The impact of the variation in death certification and coding practices on trends in mortality from ischaemic heart disease

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Abstract

This review examines the literature relating to the effect of death certification practices, coding and the terminology used by certifiers on trends in mortality from ischaemic heart disease (IHD). The review identifies factors that affect mortality trends in a number of countries and discusses methods for assessing the impact of these issues on trends in mortality from IHD. The review found that although the magnitude of the effects of the issues on trends in mortality from ischaemic heart disease varied among countries and sub-populations, miscertification and the resultant assignment of misleading ICD codes, particularly for ill-defined cardiovascular conditions, were important factors affecting the IHD mortality trends. In light of these findings, it is essential to monitor regularly the accuracy of death certificates for IHD and consider necessary adjustments in analysing mortality trends from IHD.

Introduction

Ischaemic heart disease (IHD) is a generic term used to describe disease that results from insufficient blood flow to the heart caused by the narrowing of the coronary arteries due to atherosclerosis (Jamrozik, Dobson, Hobbs et al. 2001). It includes angina pectoris, acute myocardial infarction, subsequent myocardial infarction, certain cardiac complications following acute myocardial infarction, and other forms of acute and chronic ischaemic heart disease (NCCH 2002).

Many studies (Beaglehole 1990a; Beaglehole, Dobson, Hobbs et al. 1989; Beaglehole, Stewart & Walker 1987; Dobson, Gibberd, Wheeler et al. 1981; Gordon & Thom 1975; Jackson, Stewart & Beaglehole 1990a; Pisa & Uemura 1982; Thom 1989; Uemura & Pisa 1985; Uemura & Pisa 1988) found that mortality from IHD increased in industrialized countries until the 1960s and 1970s. Although this trend was more pronounced in men than in women, IHD became a leading cause of death in middle-aged and older people for both sexes during the twentieth century. After the trend reached a peak during the 1960s and 1970s, there was a downward turn in many countries. However, to date, IHD is still the leading cause of death in many western industrialised countries. It is also an increasingly important cause of death in developing countries (Beaglehole 1990a). Each year IHD kills an estimated 7 million people, representing 13% of all male deaths and 12% of all female deaths. Moreover, 56% of those deaths occur before the age of 75 years (WHO 2001).

In Australia, IHD is also the major cause of mortality. Mortality due to IHD climbed steadily between 1940 and 1968. Since then, following the global trend, rates have declined steadily by 3.6% and 3.0% per annum in males and females, respectively. Recent studies have noted an increase in the rate of decline between 1994 and 1998; mortality rates from IHD declined 5.4% annually in males and 5.5% annually in females. In 1998 there were 171 deaths per 100,000 males and 93 deaths per 100,000 females attributed to IHD (AIHW 2000). In 2000, IHD accounted for 26,521 deaths in Australia, representing 20.7% of all deaths in that year (ABS 2001). The greatest proportion of health expenditure in Australia is spent on treatment for patients with IHD. 11.8% of a budget of 3.7 billion dollars was spent on IHD for 1993-94 (AIHW 2000). Therefore, control and prevention of IHD has been given a high priority in public health policies in Australia and across the world.

An important question is to assess whether or not the observed trends present an accurate picture of mortality rates due to IHD. Numerous studies have been conducted in order to understand the huge variation in IHD mortality across countries and sub populations within countries (Beaglehole 1990b; Beaglehole, Dobson, Hobbs, Jackson & Martin 1989; Beaglehole, Stewart, Jackson et al. 1997; Blackburn 1989; Epstein 1983; Jackson, Beaglehole, Yee et al. 1990 b; Sans, Kesteloot & Kromhout 1997; Siskind, Bain & Wilson 1987; Thom 1989). Explanations for the trends in IHD mortality are still tentative (Blackburn 1989; Dobson, Gibberd, Wheeler & Leeder 1981; Doll & Peto 1976; Kannel, Castelli & Gordon 1979; Smith & Slater 1985; Stamler, Rose, Stamler et al. 1989; Stamler, Wentworth & Neaton 1986; Uemura & Pisa 1988; Weinstein & Stason 1985; Jamrozik, Dobson, Hobbs et al. 2001).

In Australia the reduction in IHD mortality rates is believed to be due primarily to preventative measures. These include reduction in the prevalence of smoking, the control of blood pressure, improved management of IHD, and the use of anti-hypertensive drugs and medical interventions (deLooper & Bhatia 2001).

However, doubts have been raised with respect to the accuracy and validity of cross-national comparisons and trends within countries in IHD mortality rates because of large variations in diagnostic and coding practices and changes in coding rules (Beaglehole, Stewart & Walker 1987; Blackburn 1989; Boyle & Dobson 1995; Dobson, Gibberd & Leeder 1983; Lloyd Jones, Martin, Larson et al 1998; Sorlie & Gold 1987; Stehbens 1987; Jamrozik, Dobson, Hobbs et al 2001; McKenzie, Walker & Tong 2001). During the last two decades many researchers have pointed out that the changes in death certification practices, disease classification and coding practices are an important factor affecting mortality statistics (Jordan & Bass 1993; Kingsford 1995; Kircher, Nelson & Burdo 1985; McKelvie 1993; Modelmog, Rahlenbeck & Trichopoulos 1992; Myers & Farquhar 1998; Nielsen, Bjornsson & Jonasson 1991; Rooney & Devis 1996; Weeramanthri & Beresford 1992; McKenzie, Walker & Tong 2001). Since IHD is the leading cause of death, it is therefore important to examine the effect of certification and classification changes on mortality trends due to IHD. It is essential to develop suitable and practicable methods to evaluate and adjust for the trends. This paper attempts to review and update the available evidence relating to the impact of such changes on trends in mortality from IHD. The aim of this paper is to review the literature concerning the validity and reliability of death certification for mortality from IHD and to examine the effect of changes in coding rules on trends in mortality from IHD. Finally, the paper will recommend possible methodologies that could be used to adjust for mortality trends from IHD.

Method

An extensive literature search was conducted with the Medline and PubMed computer databases as well as a manual search. We searched these databases for all relevant articles published over the last three decades using the following key words: "coronary heart disease", "ischaemic heart disease", "mortality", "disease classification", "death certification", "coding", "validity" and "accuracy" in combination. All the articles related to the assessment of the impact of certification practices and changes in disease classification on trends in mortality from ischaemic heart disease, and methodologies for adjusting for these were included in this review.

Findings

A comprehensive review of the literature revealed that changes in differences in the diagnoses and terminology on death certificates and changes in coding practices can affect the trends in mortality from ischaemic heart disease. Proper adjustment is needed in the comparison of these disease trends. These findings are illustrated below:

Differences in diagnosis and terminology on death certificates

Thom (1989) stated that variation in coding can be due to differences in diagnosis and terminology on death certificates or to differences in the coding rules applied to the International Classification of Diseases (ICD). Information about the pattern of IHD is provided by routine national mortality data. Inaccuracy in death certification has been a major concern (Johansson & Westerling 2000; Jordan & Bass 1993; Myers & Farquhar 1998; Stamler, Rose, Stamler, Elliott, Dyer & Marmot 1989; Weeramanthri & Beresford 1992). Inaccuracies can occur as a result of errors in a number of steps involved in the certification process from initial completion of the death certificate by the attending doctor or the coroner through to the assignment of codes to reflect the reported conditions by the Australian Bureau of Statistics (ABS). For example, the terminology used to describe IHD is often not well defined or precise, leading to differences in the codes assigned and therefore ambiguities in the resultant statistical data. There are a number of terms used in the Index and Tabular list of the International Classification of Diseases Ninth and Tenth Revisions (WHO 1977 & 1992) that may be used by clinicians in different countries to certify deaths to an ill-defined cardiovascular disease that are actually due to IHD. These include heart failure, ventricular dysrhythmias, generalized atherosclerosis, and other ill-defined descriptions and complications of heart disease (see Table 1).

Table 1: Ill-defined cardiovascular disease, ICD-9 and ICD-10

Disease	ICD-9	ICD-10
Paroxysmal ventricular tachycardia	427.1	I47.2
Ventricular fibrillation and flutter	427.4	I49.0
Cardiac arrest	427.5	I46
Heart failure	428	I50
Myocarditis, unspecified	429.0	I51.4
Myocardial degeneration	429.1	I51.5
Cardiovascular disease, unspecified	429.2	I51.6
Complications of heart disease, unspecified	429.9	I51.9
Atherosclerosis, generalized and unspecified	440.9	I70.9

Source: Lozano et al 2001.

A doctor may certify a death as due to one or more of these ill-defined cardiovascular conditions due to insufficient or ambiguous clinical information at the time of death. Moreover, an incorrect diagnosis may also have been made (Lozano et al 2001). Using a sample of 34 780 records of deaths occurring in 1997 provided by the Australian Bureau of Statistics, we found that 8.37% of reported cardiovascular deaths were coded to one of the ill-defined ICD-10 codes in the Table above. 55.6% of cardiovascular deaths were coded to the range I20-I25, which are the more specific codes for the different forms of IHD. In other words, the non-specific or erroneous ante mortem diagnosis, documented due to diagnostic error, inadequate or misinterpreted clinical information, result in the allocation of a code that may not reflect the true cause of death. This problem has been identified and confirmed in a number of studies comparing death certificate information with autopsy results or with the diagnosis of expert panels (Cameron & McGoogan 1981a & b; Kingsford 1995; Modelmog, Rahlenbeck & Trichopoulos 1992). Discrepancies between autopsy results and death certificates have been documented to be as high as 30% (Cameron & McGoogan 1981a & b).

In an investigation undertaken by WHO, which utilised different methods of data collection, it was determined that, due to miscertification, misclassification and miscoding, mortality rates from IHD in Japan, Greece, and

France needed to be corrected by as much as 30% (Lozano et al 2001). Similarly, Lloyd-Jones et al (1998) examined the accuracy of death certificates for coding IHD as the underlying cause of death. The reference standard in this study was cause of death, as adjudicated by a panel of three physicians. It was found that IHD may be over-represented as a cause of death on death certificates due to diagnostic error. National mortality statistics, which are based on the data supplied on death certificates, may overestimate the frequency of heart disease, including IHD, by 7.9% to 24.3% in overall populations and by as much as two-fold in older persons.

It is clear that differences in diagnosis and terminology on death certificates can affect IHD mortality rates. Therefore, it is strongly recommended that validation studies of death certificate accuracy and coding be carried out regularly to identify effects that variant codes and procedures have on the classification of the cause of death. Mortality rate adjustments must be made periodically so that valid mortality databases can be established (Lozano et al 2001). The challenge lies in the most appropriate and cost-effective means of conducting such assessments.

There are several ways in which we can assess the reliability and accuracy of mortality data. One approach is that used by de Faire et al (1976) and Alderson & Meade (1967). They compared clusters or random samples of death certificates with their corresponding medical records. This approach avoids the bias inherent in traditional editing, however it is slow and expensive for routine use. In addition, this approach measures the quality of the documentation rather than improving the accuracy of the statistics. Another approach is to link different databases (Alderson & Meade 1967; de Faire, Friberg, Lorich & Lundman 1976; Gittelsohn & Senning 1979; Mahonen, Salomaa, Brommels et al 1997; Mahonen, Salomaa, Keskimaki et al 2000; Rapola, Virtamo, Korhonen et al 1997). In this approach, hospital discharge data are matched to death certificates at the national level. By matching personal details it is possible to extract information on hospital discharges due to IHD within a certain period of time. Comparisons can then be made between discharge data and the conditions mentioned on the death certificate. The difficulty with these two approaches is that the definitions of underlying cause of death provided by WHO and of the principal diagnosis or main condition used in the morbidity system are different. Thus, whilst it would be reasonable to expect some congruence in the coding for each data collection particularly with the multiple cause data now available for many mortality collections, including that in Australia, there will never be 100% agreement in the codes assigned and the diagnoses documented.

Recently, comparison with a 'gold standard' to determine the sensitivity and positive predictive value (PPV) of hospital separation data has been used in many countries. 'Gold standards' can be the data from well-designed research projects such as the MONICA (Monitoring of trends and determinants in cardiovascular disease) study. This approach has been recommended by Australian Institute of Health and Welfare to monitor the incidence of cardiovascular disease (Jamrozik et al 2001) and is supported by a number of studies (Beaglehole, Stewart & Walker 1987; Boyle & Dobson 1995; Mahonen et al 1999). A similar approach can be used for the sensitivity analysis of mortality data provided that the complex rules imposed by the World Health Organisation for the selection of codes to represent the causes of death are followed (WHO, 1992). The method can be described as a 2 x 2 table as below (see Table 2):

Table 2. Sensitivity and positive predictive value (PPV) of routine mortality data*

		Gold standard	
		IHD	+ IHD -
Routine mortality	IHD +	TP Cases (a)	FP cases (b)
statistics category	IHD −	FN cases (c)	TN Cases (d)

*TP: true positive; FP: false positive; FN: false negative; TN: true negative.

In the table above (a+b) are the deaths of IHD from mortality data; (a+c) are the true deaths of IHD according to the 'gold standard'.

The sensitivity is the proportion of cases of 'true' deaths of IHD detected by the mortality data [a/(a+c)]. The positive predictive value (PPV) is the proportion of the deaths from IHD determined from the mortality data that are true IHDs according to the "gold standard" [a/(a+b)].

The true deaths from IHD are therefore

$(a+c) = (a+b) \times (a+c) / (a+b)$

$\qquad = (a+b) \times (a/a+b)/(a/ a+c)]$

$$= (a+b) \times PPV/ sensitivity$$

Thus the true number of deaths of IHD $(a+c)$ can be estimated from the sensitivity and the PPV. The 'PPV/ sensitivity' is called an adjustment factor (Jamrozik et al 2001).

This method can be used not only to measure the quality of mortality data, but also to adjust the mortality rates for IHD. It can also be used to compare MONICA study results with routine mortality statistics or for comparing death certificates with hospital records.

Change in coding rules applied to the ICD

During the last five years two major changes have taken place in the way coding of mortality data in Australia is conducted. Firstly, an Automated Coding Software (ACS) program was introduced into Australia in 1997 for mortality coding. This software, developed by the National Centre for Health Statistics in the US, is used to code multiple causes of death as well as underlying causes of death. The availability of multiple cause data is becoming important and necessary for public health research. As deaths from chronic disease become increasingly significant and complex, it is important to have multiple cause data available to enable the analysis of coexisting conditions that may contribute significantly to a death. In addition, as the world population ages, deaths are increasingly due to a complex mix of conditions, none of which may necessarily be uniquely identifiable as the underlying cause of death (McKenzie, Walker & Tong 2001). The introduction of the ACS by the ABS has allowed for a more consistent approach to the assignment of cause of death codes and the ability to code multiple cause information in an efficient and functional way. The second major change that occurred is the use of ICD-10 for the coding of deaths. Since 1900, the International Classification of Disease has been revised approximately every 10 years (WHO, 1992). Regular revisions are necessary in order to keep the classification up-to-date with medical advances and disease nomenclature and aetiology. The change to ICD-10 coding was introduced for death certificates in Australia in 1997. In the eighth and ninth revisions of the ICD, IHD was coded to the range 410-414, while in the tenth revision codes I20-I25 are used. One complication of introducing ACS and subsequent ICD revisions has been major time disruptions in mortality and morbidity statistics (McKenzie, Walker & Tong 2001). For example, 3.3% (269/8031) of cases coded in ICD-9 to IHD were coded as non-IHD using ICD-10 (ABS unpublished data 2002). This change is a reflection of the updated rules for coding mortality introduced in the ICD-10 and the different interpretations of those rules by the ACS software, compared with the ABS manual coders. Studies of the comparability between revisions of the ICD have been carried out and published from the Fifth Revision of ICD (Anderson et al 2001). For example, Rothenberg & Aubert (1990) examined the ratio of the rates in 1979 to the rates in 1978 and found an overall fall of 17% in the age-adjusted rate for IHD. More recently a study was carried out by the Australian Bureau Statistics that measured the changes in mortality statistics between manually ICD-9, automated coding in ICD-9 and automated ICD-10 coding. The results clearly showed that these changes have affected mortality data (McKenzie Walker & Tong 2002). Results from a study in the USA also indicate that it is important to analyse the trends in mortality using the codes of ICD-9 and ICD-10 respectively (Anderson et al 2001).

Therefore, it is necessary to conduct periodic measurements of the discrepancies in cause-of death statistics resulting from classification and rule changes. This work is critical to the interpretation of mortality trends.

A major tool for assessing the impact of the coding change is the use of comparability ratios for causes of death. This method has been used since the earliest ICD revision changes (Rothenberg & Aubert 1990). It (C_i) is calculated as:

$C_i = D_{i, ICD-10} / D_{i, ICD-9}$

where Di, ICD-10 is the number of deaths due to cause i (eg, IHD) classified by ICD-10 and Di, ICD-9 is the number of deaths due to cause i classified by ICD-9. This method requires that mortality data for at least one year be coded by both revisions. A comparability ratio (C_i) of 1.00 indicates that the same number of deaths is assigned to cause i under both ICD-9 and ICD-10 and there is no net effect of the change in ICD revisions on

that particular cause of death. When the comparability ratio is greater or less than 1, it indicates an overestimation or underestimation of the mortality rate, respectively. Appropriate adjustments are required for the comparison of mortality data coded by different ICD revisions across time.

Conclusions

This literature review indicates that, although the size of the effect of changes in disease classifications on trends in IHD mortality differs among countries and sub populations, miscoding, misclassification, use of vague cardiovascular terms and rule changes were the important factors affecting mortality trends from IHD. It is therefore essential to monitor and evaluate the accuracy of death certificates for IHD periodically and to make necessary adjustments on mortality trends from IHD as required.

References

Alderson MR & Meade TW 1967, 'Accuracy of diagnosis on death certificates compared with that in hospital records', *Br J Prev Soc Med*, vol 21, no 1, pp 22-9.

Anderson RN, Minino AM, Hoyert DL & Rosenberg HM 2001, 'Comparability of cause of death between ICD-9 and ICD-10: Preliminary estimates', National Vital Statistics Reports, vol 49, no 2. <http://www.cdd.gov/nmchs/datawh/statab/unpubd/comp.htm> (accessed 8/02/2002)

Australian Bureau of Statistics 2001, Causes of death, Canberra: Australian Bureau of Statistics, 2001 (ABS Catalogue No. 3303.0).

Australian Institute of Health and Welfare 2000, Australia's Health 2000, Canberra: Australian Institute of Health and Welfare, 2000.

Beaglehole R 1990 a, 'International trends in coronary heart disease mortality, morbidity, and risk factors', *Epidemiol Rev*, vol, no pp 121-15.

Beaglehole R 1990 b, 'Variations in cardiovascular disease mortality by time and place: the challenge', *Aust N Z J Med*, vol 20, no 5, pp 636-8.

Beaglehole R, Dobson A, Hobbs MS, Jackson R & Martin CA 1989, 'CHD in Australia and New Zealand', *Int J Epidemiol*, vol 18, no 3 Suppl 1, pp S145-8.

Beaglehole R, Stewart AW, Jackson R, Dobson AJ, McElduff P, D'Este K et al. 1997, 'Declining rates of coronary heart disease in New Zealand and Australia, 1983-1993', *Am J Epidemiol*, vol 145, no 8, pp 707-13.

Beaglehole R, Stewart AW & Walker P 1987, 'Validation of coronary heart disease hospital discharge data', *Aust N Z J Med*, vol 17, no 1, pp 43-6.

Blackburn H 1989, 'Trends and determinants of CHD mortality: changes in risk factors and their effects', *Int J Epidemiol*, vol 18, no 3 Suppl 1, pp S210-5.

Boyle CA & Dobson AJ 1995, 'The accuracy of hospital records and death certificates for acute myocardial infarction', *Aust N Z J Med*, vol 25, no 4, pp 316-23.

Cameron HM & McGoogan E 1981 a, 'A prospective study of 1152 hospital autopsies: I. Inaccuracies in death certification', *J Pathol*, vol 133, no 4, pp 273-83.

Cameron HM & McGoogan E 1981 b, 'A prospective study of 1152 hospital autopsies: II. Analysis of inaccuracies in clinical diagnoses and their significance', *J Pathol,* vol 133, no 4, pp 285-300.

de Faire U, Friberg L, Lorich U & Lundman T 1976, 'A validation of cause-of-death certification in 1,156 deaths', *Acta Med Scand*, vol 200, no 3, pp 223-8.

deLooper M & Bhatia K 2001, 'Australian health trends 2001', AIHW Cat. No. PHE 24. Canberra: AIHW.

Dobson AJ, Gibberd RW & Leeder SR 1983, 'Death certification and coding for ischemic heart disease in Australia', *Am J Epidemiol*, vol 117, no 4, pp 397-405.

Dobson AJ, Gibberd RW, Wheeler DJ & Leeder SR 1981, 'Age-specific trends in mortality from ischemic heart disease and cerebrovascular disease in Australia', *Am J Epidemiol*, vol 113, no 4, pp 404-12.

Doll R & Peto R 1976, 'Mortality in relation to smoking: 20 years' observations on male British doctors', *Br Med J*, vol 2, no 6051, pp 1525-36.

Epstein FH 1983, 'International mortality trends and secular changes', *Prev Med*, vol 12, no 1, pp 210-7.

Gittelsohn A & Senning J 1979, 'Studies on the reliability of vital and health records: I. Comparison of cause of death and hospital record diagnoses', *Am J Public Health*, vol 69, no 7, pp 680-9.

Gordon T & Thom T 1975, 'The recent decrease in CHD mortality', *Prev Med*, vol 4, no 2, pp 115-25.

Heathcote CR, Keogh C & O'Neill TJ 1989, 'The changing pattern of coronary heart disease in Australia', *Int J Epidemiol*, vol 18, no 4, pp 802-7.

Jackson R, Beaglehole R, Yee RL, Small C & Scragg R 1990 b, 'Trends in cardiovascular risk factors in Auckland, 1982 to 1987', *N Z Med J*, vol 103, no 895, pp 363-5.

Jackson R, Stewart A & Beaglehole R 1990 a, 'Trends in coronary heart disease mortality and morbidity in Auckland, New Zealand, 1974-1986', *Int J Epidemiol*, vol 19, no 2, pp 279-83.

Jamrozik K, Dobson A, Hobbs M, McElduff P, Ring I, D'Este K et al. (2001), 'Monitoring the incidence of cardiovascular disease in Australia', AIHW cat. No. CVD 16. Canberra: Australian Institute Of Health and Welfare (Cardiovascular Disease Series No. 17).

Johansson LA & Westerling R 2000, 'Comparing Swedish hospital discharge records with death certificates: implications for mortality statistics', *Int J Epidemiol*, vol 29, no 3, pp 495-502.

Jordan JM & Bass MJ 1993, 'Errors in death certificate completion in a teaching hospital', *Clin Invest Med*, vol 16, no 4, pp 249-55.

Kannel WB, Castelli WP & Gordon T 1979, 'Cholesterol in the prediction of atherosclerotic disease. New perspectives based on the Framingham study', *Ann Intern Med*, vol 90, no 1, pp 85-91.

Kingsford DP 1995, 'A review of diagnostic inaccuracy', *Med Sci Law*, vol 35, no 4, pp 347-51.

Kircher T, Nelson J & Burdo H 1985, 'The autopsy as a measure of accuracy of the death certificate', *N Engl J Med*, vol 313, no 20, pp 1263-9.

Lloyd Jones DM, Martin DO, Larson MG & Levy D 1998, 'Accuracy of death certificates for coding coronary heart disease as the cause of death', *Ann Intern Med*, vol 129, no 12, pp 1020-6.

Lozano R, Murray CJ, Lopez AD & Satoh T 2001, 'Miscoding and misclassification of ischemic heart disease mortality', *World Health Organization*, Global programme on evidence for health policy working paper No. 12.

Mahonen M, Salomaa V, Brommels M, Molarius A, Miettinen H, Pyorala K et al. 1997, 'The validity of hospital discharge register data on coronary heart disease in Finland', *Eur J Epidemiol*, vol 13, no 4, pp 403-15.

Mahonen M, Salomaa V, Keskimaki I & Moltchanov V 2000, 'The feasibility of routine mortality and morbidity register data linkage to study the occurrence of acute coronary heart disease events in Finland. The Finnish Cardiovascular Diseases Registers (CVDR) Project', *Eur J Epidemiol*, vol 16, no 8, pp 701-11.

Mahonen M, Salomaa V, Torppa J, Miettinen H, Pyorala K, Immonen Raiha P et al. 1999, 'The validity of the routine mortality statistics on coronary heart disease in Finland: comparison with the FINMONICA MI register data for the years 1983-1992. Finnish multinational MONItoring of trends and determinants in CArdiovascular disease', *J Clin Epidemiol*, vol 52, no 2, pp 157-66.

McKenzie K, Walker S & Tong S 2001, "Assessment of the Impacts of the Change from Manual to Automated Coding on Australian Mortality Statistics" Journal of the Health Information Management Association of Australia, vol 30 no 3, available to subscribers at http://www.himaa.org.au/members/journal/30_3_2001/mckenzie.asp

McKenzie K, Walker S & Tong S 2001, "The impact on mortality data resulting from changes to coding practices in Australia ". Sydney: NCCH, 2002 (in press).

McKelvie PA 1993, 'Medical certification of causes of death in an Australian metropolitan hospital. Comparison with autopsy findings and a critical review', *Med J Aust*, vol 158, no 12, pp 816-8, 20-1.

Modelmog D, Rahlenbeck S & Trichopoulos D 1992, 'Accuracy of death certificates: a population-based, complete-coverage, one-year autopsy study in East Germany', *Cancer Causes Control*, vol 3, no 6, pp 541-6.

Myers KA & Farquhar DR 1998, 'Improving the accuracy of death certification', *CMAJ*, vol 158, no 10, pp 1317-23.

National Centre for Classification in Health 1988, 'Tabular list of diseases ICD-10-AM', vol 1, *National Centre for Classification in Health:* Sydney.

Nielsen GP, Bjornsson J & Jonasson JG 1991, 'The accuracy of death certificates. Implications for health statistics', *Virchows Arch A Pathol Anat Histopathol*, vol 419, no 2, pp 143-6.

Pisa Z & Uemura K 1982, 'Trends of mortality from ischaemic heart disease and other cardiovascular diseases in 27 countries, 1968-1977', *World Health Stat Q*, vol 35, no 1, pp 11-47.

Rapola JM, Virtamo J, Korhonen P, Haapakoski J, Hartman AM, Edwards BK et al. 1997, 'Validity of diagnoses of major coronary events in national registers of hospital diagnoses and deaths in Finland', *Eur J Epidemiol*, vol 13, no 2, pp 133-8.

Rooney C & Devis T 1996, 'Mortality trends by cause of death in England and Wales 1980-94: the impact of introducing automated cause coding and related changes in 1993', *Popul Trends*, vol, no 86, pp 29-35.

Rothenberg RB & Aubert RE 1990, 'Ischemic heart disease and hypertension: effect of disease coding on epidemiologic assessment', *Public Health Rep*, vol 105, no 1, pp 47-52.

Sans S, Kesteloot H & Kromhout D 1997, 'The burden of cardiovascular diseases mortality in Europe. Task Force of the European Society of Cardiology on Cardiovascular Mortality and Morbidity Statistics in Europe', Eur Heart J, vol 18, no 12, pp 1231-48.

Siskind V, Bain C & Wilson A 1987, 'Trends in coronary heart disease in Queensland, 1971-1980. An interpretation', *Am J Epidemiol*, vol 126, no 5, pp 871-81.

Smith DP & Slater C 1985, 'The pattern of ischemic heart disease 1931-1980', *Stat Med*, vol 4, no 4, pp 397-412.

Sorlie PD & Gold EB 1987, 'The effect of physician terminology preference on coronary heart disease mortality: an artifact uncovered by the 9th revision ICD', *Am J Public Health*, vol 77, no 2, pp 148-52.

Stamler J, Rose G, Stamler R, Elliott P, Dyer A & Marmot M 1989, 'INTERSALT study findings. Public health and medical care implications', *Hypertension*, vol 14, no 5, pp 570-7.

Stamler J, Wentworth D & Neaton JD 1986, 'Is relationship between serum cholesterol and risk of premature death from coronary heart disease continuous and graded? Findings in 356,222 primary screenees of the Multiple Risk Factor Intervention Trial (MRFIT)', *JAMA*, vol 256, no 20, pp 2823-8.

Stehbens WE 1987, 'An appraisal of the epidemic rise of coronary heart disease and its decline', *Lancet,* vol 1, no 8533, pp 606-11.

Thom TJ 1989, 'International mortality from heart disease: rates and trends', *Int J Epidemiol*, vol 18, no 3 Suppl 1, pp S20-8.

Uemura K & Pisa Z 1985, 'Recent trends in cardiovascular disease mortality in 27 industrialized countries', *World Health Stat Q,* vol 38, no 2, pp 142-62.

Uemura K & Pisa Z 1988, 'Trends in cardiovascular disease mortality in industrialized countries since 1950', *World Health Stat Q,* vol 41, no 3-4, pp 155-78.

Weeramanthri T & Beresford B 1992, 'Death certification in Western Australia—classification of major errors in certificate completion', *Aust J Public Health,* vol 16, no 4, pp 431-4.

Weinstein MC & Stason WB 1985, 'Cost-effectiveness of interventions to prevent or treat coronary heart disease', *Annu Rev Public Health*, vol, no pp 641-63.

World Health Organization 1977, 'Manual of International Statistical Classification of Diseases, Injuries of causes of death 9th revision', Vol 1. *WHO:Geneva.*

World Health Organization 1992, 'International Statistical Classification of Diseases and Related health Problems. 10th revision', Vol 1. *WHO: Geneva.*

World Health Organization 2001,'Cardiovascular Heart diseases,'
<http://www.who.int/ncd/cvd/index.htm> (accessed 8/02/2002)