 16.5%

• an increase in the proportion of deaths having five or more causes, from 11.4% to 20.7%.

Variation in patterns of cause of death (using either underlying or multiple cause data), including the average number of causes contributing to deaths, can be influenced by changes to the coding processes, changes in certification practices, and actual changes in the population of the diseases that cause death. It can be difficult to untangle these sources of variation without looking at the types of diseases that caused death and other factors associated with dying, including age at death. These aspects of multiple causes of death are described below.

Note: Data for 2006 and 2007 are preliminary data and are subject to revision.

Source: AIHW analysis of AIHW National Mortality Database.

Figure 1: Trends in the number of diseases contributing to deaths where the underlying cause was coded to a natural cause of death, 1997 to 2007

Variation in multiple causes of death by age at death
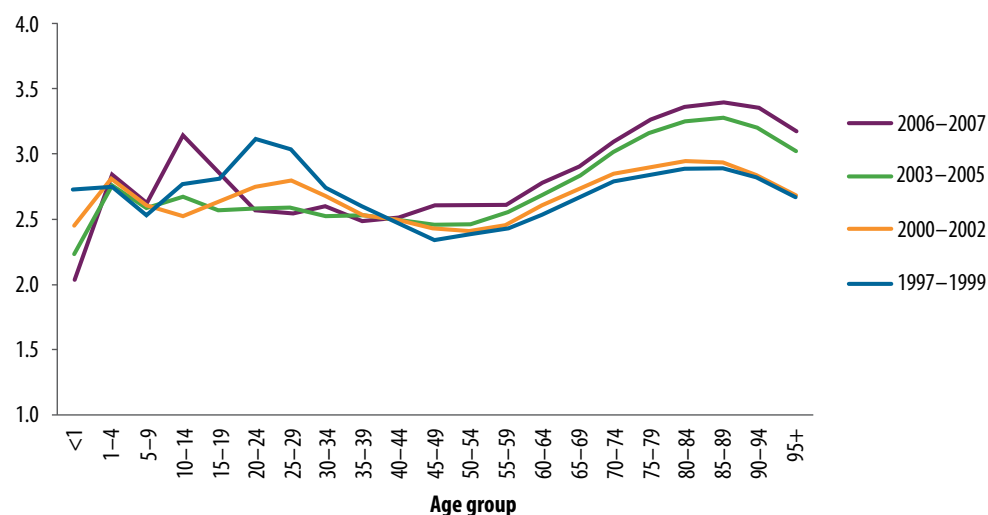
The average number of diseases causing death varies by age. Trends over time and by age at death for the average number of diseases causing death are shown in Figure 2.

For deaths among 30–59 year olds, on average, fewer conditions contributed to death compared with deaths among 60–89 year olds. Within the latter age group, the average number of causes increased with increasing age. For deaths among the very old (95 years or more) the average number of diseases contributing to death was lower than among those aged 75–94. Different researchers have attributed this result to different reasons, such as living to much older ages being associated with having better health and therefore fewer illnesses influencing death (Desequelles et al. 2010), or that less attention is given to documenting the causes of death among the very elderly (Gorina & Lentzner 2008). In the younger age groups (up to 29) there is considerable variation in the average number of causes reported for each death.

The variation over time in the average number of causes contributing to deaths among younger people is likely influenced by the smaller number of deaths that occur in these age groups as well as the types of conditions causing death among younger people. Natural deaths at these ages tend to be mainly due to perinatal conditions and congenital conditions (among under 1 year olds) and cancer in the other age groups. Among 25–64 year olds, cancers feature among the leading causes of death (AIHW 2010). Among people aged 65 or more, cardiovascular-related diseases feature more prominently in the leading causes of death (AIHW 2010).

Figure 2 displays an apparent difference in the average number of conditions causing death among people aged 65 or more over the period 2003 to 2007 compared with the period 1997 to 2002. This was due to a substantial increase in the number of deaths where hypertensive diseases were coded as an associated cause of death in 2003 onwards resulting from changes to the automated coding system for assigning causes of death (Walker 2012, personal communication).

Average number of diseases

Note: Data for 2006 and 2007 are preliminary data and are subject to revision.

Source: AIHW analysis of AIHW National Mortality Database.
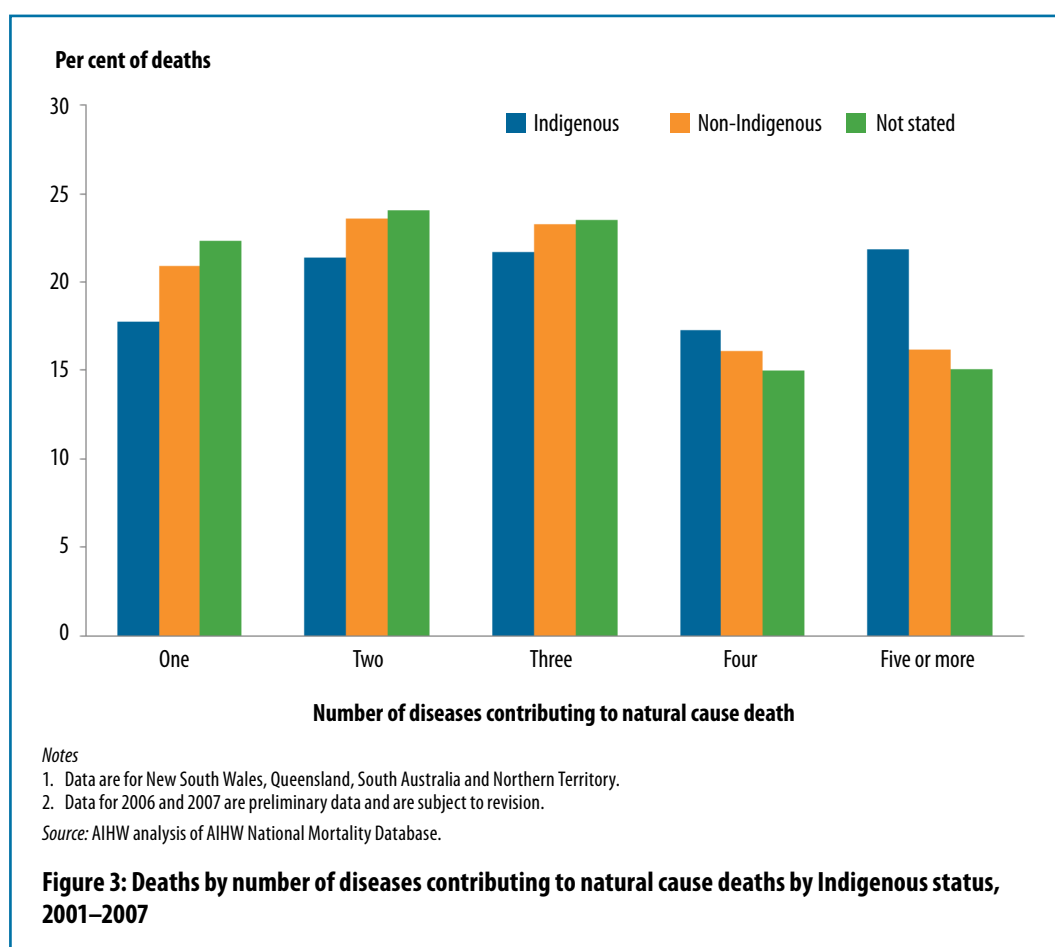
Figure 2: Average number of diseases contributing to natural cause deaths, by age group and year, 1997–2007

Variation in multiple causes of death by sociodemographic characteristics

Indigenous status

Overall, there is little difference in the average number of diseases causing (natural) deaths between Indigenous and non-Indigenous Australians; for deaths during 2001–2007, on average, 3.2 causes contributed to Indigenous deaths and 3.0 causes contributed to non-Indigenous deaths. However, the average life expectancy for Indigenous Australians is much lower than for non-Indigenous Australians; Indigenous life expectancy for 2005–2007 is estimated to be 67.2 years for males, which is 11.5 years lower than for non-Indigenous males, and 72.9 years for females, which is 9.7 years lower than for non-Indigenous females (ABS 2009).

Despite similarities in the average number of causes contributing to death overall, the proportion of deaths having a single cause was 17.7% for Indigenous deaths and 20.9% for non-Indigenous deaths (Figure 3). The proportion of deaths having two and three contributing causes was 21.4% and 21.7% for Indigenous deaths respectively, and 23.6% and 23.2% for non-Indigenous deaths respectively. The proportion of Indigenous deaths having five or more causes was greater than among non-Indigenous deaths (21.8% compared with 16.2%).

Per cent of deaths

Notes
1. Data are for New South Wales, Queensland, South Australia and Northern Territory.
2. Data for 2006 and 2007 are preliminary data and are subject to revision.

Source: AIHW analysis of AIHW National Mortality Database.

Figure 3: Deaths by number of diseases contributing to natural cause deaths by Indigenous status, 2001–2007

Socioeconomic status and remoteness of area of residence

There is no apparent relationship between the average number of causes contributing to deaths and different levels of socioeconomic status (SES) or remoteness of area of usual residence. The condition reported as the underlying cause and the age at death tend to have greater influences on the number and types of causes contributing to death (as shown elsewhere in the bulletin). Summary measures of multiple causes by SES and remoteness of area of usual residence are presented in Table 2.

The difference in the average number of diseases contributing to deaths between the lowest SES and the highest SES groups (3.2 and 3.1, respectively) is small, and there is no apparent social gradient. Similarly, in comparing different remoteness areas, although there is no apparent gradient, the average number of diseases contributing to deaths among people living in very remote areas is slightly higher compared with people living in all other areas.

The analyses presented here, by levels of socioeconomic status or remoteness by area of usual residence, provide little insight into factors influencing multiple causes of death.

Table 2: Summary of multiple causes of death for deaths due to natural causes, by socioeconomic status (2007) of area of usual residence and by remoteness of area of usual residence (2005–2007)

	Socioeconomic status of area of usual residence				
	Lowest SES	**2**	**3**	**4**	**Highest SES**
Number of deaths	29,471	29,032	24,608	22,025	22,055
Number of multiple causes	93,343	92,171	77,777	68,428	68,848
Average number of diseases per death	3.2	3.2	3.2	3.1	3.1
	Remoteness of area of usual residence				
	Major cities	**Inner regional**	**Outer regional**	**Remote**	**Very remote**
Number of deaths	237,469	87,805	39,988	4,804	2,434
Number of multiple causes	754,066	270,437	123,816	15,152	8,012
Average number of diseases per death	3.2	3.1	3.1	3.2	3.3

SES   socioeconomic status

Notes
1. Data for 2006 and 2007 are preliminary data and are subject to revision.
2. 371 deaths were excluded in the analysis by socioeconomic area due to unknown area of residence.
3. 967 deaths were excluded from the analysis by remoteness area due to unknown area of residence.

Source: AIHW analysis of AIHW National Mortality Database.

Variation in multiple causes of death by underlying cause

Some conditions contribute to death more often than is apparent from estimates based on only the underlying causes of death. Rate ratios (as described in Box 2) are used to summarise the differences between reporting estimates of mortality using multiple cause of death data compared with using only the underlying cause.

Broad categories of cause of death

Diseases usually coded as the underlying cause of death

For most of the broad categories of cause of death, the disease is more often reported as an associated cause than as the underlying cause. This is indicated by a rate ratio of more than 2.0 (Table 3). The exceptions to this are deaths with an underlying cause of cancers, diseases of the circulatory system, and maternal, perinatal and congenital conditions. In deaths involving cancers, maternal, perinatal and congenital conditions and diseases of the circulatory system, these conditions were coded as the underlying cause in 88%, 79% and 60% of deaths respectively. Put another way, for these cause groups, when all causes of death are considered, there is an additional 12% of deaths involving cancers, an additional 21% of deaths involving maternal, perinatal and congenital conditions, and an additional 40% of deaths involving circulatory system diseases compared with deaths represented by the underlying cause data.

Diseases usually coded as associated causes of death

For all broad cause groups other than cancers, diseases of the circulatory system, and maternal, perinatal and congenital conditions, a disease from the group was coded as the underlying cause in fewer than half of the deaths involving the disease—ranging from 12% of all deaths due to diseases of the blood, to 44% of deaths due to diseases of the nervous system (Table 3).

Of all deaths where infectious and parasitic diseases, diseases of the blood, skin diseases, musculoskeletal diseases and genitourinary diseases contributed to the death, fewer than 20% had these causes as the underlying cause.

Describing these outcomes using rate ratios shows the extent to which describing patterns of causes of death using only the underlying cause underestimates the contribution of some diseases to death. For example, if all deaths involving diseases of the blood and musculoskeletal, genitourinary, and infectious and parasitic diseases are considered, mortality is 8.0, 5.4, 5.3 and 5.1 times as high, respectively, as rates based on the underlying cause only. For skin, endocrine and respiratory diseases, mortality is 4.7, 3.6 and 3.6 times as high, respectively, as would be apparent from analyses based on the underlying cause only (Table 3).

Table 3: Number and rates of deaths by underlying, associated and multiple causes of death; and rate ratios for multiple to underlying causes of death, broad categories of disease, 2007

Disease category(a)	Underlying cause		Associated cause		Multiple cause		Per cent under-lying(c)	Rate ratio(d)
	Number of deaths	Deaths per 100,000	Number of deaths(b)	Deaths per 100,000	Number of deaths(b)	Deaths per 100,000		
Infectious and parasitic diseases	1,858	8.8	7,754	36.8	9,437	44.8	19.7	5.1
Cancers	40,287	191.2	13,559	64.3	45,855	217.6	87.9	1.1
Diseases of the blood	479	2.3	3,419	16.2	3,845	18.2	12.5	8.0
Endocrine diseases	5,355	25.4	14,842	70.4	19,328	91.7	27.7	3.6
Mental and behavioural disorders	5,715	27.1	13,722	65.1	18,891	89.6	30.3	3.3
Diseases of the nervous system	5,467	25.9	7,513	35.7	12,491	59.3	43.8	2.3
Diseases of the circulatory system	46,232	219.4	62,002	294.2	76,508	363.1	60.4	1.7
Diseases of the respiratory system	11,396	54.1	34,416	163.3	40,468	192.0	28.2	3.6
Diseases of the digestive system	4,760	22.6	9,210	43.7	12,365	58.7	38.5	2.6
Diseases of the skin	362	1.7	1,364	6.5	1,701	8.1	21.3	4.7
Musculoskeletal system diseases	1,091	5.2	4,991	23.7	5,883	27.9	18.5	5.4
Genitourinary system diseases	3,324	15.8	15,348	72.8	17,755	84.3	18.7	5.3
Maternal, perinatal and congenital conditions	1,157	5.5	800	3.8	1,468	7.0	78.8	1.3
All natural causes	127,562	605.3	..	..	..	..	..	..

(a) For the full name of the disease category and the ICD-10 codes that define the category, see Appendix Table A1.
(b) The information in this table refers to counts of deaths, therefore at the all (natural) causes level, the totals for associated causes and multiple causes of death are not applicable.
(c) Refers to the per cent of deaths involving the specified disease, where that disease was recorded as the underlying cause of death.
(d) The rate ratio is the rate for the deaths as multiple causes divided by the rate for the deaths as the underlying cause.

Notes
1. Deaths for 2007 are based on preliminary data and are subject to revision.
2. The total for all natural causes includes 8 deaths due to an underlying cause of diseases of the eye and adnexa and ear and mastoid processes, and 71 deaths due to Sudden Infant Death Syndrome.

Source: AIHW analysis of AIHW National Mortality Database.

Selected chronic diseases causes of death

Chronic diseases usually coded as the underlying cause of death

The majority of deaths involving colorectal, liver, lung, breast and prostate cancers have the particular cancer captured as the underlying cause—from 93% for lung cancer to 67% for prostate cancer deaths (Table 4).

The rate ratio indicates the extent to which causes of death are captured in the multiple causes relative to the underlying cause. The rate ratios for deaths involving the selected cancers are less than 2.0; this indicates that for deaths involving these cancers, more than 50% of the time the disease is reported as the underlying cause. In considering mortality for all deaths where colorectal, breast and prostate cancers contributed to the death, the mortality rates would be 20%, 30% and 50% higher respectively than the rate based on deaths where the diseases were reported as the underlying cause. For liver and lung cancer the rate would be 10% higher than the rate for these diseases as the underlying cause (Table 4).

For deaths involving CHD and cerebrovascular diseases, 62% and 57% respectively are captured in the underlying cause. The death rates for these causes would be 60% and 80% higher than the rate for the underlying cause, when considering the overall contribution of these diseases to death (Table 4).

Chronic diseases usually coded as an associated cause of death

For some chronic diseases, most of their role in contributing to deaths is not captured in analyses of the underlying cause only. Of the deaths involving chronic and unspecified kidney failure, 17% are represented in the underlying cause (Table 4). For diabetes this figure was 29% and for dementia and Alzheimer disease, 42%. When considering the contributory role of these conditions, the mortality rate would be 5.9, 3.4 and 2.4 times as high, respectively, as the underlying cause mortality rate.

More than 2 in 5 deaths (42%) involving COPD and 30% of deaths involving asthma are captured in the underlying cause. The mortality rates are 2.4 and 3.4 times as high as the underlying cause rates, if their total involvement in causing death is considered.

Table 4: Number and rates of deaths by underlying, associated and multiples cause of death; and rate ratios for multiple to underlying causes of death, selected chronic disease causes of death, 2007

Chronic disease[a]	Underlying cause		Associated cause		Multiple cause		Per cent under-lying[c]	Rate ratio[d]
	Number of deaths	Deaths per 100,000	Number of deaths	Deaths per 100,000	Number of deaths	Deaths per 100,000		
Colorectal cancer	4,107	19.5	772	3.7	4,861	23.1	84.5	1.2
Liver cancer	1,109	5.3	115	0.5	1,223	5.8	90.7	1.1
Lung cancer	7,626	36.2	581	2.8	8,198	38.9	93.0	1.1
Breast cancer[b]	2,680	25.3	780	7.4	3,460	32.7	77.5	1.3
Prostate cancer[b]	2,938	28.0	1,419	13.5	4,357	41.6	67.4	1.5
Diabetes	3,810	18.1	9,203	43.7	12,942	61.4	29.4	3.4
Dementia and Alzheimer disease	7,320	34.7	10,510	49.9	17,410	82.6	42.0	2.4
Coronary heart disease	22,729	107.9	20,758	98.5	36,748	174.4	61.9	1.6
Cerebrovascular disease	11,491	54.5	10,394	49.3	20,252	96.1	56.7	1.8
Chronic obstructive pulmonary disease	5,152	24.4	7,166	34.0	12,178	57.8	42.3	2.4
Asthma	385	1.8	918	4.4	1,303	6.2	29.5	3.4
Chronic and unspecified kidney failure	2,046	9.7	10,082	47.8	12,113	57.5	16.9	5.9

(a) For the ICD-10 codes that define each chronic disease, see Appendix Table A2.
(b) Breast cancer deaths are for females only; breast cancer and prostate cancer rates are for the female and male populations, respectively.
(c) Refers to the per cent of deaths involving the specified chronic disease, where that disease was recorded as the underlying cause of death.
(d) The rate ratio is the rate for the deaths as multiple causes divided by the rate for the deaths as the underlying cause.

Note: Deaths for 2007 are based on preliminary data and are subject to revision.
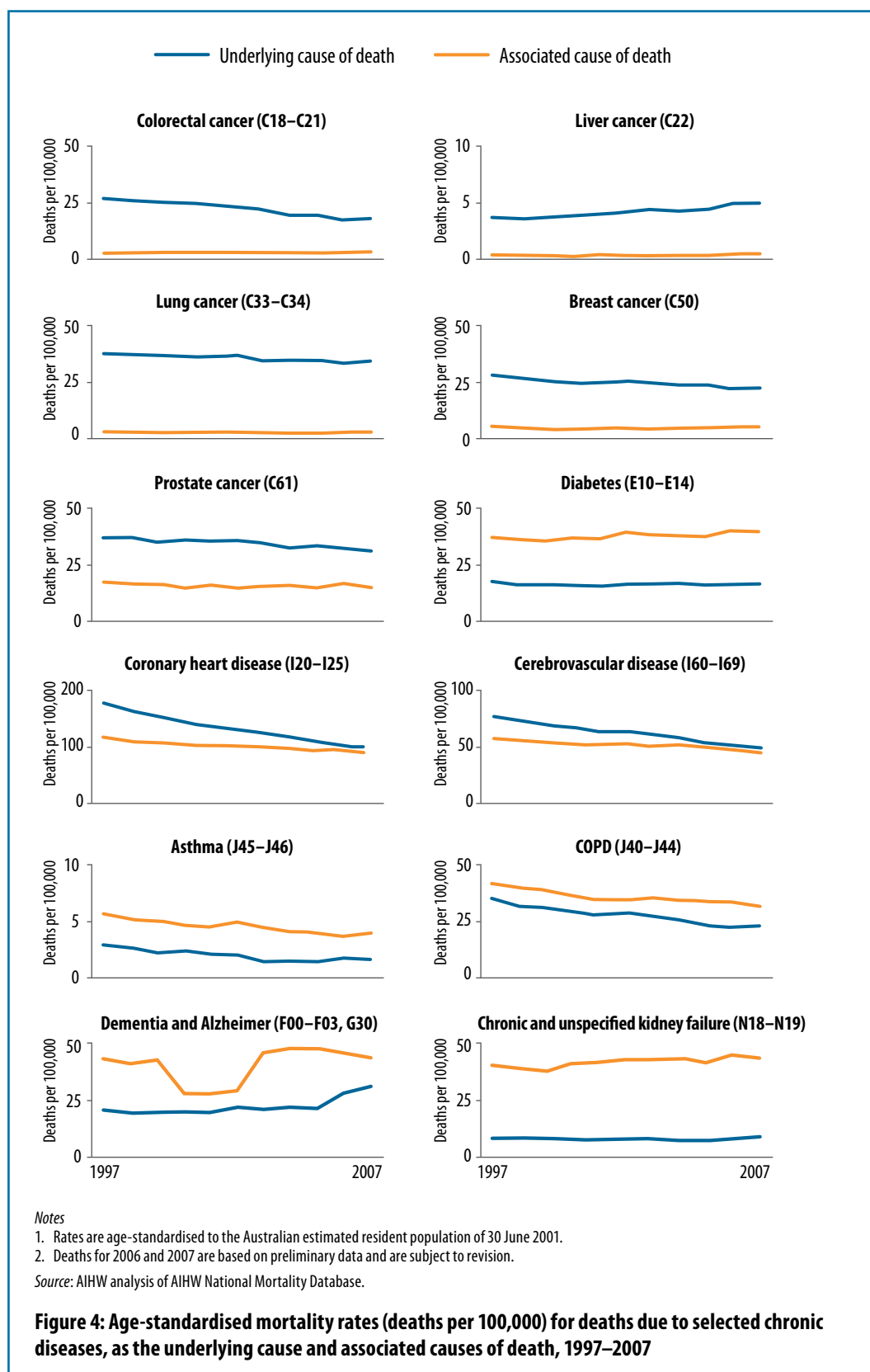
Source: AIHW analysis of AIHW National Mortality Database.

Trends in multiple causes of death for chronic diseases

Figure 4 shows trends over the period 1997 to 2007 for deaths due to the selected chronic diseases coded as the underlying cause and as an associated cause. The figure indicates the following:

* As shown earlier, deaths involving the selected cancers are more likely to be indicated as the underlying cause. This pattern is consistent over time.

* For diabetes, more deaths involving this disease are indicated by the associated causes of death than as the underlying cause of death. The mortality rates for diabetes as the underlying cause declined overall between 1997 and 2007 by 7% and mortality due to diabetes reported as an associated cause has increased by 7%.

* During the period 1997 to 2007, mortality due to both CHD and cerebrovascular diseases as represented by both the underlying and associated causes declined. As the underlying cause, the CHD mortality rate declined by 44% and for cerebrovascular disease, by 35%. The decline in the mortality rates indicated by the associated cause data was smaller—23% for CHD deaths and 22% for cerebrovascular deaths.

- The mortality rates for COPD and asthma deaths declined during the period of this analysis, for both underlying and associated causes. For asthma, the age-standardised mortality rate using the underlying cause declined from 2.9 deaths per 100,000 population to 1.7. For the associated cause, the rate declined from 5.6 deaths per 100,000 population to 4.0. The respective figures for COPD as the underlying cause were 34.3 and 22.4 deaths per 100,000 population and as an associated cause, 41.0 and 31.2.

- Deaths due to dementia and Alzheimer disease have been influenced by coding changes and changes in certification practices. In 2000, changes to the coding process resulted in a break in the time series for dementia deaths indicated as an associated cause. From 2006 there was a substantial increase in the number of deaths due to dementia and Alzheimer disease (as the underlying cause), compared with earlier years. This was attributed in part to the changes to defence veterans' entitlements that now allow for death from vascular dementia to be related to defence service and a subsequent promotional campaign around this targeted at health professionals (ABS 2008). Specifically, this has resulted in some deaths that were previously coded to cerebrovascular diseases being coded to vascular dementia.

- Death rates due to chronic and unspecified kidney failure show an increased incidence of mortality when the contributory role of this disease, rather than only underlying cause, is considered. This pattern is consistent over time; the age-standardised mortality rate for chronic and unspecified kidney failure as an associated cause was 5.0 times that of the rate using the underlying cause, in 1997 and in 2007.

Underlying cause of death — Associated cause of death

Colorectal cancer (C18–C21)

Liver cancer (C22)

Lung cancer (C33–C34)

Breast cancer (C50)

Prostate cancer (C61)

Diabetes (E10–E14)

Coronary heart disease (I20–I25)

Cerebrovascular disease (I60–I69)

Asthma (J45–J46)

COPD (J40–J44)

Dementia and Alzheimer (F00–F03, G30)

Chronic and unspecified kidney failure (N18–N19)

Notes
1. Rates are age-standardised to the Australian estimated resident population of 30 June 2001.
2. Deaths for 2006 and 2007 are based on preliminary data and are subject to revision.

Source: AIHW analysis of AIHW National Mortality Database.

Figure 4: Age-standardised mortality rates (deaths per 100,000) for deaths due to selected chronic diseases, as the underlying cause and associated causes of death, 1997–2007

Patterns of contributory causes of death

Deaths with chronic diseases as the underlying cause of death

This section describes the leading associated causes of death; that is, the diseases most often associated with each specific chronic disease as the underlying cause.

For each of the selected chronic diseases, the associated causes of death were ranked using an AIHW-modified version of the WHO-recommended classification for deriving leading causes of death (Becker et al. 2006). Figure 5 shows the five leading diseases most commonly recorded as associated causes for each of the chronic diseases as the underlying cause.

Cancers of unknown primary site were associated with all cancer deaths reported here. They contributed to 20% of colorectal, 8% of liver, 16% of lung, 23% of breast and 13% of prostate cancer deaths. The leading associated cause of death with liver cancer was cirrhosis of the liver, in 30% of these deaths. CHD featured as a leading associated causes of death among deaths with an underlying cause of cancer. Diabetes also featured as a leading associated cause for the selected cancers, except for lung cancer.
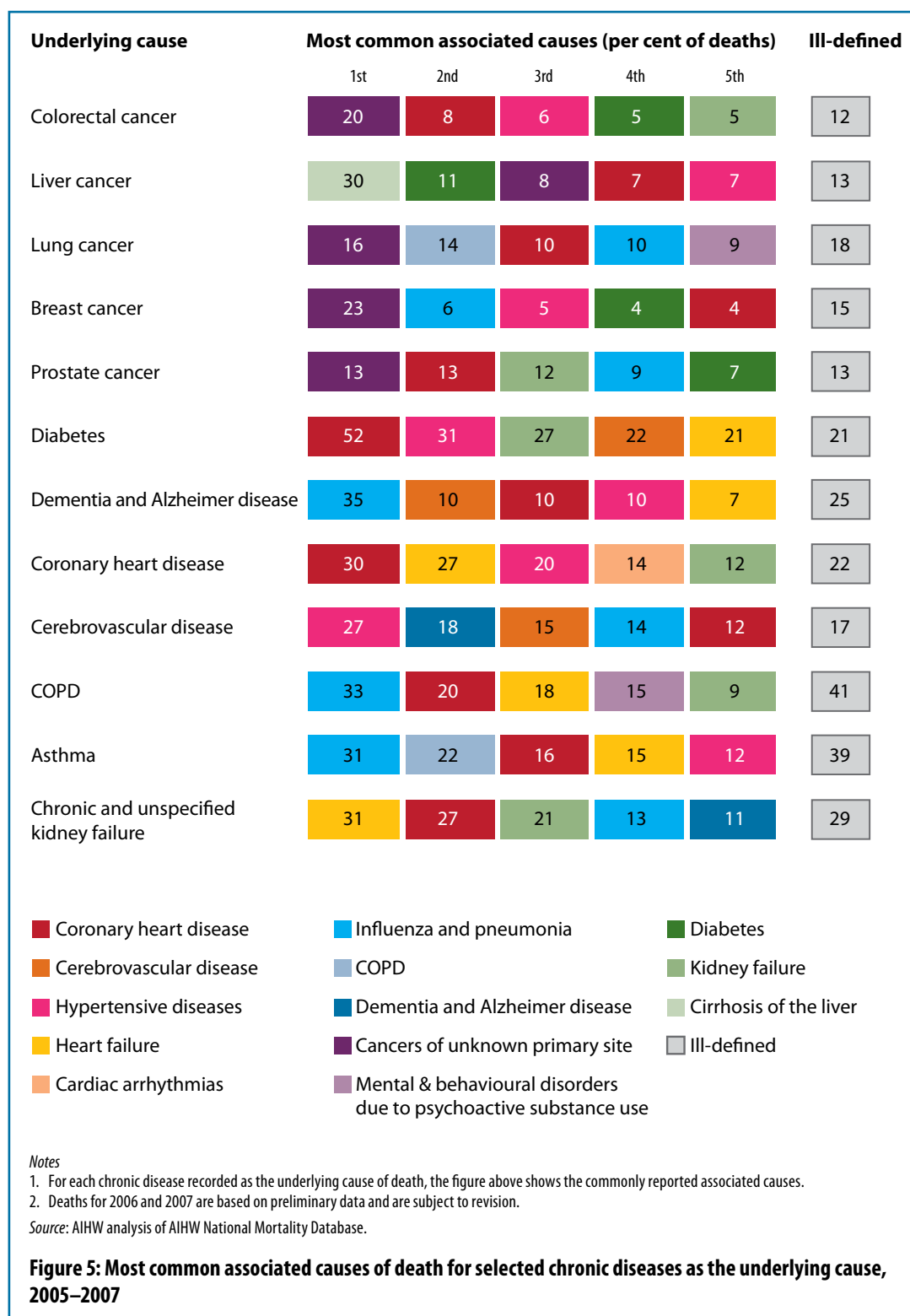
Hypertensive diseases featured in the five leading associated cause of death for most chronic disease underlying causes of death, in particular diabetes (31%), cerebrovascular diseases (27%) and CHD (20%).

CHD featured among the five leading associated causes of death for all the chronic disease underlying causes of death shown in Figure 5; it was involved in 52%, 27% and 20% of deaths due to diabetes, chronic and unspecified kidney failure and COPD respectively. In 30% of deaths where CHD occurred as the underlying cause of death, another form of CHD was also reported as an associated cause.

Influenza and pneumonia featured often as a leading associated cause of death. Both of these diseases provide an obvious target for treatment and opportunity for improving quality of life or potentially preventing some deaths due to the chronic disease with which it is associated. Influenza and pneumonia contributed to 35% of deaths due to dementia and Alzheimer disease, 33% of COPD deaths and 31% of asthma deaths.
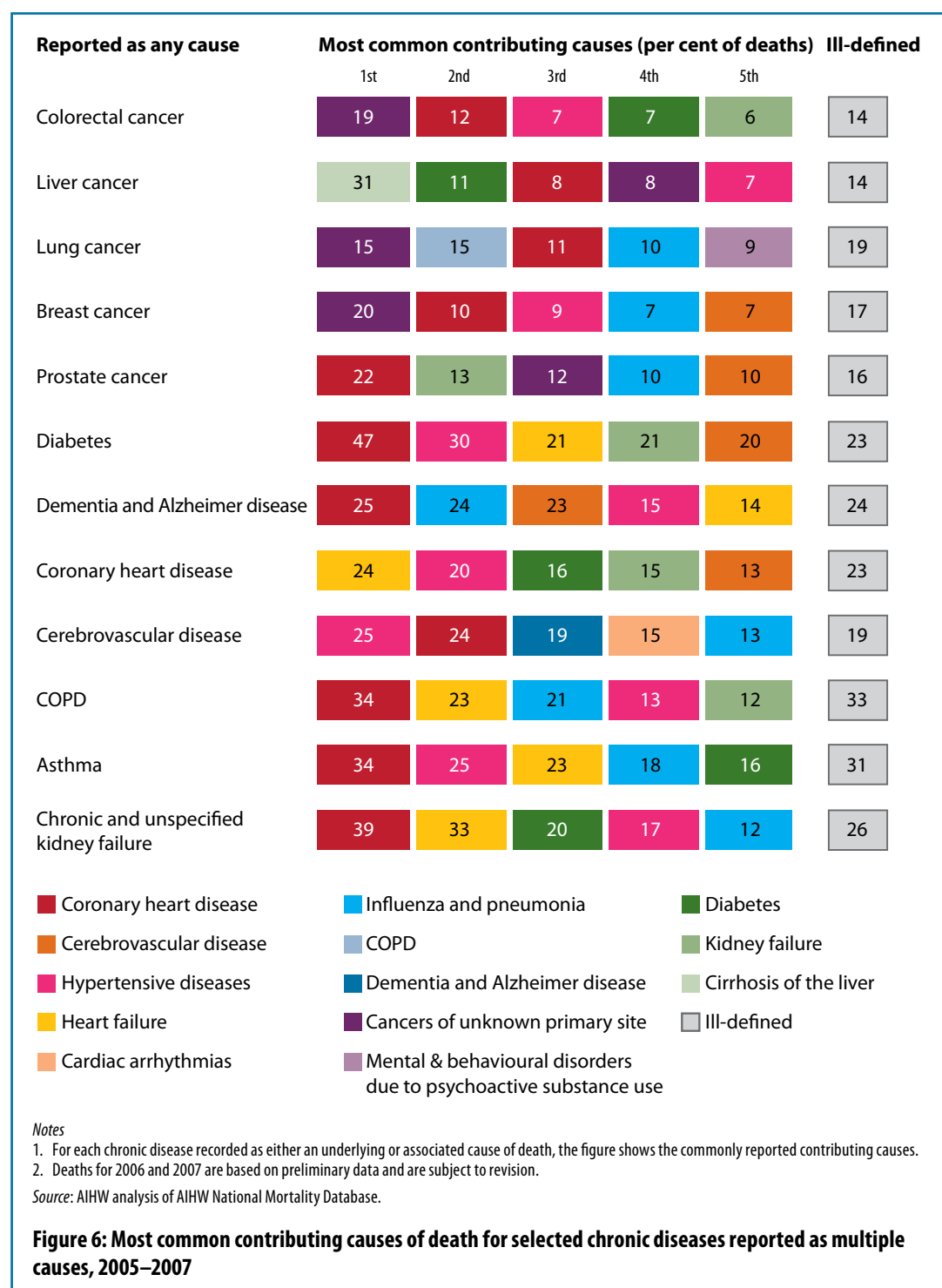
Ill-defined diseases were indicated among the leading associated causes of death in this analysis; ill-defined conditions were coded as associated causes for 41% of COPD deaths, for 39% of asthma deaths and for 29% of chronic and unspecified kidney failure deaths. Despite the estimated completeness of coverage of deaths in Australia and high-quality processing and coding of causes of death, the high proportion of ill-defined conditions raises issues around the quality of documentation of causes of death.

Underlying cause	Most common associated causes (per cent of deaths)					Ill-defined
	1st	2nd	3rd	4th	5th	
Colorectal cancer	20	8	6	5	5	12
Liver cancer	30	11	8	7	7	13
Lung cancer	16	14	10	10	9	18
Breast cancer	23	6	5	4	4	15
Prostate cancer	13	13	12	9	7	13
Diabetes	52	31	27	22	21	21
Dementia and Alzheimer disease	35	10	10	10	7	25
Coronary heart disease	30	27	20	14	12	22
Cerebrovascular disease	27	18	15	14	12	17
COPD	33	20	18	15	9	41
Asthma	31	22	16	15	12	39
Chronic and unspecified kidney failure	31	27	21	13	11	29

Legend:
- Coronary heart disease
- Cerebrovascular disease
- Hypertensive diseases
- Heart failure
- Cardiac arrhythmias
- Influenza and pneumonia
- COPD
- Dementia and Alzheimer disease
- Cancers of unknown primary site
- Mental & behavioural disorders due to psychoactive substance use
- Diabetes
- Kidney failure
- Cirrhosis of the liver
- Ill-defined

Notes
1. For each chronic disease recorded as the underlying cause of death, the figure above shows the commonly reported associated causes.
2. Deaths for 2006 and 2007 are based on preliminary data and are subject to revision.

Source: AIHW analysis of AIHW National Mortality Database.

Figure 5: Most common associated causes of death for selected chronic diseases as the underlying cause, 2005–2007

Deaths with chronic diseases as any cause of death

The following analysis is based on deaths where the chronic diseases were coded as any cause type (that is, as the underlying or as an associated cause). For these deaths, the contribution of other causes of death (also coded to either the underlying or associated causes) is assessed. The most commonly occurring contributory causes with each of the selected chronic diseases are shown in Figure 6.

Reported as any cause	Most common contributing causes (per cent of deaths)					Ill-defined
	1st	2nd	3rd	4th	5th	
Colorectal cancer	19	12	7	7	6	14
Liver cancer	31	11	8	8	7	14
Lung cancer	15	15	11	10	9	19
Breast cancer	20	10	9	7	7	17
Prostate cancer	22	13	12	10	10	16
Diabetes	47	30	21	21	20	23
Dementia and Alzheimer disease	25	24	23	15	14	24
Coronary heart disease	24	20	16	15	13	23
Cerebrovascular disease	25	24	19	15	13	19
COPD	34	23	21	13	12	33
Asthma	34	25	23	18	16	31
Chronic and unspecified kidney failure	39	33	20	17	12	26

Legend:
- Coronary heart disease
- Cerebrovascular disease
- Hypertensive diseases
- Heart failure
- Cardiac arrhythmias
- Influenza and pneumonia
- COPD
- Dementia and Alzheimer disease
- Cancers of unknown primary site
- Mental & behavioural disorders due to psychoactive substance use
- Diabetes
- Kidney failure
- Cirrhosis of the liver
- Ill-defined

Notes
1. For each chronic disease recorded as either an underlying or associated cause of death, the figure shows the commonly reported contributing causes.
2. Deaths for 2006 and 2007 are based on preliminary data and are subject to revision.

Source: AIHW analysis of AIHW National Mortality Database.

Figure 6: Most common contributing causes of death for selected chronic diseases reported as multiple causes, 2005–2007

For these chronic diseases as any type of cause (underlying or associated), the patterns of other diseases as contributing causes is similar to those for the chronic diseases as the underlying cause.

Hypertensive diseases featured as a leading contributor to deaths involving selected chronic diseases, in particular diabetes (30%), cerebrovascular diseases and asthma, (each 25%), CHD (20%) and chronic and unspecified kidney failure (17%).

CHD is a most frequently contributing condition in deaths for most of the chronic conditions reported here. It is indicated as contributing to 47% of deaths involving diabetes, 39% involving chronic and unspecified kidney failure and 34% of deaths involving each of COPD and asthma.

Diabetes was a common contributory cause, in particular for deaths involving chronic and unspecified kidney failure (20%), CHD (16%) and asthma (16%).

Cerebrovascular diseases commonly contributed to chronic disease deaths that also involved dementia and Alzheimer disease (23%), diabetes (20%) and CHD (13%).

Age at death for selected chronic diseases

Patterns of age at death were examined for any variation between deaths where the chronic disease was reported as the underlying cause or as an associated cause. The median age at death and the average number of causes reported on the death certificates for the reported chronic disease deaths, as both the underlying cause and associated cause, are shown in Table 5.

People dying with one of the selected cancers as the underlying cause were, on average younger than those who died with one of these cancers recorded as an associated cause (Table 5). The average age at death for people dying from the condition as an underlying cause was marginally higher for diabetes, dementia and Alzheimer disease, CHD, cerebrovascular disease, and chronic and unspecified kidney failure, although in these cases the age differences were smaller.

For all deaths where the chronic disease was reported as an associated cause, there were on average more causes reported on the death certificate compared with deaths where the chronic disease was reported as the underlying cause (Table 5).

Table 5: Average number of causes reported and median age at death for deaths involving selected chronic diseases, reported as the underlying cause and as a multiple cause, 2007

Cause of death	Chronic disease reported as the underlying cause		Chronic disease reported as an associated cause	
	Average number of causes per death	Median age at death	Average number of causes per death	Median age at death
Colorectal cancer	2.4	74	4.7	81
Liver cancer	2.7	72	4.7	73
Lung cancer	2.5	73	4.3	77
Breast cancer	2.3	67	4.5	83
Prostate cancer	2.5	80	4.5	83
Diabetes	4.3	80	4.7	79
Dementia and Alzheimer disease	2.9	87	4.1	86
Coronary heart disease	3.5	83	4.4	82
Cerebrovascular disease	3.1	84	4.4	83
Asthma	3.6	80	4.5	80
COPD	3.6	79	5.0	81
Chronic and unspecified kidney failure	3.6	84	4.8	82

Note: Deaths for 2007 are based on preliminary data and are subject to revision.

Source: AIHW analysis of AIHW National Mortality Database.

4 Discussion

The analyses presented here highlight the underestimation of the contribution that selected chronic diseases make to overall mortality when cause of death is described using the underlying cause only. This is particularly true for diabetes and chronic and unspecified kidney failure.

The analyses in this bulletin do not suggest that routine analyses of mortality (by underlying cause of death) should be replaced by those based on multiple causes of death. Rather, multiple cause analyses complement those using underlying cause only and provide useful additional information.

There is no standard method to analyse multiple causes of death. The analyses undertaken for this bulletin used specific disease categories. A multiple cause of death approach may be better suited using specific disease categories than for broad disease categories or all deaths. Patterns of commonly co-occurring conditions between, for example, cardiovascular diseases and all endocrine diseases do not offer the same value of insight as say between coronary heart disease and diabetes.

Multiple causes of death data can be useful for examining the quality of certification practices. Clinical accuracy and completeness of the clinical detail can be explored by using all the disease information provided in the death certificate. Assessment of the type and frequency of reporting non-specific and ill-defined causes can be used to target areas for improvement, for example, in the *Cause of death certification* booklets produced by the ABS to guide medical practitioners in completing death certificates. An analysis of the reporting practices of certifiers was not in the scope of this bulletin or any AIHW uses of the cause of death data.

Useful additional analyses using multiple causes of death include investigations at different broad age groups. For example, an account of the types of contributing causes of death among people of working age would enhance understanding of the burden of mortality as well as provide insight into emerging health trends in relation to co-morbidities among this population group.

The strength of the association between contributing causes of death can be calculated. These analyses can show whether a specific disease is more or less likely to contribute to deaths involving a disease of interest compared with another disease, or all other diseases. These sorts of analyses can be useful for guiding detailed epidemiological research, for example, to determine appropriate intervention points for the prevention of disease.

Despite the broader insight into patterns of mortality offered by the analyses provided in this bulletin, there are some data limitations. These include:

- Information from death certificates does not enable an understanding of the prevalence of co-morbidities in the population, only the diseases the person had that were instrumental in causing death.

- Certifiers' opinions of the cause of death can change over time according to new knowledge about conditions. For example, there is an increased recognition among certifiers of the risk that some chronic diseases contribute in the development of other conditions, such as diabetes being a risk factor for cardiovascular disease (Cheng et al. 2008). It is difficult to assess the propensity of certifiers to include all strongly suspected and commonly related conditions on the death certificate as compared with only including those that pathologically influenced the death.

- The mortality data available for monitoring and surveillance and statistical analysis rely on the diligence of certifiers to accurately and completely depict the conditions that were instrumental in causing the death; there are few evaluations available concerning the completeness and accuracy of death certification for Australian mortality data.

- Similarly, the introduction of, or changes to, existing policy can influence the information reported on death certificates. Changes in certification practices and to coding processes can influence the number and type of causes contributing to death (see the results section for example, of deaths involving dementia and Alzheimer disease). Variation in certification practices refers to changes in the way that a certifier documents the types of diseases that caused the death. It is difficult to evaluate these changes unless they result in measurable change to statistical patterns of causes of death.

- Completeness of death certification can also affect the reporting of contributory causes. For example, analysis of people registered for treatment for chronic kidney disease has shown that the involvement of this disease in their death is not always recorded in the deaths data, despite the severity of the disease (AIHW 2011).

- Patterns of mortality (based on both underlying and multiple cause of death data) can vary for many reasons, including changes to the coding system and coding instructions; changes in certification practices and awareness of associations between diseases; changes in policy, and of course, changes in the actual occurrence of the disease. Each of these aspects needs to be considered in analyses of multiple causes of death data to understand trends.

- Multiple causes of death data do not imply causality between conditions. Although the WHO-recommended format of the death certificate requires that the certifier indicate the duration of each reported condition for immediate, intervening and underlying causes, this information is not available in the coded data nor is it available for the causes on the death certificate that are considered to make a significant contribution to the death. Therefore only associations, rather than causal relationships, between different conditions can be examined.

5 Appendix

ICD-10 chapter level groupings of causes of death

In this bulletin patterns of multiple causes are described according to the broad-level classification of cause of death represented by ICD-10 chapters. A list of the ICD-10 chapters and the ICD-10 codes used for each chapter is presented in Table A1.

Table A1: ICD-10 chapter level cause of death and ICD-10 codes

ICD-10 chapter level cause of death	ICD-10 codes
Certain infectious and parasitic diseases	A00–B99
Neoplasms[a]	C00–D48
Diseases of the blood & blood-forming organs & certain disorders involving the immune mechanism	D50–D89
Endocrine, nutritional and metabolic diseases	E00–E90
Mental and behavioural disorders	F00–F99
Diseases of the nervous system	G00–G99
Diseases of the eye and adnexa	H00–H59
Diseases of the ear and mastoid process	H60–H95
Diseases of the circulatory system	I00–I99
Diseases of the respiratory system	J00–J99
Diseases of the digestive system	K00–K93
Diseases of the skin and subcutaneous tissue	L00–L99
Diseases of the musculoskeletal system and connective tissue	M00–M99
Diseases of the genitourinary system	N00–N99
Pregnancy, childbirth and the puerperium	O00–O99
Certain conditions originating in the perinatal period	P00–P96
Congenital malformations, deformations and chromosomal abnormalities	Q00–Q99
Symptoms, signs and abnormal clinical and laboratory findings, nec	R00–R99
Injury, poisoning and certain other consequences of external causes	S00–T98
External causes of morbidity and mortality	V01–Y98

(a) Benign and malignant tumours. Referred to as cancers in this bulletin.
nec   not elsewhere classified
Source: WHO 2009.

Deaths from selected chronic diseases

The chronic diseases selected for analysis in this bulletin are those reported in the indicator for 'Deaths from leading chronic conditions' (AIHW 2009). Although these leading chronic conditions may not equate to the leading causes of death, this set of diseases reflects conditions that are currently the focus of health-related government agencies and researchers. The selected chronic disease causes of death and the codes used to indicate deaths from these conditions are presented in Table A2. Some modifications have been made for the purpose of this bulletin, namely, that all diabetes deaths are reported and that COPD deaths include deaths that were due to bronchitis not specified as acute or chronic.

Table A2: Chronic disease causes of death and ICD-10 codes

Chronic disease cause of death	ICD-10 codes
Colorectal cancer	C18–C21
Liver cancer	C22
Lung cancer	C33–C34
Breast cancer	C50
Prostate cancer	C61
Diabetes[a]	E10–E14
Dementia and Alzheimer disease	F00–F03, G30
Coronary heart disease	I20–I25
Cerebrovascular disease	I60–I69
Chronic obstructive pulmonary disease[b]	J40–J44
Asthma	J45–J46
Chronic and unspecified kidney failure[c]	N18–N19

(a) In this bulletin, deaths from all types of diabetes were assessed. This contrasts with using only Type 2 diabetes in the indicator for 'Deaths due to leading chronic diseases' (AIHW 2009).

(b) In this bulletin, deaths from chronic obstructive pulmonary disease (COPD) include deaths due to bronchitis, not specified as acute or chronic. In the indicator for 'Deaths due to leading chronic diseases' (AIHW 2009), COPD deaths exclude deaths due to deaths due to bronchitis, not specified as acute or chronic.

(c) End-stage renal failure is referred to as 'chronic and unspecified kidney failure' which includes end-stage renal failure; the ICD-10 codes are the same as those used in the indicator for 'Deaths due to leading chronic diseases' (AIHW 2009).

Table A3: Ill-defined causes of death and ICD-10 codes

Leading cause of death	ICD-10 codes
Cardiac arrest, unspecified	I46.9
Low blood pressure, unspecified	I95.9
Other and unspecified disorders of circulatory system	I99
Acute respiratory failure, unspecified	J96.0
Respiratory failure, unspecified	J96.9
Respiratory failure of newborn	P28.5
Symptoms, signs and abnormal clinical and laboratory findings, nec (excludes R95 SIDS)	R00–R94, R96–R99

nec   not elsewhere classified
SIDS   Sudden Infant Death Syndrome

Source: WHO 2009.

Table A4: ICD-10 codes for the most common causes of death[a] occurring with selected chronic disease causes of death

Cause of death	ICD-10 codes
Cancers of unknown primary site	C26, C39, C76–C80
Diabetes[b]	E10–E14
Dementia and Alzheimer disease	F00–F03, G30
Mental & behavioural disorders due to psychoactive substance use	F10–19
Hypertensive diseases	I10–I15
Coronary heart disease	I20–I25
Cardiac arrhythmias	I47–I49
Heart failure	I50–I51
Cerebrovascular disease	I60–I69
Influenza and pneumonia	J09–J18
Chronic obstructive pulmonary disease[c]	J40–J44
Cirrhosis of the liver	K70–K76
Kidney failure	N17–N19

(a) The cause groups presented here are for the leading associated and leading multiple cause of death categories as shown in Figure 5 and Figure 6.

(b) In this bulletin, deaths from all types of diabetes were assessed. This contrasts with using only Type 2 diabetes in the indicator for 'Deaths due to leading chronic diseases' (AIHW 2009).

(c) In this bulletin, deaths from chronic obstructive pulmonary disease (COPD) include deaths due to bronchitis, not specified as acute or chronic. In the indicator for 'Deaths due to leading chronic diseases' (AIHW 2009), COPD deaths exclude deaths due to deaths due to bronchitis, not specified as acute or chronic.

Source: Leading cause of death tabulation based on Becker et al. 2006 and modified by AIHW for the Australian health context.

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AIHW 2011. Cardiovascular disease: Australian facts 2011. Cardiovascular disease series. Cat. no. CVD 53. Canberra: AIHW.

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Please note that there is the potential for minor revisions of data in this report.
Please check the online version at <www.aihw.gov.au> for any amendments.