

Multiple causes of death

Kathryn Wilkins, Marek Wysocki, Carole Morin and Patricia Wood

Abstract

Objectives

This article illustrates analytical uses of multiple-cause-of-death data, which reflect all causes entered on the death certificate, not only the single, underlying cause. Heart diseases are used as an example.

Data sources

Complete multiple-cause-of-death data were obtained from Newfoundland, Prince Edward Island, Nova Scotia, New Brunswick, Saskatchewan, Alberta, Yukon and the Northwest Territories; sample data were provided for Quebec and Ontario. The records represent 19% of deaths that occurred in Canada from 1990 to 1993.

Analytical techniques

The average number of causes per record, cause-specific frequencies and cause-specific ratios of mentions to selection as the underlying cause were calculated. Bivariate odds ratios were computed to study the association of selected causes of death with heart diseases.

Main results

Four-fifths of death certificates contained more than one cause; the maximum was 16. Certain causes such as septicaemia and atherosclerosis contributed to death much more often than they were selected as the underlying cause. Among selected causes, diabetes was most positively associated with the presence of heart diseases.

Key words

death certificates, mortality, comorbidity

Authors

Kathryn Wilkins (613-951-1769) and Patricia Wood (613-951-1648) are with the Health Statistics Division, and Marek Wysocki and Carole Morin are with the Household Survey Methods Division at Statistics Canada, Ottawa K1A 0T6.

For statistical purposes, every death is attributed to one underlying cause, but only about one in five deaths actually results from a single cause. In the majority of cases, several conditions or diseases are involved in the death.

Classifying a death by a single, underlying cause can result in the loss of information about conditions that contributed to that death. Multiple-cause data more accurately characterize the joint or sequential occurrence of factors that may be involved.¹ Such data include all morbid conditions, diseases and injuries entered on the death certificate.

For several decades, the limitations of studying mortality statistics in terms of a single cause of death have been recognized.¹⁻³ As a result of advances in automated coding that make multiple-cause analyses feasible, several such studies have been conducted in a number of countries.⁴⁻⁹

Methods

Data source

Mortality data are collected by the provincial and territorial registries of vital statistics, which are responsible for the registration of deaths that occur in their jurisdictions. Virtually complete multiple-cause-of-death data for the Atlantic provinces, Saskatchewan, Alberta and Yukon for the early 1990s were provided to Statistics Canada. Data for the Northwest Territories cover 85% of deaths that occurred there from 1990 through 1992. Data from randomly selected samples of 3% of records were available for Quebec in 1992 and Ontario in 1993. Multiple-cause data from British Columbia and Manitoba were unavailable.

	Data years	Number of records	% of all deaths [†]
Total		151,385	19.2[‡]
Newfoundland	1990-1993	15,293	99.5 [§]
Prince Edward Island	1990-1993	4,503	98.1 [§]
Nova Scotia	1990-1993	29,986	100.0 ^{††}
New Brunswick	1990-1993	22,591	100.0 ^{††}
Quebec	1992	1,452	3.0
Ontario	1993	1,898	2.5
Saskatchewan	1990-1993	31,871	99.3 [§]
Alberta	1991-1993	42,818	96.3 [§]
Yukon	1990-1992	363	100.0
Northwest Territories	1990-1992	610	84.7 [§]

Note: Annual provincial counts of all deaths were determined from figures published in *Births and Deaths (Statistics Canada, Catalogue 84-210-XPB)*.

[†] Percentage of all deaths during period indicated

[‡] Percentage of all deaths in Canada from 1990 through 1993

[§] Coverage is under 100% because of record deletions as a result of data edits.

^{††} Records exceed published number of deaths because late registrations are included.

All causes entered on a death certificate are routinely coded, a process that produces raw multiple-cause data. The multiple-cause data are then captured and processed using ACME (Automated Coding of Medical Entities) computing software, developed by the National Center for Health Statistics (NCHS) in the United States, to confirm the underlying cause of death according to World Health Organization rules.¹⁰ ACME processing of data from Alberta and Saskatchewan was carried out by the provincial offices of vital statistics; all other data used in this article were processed at Statistics Canada.

For this analysis, the multiple-cause-of-death data were further processed using TRANSAX. TRANSAX, which also was developed by the NCHS, is software designed to eliminate redundant causes within death certificates and, where appropriate, combine pairs of codes into a third code.¹⁰⁻¹²

Based on the death registration number, province and year of occurrence for each case, the cause-of-death records were matched and merged with corresponding records from the Canadian Vital Statistics Data Base (CVSDB), maintained at Statistics Canada. For example, CVSDB information on age at death and sex was appended to each record. Further edits of the merged files deleted duplicate records and ensured consistency between cause of death, age and sex for age-related and sex-specific causes.

Analytical techniques

A total of 151,385 records were analyzed, representing 19.2% of all deaths of Canadian residents from 1990 to 1993.¹³ To assess the degree to which the records used in this analysis are representative of all Canadian deaths that occurred from 1990 to 1993, the numbers of deaths by major category of underlying cause were compared with CVSDB counts. The proportions of deaths due to malignant neoplasms, diseases of the circulatory system, respiratory diseases and external causes of injury and poisoning were similar on the two files. Thus, the exclusion of British Columbia and Manitoba did not appear to bias the results.

The number of causes on each record was tabulated, as were cause-specific frequencies. For each cause, the ratio of the number of mentions to the number of times selected as underlying cause was calculated, a standard technique in analyses of multiple-cause data.^{1,5,7,9,11,12}

Based on the International Classification of Diseases, Ninth Revision (ICD-9), 56 causes of death were selected for study (Appendix, Table A).² Some of these causes were defined as groups of ICD-9 codes and others as single three- or four-digit codes. "Diseases of the heart," for instance, includes numerous three- and four-digit codes. Thus, a record could contain more than one code belonging to a particular cause. When this was the case, each separate code was counted in calculating the average number of causes per record. But for calculations of the ratio of mentions to selections as underlying cause and of odds ratios, a cause was counted only once per record regardless of how many of its component codes appeared on that record.

To measure the bivariate association between diseases of the heart and each of the other causes of death studied, odds ratios were calculated (the odds of diseases of the heart being mentioned on a death certificate, given the mention of another specific cause, divided by the odds of diseases of the heart being mentioned on a death certificate, given that the other specific cause was not mentioned). Estimates were produced separately for each sex. To construct confidence intervals, estimates of the variance of the log odds ratios were produced.¹⁴ The odds ratios were tested using two-sided significance tests at level 0.05.

All routinely published cause-of-death information for Canada is based on a single, underlying cause.^a However, multiple-cause-of-death data for most jurisdictions have recently been provided to Statistics Canada. Previously, only limited, province-level analyses of these data have been undertaken.^{15,16} This article presents findings from all multiple-cause-of-death data that Statistics Canada has compiled (see *Methods*).

The death certificate

When someone dies, the authority (usually a physician) who certifies the death is required to record all conditions considered to have caused or contributed to it on the death certificate (see *Medical Certificate of Death*). To comply with international administrative conventions, each death is classified by identifying a single, underlying cause. The underlying cause of death is defined as: a) the disease or injury that initiated the train of events leading directly to death, or b) the circumstances of the accident or violence that produced the fatal injury.² The certifier is also expected to list the causes so that the immediate, antecedent, underlying and any contributing causes are in an order that reflects the sequence of events that caused the death.

In reality, people are often afflicted with several comorbid conditions, and death may result from a combination rather than a clear sequence of causes. Thus, it may be difficult to accurately certify the order of causes of a death. In recognition of this difficulty and to standardize the procedure of single-cause attribution when more than one condition contributes to a death, World Health Organization (WHO) rules govern the selection of the underlying cause from information entered on the death certificate.²

^a For each death due to external causes of injury and poisoning (ICD-9 codes E800-E999), an additional code or codes representing the nature of the injury or injuries resulting from the accident are certified, tabulated and published.

In this article, the term “mention” means any cause entered on the medical certificate of death—the underlying, immediate, antecedent, and contributing causes.

Medical Certificate of Death

In general, the cause entered alone on the lowest used line of Part I of the Medical Certificate of Death is selected as the underlying cause, if it reasonably could have brought about the conditions entered above it.

In the death certificate below, stroke is the underlying cause of death. Stroke caused hemiplegia (paralysis of one side of the body), which, in turn, gave rise to fatal pneumonia in a person who had diabetes. However, according to usual current practices for compiling cause-of-death information, pneumonia, hemiplegia and diabetes would not be included or even considered in published statistics. (Also, because the criteria for completing the death certificate limit the inclusion of conditions that are present but do not contribute causally to death, a person might have illnesses such as arthritis or dementia that would not be entered on the certificate.)

International Form of Medical Certificate of Cause of Death^b

Cause of Death	
I	
Disease or condition directly leading to death*	(a) <u>Pneumonia</u> due to (or as a consequence of)
Antecedent causes	(b) <u>Hemiplegia</u> due to (or as a consequence of)
Morbid conditions, if any, giving rise to the above cause, stating the underlying condition last	(c) <u>Stroke</u>
II	
Other significant conditions contributing to death but not related to the disease or condition causing it	<u>Diabetes</u>
* This does not mean the mode of dying, e.g., heart failure. It means the disease, injury or complication which caused death.	

Although the underlying cause should be entered alone on the lowest used line of Part I, frequently, several conditions are entered on this and the other lines. When the order in which causes of death have been entered on the certificate does not follow the standard, the underlying cause is derived using additional WHO rules.

^b Completed sample of the international form of medical certificate of cause of death, upon which Canadian jurisdictions model their forms.⁴

Table 1
Distribution of number of causes on death certificates, selected jurisdictions, Canada, 1990 to 1993

Number of causes mentioned	Death certificates	
	Number	%
Total	151,385	100.0
1	28,454	18.8
2	47,748	31.5
3	39,792	26.3
4	21,543	14.2
5	9,056	6.0
6	3,166	2.1
7	1,101	0.7
8-16	525	0.4

Data source: Provincial and territorial registries of vital statistics

Majority of deaths have multiple causes

Few deaths result from a single cause. On the records selected for analysis, just 19% of deaths were attributed to one cause (Table 1). The maximum number of causes entered on a death certificate was 16; the average was 2.68 (about the same as the average of 2.65 causes reported for 1991 in the United States¹²). However, given the mention of a specific cause, the average varied nearly fourfold for the 56 causes analyzed, from 1.19 for certificates containing sudden infant death syndrome (SIDS) to 4.43 for those containing accidental falls (Table 2).

Indirectly, the occurrence of multiple causes of death reflects Canadians' longevity. Two-thirds of those born in 1991 can expect to live to 75, and over a third will still be alive at 85.¹⁷ By these ages, people are typically afflicted with one or more chronic conditions.^{18,19} And although

Table 2
Average number of causes on death certificates when specific cause mentioned, selected jurisdictions, Canada, 1990 to 1993

Specific cause mentioned	Average number of causes	Specific cause mentioned	Average number of causes
Accidental falls	4.43	Alzheimer disease	2.94
Septicaemia	3.77	Homicide	2.94
Endocrine, nutritional and metabolic diseases and immunity disorders	3.77	Malignant neoplasm of bladder	2.90
Diseases of the genitourinary system	3.73	Malignant neoplasm of prostate	2.86
Diabetes mellitus	3.70	Conditions originating in perinatal period	2.84
Tuberculosis	3.68	Accidents caused by fire and flames	2.82
Nephritis, nephrotic syndrome and nephrosis	3.67	Aortic aneurysm	2.75
Infectious and parasitic diseases	3.58	Malignant neoplasm of kidney	2.75
Diseases of the digestive system	3.56	Malignant neoplasm of uterus and cervix	2.75
External causes of injury and poisoning	3.53	All causes	2.68
Atherosclerosis	3.52	Malignant neoplasm of small intestine, colon, rectum	2.65
Mental disorders	3.48	Malignant neoplasm of female breast	2.64
Chronic airways obstruction, not elsewhere classified	3.46	Suicide	2.62
Parkinson disease	3.38	Leukemia	2.57
Nervous system diseases	3.35	Malignant neoplasm of lip, oral cavity and pharynx	2.57
Senile and presenile organic psychotic conditions	3.32	Malignant neoplasms	2.49
Respiratory diseases	3.30	Accidental drowning and submersion	2.46
Asthma	3.29	Malignant neoplasm of esophagus	2.45
Ill-defined and unknown causes	3.29	Malignant neoplasm of lymphatic tissue	2.42
Chronic liver disease and cirrhosis	3.28	Malignant neoplasm of liver and bile ducts	2.42
Bronchitis, emphysema, asthma	3.26	Malignant neoplasm of stomach	2.41
Pneumonia and influenza	3.17	Malignant melanoma of skin	2.39
Motor vehicle traffic accidents	3.13	Malignant neoplasm of ovary, other uterine adnexa	2.38
Congenital anomalies	3.12	Malignant neoplasm of trachea, bronchus and lung	2.34
Cerebrovascular diseases	3.04	Malignant neoplasm of pancreas	2.27
Diseases of the heart	3.03	HIV/AIDS	2.03
Ischaemic heart disease	3.02	Malignant neoplasm of brain	1.89
Hypertensive heart disease	2.98	Sudden infant death syndrome (SIDS)	1.19
Diseases of the circulatory system	2.96		

Data source: Provincial and territorial registries of vital statistics

Note: All codes appearing on death records were counted for calculations of average number of causes per record.

death certificates do not completely reflect the prevalence of disease before death, the average number of causes tends to increase with age (Chart 1). In fact, over half the deaths of people aged 65 or over were attributed to three or more causes (Chart 2).

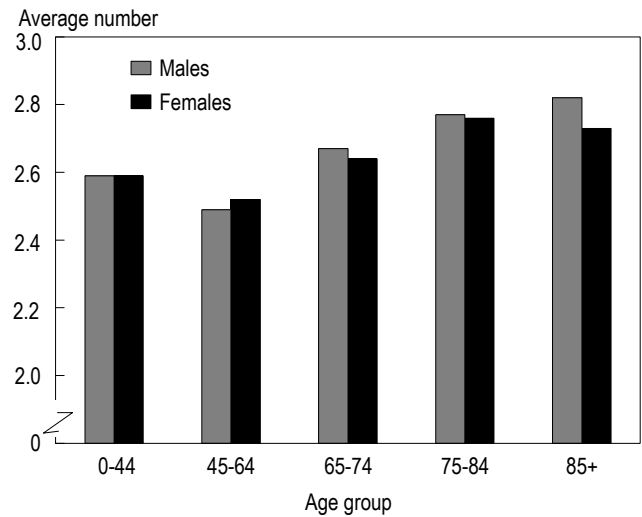
The average number of causes entered on death certificates of both males and females was higher at ages 0-44 than at ages 45-64. This reflects the substantial proportion of deaths in the younger age range that result from external causes such as motor vehicle accidents, which usually entail multiple injuries.²⁰

Always a bridesmaid . . .

Certain causes contributed to death much more often than they were selected as the underlying cause. "Ill-defined and unknown causes" had the highest ratio of mentions to selections as the underlying cause. At least one condition from the ill-defined and unknown causes group was mentioned on almost 22,000 (14%) death certificates, but selected as the underlying cause on just 1,097 of them. Thus, it was mentioned 20 times as often as it was selected as the underlying cause (Table 3). This would be expected since WHO rules preclude the selection

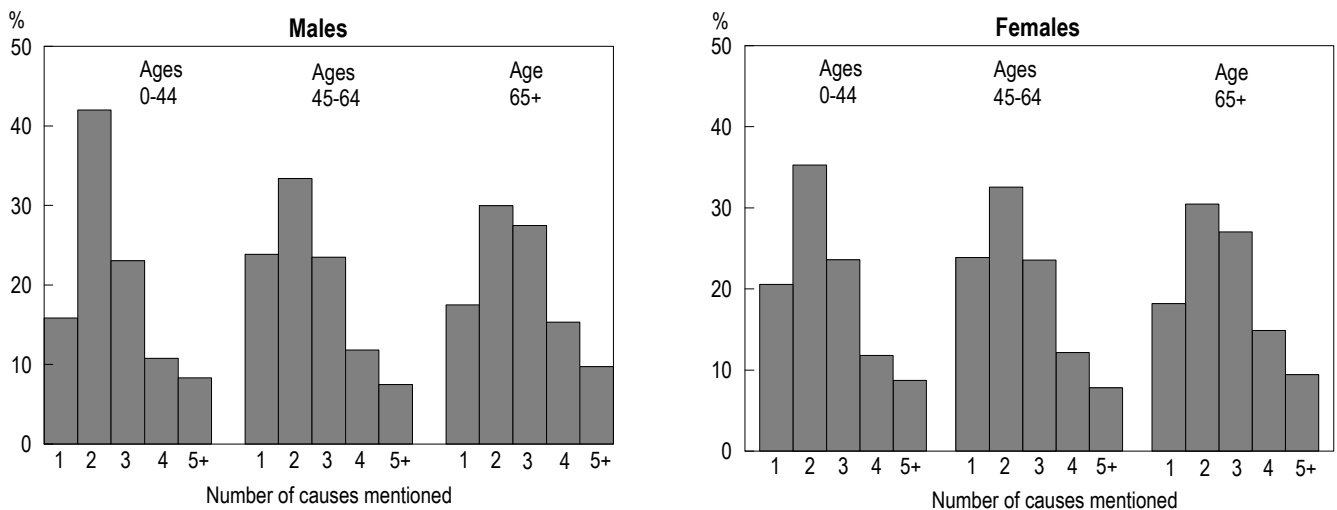
of ill-defined or unknown causes as the underlying cause when another condition that does not lie within these coding ranges is mentioned on the death certificate.²

Chart 1
Average number of causes on death certificates, by sex and age group of deceased, selected jurisdictions, Canada, 1990 to 1993



Data source: Provincial and territorial registries of vital statistics

Chart 2
Percentage distribution of number of causes on death certificates, by sex and age group of deceased, selected jurisdictions, Canada, 1990 to 1993



Data source: Provincial and territorial registries of vital statistics

Septicaemia and atherosclerosis also had high ratios of mentions to selections as the underlying cause: both were mentioned on death certificates about five times as often as they were specified as the underlying cause. Other causes with high ratios included nephritis, nephrotic syndrome and nephrosis; diseases of the genitourinary system; mental disorders; and diabetes mellitus (Chart 3). The average ages at death for the causes with the highest ratios were relatively advanced, ranging from 73 to 81.

These results are similar to findings reported in the United States and Spain.^{1,5} The high ratios for these conditions reflect the frequency with which they are included in, but do not initiate, the sequence of causes that lead to death.

Table 3
Causes of death with highest and lowest ratios of mentions to selections as underlying cause, selected jurisdictions, Canada, 1990 to 1993

Cause of death	Death certificates with any mention†	Selected as underlying cause	Ratio of mentions to underlying cause	Average age at death (when cause mentioned)
Highest ratios				
Ill-defined and unknown causes	21,919	1,097	19.98	75.7
Septicaemia	3,661	644	5.68	72.5
Atherosclerosis	7,364	1,354	4.86	80.8
Nephritis, nephrotic syndrome, nephrosis	8,958	1,936	4.63	75.7
Diseases of genitourinary system	10,999	2,640	4.17	76.3
Mental disorders	10,411	2,536	4.11	74.5
Diabetes mellitus	11,677	3,269	3.57	75.4
Lowest ratios				
Suicide	2,989	2,977	1.00	39.5
Homicide	468	465	1.01	34.3
Motor vehicle traffic accidents	3,292	3,238	1.02	38.1
Accidents caused by fire and flames	369	358	1.03	38.1
Malignant neoplasm of pancreas	2,228	2,117	1.05	71.6
Malignant neoplasm of brain	997	929	1.07	58.0
HIV/AIDS	455	423	1.08	38.2

Data source: Provincial and territorial registries of vital statistics

Note: When more than one code from a coding range defined as a cause of death (Appendix, Table A) appeared on a record, the code was counted only once for calculations of mentions-to-underlying-cause ratios.

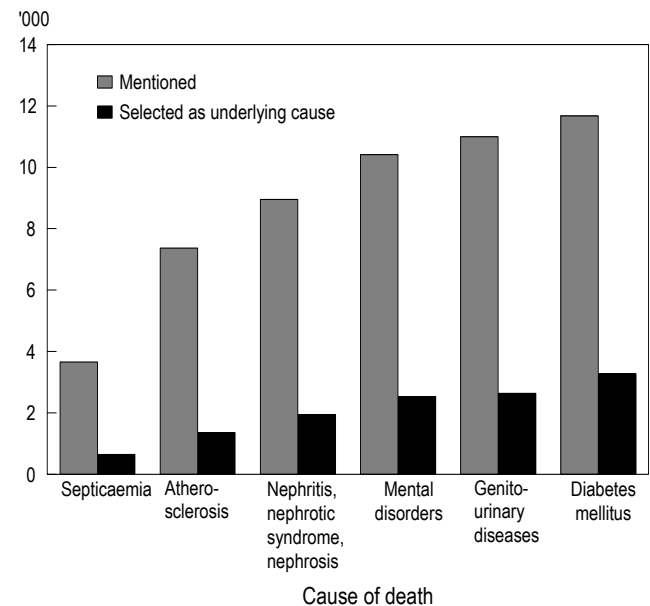
† Includes death certificates with age unknown.

Usually underlying causes

Other causes of death almost invariably appeared on death certificates as the underlying cause, so their ratios of mentions to selections as the underlying cause were approximately 1.00. Suicide, motor vehicle traffic accidents, homicide, accidents due to fire and flames, and HIV/AIDS were usually listed as underlying causes. The average ages at death from these causes were comparatively young (from age 34 to 40).

As well, two types of cancer—malignant neoplasms of the pancreas and the brain—were typically listed on the death certificate as the underlying cause, likely because of their lethality and relatively short survival time. The average age at death was 72 for pancreatic cancer and 58 for brain cancer, notably older than for the other, mostly trauma-related causes with low ratios of mentions to selections as the underlying cause.

Chart 3
Frequency of mention and specification as underlying cause on death certificates, selected causes of death, selected jurisdictions, Canada 1990 to 1993



Data source: Provincial and territorial registries of vital statistics

Rarely alone

Some underlying causes of death were rarely entered alone on the death certificate (Table 4). This applied to most external causes, which were routinely accompanied by at least one entry related to the injuries resulting from the external cause.

Death certificates with accidental falls as the underlying cause had, by far, the highest average number of causes (4.12). To some extent, this is because the average age of those who died in accidental falls was 78, and other conditions are typically present in the elderly.²⁰

Death certificates with motor vehicle traffic accident, homicide, or accident caused by fire and flames selected as the underlying cause also had higher-than-average numbers of causes. These external causes of death are more likely to involve multiple injuries than are suicides and drownings, for which the average number of causes was comparatively low.

Table 4
Underlying causes rarely reported alone on death certificates, selected jurisdictions, Canada, 1990 to 1993

Underlying cause (UDLC)†	Number of deaths‡	Deaths for which UDLC is only cause %	Average number of causes per death	Average age at death Years
Accidental falls	1,360	0	4.12	77.70
Accidental drowning and submersion	466	0	2.41	34.78
Motor vehicle accidents	3,238	0.12	3.11	37.68
Homicide	465	0.43	2.94	34.19
Suicide	2,977	0.64	2.62	39.46
Accidents caused by fire and flames	358	0.84	2.78	37.31
Diabetes mellitus	3,269	2.32	3.32	75.16
Tuberculosis	149	6.71	3.20	71.48
Chronic airways obstruction, n.e.c.	4,599	7.33	2.98	77.67
Septicaemia	644	8.07	3.28	73.94

Data source: Provincial and territorial registries of vital statistics

Note: All codes on death records were counted for calculations of average number of causes per record.

† ICD-9 codes at three-digit level, not ranges of codes

‡ Includes age unknown.

n.e.c. Not elsewhere classified

The non-external underlying causes least likely to occur alone on death certificates included diabetes mellitus, for which the average number of causes was 3.32, septicaemia (3.28 causes), tuberculosis (3.20), and chronic airways obstruction, not elsewhere classified (2.98). The high averages are a consequence of the complex of health problems that often attend these conditions, since the average ages at death when these diseases were the underlying cause were fairly advanced, ranging from 71 to 78.

Most often alone

By contrast, other causes were usually reported alone on death certificates. This was most frequently the case with SIDS: 98% of deaths for which SIDS was the underlying cause were attributed to SIDS only (Table 5). The ICD-9 code for SIDS is in the ill-defined and unknown

Table 5
Underlying causes frequently reported alone on death certificates, selected jurisdictions, Canada, 1990 to 1993

Underlying cause (UDLC)†	Number of deaths‡	Deaths for which UDLC is only cause %	Average number of causes per death	Average age at death Years
Sudden infant death syndrome	339	98.2	1.02	0.01
Malignant neoplasm of brain	929	50.3	1.79	57.8
HIV/AIDS	423	44.9	1.91	38.0
Malignant neoplasm of pancreas	2,117	35.5	2.19	71.3
Malignant neoplasm of lymphatic tissue	2,193	34.4	2.22	68.1
Malignant melanoma of skin	387	33.9	2.21	61.1
Malignant neoplasm of stomach	1,697	31.8	2.28	71.7
Aortic aneurysm	1,578	31.3	2.35	75.4
Malignant neoplasm of liver and bile ducts	625	30.9	2.29	69.6
Malignant neoplasm of ovary, other uterine adnexa	852	30.4	2.28	66.6

Data source: Provincial and territorial registries of vital statistics

Note: All codes on death records were counted for calculations of average number of causes per record.

† ICD-9 codes at three-digit level, not ranges of codes

‡ Includes age unknown.

The case of heart diseases

Multiple-cause-of-death data show that some causes frequently appear together.²¹ This is illustrated in the case of heart diseases, which were chosen for analysis because of their importance not only as an underlying cause of death, but also as an associated cause.

Diseases of the heart led all other causes, being mentioned on 68,729 (45%) of the 151,385 death certificates analyzed, but selected as the underlying cause on just 29% of them. However, relatively few statistically significant positive associations between mentions of heart diseases and mentions of other causes were found (Appendix, Table B). For males, only 6 of 37 odds ratios were significantly different from and above 1.0, while 30 were significantly different from and lower than 1.0, and one was not significant. Similarly for females, 7 of 39 odds ratios were significant and above 1.0; 30 were significant and below 1.0; and two were not significant.

For both sexes the highest odds ratio was for diabetes mellitus. The odds of diseases of the heart occurring on a death certificate that contained a mention of diabetes were over two and a half times as great as for certificates that did not mention diabetes. The risk of heart disease is known to be elevated in people with diabetes, and the physiological basis of the link between these diseases is well documented in the medical literature. As well, diabetes is a common precursor of atherosclerotic coronary disease manifested by angina or myocardial infarction.²² Not surprisingly then, mentions of atherosclerosis were also positively associated with mentions of diseases of the heart.

Positive associations occurred between diseases of the heart and several respiratory diseases, including chronic airways obstruction (not elsewhere classified) and bronchitis, emphysema and asthma. The associations between these diseases and diseases of the heart on the death certificate may reflect exposure to tobacco smoking, which is a risk factor for both heart disease and chronic obstructive respiratory diseases.

Nephritis, nephrotic syndrome and nephrosis were positively associated with mentions of diseases of the heart. This was expected, in view of the common occurrence of cardiovascular complications such as hypertension in people with renal failure.

Mentions of SIDS and of most external causes of death (drowning, accidents caused by fire and flames, homicide, motor vehicle traffic accidents, and suicide) showed the strongest negative associations with diseases of the heart. This is not surprising, given the young average ages at death and the acute nature of SIDS and these external causes.

Generally, the magnitudes of the odds ratios and the causes of death that were positively and negatively associated with diseases of the heart were similar for males and females. An exception was accidental falls, which was positively associated with diseases of the heart among females but negatively associated among males. The positive association reflects the typical comorbidity among elderly women who are at greatest risk of sustaining an accidental fall that leads or contributes to death.

causes group,^c and as such, according to WHO coding rules, is not to be selected as the underlying cause when any other condition (that is not also an ill-defined condition) is on the death certificate.² Therefore, when SIDS was designated the underlying cause of death, it was typically the only cause. An average of 1.02 causes were listed on death certificates with SIDS as the underlying cause.

Malignant neoplasm of the brain and HIV/AIDS ranked second and third, in terms of the frequency with which they were reported alone as underlying causes of death. When designated the underlying cause, malignant neoplasm of the brain was reported alone 50% of the time, and these death certificates averaged 1.79 causes. HIV/AIDS was reported alone 45% of the time and averaged 1.91 causes.

The average number of causes on death certificates with any malignant neoplasm as the underlying cause was usually low. (The exceptions were cancer of the uterus and cervix, kidney, prostate and bladder.) This reflects the ultimately fatal course of many cancers. It also suggests a generally lower prevalence of comorbid conditions among people dying from cancer, compared with other causes, and corroborates the findings of a recent multiple-cause study in the Netherlands.⁷

Implications for future research

The use of single-cause mortality data bases tends to obscure the contribution of causes that are entered on the death certificate but are infrequently selected as the underlying cause. With multiple-cause data, it is possible to assess the importance of these nonunderlying causes. Such data represent more completely, and thus more accurately, the complicated and sometimes synergistic causal circumstances of death (see *The case of heart diseases*). Multiple-cause data provide an opportunity to study the complexity of morbid conditions that are involved in death and

^cFor this analysis, SIDS was examined separately and is shown as a separate entry in Appendix Table A.

the contribution of these conditions to mortality rates.

From a public health policy perspective, multiple-cause data are valuable for revealing disorders that are relatively infrequent selections as the underlying cause of death, but which contribute to frailty, and ultimately, to the risk of dying. Because a death may result from a certain combination of conditions rather than a single cause, it may be possible to delay it by intervening in one or more of the nonunderlying causes.²¹

In Canada, the implementation of technological enhancements to the means by which death data are processed will soon make more multiple-cause-of-death data available. The analytical potential of the data is great, both for those interested in exploring associations between conditions leading to death and those seeking a more complete representation of the causes of death.

References

- 1 Israel RA, Rosenberg HM, Curtin L. Analytical potential for multiple cause-of-death data. *American Journal of Epidemiology* 1986; 124(2): 161-79.
- 2 World Health Organization. *Manual of the International Statistical Classification of Diseases, Injuries and Causes of Death, 9th Revision*, Vol. 1. Geneva: World Health Organization, 1977.
- 3 Dorn HF, Moryama IM. Uses and significance of multiple cause tabulations for mortality statistics. *American Journal of Public Health* 1964; 54: 400-6.
- 4 Newens AJ, Forster DP, Kay DWK. Death certification after a diagnosis of presenile dementia. *Journal of Epidemiology and Community Health* 1993; 47: 293-7.
- 5 Tardon AG, Zaplana J, Hernandez R, et al. Usefulness of the codification of multiple causes of death in mortality statistics. *International Journal of Epidemiology* 1995; 25(5): 1132-7.
- 6 Lindahl BIB, Johansson LA. Multiple cause-of-death data as a tool for detecting artificial trends in the underlying cause statistics: a methodological study. *Scandinavian Journal of Social Medicine* 1994; 2: 145-58.
- 7 Mackenbach JP, Kunst AE, Lautenbach H, et al. Competing causes of death: An analysis using multiple-cause-of-death data from The Netherlands. *American Journal of Epidemiology* 1995; 141(5): 466-75.
- 8 Coste J, Jouglu E. Mortality from rheumatoid arthritis in France, 1970-1990. *International Journal of Epidemiology* 1994; 23(3): 545-52.
- 9 Bradshaw BS, Blanchard S, Thompson GH. Emergence of diabetes mellitus in a Mexican-origin population: A multiple cause-of-death analysis. *Social Biology* 1995; 42(1-2): 36-49.
- 10 National Center for Health Statistics. *Computer installation instructions for the "Medical Index, Classification, and Retrieval" (MICAR) and "Automatic Classification of Medical Entities" (ACME ICD-9) and "Translation of Axis" (TRANSAX ICD-9)*. Division of Vital Statistics, Technical Services Branch, Research Triangle Park, North Carolina, 1992.
- 11 Chamblee RF, Evans MC. TRANSAX: The NCHS system for producing multiple-cause-of-death statistics, 1968-78. *Vital and Health Statistics* (Public Health Service, Series 1, no. 20) Washington, D.C.: U.S. Government Printing Office, 1986.
- 12 Kochanek KD, Rosenberg HM. Issues, considerations and examples in the use of multiple causes of death in United States Government statistics. Presented to the *World Health Organization Heads of Collaborating Centres Ad Hoc Meeting on Multiple Cause Analyses*, London, April, 1994.
- 13 Statistics Canada. *Births and Deaths, 1995* (Catalogue 84-210-XPB) Ottawa: Minister of Industry, 1996.
- 14 Agresti A. *Categorical data analysis*. New York: John Wiley and Sons, 1990.
- 15 Macdonald JM, Tuk TA, Cranfield C. *Cancer mortality in British Columbia 1988-1992: Patterns of underlying cause and multiple cause data*. Victoria: Division of Vital Statistics, British Columbia Ministry of Health and Ministry Responsible for Seniors, 1993.
- 16 Tuk TA, Macdonald J. *Drug-related deaths in British Columbia: 1981 to 1993*. Victoria: Division of Vital Statistics, British Columbia Ministry of Health and Ministry Responsible for Seniors, 1994.
- 17 Statistics Canada. *Life tables, Canada and the provinces, 1990-1992* (Catalogue 84-537) Ottawa: Minister of Industry, 1995.
- 18 Hoffman C, Rice D, Sung H-Y. Persons with chronic conditions—Their prevalence and costs. *Journal of the American Medical Association* 1996; 276(18): 1473-9.
- 19 Wilkins K, Park E. Chronic conditions, physical limitations and dependency among seniors living in the community. *Health Reports* (Statistics Canada, Catalogue 82-003-XPB) 1996; 8(3): 7-15.
- 20 Wilkins K. Causes of death: How the sexes differ. *Health Reports* (Statistics Canada, Catalogue 82-003) 1995; 7(2): 33-43.
- 21 Manton KG, Stallard E, Poss SS. Estimates of U.S. multiple cause life tables. *Demography* 1980; 17(1): 85-102.
- 22 Berkow R, Fletcher AJ (editors). *The Merck manual of diagnosis and therapy*. Rahway, New Jersey: Merck Research Laboratories, 1992.

Appendix

Table A

Causes of death selected for study

Cause of death	ICD-9 code	Cause of death	ICD-9 code
All causes	001-999	Diseases of the circulatory system	390-459
Infectious and parasitic diseases	001-139	Diseases of the heart	391, 392.0, 393-398, 402, 404, 410-416, 420-429
Tuberculosis	010-018, 137	Hypertensive heart disease	402, 404
Septicaemia	038	Ischaemic heart disease	410-414
HIV/AIDS	042-044	Cerebrovascular disease	430-438
Malignant neoplasms	140-208	Atherosclerosis	440
Malignant neoplasm of lip, oral cavity and pharynx	140-149	Aortic aneurysm	441
Malignant neoplasm of esophagus	150	Respiratory diseases	460-519
Malignant neoplasm of stomach	151	Pneumonia and influenza	480-487
Malignant neoplasm of small intestine, colon and rectum	152-154	Bronchitis, emphysema, asthma	490-493
Malignant neoplasm of liver and bile ducts	155	Asthma	493
Malignant neoplasm of pancreas	157	Chronic airways obstruction, not elsewhere classified	496
Malignant neoplasm of trachea, bronchus and lung	162	Diseases of the digestive system	520-579
Malignant melanoma of skin	172	Chronic liver disease and cirrhosis	571
Malignant neoplasm of female breast	174	Diseases of the genitourinary system	580-629
Malignant neoplasm of uterus and cervix	179-182	Nephritis, nephrotic syndrome and nephrosis	580-589
Malignant neoplasm of ovary, other uterine adnexa	183	Congenital anomalies	740-759
Malignant neoplasm of prostate	185	Conditions originating in perinatal period	760-779
Malignant neoplasm of bladder	188	Ill-defined and unknown causes	797-799 except 798.0
Malignant neoplasm of kidney	189.0-189.2	Sudden infant death syndrome	798.0
Malignant neoplasm of brain	191	External causes of injury and poisoning	E800-E999
Malignant neoplasm of lymphatic tissue	200-203	Motor vehicle accidents	E810-E825, E929.0
Leukemia	204-208	Accidental falls	E833-E835, E880-E888
Endocrine, nutritional and metabolic diseases and immunity disorders	240-279	Accidents caused by fire and flames	E890-E899
Diabetes mellitus	250	Accidental drowning and submersion including watercraft, water transport accidents	E830, E832, E910
Mental disorders	290-319	Suicide	E950-E959
Senile and presenile organic psychotic conditions	290	Homicide	E960-E969
Diseases of the nervous system and sense organs	320-389		
Alzheimer's disease	331.0		
Parkinson's disease	332		

Source: World Health Organization (reference 2)

Table B

Odds ratios for mention of selected causes when diseases of the heart was mentioned on death certificates, by sex, selected jurisdictions, Canada, 1990 to 1993

Other cause mentioned on death certificate	Males		Females	
	Odds ratio	95% confidence interval	Odds ratio	95% confidence interval
Diabetes mellitus	2.70	2.55, 2.86	2.57	2.43, 2.72
Atherosclerosis	2.26	2.11, 2.42	1.56	1.46, 1.67
Chronic airways obstruction, not elsewhere classified	1.61	1.53, 1.69	1.57	1.46, 1.68
Asthma	1.59	1.31, 1.93	1.45	1.21, 1.74
Nephritis, nephrotic syndrome and nephrosis	1.37	1.30, 1.45	1.41	1.33, 1.51
Bronchitis, emphysema, asthma	1.16	1.06, 1.26	1.23	1.10, 1.38
Tuberculosis	.90	.68, 1.19	.96	.69, 1.33
Parkinson's disease	.83	.73, .94	.84	.73, .97
Accidental falls	.80	.72, .89	1.19	1.08, 1.32
Aortic aneurysm	.79	.71, .89	.91	.78, 1.06
Senile and presenile organic psychotic conditions	.78	.70, .88	.77	.70, .85
Cerebrovascular disease	.77	.73, .80	.68	.65, .71
Alzheimer's disease	.68	.61, .75	.61	.55, .66
Pneumonia and influenza	.55	.52, .57	.58	.55, .60
Malignant neoplasm of prostate	.47	.44, .50	...	...
Septicaemia	.47	.42, .52	.53	.48, .59
Chronic liver disease and cirrhosis	.44	.39, .50	.39	.33, .46
Malignant neoplasm of bladder	.44	.38, .51	.39	.30, .50
Malignant neoplasm of kidney	.36	.30, .42	.30	.24, .38
Leukemia	.34	.29, .40	.38	.32, .45
Malignant neoplasm of lymphatic tissue	.33	.29, .37	.32	.28, .36
Malignant neoplasm of uterus and cervix	...	...	.30	.26, .36
Malignant neoplasm of small intestine, colon, rectum	.30	.28, .34	.26	.24, .29
Malignant neoplasm of lip, oral cavity and pharynx	.29	.23, .36	.23	.16, .34
Malignant neoplasm of stomach	.29	.25, .33	.28	.24, .34
Malignant neoplasm of female breast	...	...	.28	.26, .31
Malignant melanoma of skin	.27	.20, .37	.30	.20, .44
Malignant neoplasm of esophagus	.25	.21, .31	.19	.13, .28
Malignant neoplasm of trachea, bronchus and lung	.25	.24, .27	.21	.19, .23
Malignant neoplasm of liver and bile ducts	.24	.19, .31	.23	.16, .32
Malignant neoplasm of ovary, other uterine adnexa	...	...	.23	.19, .27
Malignant neoplasm of pancreas	.21	.18, .25	.21	.18, .25
Malignant neoplasm of brain	.12	.09, .16	.17	.13, .23
HIV/AIDS	.10	.07, .14	.17	.05, .57
Accidents caused by fire and flames	.09	.06, .15	.05	.02, .13
Accidental drowning and submersion	.07	.04, .10	.09	.03, .24
Motor vehicle traffic accidents	.06	.05, .07	.06	.05, .08
Homicide	.05	.03, .09	.03	.01, .07
Suicide	.03	.03, .04	.03	.02, .06
Sudden infant death syndrome	.02	.01, .05	.01	.00, .05

Data source: Provincial and territorial registries of vital statistics

Note: In cases when more than one code from a group of codes defining a cause of death appeared on a record (Appendix, Table A), the code was counted only once.
... Not applicable