ICD coding changes and discontinuities in trends in cause-specific mortality in six European countries, 1950–99

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Objective To evaluate how often coding changes between and within revisions of the *International Classification of Diseases* (ICD) complicate the description of long-term trends in cause-specific mortality.

Methods Data on cause-specific mortality between 1950 and 1999 for men and women aged 60 and older were obtained from Denmark, England and Wales, Finland, the Netherlands, Norway and Sweden. Data were obtained by five-year age groups. We constructed a concordance table using three-digit ICD codes. In addition we evaluated the occurrence of mortality discontinuities by visually inspecting cause-specific trends and country-specific background information. Evaluation was also based on quantification of the discontinuities using a Poisson regression model (including period splines). We compared the observed trends in cause-specific mortality with the trends after adjustment for the discontinuities caused by changes to coding.

Findings In 45 out of 416 (10.8 %) instances of ICD revisions to cause-specific mortality codes, significant discontinuities that were regarded as being due to ICD revisions remained. The revisions from ICD-6 and ICD-7 to ICD-8 and a wide range of causes of death, with the exception of the specific cancers, were especially affected. Incidental changes in coding rules were also important causes of discontinuities in trends in cause-specific mortality, especially in England and Wales, Finland and Sweden. Adjusting for these discontinuities can lead to significant changes in trends, although these primarily affect only limited periods of time.

Conclusion Despite using a carefully constructed concordance table based on three-digit ICD codes, mortality discontinuities arising as a result of coding changes (both between and within revisions) can lead to substantial changes in long-term trends in cause-specific mortality. Coding changes should therefore be evaluated by researchers and, where necessary, controlled for.

Keywords International Classification of Diseases/history; Mortality/trends; Cause of death/trends; Bias (Epidemiology); Research design; Evaluation studies; Europe; Denmark; Finland; Netherlands; Norway; Sweden; United Kingdom (*source: MeSH, NLM*).

Mots clés Classification internationale des maladies/histoire; Mortalité/orientations; Cause décès/orientations; Biais (Epidémiologie); Projet recherche; Etude évaluation; Europe; Danemark; Finlande; Pays-Bas; Norvège; Suède; Royaume-Uni (*source: MeSH, INSERM*).

Palabras clave Clasificación Internacional de Enfermedades/historia; Mortalidad/tendencias; Causa de muerte/tendencias; Sesgo (Epidemiología); Proyectos de investigación; Estudios de evaluación; Europa; Dinamarca; Finlandia; Países Bajos; Noruega; Suecia; Reino Unido (*fuente: DeCS, BIREME*).

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Voir page 911 le résumé en français. En la página 912 figura un resumen en español.

Introduction

The study of trends in cause-specific mortality is an important subject in epidemiology, demography and public health. However, assessment of long-term mortality trends in causes of death can be hampered by changes in coding. For example, numerous revisions of the *International Classification of Diseases* (ICD) have to be taken into account. Not only can these revisions lead to changes in coding rules but additionally each ICD classification can include a different number of items to code the causes of death, causing inconsistency over time. Solutions to overcome the bias that may result vary from simple and crude to elaborate and accurate.

A simpler approach is to study mortality trends only in broad, aggregated groups of causes of death or in specific diseases for which the coding is known to have been consistent over time (*1*). However, many specific causes of death cannot be studied appropriately with these approaches.

Bridge coding is an accurate approach. In bridge coding cross-classifications between successive ICD revisions are used; these are based on the double coding of all causes of death (*2*). These cross-classifications, however, exist for only a small number of countries and ICD revisions, and their results may not be directly applicable to all countries owing to differences in coding practices and differences in the application of new ICD revisions between countries (*3*, *4*).

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Vallin & Meslé (*4–6*) elaborately and accurately reconstructed coherent series of data for causes of death in France for the years 1925–94, according to ICD-9. They used carefully constructed concordance tables based on four-digit codes; these concordance tables linked the codes for a specific cause of death through each successive ICD revision. Transition coefficients were calculated to redistribute the numbers of causes of death, based on cross-tabulation of the number of deaths for different revisions. Unfortunately, four-digit codes are not available in many countries. Furthermore, this method is quite time-consuming, and the redistribution of deaths in one country is not directly applicable to other countries.

An intermediate approach is to use concordance tables based on three-digit codes without redistributing the numbers of deaths (*7*). These concordance tables often underlie the selection of the codes used for successive ICD revisions in studies on long-term trends in cause-specific mortality (*8–10*). However, it is unclear whether mortality discontinuities caused by changes in ICD codes can be avoided using this intermediate approach.

Moreover, discontinuities in cause-specific trends can also result from incidental changes in coding rules, e.g. changes within ICD revisions in coding rules applied at statistical offices. The extent to which coding problems remain and may bias the study of trends in cause-specific mortality have not yet been estimated systematically. An assessment of the experience in several countries may aid researchers intending to study these long-term trends.

In this study, we evaluated how often coding problems complicate the description of long-term trends in mortality despite the use of a carefully constructed concordance table that is based on the three-digit codes. We used data from six European countries covering a broad selection of specific causes of death between 1950 and 1999. We considered the effect of mortality discontinuities caused by coding changes both between and within ICD revisions. We assessed in which situations (countries, causes of death) these coding changes led to discontinuities and whether adjustment for these discontinuities resulted in different estimates of trends in cause-specific mortality.

Methods

Data were obtained on the underlying cause of death, total mortality and mid-year population for Denmark, England and Wales, Finland, the Netherlands, Norway and Sweden. These data were stratified by year of death (1950–99), sex and five-year age group for people aged 60 and older. Data were obtained from the National Institute of Public Health (Denmark), the Office for National Statistics (England and Wales), Statfin (Finland), Statistics Netherlands, NIDI (Netherlands), Statistics Norway (Norway) and the National Board of Health and Welfare (Sweden). Data were available only from 1951 for Finland and Norway. They were available for Sweden from 1952. Data for Denmark were available from 1951 to 1998.

The number of deaths for each cause of death in the oldest age groups ($\geq$85 for England and Wales and the Netherlands up until 1969, and $\geq$90, $\geq$95 and $\geq$100 for all other countries and periods) were redistributed into five-year age groups up to the age of $\geq$100 years using the distribution observed for total mortality among these age groups. Data on mortality for the oldest age groups were available from the Kannisto-Thatcher Database on Old Age Mortality (*11*).

We selected 26 causes of death, mainly on the basis of their relative importance in old-age mortality (Table 1). For Finland, the registry of causes of death by three-digit code was not available and instead data from aggregated code groups were supplemented with data from specific three-digit codes for the selected causes of death.

Five different revisions of the ICD occurred between 1950 and 1999 (Table 2), but because the codes remained identical in ICD-6 and ICD-7, only four revisions had to be bridged in order to reconstruct the causes of death. For this purpose, we carefully constructed a concordance table using three-digit codes, building on existing concordance tables (*7*, *12*, *13*) and using information from WHO (*14–18*) (Table 1). The basic rule we applied was that we aimed to safeguard the continuity of the medical content on the causes of death. For Denmark, a country-specific adjustment of the concordance table was made in order to include codes 260–265 for diabetes mellitus for the years 1965–68 (K. Juel, National Institute of Public Health, Denmark, personal communication about diabetes codes, June 2002).

The first step in our evaluation was to visually inspect trends in cause-specific mortality for the combined data on men and women aged 60 years and older. In our evaluation of mortality discontinuities we distinguished between those that were the result of revisions to the ICD, those that were the result of incidental changes in coding rules that applied to many causes of death simultaneously, and those that were the result of incidental changes in coding rules that were applied only to a specific cause of death, for example less restrictive coding for diabetes mellitus. In addition, country-specific background information was obtained through personal communication with national statistical offices or related institutes on the possible cause of observed discontinuities and on national coding practices and coding problems.

In the second step, mortality discontinuities resulting from ICD revisions and generally applied incidental changes in coding rules were quantified in cause-specific Poisson regression models and tested for statistical significance at the 95% significance level. The dependent variable was the number of deaths, with the mid-year population used as an offset variable. The independent variables were age (five-year age groups) and year of death (using splines). Spline functions divide the overall trend into a number of separate, adjacent segments (*19*) and allow a detailed description of long-term mortality trends to be made. In our analysis, we used five decade-specific segments (1950–59 to 1990–99). To these regression models we added transition variables indicating the ICD revisions (i.e. ICD-6 and ICD-7 to ICD-8, ICD-8 to ICD-9, or ICD-9 to ICD-10) or the general incidental changes in coding rules.

In the third step, we used two criteria to judge whether significant mortality discontinuities were due to coding problems. The first criterion was to ensure that the significant effect could not be attributed to non-linear trends or to a single outlier, for instance an influenza epidemic nearby. The second criterion was to determine whether the observed effect could be related to the coding problem, for example as a direct result of a change at the level of four-digit codes or as an indirect result of an opposite effect on a complementary cause of death. These judgements were based primarily on visual inspection of cause-specific mortality trends without the use of statistical tests.

The identification of mortality discontinuities was based on the trends for men and women combined because changes in coding rules most likely operate in the same manner for both

Table 1. **The concordance table used for bridging five revisions of the *International Classification of Diseases* (ICD)**

Cause of death	ICD-6 and ICD-7	ICD-8	ICD-9	ICD-10
Infectious and parasitic diseases	001–138	000–136	001–139	A00–B99
Cancer of the oesophagus	150	150	150	C15
Cancer of the stomach	151	151	151	C16
Cancer of the colorectum	153–154	153–154	153–154	C18–C21
Cancer of the pancreas	157	157	157	C25
Cancer of the upper respiratory tract	140–148, 160, 161	140–149, 160, 161	140–149, 160, 161	C00–C14, C30–C32
Cancer of the lung	162–163	162	162	C33–C34
Cancer of the breast	170	174	174–175	C50
Cancer of the prostate	177	185	185	C61
Cancer of the bladder	181	188	188	C67
Cancer of the kidney	180	189	189	C64–C66, C68
Cancers, unspecified	198–199, 230–239	195–199, 230–239	195–199, 235–239	C76–C80, C97, D37–D48
Other cancers	Rest[a] (140–239, 294)	Rest (140–239)	Rest (140–239)	Rest (C00–D48)
Diabetes mellitus	260	250	250	E10–E14
Dementia and Alzheimer disease	304–306	290, 293	290, 331	F00, F01, F03, G30
Ischaemic heart disease	420	410–414	410–414	I20–I25
Other heart diseases	400–402, 410–416, 421–422, 430–434, 440–447	390–398, 400–404, 420–425, 427–429	390–398, 401–405, 416, 420–429	I00–I13, I15, I27, I30–I52
Cerebrovascular diseases	330–334	430–434, 436–438	430–434, 436–438	I60–I69
Other circulatory diseases	Rest (400–468)	Rest (390–458, excluding 435 & 446)	Rest (390–459, excluding 435 & 446)	Rest (I00–I99)
Pneumonia/influenza	480–483, 490–493	470–474, 480–483, 485–486	480–487	J10–J18
Chronic obstructive pulmonary disease	501, 502, 526, 527, 241	490–493, 518	490–494, 496	J40–J47
Senility	794	794	797	R54
Other symptoms and ill-defined conditions	Rest (780–795)	Rest (780–796)	Rest (780–799)	Rest (R00–R99)
Other diseases	Rest (001–795)	Rest (000–796)	Rest (001–799)	Rest (A00–R99)
Accidental fall	E900–904	E880–887	E880–888	W00–W19, X59
Other external causes	Rest (E800–999)	Rest (E800–999)	Rest (E800–999)	Rest (V01–Y98)

[a] Remainder of codes not used in this table.

sexes, at least in regard to the direction of the effect. Outliers (i.e. single years of exceptional cause-specific mortality) were excluded from our analysis. For example, in the Netherlands in 1953 mortality from "external causes" increased as a result of a severe flood (*20*). For a year to be classed as an outlier, the mortality rate had to be significantly different from mortality in the years within the decade, with rate ratios of the parameter estimates at least higher than 1.1 or lower than 0.9.

In order to evaluate whether mortality discontinuities regarded as being related to changes in coding biased the description of long-term trends in cause-specific mortality, we compared observed mortality trends with trends after adjustment. Adjustment involved including the transition variables, that were associated with mortality discontinuities related to coding changes, in the cause-specific and sex-specific regression models. We stratified this analysis by sex because cause-specific mortality trends are likely to be different for the two sexes and consequently the description of the trends may be biased differently for men and women when coding changes are ignored.

Findings

When a concordance table based on three-digit codes is applied to the data, in 191 out of 416 instances of ICD revisions to cause-specific mortality codes significant mortality discontinuities remained (Table 3). Of these significant mortality discontinuities, 24% were not the result of non-linear trends or single outliers, and they were consequently regarded as being due to the ICD revisions. Thus, in 45 out of 416 (10.8 %)

Table 2. **Revisions of the *International Classification of Diseases* (ICD) in 1950–99, by country**

Country	ICD-6	ICD-7	ICD-8	ICD-9	ICD-10
Denmark	1951–57	1958–68	1969–93	NA[a]	1994–98
England and Wales	1950–57	1958–67	1968–78	1979–99	NA
Finland	1951–57	1958–68	1969–86	1987–95	1996–99
France	1950–57	1958–67	1968–78	1979–99	NA
Netherlands	1950–57	1958–68	1969–78	1979–95	1996–99
Norway	1951–57	1958–68	1969–85	1986–95	1996–99
Sweden	1952–57	1958–68	1969–86	1987–96	1997–99

[a] NA = not applicable.

revisions to cause-specific mortality codes, significant mortality discontinuities that were regarded as being due to ICD revisions remained. These ICD-related mortality discontinuities affected 11 out of 26 causes of death, primarily "other heart diseases", ischaemic heart disease, unspecified cancers, other symptoms, infectious diseases, dementia, and "other circulatory diseases". In contrast, the specific cancers that were included in our study did not show ICD-related mortality discontinuities. The proportion of ICD-related mortality discontinuities ranged from 1.9% in Denmark to 16.7% in the Netherlands. The revision from ICD-6 and ICD-7 to ICD-8 was the revision most prone to showing ICD-related discontinuities (16.0 %). The proportion of discontinuities for the revision from ICD-8 to ICD-9 was 10.8% and for ICD-9 to ICD-10 the proportion was 4.6%.

Two generally applied incidental changes in coding rules were identified. In England and Wales a broadening of coding rule 3 in the period 1984–92 caused the conditions directly leading to death being coded for less often, while conditions often mentioned in part II of the death certificate (conditions which contributed to the death but were not part of the direct causal sequence) were coded for more often as the underlying cause of death (*21*). In Sweden, from 1981 onwards some additional coding rules were implemented that had the reverse effect (A. Edberg, National Board of Health and Welfare, Sweden, personal communication, July 2002). These generally applied coding rules affected approximately half of the causes of death under consideration, including the specific cancers. For pneumonia and other heart diseases, both conditions leading directly to death, an important lowering of mortality rates in England and Wales in the period 1984–92 occurred, whereas in Sweden from 1981 onwards mortality associated with these conditions increased. For diabetes mellitus, a disease that is not part of the direct causal sequence, the reverse effects appeared (Table 4, web version only, available at: http://www.who.int/bulletin).

The remaining incidental changes in coding rules (n = 22) occurred primarily in Finland and Sweden (Table 5, web version only, available at: http://www.who.int/bulletin). Eleven of the 26 causes of death were affected, especially diabetes. In eight cases an additional mortality discontinuity occurred as a result of a one-year lag in applying a change in coding rules.

For cerebrovascular diseases, controlling for the incidental change in the coding rules in England and Wales (1984–92) and Finland (1956–58) led to significant changes in annual decade-specific mortality in England and Wales in the 1980s and 1990s, but a change in trend did not occur in Finland in the 1950s (Table 6). A change in trend also occurred for other causes of death subject only to incidental changes (i.e. most specific cancers, chronic obstructive pulmonary disease and accidental falls). The changes, however, were often insignificant, and the major changes were restricted to a limited period (data not shown).

For ischaemic heart disease, the revision from ICD-6 and ICD-7 to ICD-8 led to a significantly altered description of the mortality trend in all countries in the 1960s, and sometimes also affected the trends in the 1950s or the 1970s, or both. Controlling mainly for ICD revisions also led to significant changes in mortality trends for infectious diseases and unspecified cancers, although they were less pronounced (data not shown).

For diabetes mellitus, controlling for a large number of mortality discontinuities changed the mortality trends significantly, affecting the annual changes not only in size but also in direction in a number of decades, especially in the Netherlands and Sweden. Controlling for a combination of different coding problems also led to a significant change in almost the entire trend for dementia, other heart diseases and pneumonia (data not shown).

Discussion

Despite using a concordance table based on three-digit ICD codes, in 10.8% of the revisions to codes for cause-specific mortality, significant discontinuities, regarded as being due to ICD revisions, remained. Especially affected were the revisions from ICD-6 and ICD-7 to ICD-8 and a wide range of causes of death, with the exception of the specific cancers. Incidental changes in coding rules were important causes of discontinuities in cause-specific mortality trends as well, especially in England and Wales, Finland and Sweden. Adjusting for these discontinuities can lead to significant changes in trends in cause-specific mortality, although these primarily affect only limited periods of time.

The range in differences between countries in terms of ICD-related mortality discontinuities (1.9 % for Denmark to 16.7 % for the Netherlands) could partly be due to an underestimation of the percentage for Denmark caused by the lack of implementation of ICD-9. As for the revision of ICD-8 to ICD-9, in general fewer mortality discontinuities were observed. However, it is most likely that the differences between countries are related to differences in applying the ICD revisions.

Evaluation of data and methods

In this paper we developed a method to evaluate and adjust for mortality discontinuities caused by coding problems. A major advantage of our method when compared to the bridge coding

Table 3. **Mortality discontinuities by country, cause of death and revision of *International Classification of Diseases* (ICD) for men and women aged 60 years and older, 1950–99**[a]

Cause of death	ICD revision	Transition rate[b]					
		Denmark[c]	England and Wales	Finland	Netherlands	Norway	Sweden
Infectious diseases	6/7 to 8	**1.56**	0.83	1.23	**1.74**	**1.74**	**1.32**
	8 to 9	—[d]	1.07	NS[e]	NS	NS	NS
	9 to 10	NS	—	1.20	NS	NS	1.12
Cancer of the oesophagus	6/7 to 8	NS	NS	NS	NS	NS	NS
	8 to 9	—	NS	NS	NS	NS	NS
	9 to 10	NS	—	NS	NS	NS	NS
Cancer of the stomach	6/7 to 8	NS	NS	NS	0.93	0.93	NS
	8 to 9	—	NS	NS	NS	NS	NS
	9 to 10	NS	—	NS	NS	NS	NS
Cancer of the colorectum	6/7 to 8	NS	1.05	NS	NS	0.92	1.07
	8 to 9	—	0.97	NS	NS	NS	NS
	9 to 10	NS	—	NS	NS	NS	NS
Cancer of the pancreas	6/7 to 8	NS	NS	NS	NS	NS	NS
	8 to 9	—	NS	NS	NS	NS	NS
	9 to 10	NS	—	NS	NS	NS	NS
Cancer of the upper respiratory tract	6/7 to 8	NS	1.07	NS	NS	NS	NS
	8 to 9	—	1.04	NS	NS	NS	NS
	9 to 10	NS	—	NS	NS	NS	NS
Cancer of the lung	6/7 to 8	NS	0.98	NS	0.96	NS	1.06
	8 to 9	—	NS	NS	0.97	NS	NS
	9 to 10	1.06	—	NS	NS	NS	NS
Cancer of the breast	6/7 to 8	NS	NS	NS	0.95	0.90	1.15
	8 to 9	—	NS	NS	NS	NS	NS
	9 to 10	NS	—	NS	NS	NS	NS
Cancer of the prostate	6/7 to 8	NS	NS	1.15	0.88	NS	1.13
	8 to 9	—	NS	NS	NS	NS	NS
	9 to 10	NS	—	NS	0.93	NS	1.05
Cancer of the bladder	6/7 to 8	NS	NS	NS	NS	NS	NS
	8 to 9	—	0.96	NS	NS	NS	NS
	9 to 10	NS	—	0.81	NS	NS	NS
Cancer of the kidney	6/7 to 8	1.15	NS	NS	0.90	NS	1.21
	8 to 9	—	NS	NS	NS	NS	NS
	9 to 10	NS	—	NS	NS	NS	NS
Cancers, unspecified	6/7 to 8	0.77	**1.07**	NS	**1.39**	**1.47**	**1.18**
	8 to 9	—	**1.24**	0.89	0.83	1.11	NS
	9 to 10	0.90	—	NS	1.05	0.88	1.06
Other cancers	6/7 to 8	NS	0.98	0.93	**0.85**	**0.89**	1.03
	8 to 9	—	0.99	NS	1.03	NS	1.07
	9 to 10	NS	—	NS	NS	1.08	NS
Diabetes mellitus	6/7 to 8	NS	NS	NS	**0.67**	NS	0.90
	8 to 9	—	0.92	1.30	**0.82**	NS	NS
	9 to 10	0.84	—	NS	1.20	NS	NS
Dementia and Alzheimer disease	6/7 to 8	0.96	0.92	0.64	0.78	NS	NS
	8 to 9	—	**1.92**	0.93	0.55	**1.91**	**1.48**
	9 to 10	1.05	—	**1.37**	0.73	NS	1.27
Ischaemic heart disease	6/7 to 8	0.87	**1.12**	**1.08**	**1.13**	**1.32**	**1.23**
	8 to 9	—	0.95	NS	**0.94**	NS	0.93
	9 to 10	0.97	—	0.94	NS	NS	0.97
Other heart diseases	6/7 to 8	0.73	**0.76**	**0.68**	**0.83**	**0.50**	**0.51**
	8 to 9	—	**1.18**	0.96	**1.20**	NS	**1.29**
	9 to 10	1.10	—	1.06	0.89	NS	1.07
Cerebrovascular diseases	6/7 to 8	0.91	1.03	0.88	NS	1.03	NS
	8 to 9	—	0.99	0.93	0.97	NS	NS
	9 to 10	0.95	—	NS	0.94	NS	1.05

(Table 3, cont.)

Cause of death	ICD revision	Transition rate[b]					
		Denmark[c]	England and Wales	Finland	Netherlands	Norway	Sweden
Other circulatory diseases	6/7 to 8	1.11	1.12	1.14	**1.43**	1.09	0.95
	8 to 9	—	0.89	NS	**0.92**	**0.89**	NS
	9 to 10	0.92	—	**1.17**	NS	NS	NS
Pneumonia/influenza	6/7 to 8	0.94	1.19	1.53	**2.08**	1.14	NS
	8 to 9	—	0.95	NS	NS	NS	**0.84**
	9 to 10	0.77	—	NS	0.89	**0.62**	0.82
Chronic obstructive pulmonary disease	6/7 to 8	0.77	0.99	0.87	0.86	NS	0.83
	8 to 9	—	1.17	0.93	0.86	NS	NS
	9 to 10	NS	—	1.14	1.08	NS	NS
Senility	6/7 to 8	0.83	NS	0.76	1.06	0.84	NS
	8 to 9	—	0.82	0.58	0.69	NS	NS
	9 to 10	0.86	—	NS	0.93	0.76	NS
Other symptoms and ill-defined conditions	6/7 to 8	NS	**1.68**	NS	1.13	**0.90**	0.74
	8 to 9	—	**0.31**	0.51	**0.47**	1.10	NS
	9 to 10	NS	—	NS	1.15	0.70	**2.04**
Other diseases	6/7 to 8	0.80	NS	0.82	NS	0.89	NS
	8 to 9	—	NS	1.18	1.25	NS	1.15
	9 to 10	1.05	—	**0.83**	0.98	1.09	**0.92**
Accidental fall	6/7 to 8	0.84	1.13	NS	0.94	NS	1.41
	8 to 9	—	0.96	NS	NS	NS	1.16
	9 to 10	NS	—	1.15	NS	1.11	1.38
Other external causes	6/7 to 8	NS	0.91	NS	NS	NS	NS
	8 to 9	—	1.10	1.22	NS	NS	0.94
	9 to 10	NS	—	NS	NS	1.18	NS

[a] Values in bold indicate that the mortality discontinuity cannot be attributed to non-linear trends or a single outlier.
[b] The relative size of the increase or lowering of the fitted mortality rate for the period immediately after the coding change compared with the mortality rate immediately before.
[c] For Denmark the ICD revision 9 to 10 is actually from ICD-8 to ICD-10; ICD-9 was not used.
[d] — = not applicable
[e] NS = parameter estimate is not significant.

method (*2*) is that our method can detect incidental changes in coding rules. In comparison to the method developed by Vallin & Meslé our method can be easily applied to other countries and can be extended to new ICD revisions fairly easily. Moreover, estimates of discontinuities observed using our method can easily be taken into account in trend analyses using regression or related techniques.

Inherent in our adjustment method is the assumption that the relative increase or decrease in mortality is equal in all years prior to or after the transition. For ischaemic heart disease, however, inclusion of code 422.1 in ICD-6 and ICD-7 for England and Wales and Norway, which was done to ensure better comparability with codes in ICD-8 (*22*), gave different results than our adjustment, primarily due to a change in the frequency of use of this code throughout ICD-6 and ICD-7. Although we could not explicitly check this assumption for other causes of death, note that the mortality discontinuity for ischaemic heart disease that appeared during the transition to ICD-8 is much more pronounced in absolute terms than the transitions for other causes of death.

The transition coefficients we found for people aged 60 and older cannot be applied directly to other age groups. A comparison of the transition rates for people aged ⩾60 and ⩾80 yielded changes greater than 10% in almost half of the cases (data not shown). Therefore, adjustment should be age-specific.

Persisting problems in studies of long-term mortality trends

The comparability of cause of death statistics over time is affected not only by ICD revisions or incidental changes in coding rules but also by changes in the reporting of the cause of death on death certificates and by changes in the number of deaths from ill-defined causes and other unspecified causes (*1*, *4*).

Changes in the reporting of causes of death on the death certificate may be the result of developments in medical science or the use of new diagnostic techniques as well as changes in concepts of diseases (*1*). For example, a growing propensity for physicians to report dementia as an underlying cause of death may have contributed to the large annual increases in mortality from "dementia and Alzheimer disease" among elderly people aged 80 years and older in a number of north-western European countries in the 1980s and 1990s (*23*). Part of the increase in mortality rates from chronic obstructive pulmonary disease may be the result of increased diagnosis and changes in how physicians code for the disease (*24*, *25*).

An increase in the number of deaths from "symptoms and ill-defined conditions" may be the result of both stricter diagnostic criteria for a given specific disease and a real increase in unknown causes (*26*). However, mortality trends in "symptoms and ill-defined conditions" are also often closely related to the quality and the accuracy of the diagnosis (*1*, *26*) (F. Meslé, unpublished data presented October 2000). For example, the

Table 6. **Decade-specific mortality trends for selected causes of death, 1950–99, before and after controlling for mortality discontinuities resulting from coding problems with the *International Classification of Diseases* (ICD) by country and sex for people aged 60 years and older.** Each cause of death considered is typical of a specific type of coding change

Disease and country	Trend	Annual changes (%)[a]									
		Men					Women				
		1950s	1960s	1970s	1980s	1990s	1950s	1960s	1970s	1980s	1990s
Cerebrovascular diseases											
England and Wales	Observed	-0.13	-1.17	-2.92	**-2.30**	**-3.96**	-0.52	-1.29	-2.69	**-2.25**	**-3.43**
	Controlled for coding change 1984–92	-0.13	-1.16	-2.96	**-3.22**	**-2.54**	-0.52	-1.28	-2.73	**-3.05**	**-2.19**
Finland	Observed	0.25	-1.04	-4.10	-2.08	-2.77	-0.86	-2.21	-5.46	-1.35	-3.45
	Controlled for coding change 1956–58	0.18	-0.78	-4.16	-2.06	-2.78	-1.02	-1.73	-5.58	-1.32	-3.46
Ischaemic heart disease											
England and Wales	Observed	**3.70**	**2.89**	-0.09	-1.49	-3.83	**3.43**	**3.87**	**-0.58**	-1.04	-3.72
	Controlled for revision from ICD-6/ ICD-7 to ICD-8	**3.95**	**2.10**	-0.17	-1.47	-3.84	**4.09**	**1.81**	**-0.77**	-0.99	-3.73
Finland	Observed	3.77	4.22	-0.50	-1.44	-3.40	3.74	**5.45**	-1.12	-0.49	-2.60
	Controlled for revision from ICD-6/ ICD-7 to ICD-8	3.98	3.73	-0.61	-1.41	-3.41	4.37	**3.98**	-1.41	-0.42	-2.62
Netherlands	Observed	5.96	**4.18**	-0.43	-2.68	-3.88	**4.45**	**3.40**	-1.56	**-3.08**	-3.25
	Controlled for revision from ICD-6/ ICD-7 to ICD-8 and ICD-8 to ICD-9	6.39	**3.12**	-0.14	-2.44	-3.97	**5.37**	**1.06**	-1.36	**-2.73**	-3.38
Norway	Observed	**5.89**	**5.45**	**-0.49**	-0.71	-4.11	**2.29**	**6.52**	**-1.50**	-1.01	-3.32
	Controlled for revision from ICD-6/ ICD-7 to ICD-8	**6.91**	**3.15**	**-0.97**	-0.58	-4.16	**4.20**	**1.91**	**-2.34**	-0.79	-3.40
Sweden	Observed	**2.77**	**6.40**	**0.81**	**-3.93**	-3.69	**-0.24**	**6.23**	**-0.83**	**-4.88**	-3.25
	Controlled for revision from ICD-6/ ICD-7 to ICD-8 and coding change from 1970 onwards	**4.02**	**3.82**	**-0.02**	**-3.72**	-3.78	**1.39**	**2.72**	**-1.81**	**-4.63**	-3.35
Diabetes mellitus											
Denmark	Observed[b]	4.34	**6.17**	-1.36	3.07	0.85	0.59	**6.52**	-3.72	0.51	-0.48
	Controlled for coding change from 1965 onwards	4.50	**-3.09**	-0.19	2.74	1.11	0.58	**-4.40**	-2.31	0.10	-0.12
England and Wales	Observed	-0.84	3.72	-0.33	**5.34**	**-5.55**	-1.76	1.89	-2.82	**4.56**	**-6.55**
	Controlled for coding change 1984–92	-0.87	3.79	-0.55	**1.50**	**0.08**	-1.78	1.95	-3.02	**0.43**	**-0.47**
Netherlands	Observed[c]	3.77	**-1.68**	**-4.52**	**10.22**	**-3.65**	2.84	**-3.47**	**-6.86**	**8.79**	**-5.14**
	Controlled for revision from ICD-6/ ICD-7 to ICD-8, ICD-8 to ICD-9, and coding change from 1984 onwards	2.87	**0.93**	**-1.02**	**-2.19**	**-1.82**	1.84	**-0.52**	**-3.40**	**-3.12**	**-3.38**
Norway	Observed	0.69	-1.60	4.12	1.68	2.54	2.27	-4.40	1.84	0.72	**1.62**
	Controlled for coding change from 1996 onwards	0.67	-1.53	3.91	2.31	-0.63	2.24	-4.32	1.54	1.67	**-3.31**
Sweden	Observed[d]	4.28	**1.89**	**-2.58**	**1.57**	1.32	2.37	**0.92**	**-4.01**	**-1.11**	0.04
	Controlled for coding change from 1981 onwards	3.03	**4.38**	**0.96**	**3.67**	0.69	1.14	**3.45**	**-0.14**	**1.30**	-0.74

[a] Trend estimates in bold denote a significant difference between observed annual changes and annual changes after controlling for mortality discontinuities arising from coding problems.
[b] Data for 1995–98 were excluded due to very erratic trend.
[c] Data for 1971 were excluded due to exceptionally high mortality rate.
[d] Data for 1970–80 were excluded due to very erratic trend.

increase in "symptoms and all ill-defined conditions" among people aged 80 years or older in Denmark, England and Wales, the Netherlands and Sweden from the 1980s onwards (*23*) may partly be the result of less detailed and less accurate diagnosis and reporting by physicians.

Both problems can bias mortality trends in other causes of death as well. For example, the increasing tendency to report "symptoms and ill-defined conditions" such as "sudden death" as the underlying cause of death may result in an underestimation of an increase (or overestimation of a decrease) in mortality from

cardiovascular diseases (*26*). Unfortunately, there are no formal methods that can be used to cope with changes in the reporting of causes of death on the death certificate because they result in gradual shifts that are difficult to detect and quantify (*4*). The number of deaths attributed to ill-defined or unknown causes are increasingly being redistributed by researchers among specific causes (*5*, *27*). This applies especially to heart disease; it is less common for cancer-related deaths (F. Meslé, unpublished data presented October 2000). However, it remains unclear whether these reclassifications, which are based on assumptions about, among others, the distribution of ill-defined or unknown causes among specific causes of death, actually lead to improvements in assessing long-term trends in cause-specific mortality. Aggregating ill-defined causes of death with specific causes probably will improve the comparability of data over time but information on specific causes of death will be lost, and this may be an unacceptable loss in many cases.

Conclusions

When describing long-term trends in cause-specific mortality, evaluating and adjusting for mortality discontinuities caused by coding changes between and within ICD revisions is essential because these changes can substantially bias the description and analysis of cause-specific trends in mortality. An accurate and fairly easy method for evaluating and adjusting for these coding-related mortality discontinuities has been proposed in this paper — that is, a combination of visual inspection of the trends and the use of a formal regression method after application of a concordance table based on three-digit ICD codes. The other problems that remain when studying long-term trends in cause-specific mortality, such as changes in the reporting of causes of death by physicians, should always be taken into account when interpreting these trends. ■

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Résumé

Modifications de la codification selon la Classification internationale des maladies (CIM) et discontinuités des tendances de la mortalité par cause dans six pays européens, 1950-99

Objectif Évaluer la manière dont les fréquentes modifications de la codification entre les révisions de la *Classification internationale des maladies* (CIM) et au cours de celles-ci compliquent la description des tendances à long terme de la mortalité par cause.

Méthodes Des données relatives à la mortalité par cause des hommes et des femmes de 60 ans et plus entre 1950 et 1999 ont été obtenues auprès de l'Angleterre et du Pays de Galles, du Danemark, de la Finlande, de la Norvège, des Pays-Bas et de la Suède. Ces données ont été fournies par tranche d'âge de cinq ans. Les auteurs ont construit un tableau de concordance à l'aide des codes CIM à trois caractères. Ils ont également évalué l'apparition de discontinuités de la mortalité en examinant visuellement les tendances de la mortalité par cause et les informations générales particulières aux différents pays. L'évaluation a aussi été réalisée à partir d'une quantification des discontinuités par un modèle de régression de Poisson (comprenant des fonctions splines périodiques). Les auteurs ont comparé les tendances observées pour la mortalité par cause avec les tendances de cette mortalité après ajustement pour les discontinuités provoquées par les modifications de codification.

Résultats Dans 45 des 416 cas (10,8 %) de révision de la CIM portant sur les codes de mortalité par cause, il est resté des discontinuités importantes, qui ont été considérées comme dues aux révisions de la CIM. Les révisions de la CIM-6 et des CIM-7 et CIM-8, ainsi qu'une large palette de causes de décès, à l'exception des cancers spécifiques, étaient particulièrement concernées. Des modifications imprévues des règles de codification ont constitué également d'importantes causes de discontinuité dans les tendances de la mortalité par cause, notamment en Angleterre et au Pays de Galles, en Finlande et en Suède. L'ajustement pour tenir compte de ces discontinuités peut conduire à des variations notables des tendances, bien que ces variations n'affectent principalement que des périodes de temps limitées.

Conclusion En dépit du tableau de concordance soigneusement établi à partir des codes CIM à trois caractères, les discontinuités de la mortalité résultant des modifications de codification (tant entre les révisions qu'au cours de celles-ci) peuvent entraîner des variations substantielles des tendances à long terme de la mortalité par cause. Il conviendrait donc que ces modifications de codification soient évaluées par des chercheurs et, si besoin est, prises en compte.

Resumen

Cambios de codificación de la CIE y discontinuidades en las tendencias de la mortalidad por causas específicas en seis países europeos, 1950–1999

Objetivo Evaluar con qué frecuencia los cambios de codificación entre y dentro de las revisiones de la Clasificación Internacional de Enfermedades (CIE) complican la descripción de las tendencias a largo plazo de la mortalidad por causas específicas.

Métodos Se obtuvieron datos de Dinamarca, Inglaterra y Gales, Finlandia, los Países Bajos, Noruega y Suecia sobre la mortalidad por causas específicas de hombres y mujeres de 60 y más años entre 1950 y 1999. Los datos correspondían a grupos de edad de cinco años. Construimos un cuadro de concordancia con los códigos de tres dígitos de la CIE. Además evaluamos la aparición de discontinuidades de la mortalidad examinando visualmente las tendencias por causas específicas y los antecedentes propios de cada país. Como parte de la evaluación, asimismo, se cuantificaron las discontinuidades mediante el modelo de regresión de Poisson (incluida interpolación polinómica). Comparamos las tendencias observadas en la mortalidad por causas específicas con las tendencias obtenidas tras ajustar en función de las discontinuidades causadas por los cambios de codificación.

Resultados De 416 casos de revisión de la CIE que afectaban a códigos de mortalidad por causas específicas, en 45 (10,8%) seguía habiendo discontinuidades significativas que se atribuyeron a las revisiones de la CIE. El problema se centraba especialmente en los cambios introducidos entre las clasificaciones CIE-6 y CIE-7 y la CIE-8 y en una amplia variedad de causas de defunción, exceptuando cánceres específicos. Algunos cambios secundarios de las reglas de codificación eran también una causa importante de discontinuidad en las tendencias de la mortalidad por causas específicas, sobre todo en Inglaterra y Gales, Finlandia y Suecia. El ajuste para estas discontinuidades puede alterar notablemente las tendencias, aunque la mayoría de los cambios afectan sólo a periodos limitados.

Conclusión Pese a usar un cuadro de concordancia cuidadosamente elaborado con los códigos de tres dígitos de la CIE, las discontinuidades de la mortalidad resultantes de los cambios de codificación (tanto entre revisiones como dentro de ellas) pueden modificar sustancialmente las tendencias a largo plazo de la mortalidad por causas específicas. Por consiguiente, es preciso que los investigadores evalúen los cambios de codificación y que cuando sea necesario controlen ese factor.

Arabic

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Table 4. **Significant mortality discontinuities resulting from generally applied changes in coding rules in the *International Classification of Diseases*, 1950–99 by cause of death for men and women aged 60 years and older**[a]

Cause of death	Transition Rate[b,c]	
	England and Wales, 1984–92	Sweden from 1981 onwards
Infectious diseases	1.11	NS
Cancer of the oesophagus	NS[d]	NS
Cancer of the stomach	1.03	NS
Cancer of the colorectum	**1.03**	0.89
Cancer of the pancreas	**1.04**	NS
Cancer of the upper respiratory tract	NS	**0.84**
Cancer of the lung	1.02	0.93
Cancer of the breast	**1.05**	NS
Cancer of the prostate	NS	**0.77**
Cancer of the bladder	NS	**0.85**
Cancer of the kidney	1.04	**0.87**
Cancers, unspecified	**0.96**	1.07
Other cancers	**1.05**	**0.86**
Diabetes mellitus	**1.45**	**0.50**
Dementia and Alzheimer disease	**2.18**	1.57
Ischaemic heart disease	1.01	NS
Other heart diseases	**0.87**	**1.54**
Cerebrovascular diseases	**1.08**	0.96
Other circulatory diseases	**0.90**	1.27
Pneumonia/influenza	**0.52**	**1.28**
Chronic obstructive pulmonary disease	1.08	0.86
Senility	0.80	NS
Other symptoms and ill-defined conditions	NS	1.39
Other diseases	**1.23**	0.86
Accidental fall	1.03	**0.53**
Other external causes	1.07	0.91

[a] Table shows discontinuities at 95% significance.
[b] The relative size of the increase or lowering of the fitted mortality rate for the period immediately after or during the coding change compared with the mortality rate immediately before or adjacent to the coding change.
[c] Values in bold indicate that mortality discontinuity cannot be attributed to non-linear trends or a single outlier.
[d] NS = parameter estimate is not significant.

Table 5. **Cause-specific mortality discontinuities resulting from incidental changes in coding rules in the *International Classification of Diseases*, 1950–99, for men and women aged 60 years and older, by country**

Country	Cause of death	Period	Cause of irregularity	Transition rate[a]
Denmark	Diabetes mellitus	1965 onwards	Less restrictive practice in coding diabetes as the underlying cause of death from 1965 onwards[b]	2.30
Denmark	Other diseases	1965 onwards	Less restrictive practice in coding diabetes as the underlying cause of death from 1965 onwards[b]	0.95
England and Wales	Diabetes mellitus	1984	One-year lag in change in coding rule 1984–92	0.90
Finland	Infectious diseases	1956–58	Change in coding rule	1.21
Finland	Dementia and Alzheimer disease	1956–58	Change in coding rule	0.00
Finland	Other heart diseases	1956–58	Change in coding rule	0.85
Finland	Cerebrovascular diseases	1956–58	Change in coding rule	1.14
Finland	Other circulatory diseases	1962 onwards	Change in coding rule	1.52
Finland	Other circulatory diseases	1962	One-year lag in change in coding rule from 1962 onwards	0.87
Finland	COPD[c]	1956–58	Change in coding rule	1.43
Finland	Other diseases	1956–58	Change in coding rule	1.21
Netherlands	Diabetes mellitus	1984 onwards	More strict application of the ICD rule that codes diabetes as an underlying cause when circulatory diseases are intermediate causes (*28*)	2.70
Netherlands	Diabetes mellitus	1984	One-year lag in change in coding rule from 1984 onwards	0.47
Netherlands	Diabetes mellitus	1985	Lag in change in coding rule from 1984 onwards	0.67
Norway	Diabetes mellitus	1997 onwards	From 1997 onwards Statistics Norway asked for additional information when diabetes mellitus was unspecified (i.e. type, complication, duration and whether it should be the underlying cause of death). This led to more specific diagnoses and to diabetes being coded more often as the underlying cause of death[d]	1.43
Norway	Dementia and Alzheimer disease	1986	One-year lag in the introduction of ICD-9	0.82
Sweden	Ischaemic heart disease	1970 onwards	Change in coding rule	1.08
Sweden	Ischaemic heart disease	1970	One-year lag in change in coding rule from 1970 onwards	0.93
Sweden	Other heart diseases	1970 onwards	Change in coding rule	0.56
Sweden	Pneumonia/influenza	1970 onwards	Change in coding rule	0.38
Sweden	Pneumonia/influenza	1970	One-year lag in change in coding rule from 1970 onwards	1.83
Sweden	Accidental fall	1981	One-year lag in change in coding rule from 1981 onwards	1.29

[a] The relative size of the increase or lowering of the fitted mortality rate for the period immediately after or during the coding change compared with the mortality rate immediately before or adjacent to the coding change.
[b] Background information derived from personal communication with Knud Juel (National Institute of Public Health, Denmark).
[c] COPD = chronic obstructive pulmonary disease.
[d] Background information derived from personal communication with Anne Gro Pedersen (Statistics Norway).