RESEARCH REPORT

Avoidable mortality in Europe (1980–1997): a comparison of trends

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Study objective: To analyse international variations of trends in ''avoidable'' mortality (1980–1997).
Design: A multilevel model was used to study trends in avoidable and ''non-avoidable'' mortality and trends by cause of death.
Setting: Fifteen countries of the European Union, the Czech Republic, and Hungary.
Participants: 19 avoidable causes of death among men and women aged 0–64 years. Mortality and population data were derived from the WHO mortality database; and perinatal mortality rates, from the Health for All statistical database.
Main results: Avoidable mortality declined (1980–1997) in all the countries except Hungary. The difference between the trends in avoidable and non-avoidable mortality was small (−2.4% compared with −1.5%) and diminished over time. The largest trend variations between countries are attributable to causes mainly or partly amenable to prevention. For five of the 19 causes of death the international variations diminished over time. Various countries show trends that deviate significantly ($p<0.003$) from the mean trend.
Conclusions: One explanation for the small and diminishing difference between avoidable and non-avoidable mortality is that some large avoidable causes show unfavourable trends. Another possible explanation is that the category of non-avoidable mortality is ''polluted'' by causes that have become avoidable with time. It is therefore suggested that Rutstein's lists of avoidable outcomes (1976) be updated to enable the appropriate monitoring of healthcare effectiveness. In countries that show unfavourable developments for specific avoidable causes, further research must unravel the causes of these trends.

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In 1976, Rutstein *et al* systematically identified health outcomes (death, disease, and disability) that may be considered avoidable, given the medical knowledge available then.[1] ''Avoidable'' here means that the excess occurrence of these outcomes points to potential problems in health care. The lists with outcomes were updated only once, in 1980,[2] so they are now almost 25 years old. Despite their age, Rutstein's lists are still used to study variations in avoidable mortality, for example between regions, between countries, or in time. These variations provide a signal to healthcare workers and policy makers, which may prompt further investigation.

Avoidable mortality has been analysed in individual countries[3–6] and also within Europe.[7–12] Only a few studies have dealt with international trends in mortality.[9 11 13] One of the conclusions of these studies is that the reduction of mortality was generally greater for avoidable causes than for all cause or other mortality. Charlton *et al* concluded this from a study of the period 1950–1980[9]; Simonato *et al*, from an analysis of the period 1955–1994[11]; and Kjellstrand *et al*, from a study on trends between 1980 and 1990.[13]

We studied international variations in mortality in Europe for a broad range of causes in the period 1980–1997. Our first aim was to examine whether avoidable mortality is still declining faster than other—that is, non-avoidable mortality (which would indicate that the term ''avoidable'' is still warranted). Our second aim was to study the trends in avoidable mortality by cause of death and by country in the more recent years, 1989–1997.

METHODS

We studied 19 avoidable causes of death for those 0–64 years old (table 1). Our selection was based on the selection from the European Community (EC) Working Group.[7 8] They chose causes of death from Rutstein's lists (1976)[1] representing the outcomes of both healthcare interventions (appendicitis, Hodgkin's disease, etc) and national health policies (for example, lung cancer and liver cirrhosis). We did not study all the causes of death in the EC Working Group's selection because of insufficient numbers of deaths in some countries that were associated with abdominal hernia, maternal deaths, and some infectious diseases (typhoid, whooping cough, tetanus, measles, and osteomyelitis).

Age and sex specific mortality rates were derived from the WHO Mortality Database, WHO Geneva, version of 14 July 2000. Perinatal mortality/1000 deliveries was available from the Health for All (HFA) Statistical Database, WHO Regional Office for Europe, Copenhagen, Denmark, version of July 2000. Data from 17 countries were used (table 2).

Analysis was restricted to mortality below the age of 65. We calculated the age and sex standardised mortality rates using the European standard population[14] and weighting both sexes equally. Directly standardised rates were plotted against the calendar year for each country. SAS PROC MIXED was used to fit a multilevel (random slope) model to the data. We used this model as we thought there might be both a general Europe-wide trend and individual differences in trends between countries. Both effects are modelled simultaneously in a random slope model, which makes it easy to test whether trends in individual countries differ from the general trend. We preferred modelling of directly standardised rates over Poisson regression of age and sex specific data, as the latter yields less comparable, indirectly standardised rates.[15]

We used the following model:

- $M_{it} = \alpha_0+\alpha_i+\beta_0 t+\epsilon_{it}$, where M_{it} is the standardised mortality rate in year t for country i, α_0 and β_0 are the intercept and slope for all countries on average, α_i and β_i are the

Table 1 Selected causes of death and ICD codes

Cause of death	ICD 8	ICD 9
Tuberculosis	010–019	010–018, 137
Appendicitis	540–543	540–543
Lung cancer	162	162
Bladder cancer	188	188
Liver cancer	155	155.0
Testis cancer	186	186
Liver cirrhosis	571	571
Perinatal	760–778	760–779
Motor vehicle accidents	E810–823	E810–819
Skin cancer	172–173	172–173
Breast cancer	174	174
Cervix cancer	180	180
Hodgkin's disease	201	201
CVA/hypertension	400–404, 430–8	401–405, 430–438
Asthma/bronchitis/emphysema	490–493	490–493
Cholelithiasis/cholecystitis	574–575	574–575.1, 576.1
Pneumonia/influenza	481–486	480–486, 487
Leukaemia	204–208	204–208
Chronic rheumatic heart disease	393–398	390–398, 242

ICD, International Classification of Diseases of the World Health Organisation; CVA, cardiovascular accident.

deviations of the intercept and slope of country i from this average, and ϵ_{ij} is an error term with mean 0. We used this model and Bonferroni adjustment to calculate which countries had a β_i that differed significantly from 0. In other words, we indicated which countries have mortality rates that decreased significantly faster or slower than the average decrease over all countries.

As important extra-Poisson variation existed in the data, we calculated the variance ϵ_{it} as:

$$Var(\varepsilon_{it} = \left[\frac{1}{n}SSE_i - \frac{1}{n}\sum_t E(var_P(i,t))\right] + E(var_P(i,t))$$

where E(var$_P$) is the expected variance based on the Poisson distribution as calculated from the numbers of death, *SSE* is the sum of the squared residuals around the regression line, and n is the number of years for which a standardised rate is available.

The relative decrease of mortality was studied with similar models using $\log(M_{it})$ as a dependent variable.

In many cases, the country specific slope β_i correlated negatively (and statistically significantly) with the country specific intercept α_i This indicates that mortality decreases faster in countries that start with high mortality. Such a "catch up" phenomenon is to be expected. We were also interested in which countries have mortality rates that decreased significantly faster or slower than the average decrease over all countries after we took this "catch up" phenomenon into account. To estimate this, we refitted the model with an extra term $\gamma_0\ \hat{M}_{i,1989}$, where $\hat{M}_{i,1989}$ is the mortality rate in 1989 as estimated by a previous model, restraining the covariance of α_i and β_i to 0. This model was iteratively refitted until $\hat{M}_{i,1989}$ no longer changed.

Table 2 Countries under study and the periods for which mortality data were available

Country	Period in which data were available
Belgium	1980–1994
Denmark	1980–1996
Germany	1980–1998
Finland	1980–1996
France	1980–1997
Greece	1980–1997
Hungary	1980–1998
Ireland	1980–1996
Italy	1980–1996
Luxembourg	1980–1997
Netherlands	1980–1997
Austria	1980–1998
Portugal	1980–1998
Spain	1980–1997
Czech Republic	1980–1998
Sweden	1980–1996
United Kingdom	1980–1998

RESULTS

Avoidable mortality in absolute numbers declined between 1980 and 1997 in the selected European countries with the exception of Hungary (which showed an increase of 14.9 deaths/100 000 people over 10 years). Because of its exceptional position (fig 1), Hungary was excluded from the analysis. Non-avoidable mortality, in absolute numbers, declined faster than avoidable mortality (−27.1/100 000 versus −25.3/100 000 over 10 years), but the difference was not significant ($p = 0.7$). There was also no significant difference in the rate of decline between the first half of the period (1980–1989) and the second half (1989–1997) ($p = 0.07$).

Six countries became EC members during the study period: Greece (1981), Portugal and Spain (1986), and Finland, Austria, and Sweden (1995). Political changes in the Czech Republic took place in 1989. We investigated whether the trends in all avoidable and non-avoidable mortality were different in Spain before and after 1986 and in the Czech Republic before and after 1989. Only for avoidable mortality in Spain were there statistically significant differences between the two periods—the decline was only present in the first period. There were not enough data available to make comparisons for Portugal, Greece, Finland, Austria, and Sweden for the periods before and after they joined the EC.

From the viewpoint of healthcare effectiveness, we are also interested in proportional declines in mortality because they give insight into the possible contribution of medical interventions to the mortality decline independently of the number of death causes. The rate of avoidable mortality between 1980 and 1997 diminished faster than the rate of non-avoidable mortality (−2.4%/year versus −1.5%/year). There is a significant difference between the trends in avoidable and non-avoidable mortality ($p = 0.002$). The annual decrease in the first half of the period (1980–1989)

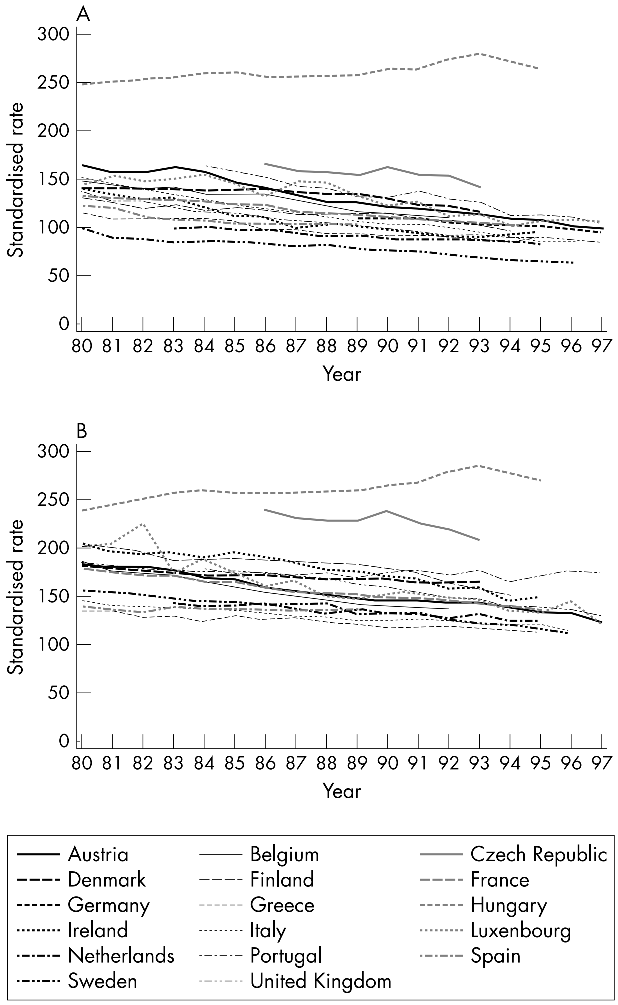

Figure 1 Trends in 17 European countries, 1980–1997: (A) avoidable mortality; (B) non-avoidable mortality.

was 2.5% for avoidable mortality and 1.4% for non-avoidable mortality ($p = 0.006$). Between 1989 and 1997, the percentages were 2.5 and 1.8 ($p = 0.03$). This means that the proportional decline of non-avoidable mortality accelerated in contrast with the decline of avoidable mortality, and that the difference between the declining rates decreased. We added the variation of decline between countries to the model, which statistically significantly improved the fit of the model for both periods and for both avoidable and non-avoidable mortality. This shows that the rates of decline differed by country (table 3).

We studied trends in individual causes in detail for the period 1989–1997. The starting levels in 1989 varied greatly, from 0.07 deaths/100 000 people for appendicitis to 19.3 deaths/100 000 people for lung cancer. On average, the largest decline (in absolute numbers) found in this period was for CVA/hypertension; and the smallest, for pneumonia/influenza. Proportionally, the largest average declines in this period were found for chronic rheumatic heart disease, asthma/bronchitis/emphysema and tuberculosis, while small declines were found for leukaemia and skin cancer (table 4).

The largest trend variations between countries are for causes of death that are mainly or partly avoidable by primary prevention (motor vehicle accidents (fig 2), perinatal mortality, liver cirrhosis, lung cancer); the smallest, for causes that are amenable to curative intervention (appendicitis, testis cancer, Hodgkin's disease, and cholecystitis/cholelithiasis). A significant correlation ($p<0.05$) exists between the starting level (1989) and the trend for five of the 19 causes of death (table 4). Visual inspection and calculation of the variance function show that the trends converged during the study period for these causes.

Statistically significant less than average declines of avoidable mortality were found for 10 countries, as were statistically significant more than average declines for another 10 countries (table 4). However, systematic geographical patterns were not directly visible. In the Czech Republic, Denmark, and Germany, more than average declines were found for causes mainly amenable to medical care (among which appendicitis and testis cancer). More than average declines for causes of death amenable to prevention (such as lung and skin cancer and liver cirrhosis) were found in Portugal, Spain, Italy, the United Kingdom, Ireland, and Finland. Less than average declines were found in Spain and Portugal for various neoplasms. Six countries showed less than average declines (the Netherlands, Sweden, Belgium, France, Greece, and Luxembourg), mainly for causes amenable to curative interventions (for example, CVA/hypertension and chronic rheumatic heart disease).

After adjustment for the starting level (for those causes of death for which a significant association exists between the trend and the starting level) only six countries remained for which significantly deviating trends were found (table 4). Only two of those countries showed less than average declines: the United Kingdom (for liver cirrhosis and perinatal mortality) and France (for breast cancer).

Ranking the countries revealed that the Czech Republic had the strongest trends in avoidable mortality (1989–1997). Despite differences in the declining rate of mortality, there were only moderate rearrangements in the ranking of avoidable causes of death (table 5). Greece and France were the only countries that fitted into more than one place, while Italy was the only country that rose by more than one place.

DISCUSSION

Up to date trend analyses generally show that, as expected, avoidable mortality declined much faster over the past decades than other causes of death.[4–6 9 13 17] Therefore, avoidable mortality was considered a valid indicator for the effectiveness of prevention and medical care. We found that the proportional change in avoidable mortality in the period 1989–1997 (−2.5%/year) was indeed statistically significantly larger than the change in non-avoidable mortality (−1.8%/year). However, the difference between 2.5% and 1.8% (although statistically significant) is much smaller than that reported by others who studied earlier periods within Europe.[9 13 16 18] Furthermore, the difference between the trends was found to decrease over time.

The comparatively slow decline of avoidable mortality in our study compared with that of previous studies may be primarily attributable to differences in data quality. Differences in diagnostic and certifying procedures complicate both national and international studies on mortality. They may have influenced the results for the individual causes of death. The aggregate measures of avoidable and non-avoidable mortality are probably less biased by these differences.[11]

A second possible explanation of the relatively slow decline of avoidable mortality in our study is that we included some avoidable causes of death (lung cancer, breast cancer, liver cirrhosis, and motor vehicle accidents) that were not included in most other studies on avoidable mortality (with the exception of Albert *et al*,[17] Humblet *et al*,[6] and Simonato *et al*[11]). In our study, particularly lung cancer and breast cancer have relatively large impacts on the trend in total avoidable mortality as they represent rather large causes of

Table 3 Annual decline of avoidable and unavoidable mortality in percentages, 1989–1997

Country	Avoidable mortality 1980–1989	Unavoidable mortality	Avoidable mortality 1989–1997	Unavoidable mortality
1 Austria	3.3 (2.4–4.1)	2.4 (2.0–2.7)	3.0 (2.6–3.4)	2.0 (1.5–2.5)
2 Belgium	2.4 (1.8–3.0)	2.7 (2.2–3.0)	2.3 (1.3–3.2)	1.2 (0.7–1.7)
3 Czech Republic	2.1 (1.4–2.8)	1.8 (0.8–2.6)	2.8 (1.4–4.1)	2.7 (1.4–3.8)
4 Denmark	0.1 (−0.4–0.5)	1.1 (0.8–1.4)	2.9 (2.1–3.5)	1.5 (0.8–2.2)
5 Finland	2.0 (1.3–2.7)	0.9 (0.4–1.4)	3.9 (3.0–4.6)	3.3 (2.7–3.8)
6 France	2.1 (1.9–2.3)	1.7 (1.4–1.9)	2.2 (1.8–2.6)	1.6 (1.2–2.0)
7 Germany	2.5 (0.0–4.9)	1.5 (0.0–2.9)	1.7 (1.3–2.1)	2.5 (1.9–3.0)
8 Greece	2.5 (2.1–2.8)	1.0 (0.7–1.2)	1.4 (0.7–2.0)	0.8 (0.4–1.3)
9 Ireland	4.2 (3.4–4.8)	1.4 (1.0–1.9)	2.1 (0.9–3.3)	2.5 (1.8–3.2)
10 Italy	3.9 (3.6–4.1)	1.4 (1.1–1.7)	3.5 (2.8–4.0)	1.2 (0.6–1.7)
11 Luxembourg	0.9 (0.3–1.5)	2.3 (1.5–3.0)	3.0 (2.0–4.0)	1.9 (1.0–2.8)
12 Netherlands	1.7 (1.0–2.4)	1.2 (0.5–1.9)	1.6 (1.1–2.2)	1.4 (0.9–1.8)
13 Portugal	4.0 (3.4–4.4)	1.1 (0.5–1.6)	3.0 (2.2–3.8)	0.4 (−0.2–1.0)
14 Spain	2.6 (2.1–3.1)	0.0 (−0.2–0.3)	2.5 (0.9–4.1)	1.4 (−0.1–2.8)
15 Sweden	2.4 (1.6–3.1)	1.5 (1.2–1.8)	2.5 (2.2–2.8)	2.2 (1.9–2.5)
16 United Kingdom	3.1 (2.7–3.5)	1.2 (1.0–1.5)	2.1 (0.7–2.0)	2.6 (2.2–2.8)
Mean decline	2.5 (1.8–3.1)	1.4 (1.1–1.8)	2.5 (2.0–3.0)	1.8 (1.3–2.3)

The values are derived from the model presented in the methods section.

death (29% of all avoidable causes) that show a comparatively small decline.

Finally, the small and decreasing difference in decline between avoidable and non-avoidable mortality may be attributable to the fact that the non-avoidable mortality category increasingly includes death causes that have become avoidable over time. An example is coronary heart disease. In contrast with the time in which Rutstein *et al* composed their lists, it is now justifiable to include this disease in the avoidable group (as Humblet *et al* did), given the evidence of the effectiveness of the available prevention and treatment. At the same time, the "traditional" selections of avoidable

Table 4 Trends in avoidable mortality: mean decrease and variation between countries according to the model

	Mortality/ 100000 (0–64 years of age) in 1989 (according to the model)	Decline in 10 years; mortality/ 100000 (0–64 years of age)	Percentage decline/ year (0–64 years of age) 1989–1997	Variation between countries (SD) in decline/ 10 year§	Decline dependent on starting level (1989) (p value)	Countries showing a more than average decline (p<0.003)‡	Countries showing a less than average decline (p<0.003)‡
Tuberculosis	0.68	0.40	6.3	0.30	0.16	Austria, Spain	Netherlands, Sweden
Appendicitis	0.07	0.03 (BS)	2.0	0.06	0.05	Czech Republic	Belgium
Lung cancer	19.3	2.1	1.0	2.6	0.13	Italy, United Kingdom	Portugal, Spain
Bladder cancer	1.48	0.38	2.6	0.18	0.32		
Liver cancer	1.13	0.23	1.3	0.25	0.17*	United Kingdom	France
Testis cancer	0.22	0.10	1.3	0.11	0.02	Czech Republic, Denmark, Germany	
Liver cirrhosis	10.5	2.5	2.3	2.7	0.03	**Italy, Spain**	**United Kingdom**
Perinatal	12.6	3.9	3.5	3.4	0.07	**Czech Republic** Portugal	**United Kingdom**
Motor vehicle accidents	14.6	4.0	3.4	4.4	0.15	Finland, Portugal, Spain	Czech Republic
Skin cancer	1.54	0.18 (NS)	0.9	0.37	0.06	**Ireland**	Greece
Breast cancer	10.0	1.32	1.3	0.98	0.03	United Kingdom	**France**
Cervix cancer	1.33	0.35	2.4	0.38	0.13	United Kingdom	Portugal, Spain
Hodgkin's disease	0.60	0.25	4.1	0.15	0.4		
CVA/hypertension	16.1	4.7	3.2	2.5	0.02	Czech Republic, Portugal	Netherlands, Sweden
Asthma/bronchitis/ emphysema	4.1	2.4	6.3	1.7	0.007	Czech Republic, Denmark	France, Greece, Spain
Cholelithiasis/ cholecystitis	0.20	0.09 (BS)	2.3	0.16	0.05	Czech Republic, Germany	
Pneumonia/influenza	2.77	0.02 (NS)	1.1	0.97	0.9	Austria, **France†**	United Kingdom
Leukaemia	2.34	0.16 (NS)	0.6	0.30	0.05	Czech Republic	Spain
Chronic rheumatic heart disease	0.95	0.62	7.4	0.55	0.007	Czech Republic, Spain	Belgium, Greece, Luxembourg
All avoidable mortality	101.1	24.2	2.4	8.8	0.03		Greece, Netherlands, Sweden
Other mortality	171.9	30.5	1.5	17.1	0.03	**Finland**	Greece, **Portugal**

NS, not significant; BS, borderline significant (0.05<p<0.1); *correlation positive instead of negative; countries in bold type, countries for which more or less than average declines remained after adjustment for starting level (significantly deviating trends); †in France no more than the average decline of mortality attributable to pneumonia/influenza was found before adjustment of the starting level; ‡equal to a Bonferroni adjusted p value<0.05; §adding variation between countries in decline to the model statistically significantly improved the fit of the model

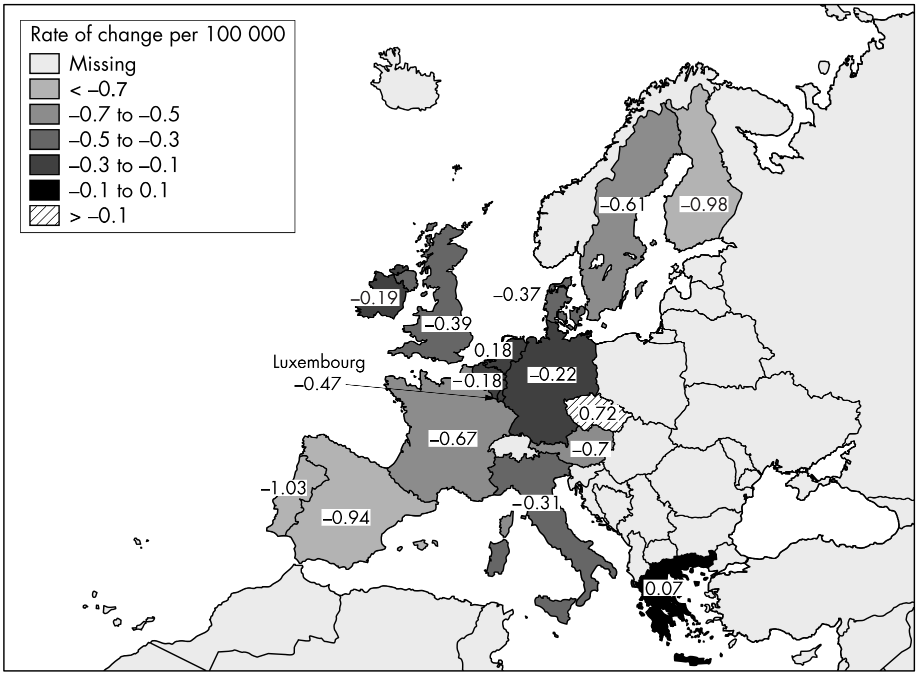

Figure 2 Proportional mortality decline per year for motor vehicle accidents among men and women (0–64 years) in the period 1989–1997.

causes of death may include causes for which it has become questionable whether improvements in medical care and prevention nowadays still contribute to their decline over time. For the "surgical" causes (such as appendicitis, cholecystitis, and cholelithiasis), for example, effective interventions were introduced long before 1980. Our suggestion for further work is to reconsider and standardise the selection of the current causes of death to be included in studies on avoidable mortality. This will improve the comparability of studies on avoidable mortality and the sensitivity of avoidable mortality to variations in the quality of health care. To define such a standard set of causes of death, a critical and systematic revision of Rutstein's lists is indicated.

The largest mortality trend variations in the countries studied are those for causes amenable to prevention; and the smallest, for causes amenable to curative care. The causes amenable to cure also show the largest percentage declines, a fact that has also been reported by others.[9 11 20 21] European countries in general probably reached more consensus about how to provide medical care than about methods for effective prevention. The use of standards and protocols in medical care may have played a part here. Converging trends were found for various causes of death, such as testis cancer, liver cirrhosis, breast cancer, CVA/hypertension and asthma/bronchitis/emphysema, which may suggest that medical and preventive care is being increasingly provided for these diseases in a uniform way. None the less, the evolution of cause specific mortality depends not only on changes in the quality of medical care and prevention, but also on changes in the quality of mortality data (as already mentioned), on changes of incidence, severity and a variety of factors outside the medical care system. Further research is thus needed to find out what factors may have contributed to the variations of the trends within Europe.

The United Kingdom and France were the only countries showing less than average declines after adjustment for the starting level for liver cirrhosis, perinatal mortality (United

Table 5 Ranking of countries by mortality trends (after correction for the starting level) and mortality levels in 1989 and 1995

Ranking by mortality trend (from most to least decline)	Ranking by level in 1989 (from lowest to highest level)	Ranking by level in 1995 (from lowest to highest level)
Czech Republic	Sweden	Sweden
Portugal	Netherlands	Finland
Finland	Finland	Netherlands
Italy	Ireland	Ireland
Denmark	Greece	United Kingdom
Luxembourg	United Kingdom	Italy
Austria	France	Greece
Spain	Spain	Spain
Belgium	Germany	France
France	Italy	Germany
United Kingdom	Belgium	Belgium
Ireland	Austria	Austria
Sweden	Luxembourg	Luxembourg
Germany	Denmark	Denmark
Netherlands	Portugal	Portugal
Greece	Czech Republic	Czech Republic

Key points

- Between 1980 and 1997, avoidable mortality declined in 15 European countries and the Czech Republic, but not in Hungary.
- The difference between the trends in avoidable mortality and non-avoidable mortality was small and declined over time.
- Various countries showed trends that deviated significantly from the mean trend. The largest trend variations existed for causes that are mainly or partly amenable to prevention.
- The selection of causes of death to be included in studies on avoidable mortality have to be standardised, for which a critical revision of Rustein's lists is indicated.

Kingdom) and breast cancer (France). The comparatively small decline of liver cirrhosis was preceded by increased alcohol consumption in the United Kingdom between 1970 and 1980. The prevalence of alcohol dependence has also risen fairly rapidly since 1991.[22] A possible factor in the comparatively slow decline of perinatal mortality in the United Kingdom is that more babies are born alive after comparatively short gestations.[23 24] However, birth weight is only one of the factors that may explain international variations in perinatal mortality.[25] Finally, the comparatively slow decline of breast cancer mortality in France may be attributable to relatively unfavourable developments in the risk factors for breast cancer or the quality of interventions.

Hungary showed an increase in avoidable mortality between 1980 and 1997. Velkova *et al* (1997) also report relatively high levels of mortality attributable to causes amenable to medical intervention in countries of Central and Eastern Europe (including Hungary) compared with those in Western Europe.[19] Their results suggest that the contribution of medical care to the gap in life expectancy may not be as limited as has often been asserted. Introducing effective strategies for prevention and improving the standards of medical care in the countries of Central and Eastern Europe may contribute to bridging the gap in health between Eastern and Western Europe.

In conclusion, this study indicates that the difference in decline between avoidable and non-avoidable mortality is small and it is diminishing. Effort is therefore needed to continue to reduce specific causes of avoidable mortality. Furthermore, some individual countries show comparatively unfavourable developments in avoidable mortality, which can be considered a signal pointing to possible unfavourable developments in the quality of prevention or medical care, or both. Research in these countries must unravel the causes of these trends in order to identify unfavourable developments. Finally, we suggest that the selection of the current causes of death be reconsidered and standardised for the purposes of studies on avoidable mortality. A critical revision of Rutstein's lists is indicated. The revised lists should contain all causes of death that are avoidable at the moment, given the available knowledge about prevention and medical care. The date when the cause of death became avoidable should be given for each cause on the lists. This effort will make avoidable mortality a more useful health outcome for monitoring the quality and effectiveness of health care in the 21st century.

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