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Trends in mortality from coronary heart and cerebrovascular disease in Switzerland, 1969-87

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Major declines in mortality from cerebrovascular and coronary heart diseases have been observed in several developed countries over the last few decades. The observed trends have started earlier and have been geographically more widespread for cerebrovascular diseases, and can be partly or largely explained in terms of better control of hypertension[1-3]. For ischaemic heart disease, the declines started in the late 1960's or early 1970's in the United States, and in a few other countries as Australia[4-7], but were observed only more recently in western European countries, such as Britain, Scandinavia, France, Germany or Italy[7]. The interpretation of these trends is certainly more complex, and probably involves a combination of reduced smoking, improved diet with reduced serum cholesterol levels, more efficient control of hypertension, and increased physical exercise[8-9].

On an international scale, Switzerland is characterized, like France, by comparably low rates for cardiovascular disease, at least in comparison with available information on serum cholesterol levels, although prevalence of the major risk factors does not seem to be different from most other developed areas of the world[10] except hypertension which tends to be rather uncommon in the Swiss populations studied. For instance, among 35 industrialized countries considered in a recent overview, Switzerland ranked 29th for males and 32nd for females in relation to ischaemic heart disease (in 1985), and 35th (i.e. had lowest rates for both sexes) for cerebrovascular disease[7]. Inferences on trends in coronary heart disease are strongly dependent on the classification and categorization chosen. For instance, an analysis including «all non-rheumatic heart disease and hypertension» showed appreciable declines between 1951 and 1976 (-13% in males, -40 % in females)[11], while, when only ischaemic heart diseases were considered, mortality for males aged 30 to 79 increased between 1952 and 1967 (+11%), while declining in females (- 37 %)[7]. A study restricted to the period 1969-82 found a 9% fall in all vascular diseases in Swiss males, and a 22% in females, which were due to declines in cerebrovascular diseases and non-ischaemic heart diseases, while ischaemic heart diseases rose by 11% in males and 7% in females[12].

Uniform and standardized classification of causes of death has been available from 1969 onwards, with the adoption of the 8th Revision of the International Classification of Diseases (ICD). Thus, we have now up-dated the analysis of trends in cerebrovascular and coronary heart disease mortality in Switzerland from 1969 to 1987, on the basis of age-specific and age-standardized rates derived from official vital statistics.

Material and methods

Death certification numbers by cause, stratified for sex and age in five-year groups for the period 1969-87 have been derived from magnetic support produced by the Swiss Federal Office of Statistics (SFOS). From 1969 onwards, causes of deaths were coded according to the standard International Classification of Diseases (ICD), 8th Revision. To assure internal comparability of diagnosis and classification, only the overall groups of all ischaemic heart diseases (8th ICD, 410-414) and all cerebrovascular diseases (8th ICD, 430-438) have been considered.

Estimates of the resident population for the corresponding calendar period were provided by the SFOS. Using these numerators and denominators, age-specific death certification rates were computed for three calendar quinquennia (1969-73 to 1979-83) plus 1984-87 and ten five-year age groups (from 25-29 to 70-74). Age-standardized mortality rates (at all ages and truncated 35-64 years) were derived by the direct method using the 1980 Swiss Census population, the European and World population as standards.

The effects of age, cohort of birth and period of death were evaluated applying a log-linear Poisson model to the matrices of age-specific rates. The whole procedure was implemented using GLIM[13] with appropriate user supply macros (which are available on request from F.Levi)[14,15].

The major conceptual problem in any age/period/cohort model is that these three factors are not independent, i.e. there is an exact linear relationship

between them[16-19]. Consequently, when two of them are defined (i.e. age and cohort) the third (period) will be fixed automatically. To overcome this, we first developed the three possible two-factor models (age/cohort; age/period; cohort/period). In the latter model, cohort and period values were estimated after defining the age effect alone[20]. The age/cohort/period model presented was subsequently obtained by minimizing the sum of the euclidean distances between these three two-factor models.

Thus, the procedure used is conceptually similar, though not equivalent, to that originally described by Osmond and Gardner[20]. In fact, the procedure of minimization implemented by the GLIM macros is based on the least squares weighted on the inverse of the like hood of each two-factor model, taken as a measure of goodness of fit[14], whereas Osmund and Gardner[20] used the mean residual sum of squares, minimizing the sum of distances as a measure of the goodness of fit.

To overcome the non-identifiability property of age-period-cohort models, other solutions were proposed, based on the choice of different constraints *a priori* justified by biological knowledge which, however, often produce rather different parameter estimates according to the constraints, which are unbiased only when the constraints posed are strictly reflected in the data[16].

From the algebraic viewpoint, models including arbitrary constraints have, of course, similar limitations. However, whenever the constraints imposed produce easily interpretable parameter estimates, without privileging any parameter *a priori*, the resulting model is of interest as a summary guide for the analysis of epidemiological data.

Age values are assimilable to rates per 100 000 population, and represent a weighted average of the age curve over the 19-year calendar period considered. Cohort of birth and period of death values were averaged to unity. Therefore, they can be interpreted as the estimated risk of death from coronary heart and cerebrovascular disease for each specific cohort or period compared to the whole of the data considered (although the results from the model should be viewed chiefly in relative terms of changes in slopes, rather than of point estimates of any single value).

Whereas age and period values are always based on four age-specific rates, cohort estimates for earlier or more recent generations are based on fewer age-specific rates in the original matrices (i.e. only one for the 1900 cohort, two for the 1905 and so on, and respectively, only one for the 1960 cohort, two for 1955, and so on). Thus, values for extreme cohorts are clearly subject to greater random variation, and are hence less stable. Problems of random variation are particularly relevant for more recent generations, since their estimates are based on rates in younger age groups, when absolute numbers of deaths are smaller.

Results

Trends in age-standardized rates for all ischaemic heart diseases are presented in Table 1 and Figure 1. Overall rates for the mid-late 1980's in males were similar to the late 1960's, although some upward

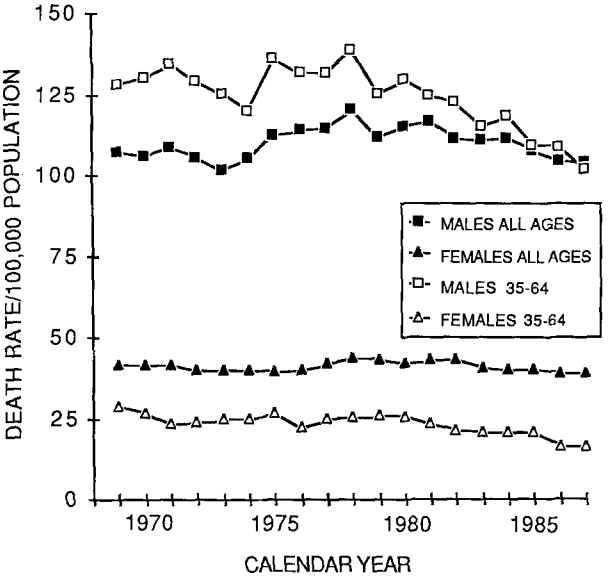

Fig. 1. Trends in age-standardized (World) mortality rates from ischaemic heart diseases (ICD-8 : 410-4) in Switzerland, 1969-1987.

trend was evident up to the late 1970's (with a peak rate of 120.4 in 1978), followed by steady declines in more recent years. Truncated 35-64 years rates were somewhat upwards up to the mid 1970's, too, but the subsequent declines were considerably larger, the rate for 1984-87 being 15% lower than that of 1969-73.

For females, overall age-standardized rates were stable throughout the 19-year period considered, around a value of 40/100 000, whereas truncated ones tended to decrease, particularly in most recent years: the rate for 1984-87 was over 25% less than that of the first calendar quinquennium considered (Figure 1). Examination of age-specific rates (Figure 2) showed that, for both sexes, the declines at

Tab. 1. Age-standardized death certification rates per 100 000 males and females from all ischaemic heart diseases (ICD-8: 410-414). Switzerland, 1969-87.

	Males, all Ages				Females, all Ages			
	CH80 Standard*	European Standard	World Standard	Mean annual number of cases	CH80 Standard	European Standard	World Standard	Mean annual number of cases
1969-73	158.6	163.1	105.8	4,171	101.8	68.2	40.7	2,546
1974-78	171.7	176.5	113.6	4,936	103.3	68.8	40.8	2,982
1979-83	173.0	178.1	113.3	5,409	109.6	71.8	42.0	3,655
1984-87	164.3	169.2	106.9	5,551	105.2	68.0	39.2	3,966

* 1980 Swiss Census population

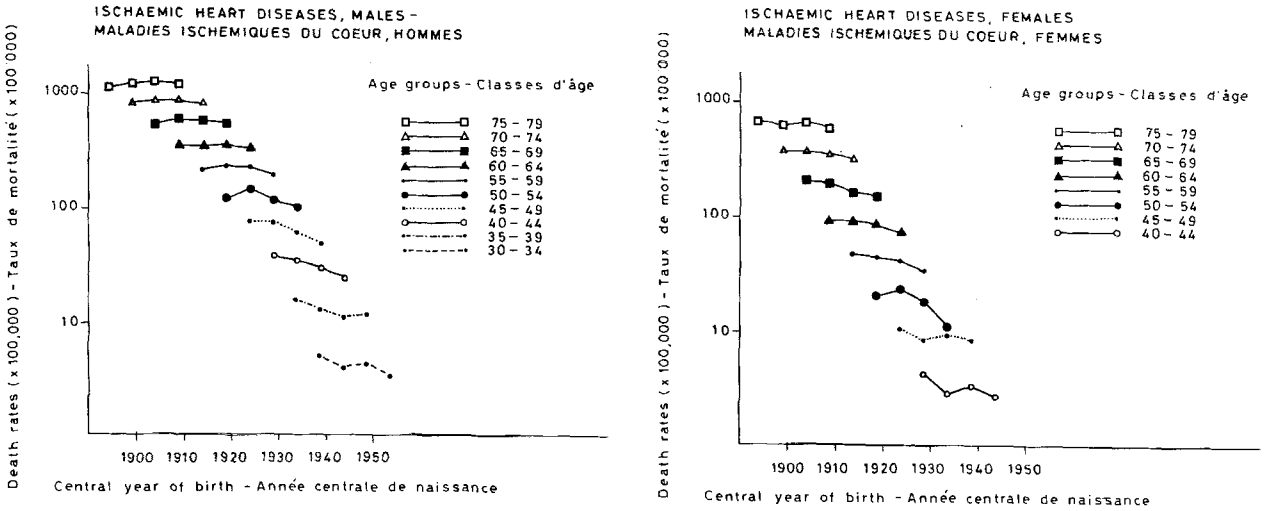

Fig. 2. Trends in age-specific mortality rates from ischaemic heart diseases according to central years of birth cohort in a) males and b) females in Switzerland, 1969-1987.

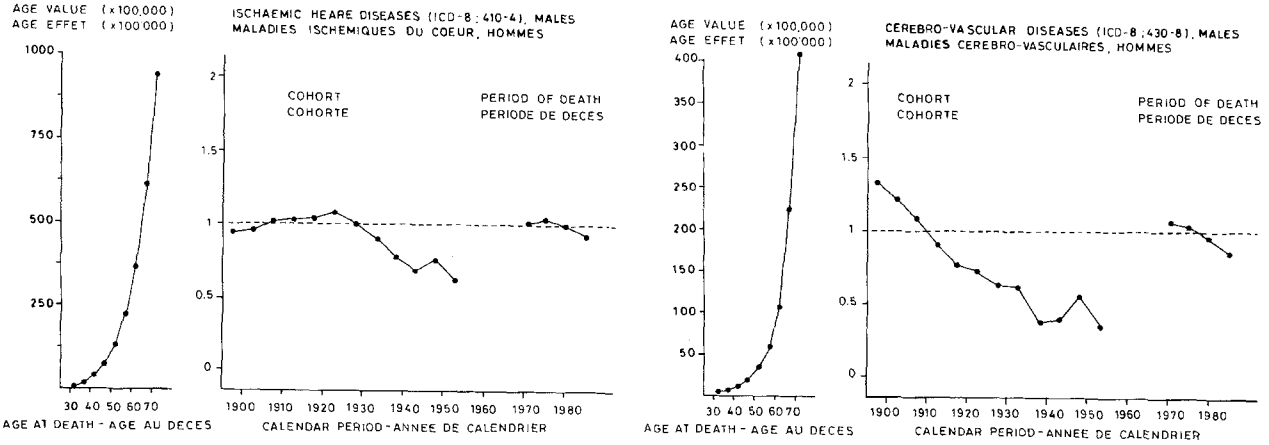

Fig. 3. Age, cohort, period of death values for ischaemic heart diseases in a) males and b) females aged 25-74. Death certification rates in Switzerland, 1969-1987.

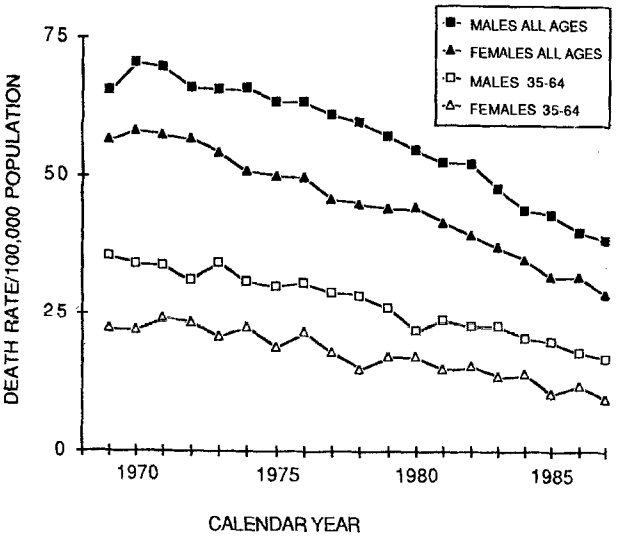

Fig. 4. Trends in age-standardized (World) mortality rates from cerebrovascular diseases (ICD-8 : 430-8) in Switzerland, 1969-1987.

younger ages were already evident in the earlier calendar periods whereas above age 50 some fall became apparent only in most recent years. Above age 65, ischaemic heart disease mortality was indeed upwards in males up to the mid 1970's. This increase may at least partially not be real but due to changes in diagnosis and certification, particularly from

Tab. 2. Age-standardized death certification rates per 100 000 males and females from cerebrovascular diseases (ICD-8: 430-438). Switzerland, 1969-87.

	Males, all Ages				Females, all Ages			
	CH80 Standard*	European Standard	World Standard	Mean annual number of cases	CH80 Standard	European Standard	World Standard	Mean annual number of cases
1969-73	112.3	115.3	67.4	2,755	156.4	99.6	56.6	3,736
1974-78	105.2	108.5	62.8	2,927	135.1	85.5	48.2	3,804
1979-83	88.7	91.9	52.8	2,794	116.7	73.5	41.2	3,915
1984-87	69.4	71.9	41.2	2,437	91.3	57.2	31.7	3,535

* 1980 Swiss Census population

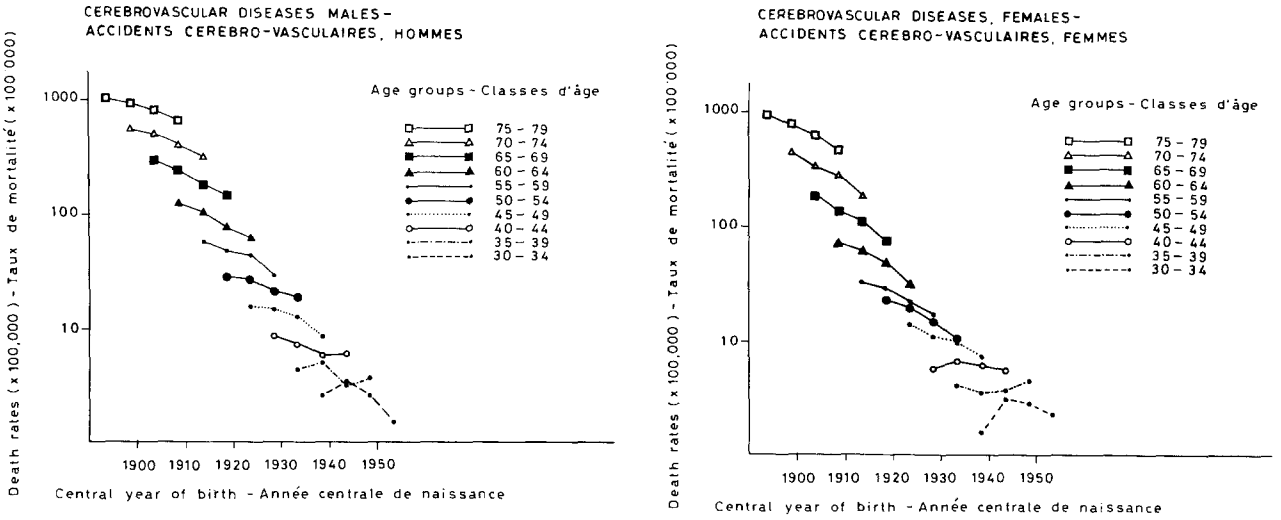

Fig. 5. Trends in age-specific mortality rates from cerebrovascular diseases according to central years of birth cohort in a) males and b) females in Switzerland, 1969-1987.

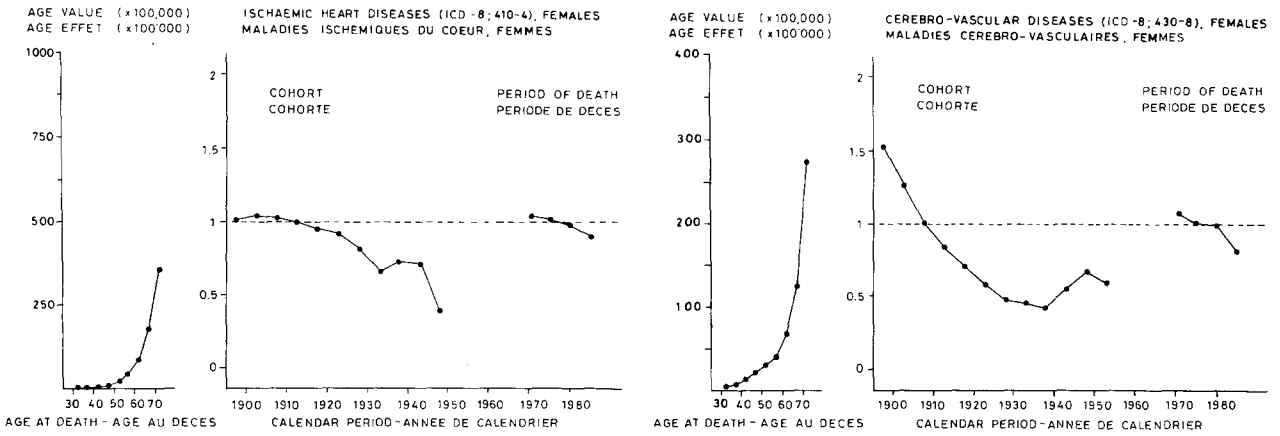

Fig. 6. Age, cohort, period of death values for cerebrovascular diseases in a) males and b) females aged 25-74. Death certification rates in Switzerland, 1969-1987.

unspecific heart disease. Thus, both period and cohort components are borne out by the age/period/cohort model (Figure 3): in males, the cohort values were upwards up to the 1920 generation, and decreased thereafter, and the period effect upwards up to the early 1970's, and declined afterwards. Although the general pattern is similar in females, both cohort and period peaks occurred earlier than in males. While the shape of the curves derived from the model is thus consistent with the data, the absolute values of the estimates must be considered with due caution, since when the slope of the cohort and period effect is similar the model has major difficulties in disentangling which is the major underlying component, and tends systematically to overweight the component with larger number of points, i.e. the cohort one [14].

In relation to cerebrovascular diseases, the overall declines were around 40% in males (from 67.4 to 41.2 /100 000) and 45% in females (from 56.6 to 31.7/100 000 – Figure 4 and Table 2). Although the falls appeared somewhat larger in the truncated rates, this is partly artefactual and due to the bias introduced by the 80+ age category, which is not age-standardized. The falls were indeed comparable in both sexes between age 45 and 79, while little appreciable decline was evident below age 45, particularly in females (Figure 5). The estimates for the age/period/cohort model were thus downwards both in the period and in the cohort component (Figure 6), although, as previously noted for ischaemic heart disease, the greater weight given to the cohort component is probably artefactual, and due to the limitations of the model.

Discussion

The present analyses of trends in cardio- and cerebrovascular disease in Switzerland from 1969 to 1987 confirm the substantial decline in certified mortality from stroke, which was around or over

40% in both sexes and persisted up to most recent years. This trend is of particular interest, since Swiss rates are at the lowest level for any industrialized country [7]. It is possible that at least part of these low rates are due to the high quality standard of Swiss death certification[21], since several sudden deaths may be erroneously attributed to stroke in the absence of accurate diagnostic confirmation. An efficient control of risk factors for cerebrovascular disease, particularly hypertension, may, however, play an important role for such remarkably low rates. The 1982 National Health Survey found that 71% of the Swiss population aged 20 and over had a blood pressure measurement within the year before interview[22]. The prevalence of hypertension in the Swiss areas included in the MONICA project was only about 15%, among the lowest rate observed in any European population [10].

Mortality from ischaemic heart disease is comparably low in Switzerland, too, particularly in reference to the major known determinant of the disease, i.e. serum cholesterol levels[23]. Together with France, Switzerland represents in fact an important outlier in the correlation, on a global scale, between mortality from coronary heart disease and serum cholesterol (although this correlation appears weaker on an European scale). The pattern of trends observed over the last two decades is nonetheless similar to those registered in most other western European countries, including Britain, Germany, France and Italy, where trends for males have been constant or upwards up to the mid 1970's, but have started to fall since the late 1970's, i.e. with a delay of 10 to 15 years in comparison with the United States or Australia[7]. For females, most European countries have shown long-lasting, however generally moderate, downward trends[7].

As for other industrialized countries, the determinants of this decline in ischaemic heart disease mortality should be searched in a complex of not totally quantified factors affecting incidence of the disease and its prognosis, which include some reduced prevalence of smoking in middle age men[24], a more efficient control of hypertension[9,22,25,26], some decrease in animal fat consumption[8], a diet richer in foods as fruits, vegetables, fish[27] or specific micronutrients[28] which may have some favourable impact on the disease[27-31]. Further, advances in early diagnosis and improved treatment should be considered, too, although it is difficult to quantify the impact, on a national scale, of various medical[32-36] and, possibly, surgical[37] interventions.[1] The fact that both inspection of age-specific rates and the estimates of the age/period/cohort model indicated the presence of a cohort effect on this downward trend is of potential interest in the interpretation, since it would suggest the importance of long-lasting determinants of the disease on subsequent mortality rates[21,38].

Certainly, in terms of public health implications, this decline in ischaemic heart disease mortality, although relatively moderate, is of major public health relevance, and corresponds to the avoidance of over 1300 deaths per year, since 9691 deaths were observed in 1987 vs about 11 000 expected on the basis of 1978 rates. Even greater is the importance of the fall in cerebrovascular disease over the 19-year period considered, which corresponds to the avoidance of over 4000 deaths per year (5727 vs approximately 10 000).

Summary

Trends in age-specific and age-standardized death certification rates from all ischaemic heart disease and cerebrovascular disease in Switzerland have been analysed for the period 1969-87, i.e. since the introduction of the Eighth Revision of the International Classification of Diseases for coding causes of death. For coronary heart disease, overall age-standardized rates of males in the mid-late 1980's were similar to those in the late 1960's, although some upward trend was evident up to the mid 1970's (with a peak rate of 120.4/100 000, World standard, in 1978) followed by steady declines in more recent years (103.8/100 000 in 1987). These falls were larger in truncated (35 to 64 years) rates. For females, overall age-standardized rates were stable around a value of 40/100 000, while truncated rates tended to decrease, particularly over most recent years, with an overall decline of over 25%. Examination of age-specific trends showed that in both sexes declines at younger ages were already evident in the earlier calendar period, while above age 50 some fall became evident only in most recent years. Thus, in a formal log-linear age/period/cohort model, both a period and a cohort component emerged. In relation to cerebrovascular diseases, the overall declines were around 40% in males (from 67.4 to 41.2 /100 000, World standard) and 45% for females (from 56.6 to 31.7/100 000), and were proportionally comparable across subsequent age groups above age 45. The estimates for the age/period/cohort model were thus downwards both for the period and the cohort component although, in such a situation, it is difficult to disentangle the major underlying component. These persistent declines in stroke mortality are remarkable, since certified mortality is now lower in Switzerland than in any other industrialized country, and correspond to the avoidance of over 4000 deaths per year, as compared with the rates of the late 1960's or early 1970's. The recent falls in ischaemic heart disease mortality are similar to those observed in several other western European countries with a 10 to 15 year delay in comparison with the USA, and are of major public health relevance, too, since they correspond to the avoidance of about 1300 deaths per year.

Résumé

Evolution de la mortalité par cardiopathie ischémique et par maladie cérébrovasculaire en Suisse, 1969-1987

Les tendances des taux suisses de mortalité, spécifiques et corrigés pour l'âge, attribués à l'ensemble des maladies ischémiques du cœur et des affections cérébrovasculaires ont été analysées pour la période de 1969 à 1987, ceci notamment depuis l'introduction de la Huitième Révision de la Classification Internationale des Maladies. Chez l'homme, la mortalité corrigée par maladie ischémique du cœur relevée dans la deuxième moitié des années 80 était superposable à celle des années 60. Cette situation était précédée par une phase de progression des taux jusqu'à la moitié des années 70 (culminant à 120.4/100 000, standard mondial, en 1978) et suivie d'une diminution constante des taux au cours des années plus récentes (103.8/100 000 en 1987), plus marquée dans la population tronquée entre 35 et 64 ans d'âge. Chez la femme suisse, les taux corrigés pour tous les âges étaient stables autour de 40/100 000, alors que la mortalité tronquée tendait à décroître, surtout dans les années les plus récentes, avec une diminution globale de plus de 25%. L'inspection des tendances par groupes d'âges a montré que, pour les deux sexes et aux plus jeunes âges, les diminutions étaient évidentes déjà au début de la période considérée, alors qu'après 50 ans quelques diminutions devenaient manifestes seulement dans les années les plus récentes. Par conséquent, l'analyse par un modèle log-linéaire âge/période/cohorte a mis en évidence une composante de période autant que de génération. Les affections cérébro-vasculaires ont globalement diminué d'environ 40% chez l'homme (de 67.4 à 41.2/100 000, standard mondial) et de 45% chez la femme (de 56.6 à 31.7/100 000), et, proportionnellement, d'une manière comparable à travers les groupes d'âge successifs au-delà de 45 ans. Les estimations à partir du modèle âge/période/cohorte étaient donc en diminution pour la composante de période autant que de cohorte bien que, dans une telle situation il soit difiicile de déterminer quelle est la principale composante sous-jacente. La persistance de ces diminutions de mortalité par maladie cérébro-vasculaire est remarquable, le niveau de ces affections en Suisse n'étant dépassé par aucun autre pays industrialisé. Par rapport à la situation de la fin des années 60 ou du début des années 70, les diminutions représentent plus de 4000 décès évités par année. Les reculs de la mortalité par maladies ischémiques du coeur ressemblent à ce que l'our observe dans d'autres pays d'Europe occidentale, avec toutefois un décalage de 10 à 15 ans par rapport aux Etats-Unis. Dans une optique de santé publique, ces baisses revêtent donc aussi une importance considérable.

Zusammenfassung

Trendanalyse der Sterblichkeit an koronarer Herzkrankheit und zerebrovaskulären Krankheiten in der Schweiz von 1969 bis 1987

Die vorliegende Arbeit befasst sich mit Veränderungen der altersstandardisierten Sterberaten für koronare Herzkrankheit sowie für zerebrovaskuläre Krankheiten in der Schweiz in der Zeitperiode von 1969 bis 1987 (seit der Einführung der 8. Revision der internationalen Klassifikation der Krankheiten). Die Sterblichkeit an koronarer Herzkrankheit ist seit Mitte der 80er Jahre wieder auf das Niveau der späten 60er Jahre zurückgegangen, nachdem in den 70er Jahren eine Zunahme zu verzeichnen war. Die höchste Rate wurde mit 120,4 pro 100 000 im Jahr 1978 erreicht und ist in der Zwischenzeit auf 103,8 pro 100 000 (1987) zurückgegangen (standardisiert nach der Weltbevölkerung). Der Rückgang war bei den mittleren Jahrgängen (35-64 Jahre) noch deutlicher. Die Sterblichkeit bei Frauen war über diese Zeitperiode relativ stabil (40/100 000); bei den mittleren Jahrgängen zeigte sich auch hier ein deutlicher Rückgang um rund 25%. Die nähere Analyse altersspezifischer Trends zeigt, dass der Rückgang der Sterblichkeit bei jüngeren Altersgruppen beider Geschlechter schon früher nachweisbar ist, während eine Reduktion des Sterberisikos vom 50. Altersjahr an erst kürzlich sichtbar geworden ist. In einem statistischen Modell (Alters-, Zeitperiode-, Kohorten-Modell) zeigt sich daher ein Beitrag zur Sterberisikoabnahme sowohl aufgrund eines Zeitperioden- als auch eines Geburtskohorten-Effektes. Die zerebrovaskulären Erkrankungen zeigen einen deutlicheren Rückgang: Er betrug ungefähr 40% bei der Sterblichkeit der Männer (67,4 auf 41,2 pro 100 000) und ungefähr 45% bei Frauen (von 56,6 auf 31,7 pro 100 000). Aehnliche Rückgänge ergeben sich für die verschiedenen Altersgruppen vom 45. Altersjahr an. Die kontinuierliche Reduktion der Schlaganfallsterblichkeit ist besonders bemerkenswert, da die Sterblichkeit an dieser Krankheit in der Schweiz nun niedriger als in irgendeinem anderen industrialisierten Land ist. Würden heute noch die Sterberaten von 1960 oder anfangs 1970 vorherrschen, so träten jährlich rund 4000 Todesfälle pro Jahr mehr auf. Der kürzliche Rückgang, auch bei der Sterblichkeit der koronaren Herzkrankheit ist mit der Entwicklung in anderen westeuropäischen Ländern vergleichbar. Wenn hier noch die früheren Raten gelten würden, müsste mit rund 1300 Todesfällen pro Jahr mehr gerechnet werden.

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