Journal of Official Statistics, Vol. 19, No. 1, 2003, pp. 71–79

Ischemic Heart Disease and Acute Myocardial Infarction as Cause of Death in a Cause-of-death Register

Boo Svartbo[1], *Lars Olov Bygren*[1], *Anders Eriksson*[2], *Gösta Bucht*[3], *and Lars Age Johansson*[4]

Mortality can serve as a measure of prognoses of a disease and of the effects of treatment. The accuracy of cause-of-death in the register is important.

For a stratified simple random sample, a new death certificate was completed on the basis of hospital records from the last episode of care.

Of the 239 patients whose official underlying cause of death was ischemic heart disease (IHD), 215 were deemed by the panel to have IHD. Within the IHD group, 153 patients officially had acute myocardial infarction (AMI) as the underlying cause of death and out of those, 113 were deemed by the panel to have AMI. Autopsy did not seem to improve the accuracy.

The recommendation as to follow-up cohorts concerning AMI must be to read carefully the last clinical record of the deceased or keep in mind that AMI as underlying cause of death in the registers is accurate primarily when death occurs before the age of 45 years.

Key words: Mortality statistics; validity; international classification of diseases.

1. Introduction

Mortality statistics may be used for a variety of purposes. In clinical research, mortality can serve as a measure of the prognosis of a disease and of the effects of treatment. In epidemiology, mortality statistics are often used as a measure of health in a population and to determine the funding allocation to the health service. Mortality is also often used when discussing the etiology of diseases. The quality requirement of the data may vary according to its intended purpose, but users must be aware of the possible errors and their sources (Prior 1985; Armstrong 1996; Maudsley 1996; Myers 1998).

In ischemic heart disease (IHD), mortality statistics are still the chief source of information concerning variations in time and space, identification of risk factors and evaluation of treatment programs. IHD deserves particular attention as it still is the most common cause of death in the western world (Beaglehole 1990; Hanzlick 1996; Jougla 1998). The earlier experience of the mortality statistics is that the accuracy of individual diagnoses (3-digit level) varies considerably, whereas the wider diagnostic groups are more

[1] Department of Community and Rehabilitation, Social Medicine, Umeå University, SE-901 85 Umeå, Sweden
[2] Department of Community and Rehabilitation, Forensic Medicine, Umeå University, SE-907 12 Umeå, Sweden
[3] Department of Community and Rehabilitation, Geriatrics, Umeå University, SE-901 85 Umeå, Sweden
[4] Statistics Sweden, SE-104 51 Stockholm, Sweden

Acknowledgments: This study has been supported by the Bank of Sweden Tercentenary Foundation (grant no 84/202:1) and Statistics Sweden. Lennart Bäckman, MD, assisted with the administration and analysis of the material.

accurate (Gittelsohn 1979; WHO 1977; Tardon 1995). Regional differences in the mortality in ischemic heart disease might also be a result of applying differing regional criteria for the diagnosis (Alderson and Meade 1967; Hanzlick 1993; Davis 1997). In order to investigate the accuracy and to stimulate action to improve the quality of death registers, we analyzed some determinants of the accuracy of IHD and AMI by comparing the official causes of death with those based on clinical and autopsy records. We found a good predictive value of IHD in the official cause of death register while for AMI it was not very good.

2. Material and Methods

2.1. Database and study sample

The population consisted of all 36,642 deceased in the age range 15–74 years in Sweden during 1984. It was stratified according to age and four diagnostic classes, and simple random samples were drawn from each stratum. The class ''IHD'' in the B-list of the World Health Organization's 9th revision of the international classification of diseases (ICD) defined our diagnostic class as ICD numbers 410–414 and ''Acute Myocardial Infarction (AMI)'' as ICD number 410. The other three strata were Breast Cancer, Pneumonia, and Other Causes. These were treated here as one non-IHD group and weighted accordingly. Stratum weights were calculated as the sum of ratios based on number of cases with a certain diagnosis and a certain age group divided by total number of deceased.

2.2. Study sample

A stratified simple random sample of 1,376 cases was drawn from three age classes of diseased (Table 1). Of these, there were 250 cases with IHD as the underlying cause of death (UCD) and 1,126 ''non-IHD'' cases. Out of the 250 in the IHD group 162 cases were further classified as AMI and accordingly 1,214 cases were classified as ''non-AMI.'' For each case the clinical records and the autopsy report, if any, were requisitioned from the department where the death certificate was issued. In 71 cases, no record could be retrieved and these cases were excluded from all analyses, leaving 239 cases of death from IHD and 1,066 non-IHD cases. When studying AMI deaths, 9 cases had to be excluded, as clinical records could not be found, leaving 153 AMI deaths and 1,152 non-AMI cases (Table 1). The sample weights were maintained to achieve simpler estimations more free of assumptions. The majority of records and autopsy reports came from hospitals, 83 from general practitioners, and 272 from Institutes of Forensic Medicine. The large number of autopsy reports from Forensic Medicine is explained by the fact that most people who died outside institutions, or unnaturally, were taken to Forensic Medicine.

2.3. Procedure

Three of us, representing an expertise in geriatrics, internal medicine, pathology, forensic medicine, public health, and epidemiology, constituted a panel who ascertained the chain of events leading to death. The records were scrutinized and assessed and the results were reported to the panel. Each case was discussed until consensus was reached. A new death certificate was then issued by the panel and coded at Statistics Sweden according to the coding rules of ICD 9.

Table 1. The number of deceased in 1984 in Sweden in our samples of IHD, AMI, non-IHD and non-AMI cases, and attrition

Age at death	IHD	Non-IHD	AMI	Non-AMI	All
Population					
15–44	182	3,292	121	3,353	3,474
45–64	3,584	9,054	2,390	10,248	12,638
65–74	7,589	12,941	5,129	15,401	20,530
15–74	**11,355**	**25,287**	**7,640**	**29,002**	**36,642**
Sample					
15–44	50	193	31	212	243
45–64	100	446	64	482	546
65–74	100	487	67	520	587
15–74	**250**	**1,126**	**162**	**1,214**	**1,376**
Attrition					
15–44	1	14	1	14	15
45–64	5	26	4	27	31
65–74	5	20	4	21	25
15–74	**11**	**60**	**9**	**62**	**71**

The underlying cause of death, according to the original death certificate, was compared with the panel's ''new underlying cause of death,'' the cause being selected according to the ICD instructions. The effect of the ICD coding rules was also demonstrated by comparing the panel's underlying cause of death before with what it was after the coding rules had been applied. The age of the issuing doctor, the specialty in which he or she worked and the type of hospital were all coded from the registers of doctors and hospitals, respectively. A retest was conducted more than one year after the first assessment.

2.4. Statistics

The total number of deceased in the population during one year in the age interval 15–74 years of age was 36,642 (Table 1). The total was stratified and divided into four main groups, three of them diagnoses and the fourth Others, and within each group according to age intervals as follows:

Diagnosis	Total number	In strata	Year group
Breast cancer	91	50	15–44
(ICD number 174)	503	100	45–64
	365	100	65–74
IHD	182	50	15–44
(ICD number 410–414)	3,584	100	45–64
	7,589	100	65–74
Pneumonia	36	36	15–44
(ICD number 1480–486)	226	100	45–64
	581	100	65–74
Other	3,165	107	15–44
	8,325	246	45–64
	11,995	287	65–74
Total	36,642	1,376	

AMI, ICD number 410, was drawn from the group IHD, and from the group Other stroke (ICD 430–438) was analysed.

In all the following analyses we applied the sum of the population weights of relevant substrata and then calculated kappa (Tables 2–4) by setting the total number of cases as 100 and distributed it into the four cells in the 2×2 table. When standard errors of kappa were calculated the point estimates of sample weights and point estimates of fraction data were used.

The degree of agreement between the new death certificates and the official statistics was described with Cohen's kappa (Fleiss 1981). Kappa < 0.00 was described as ''poor'' agreement, kappa values of 0.00–0.19 and 0.20–0.39 and the following quintiles were described as ''slight, fair, moderate, substantial, and almost perfect'' agreement (Landis and Koch 1977; Siegel 1992). In computing sensitivity and specificity the panel's cause was the standard.

3. Results

The data before using the weighting procedure shows that among the 239 patients whose official underlying cause of death was IHD, 215 were deemed by the panel to have IHD. Within the IHD group, 153 patients had AMI as the official underlying cause of death and out of these, 113 were deemed by the panel to have AMI. On the other hand, in the 1,066 cases originally reported as non-IHD, IHD was deemed after applying the sample weights to be the true underlying cause, while in the 1,152 originally reported as non-AMI, about 38 were deemed by the panel to be true AMI cases. Falsely classified were 5.5% for IHD and 7.8 for AMI.

Table 2. IHD and AMI as official underlying causes of death and as the true underlying causes of death according to the panel in different age classes at death

Validated cause	Age at death, years			All ages
	15–44	45–64	65–74	
IHD, *n*	228	515	562	$n = 1{,}305$
True IHD[1]	4.7	25.4	33.1	27.7
False IHD[1]	0.5	3.0	3.9	3.3
True non-IHD[1]	94.8	69.6	60.5	66.9
False non-IHD[1]	0	2.1	2.6	2.2
Sensitivity	100%	92%	93%	93%
Predictive value	90%	93%	89%	89%
Cohen's kappa	0.94	0.87	0.86	0.87
SEM kappa	0.008	0.005	0.005	0.005
AMI, *n*	228	515	562	$n = 1{,}305$
True AMI[1]	2.6	12.8	18.3	14.9
False AMI[1]	0.6	5.1	6.2	5.3
True non-AMI[1]	96.5	79.4	72.7	77.3
False non-AMI[1]	0.3	2.7	2.7	2.5
Sensitivity	89%	83%	87%	86%
Predictive value	80%	72%	75%	74%
Cohen's kappa	0.84	0.70	0.75	0.75
SEM kappa	0.02	0.009	0.008	0.009

[1]Per 100 persons.

Table 3. The degree of agreement as to IHD being the underlying cause of death, between the official register and the expert panel, according to hospital type and size

Validated cause	Institute of Forensic Medicine[1] ($n = 272$)	Hospital type			Nursing home[5] Health centre ($n = 179$)
		Large[2] ($n = 218$)	Intermediate[3] ($n = 336$)	Small[4] ($n = 298$)	
True IHD[6]	30.59	20.75	27.91	26.94	26.61
False IHD[6]	0.40	10.24	3.08	4.05	3.88
True non-IHD[6]	67.01	67.61	66.52	65.92	67.48
False non-IHD[6]	2.00	1.40	2.49	3.10	2.03
Sensitivity	94%	94%	92%	90%	93%
Predictive value	99%	67%	90%	87%	87%
Cohen's kappa	0.95	0.71	0.87	0.83	0.86
SEM (kappa)	0.004	0.008	0.005	0.006	0.006

[1]Serving the police and issuing most certificates for unnatural deaths and outpatient deaths.
[2]Serving a population of about one million and having all specialties.
[3]Serving a population of some hundred thousands and having no clinical superspecialties.
[4]Serving a population of up to one hundred thousand and having five or six clinical specialties.
[5]Serving a population of about ten thousand.
[6]Per 100 persons aged 15–74 years at death.

This leaves us with high degrees of sensitivity and specificity and a good predictive value of IHD in the official cause of death register. In the narrower class AMI, these measures were lower. When evaluated with kappa, the agreement was 'substantial' (Table 2).

The death certificate includes all causes: direct, intermediate, underlying, and contributory. The condition which should have been stated as the underlying cause was sometimes designated as direct, intermediate, or contributory. Almost all true cases of IHD were found in the register, if all cases on the certificate were taken into account.

Table 4. The degree of agreement as to AMI being the underlying cause of death, between the official register and the expert panel according to hospital type and size

Validated cause	Institute of Forensic Medicine[1] ($n = 272$)	Hospital type			Nursing home[5] Health centre ($n = 179$)
		Large[2] ($n = 218$)	Intermediate[3] ($n = 336$)	Small[4] ($n = 298$)	
True AMI[6]	11.31	14.65	18.45	19.34	9.37
False AMI[6]	1.90	10.24	5.50	4.72	9.16
True non-AMI[6]	84.9	72.77	73.74	72.71	80.14
False non-AMI[6]	1.89	2.34	2.31	3.23	1.34
Sensitivity	86%	86%	89%	86%	88%
Predictive value	86%	59%	77%	80%	51%
Cohen's kappa	0.84	0.62	0.78	0.78	0.59
SEM (kappa)	0.008	0.009	0.008	0.008	0.011

[1]Serving the police and issuing most certificates for outpatient deaths.
[2]Serving a population of about one million and having all specialties.
[3]Serving a population of some hundred thousands and having no clinical superspecialties.
[4]Serving a population of up to one hundred thousand and having five or six clinical specialties.
[5]Serving a population of about ten thousand.
[6]Per 100 persons aged 15–74 years at death.

3.1. Independent variables

3.1.1. Age at death

The age range of the sample excluded the very young and the very old. However, within the age range 15–74 years the agreement differed between the age groups, depending on whether the diagnosis was IHD or AMI. In the age group 15–44 the accuracy of the AMI diagnosis as the cause of death was better than in the older groups. For all groups the agreement kappa was either ''substantial'' or ''almost perfect'' (0.70–0.94), and slightly higher for IHD than for AMI (Table 2).

3.1.2. Age and place of work of doctors

The experience of the doctor who issued the original death certificate was investigated by dividing the doctors into different age groups. No noteworthy differences between the old and young doctors could be found, either for IHD or for AMI (data not shown). The type of hospital played some part, the intermediate and smaller hospitals showing a better agreement than the larger hospitals. The Institutes for Forensic Medicine were the most accurate in setting both IHD and AMI as the underlying cause of death (kappa 0.95 and 0.84, respectively) (Tables 3 and 4).

Regional differences were found for the diagnosis AMI, the most rural area having the lowest degree of agreement between the registered cause and the true one, according to the panel. For patients with the diagnosis, IHD, no noteworthy regional differences could be found (data not shown).

The agreement between the registered cause and the true one, according to the panel, for both IHD and AMI was ''substantial'' or ''almost perfect'' irrespective of whether an autopsy was performed or not (data not shown). Certificates issued at the clinical pathology departments had only ''substantial'' agreement with the panel's assessment as the underlying cause of death for both IHD and AMI (kappa 0.79 and 0.78, respectively).

A reliability study was performed more than one year after the first assessment by the panel. A simple random sample of 100 cases was selected for retest. Four of these 100 cases were excluded from the study as the records were not available; 96 cases therefore were analyzed. The same procedure as in the first study was applied to reach consensus in the team for the individual cases, on both occasions the coding being carried out according to the ICD rules. The agreement at the category level of the code for underlying cause of death (UCD) between the two studies was 77%. Of the 25 patients who were deemed to have ischemic heart disease (IHD, codes 410–414) the first time, 22 were so deemed the second time (kappa = 0.90). Regarding the diagnosis ''acute myocardial infarction'' (AMI, code 410), 13 cases were classified as AMI the first time, and 12 of these also the second time (kappa = 0.91).

4. Discussion

We have concentrated the analysis on kappa although we have only used the point estimates of the sample weights and of the frequencies, but the number in the 2×2 tables has been set as low as 100. The result is an estimate of the confidence interval that is good enough.

The difference in accuracy between IHD and AMI is partly to be explained by the narrowing of the diagnostic range. It is not always as easy to establish the chain of events leading to death as it is to establish a single cause. Two or more quite different underlying causes of death may be fully justified. The discussion within the panel was sometimes lengthy at the beginning of the study, for instance as regards chronic alcoholism, as there is a wide range of other diseases and injuries where the probability of death is increased by alcoholism (Gardner 1977; Saitz 1997). It can be a matter of discussion what had occurred or whether the chain of events started with the alcoholism.

Hospitalization because of alcoholism or bronchial asthmas or lung disease is always followed by an increased risk (Koivulu 1994; Wright 1994; Smyth 1996). However, for a disease or condition to be designated the underlying COD it must have initiated the chain of events that led to death (WHO 1977) and not merely increased the susceptibility to other fatal conditions. Unless it is a distinct aggravation, the disease must be regarded as a contributing cause rather than the underlying cause (Sundman 1988; Cina 1999; D'Amico 1999).

The criteria for causes of death in the panel's discussion were implicit. Where reliability could perhaps have been improved by explicit criteria, the procedure probably favored high validity, while reliability was still acceptable. The panel's certificate cannot always be regarded as a ''gold standard'' and we have therefore eschewed this term. The experts could however discuss the case amongst themselves and they had more data, e.g., the autopsy record, and had more insight into the theoretical and practical problems of assessing the UCD, than had the average certificate-issuing doctor. On the other hand the attending doctor sometimes had data that he/she did not record. The panel accepted the doctor's description of the clinical course of the disease and merely interpreted it in the form of an accurate death certificate, without seeing the doctor's certificate. Our retest demonstrated the accuracy of the panel work, with very high agreement between the two events. The study is easily reproduced, provided the panel has broad expertise in assessing causes of death in everyday practice.

One quite disturbing finding was that autopsied cases were not coherent with higher accuracy than other cases. An explanation could be that the autopsied cases were harder for the attending doctor to classify as to causes of death and for this very reason sent for autopsy. We believe, however, that there is a potential of increasing the accuracy of the death certificate with a better collaboration between the pathologist and the doctor.

Our results are comparable to those found in other countries. Death certification was first introduced, nationally, in England and Wales in 1837. The Office of Registrar General was created, and death registration became compulsory to prove death legally and improve mortality data. The complex legislation concerning certification, registration, and disposal of the dead was reviewed in the Brodrick report (Report 1971).

The Cause of Death statement is in the internationally agreed format based on the philosophically enigmatic concept of Underlying Cause of Death. This cause can be defined pragmatically as the entity initiating the causal chain leading to death, i.e., a single-cause basis, and questions arise regarding for example the multifactorial nature of disease and how the causal sequence started. The death certificate originally invited a single entry; and even though multiple entries were commonplace, only one would be coded. An international standard Cause of Death statement was then introduced that

allowed multiple entries but encouraged the certifiers to identify Underlying Cause of Death in the sequence. Strict international rules for ''single-cause coding'' were agreed upon in 1948.

Beyond more robust evidence, a different educational perspective to apply the available evidence more effectively is required, advancing from merely urging educational input to evidence-based interventions. Certifiers are receptive to more education about death certification, but it is not yet known which interventions are best (Maudsley 1996). The flaws in the theoretical framework of cause of death and the routine nature of death certification are unavoidable, but necessary considerations. Certifiers need practical feedback mechanisms to improve understanding of the construction of mortality data.

Mortality data are essential for many aspects of everyday public health practice. More meaningful estimates of accuracy are thus required, as are evidence-based interventions, educational commitment and continuing quality assurance at all levels. Autopsy is not the only answer to inadequate cause of death wording, but the potential contribution of pathologists cannot be underestimated, e.g., in assisting the death certification of autopsied and unautopsied deaths and in facilitating good practice. Given the epidemiological origins of death certification and the clear potential for further improvement through dialogue and sharing expertise with clinicians, continued development should be a role within public health medicine.

5. References

Alderson, M.R. and Meade, T.W. (1967). Accuracy of Diagnosis on Death Certificates Compared with that in Hospital Records. British Journal of Preventive and Social Medicine, 21, 22–29.

Armstrong, D., Wing, S., and Tyroler, H.A. (1996). Race Differences in Estimates of Sudden Coronary Heart Disease Mortality, 1980–1988: The Impact of Ill-defined Death. Journal of Clinical Epidemiology, 49, 1247–1251.

Beaglehole, R. (1990). International Trends in Coronary Heart Disease. Mortality, Morbidity and Risk Factors. Epidemiological Review, 12, 1–15.

Cina, S.J. (1999). Accuracy of Death Certification in Two Tertiary Care Military Hospitals. Military Medicine, 164, 897–899.

D'Amico, M., Agozzino, E., Biagino, A., Simonetti, A., and Marinelli, P. (1999). Ill-defined and Multiple Causes on Death Certificates – A Study of Misclassification in Mortality Statistics. European Journal of Epidemiology, 15, 141–148.

Davis, G.G. (1997). Mind Your Manners. Part I: History of Death Certification and Manner of Death Classification. American Journal of Forensic Medicine and Pathology, 18, 219–223.

Fleiss, H.J. (1981). Statistical Methods for Rates and Proportions, 2nd ed. New York, NY: John Wiley & Sons, 217–225.

Gardner, A. and Berglund, M. (1977). Mortality of Treated Alcoholics After Eight Years in Relation to Short-term Outcome. Alcohol and Alcoholism, 32, 573–579.

Gittelsohn, A. and Senning, J. (1979). Studies on the Reliability of Vital and Health Records: I. Comparison of Cause of Death and Hospital Record Diagnoses. American Journal of Public Health, 69, 680–689.

Hanzlick, R. (1993). Death Certificates. The Need for Further Guidance. American Journal of Forensic Medicine and Pathology, 14, 249–252.

Hanzlick, R. (1996). The Relevance of Queries and Coding Procedures to the Writing of Cause-of-death Statements. American Journal of of Forensic Medicine and Pathology, 17, 319–323.

Jougla, E., Pavillon, G., Rossollin, F., De Smedt, M., and Bonte, J. (1998). Improvement of the Quality and Comparability of Causes-of-death Statistics Inside the European Community. EUROSTAT Task Force on ''Causes of Death Statistics.'' Revue Epidemiologique Santé Publique, 46, 447–456.

Koivulu, J., Sten, M., and Mäkälä, P.H. (1994). Risk Factors for Pneumonia in the Elderly. American Journal of Medicine, 96, 313–320.

Landis, J.R. and Koch, G.G. (1977). The Mesurement of Observer Agreement for Categorical Data. Biometrics, 33, 159–174.

Maudsley, G. and Williams, E.M. (1996). ''Inaccuracy'' in Death Certification – Where Are We Now? Journal of Public Health Medicine, 18, 59–66.

Myers, K.A. and Farquhar, D.R. (1998). Improving the Accuracy of Death Certification. Canadian Medical Association Journal, 158, 1317–1323.

Prior, L. (1985). Making Sense of Mortality. Sociology of Health and Illness, 12, 167–190.

Report of the Committee on Death Certification and Coroners. Cmnd 4810. London: HMSO, 1971.

Saitz, R., Ghali, W.A., and Moskowitz, M.A. (1997). The Impact of Alcohol-related Diagnoses on Pneumonia Outcomes. Archives of Internal Medicine, 157(13), 1446–1452.

Siegel, D.G., Podgor, M.J., and Remaley, N.A. (1992). Acceptable Values of Kappa for Comparison of Two Groups. American Journal of Epidemiology, 135, 571–578.

Smyth, E.T., Wright, S.C., Evans, A.E., Sinnamon, D.G., and MacMahon, J. (1996). Death from Airways Obstruction; Accuracy of Certification in Northern Ireland. Thorax, 51, 293–297.

Sundman, L., Jacobsson, S., Nyström, L. et al. (1988). A Validation of Cause of Death Certification in Two Swedish Municipalities. Scandinavian Journal of Primary Health Care, 6, 205–211.

Tardon, A.G., Zaplana, J., Hernandez, R., and Cueto, A. (1995). Usefulness of the Codification of Multiple Causes of Death in Mortality Statistics. International Journal of Epidemiology, 24, 1132–1137.

World Health Organization (1977). Manual of the International Statistical Classification of Disease, Injuries and Causes of Death, Vol. 1, 9th revision. Geneva.

Wright, S.C., Evans, A.E., Sinnamon, D.G., and MacMahon, J. (1994). Asthma Mortality and Death Certification in Northern Ireland. Thorax, 49, 141–143.

Received August 1999
Revised June 2002