Sozial- und Präventivmedizin Médecine sociale et préventive 29, 253 – 257 (1984)

Analysing Trends in Cardiovascular Mortality: Some Methodological Points[1]

F. Paccaud

INSTITUT UNIVERSITAIRE DE MEDECINE SOCIALE ET PREVENTIVE
17, RUE DU BUGNON, 1011 LAUSANNE

Since several years, trends in coronary heart disease (CHD) mortality are currently thought to reflect changes in health related habits (1). Furthermore, these trends may be used to monitor the outcomes of prevention campaign : a recent WHO report (2) stated that "more could be learned about the feasibility, safety and effectiveness of preventive strategies by closer surveillance of these (CHD mortality) trends". It is thus obvious that mortality statistics, despite numerous drawbacks, remain an important part of the available information system, even if other sources will be developed (3).

This paper comments on basic methodological aspects of trends analysis; a pratical example with Swiss data will be presented, regarding a recent CHD mortality drop in middle-aged men.

CHD mortality trends in Switzerland

Several papers have dealt with the question of cardiovascular mortality trends in Switzerland. In a comparative study (4), Switzerland was classified among countries with no or little change in coronary heart diseases (CHD) mortality for men aged 40-69 years between 1968 and 1977. This was also obvious in figures presented by Epstein and Pisa (5).

Other papers, however, presented a somewhat different picture. Guberan (6) showed a decrease of "non rheumatic heart diseases" mortality (a diagnostic grouping used to overcome the classification change which took place in 1969 in Switzerland), in all age groups for males, between 1951 and 1976. Gass (7), studying the period between 1969-72 and 1975-76, showed a decrease in CHD mortality for men aged 35-44 and an increase for men aged 45-74 years. Neury (8) studied the period between 1969-73 and 1974-78, and showed an increase in CHD mortality for men aged 40 years and more.

Alexander, Junod and Wietlisbach (9) studied the period between 1969 and 1979. To avoid possible confounding effects due to dramatic change in migration patterns during the seventies, the analysis was limited to Swiss citizens only. Using a birth cohort life table for men aged 45 to 80, the trend for CHD mortality was estimated positive (1 % per year) by a regression model.

The most recent paper (10) showed little change in age standardized CHD mortality for Swiss males aged 25-64 years between 1969-72 and 1979-82; the rates decreased for males aged 35-54 years, but increased for those aged 55 and more.

These somewhat conflicting results reflect differences in diagnostic grouping, age range considered, standardisation procedures used and population choice. They also partly reflect the fact that a downturn of CHD mortality probably occurred in Switzerland in the mid-seventies for middle aged men. For Swiss men aged 35-64 years, CHD mortality (age-standardized) decreased between 1975-76 and 1981-82 from 141 to 131 (per 100 000); this decrease was steady during this period (1977-78 : 139; 1979-80 : 134).

This drop will be dicussed here, as an example of what can be said about consistency of such trends. All data used here (vital statistics and population estimates) have been produced by the Federal Office of Statistics. Mortality rates for the age group 35-64 years are always standardized (direct method), with 1981-82 population as reference. The tables presented below show the changes in number or rates, expressed in percent; these changes are to be read as follows :

$$\left\{ 1 - \frac{\text{value observed in 1975-76}}{\text{value observed in 1981-82}} \right\} \times 100$$

Is the decline real ?

Many factors independent of the "force" of CHD morbidity in a population can explain observed trends in mortality : these time dependent factors include access to medical services, progress of therapeutics, accuracy of medical diagnosis and quality of cause of death assessment and coding. Although other available data have to be used and developed to deal with these questions, more should be gained by a closer examination of usual mortality statistics.

One way of looking at CHD mortality change is to consider its relationship with overall mortality variations. Note that CHD mortality can be viewed as determined by two independent factors : overall mortality and proportion of CHD deaths among all deaths. Thus, CHD mortality can be expressed as follows :

CHD mortality =

overall mortality
x
proportion of CHD deaths among all deaths

Table 1 shows that, like CHD mortality, overall mortality decreased in each age subgroup; the age-standardized drop was 6.4 %, thus very similar to the CHD mortality decrease (6.6 %). Reflecting different trends in proportions of CHD deaths, the overall mortality drop was somewhat lower than CHD mortality decrease in younger age subgroups (35-54 years), and somewhat higher in older age subgroups (55-64 years).

Since CHD is an important cause of death in this age group (ranging from 10 to 20 % of all deaths), one could ask to what extent the CHD drop was responsible for the overall mortality decrease. Table 2 shows the relative importance of CHD and non-CHD mortality in the overall decrease (this is done by considering that overall mortality is determined by the addition of the CHD and non-CHD mortality; thus, holding constant the

1) Based on a paper ("Measuring the Outcomes of Prevention of Cardiovascular Diseases", ICP/NCD 003 m 02/18), prepared for a W.H.O. meeting on the prevention of Non-communicable Diseases, held in Brioni (September 1984).

Table 1 :

CHANGE (%) IN CHD MORTALITY, OVERALL MORTALITY AND PROPORTION OF CHD DEATHS AMONG ALL DEATHS 1975-76/1981-82

Age	CHD mortality	Overall mortality	Proportion of CHD deaths
35-39	- 13.4	- 12.5	- 0.9
40-44	- 16.6	- 5.7	- 10.4
45-49	- 14.7	- 9.1	- 5.1
50-54	- 21.8	- 11.7	- 9.0
55-59	- 1.2	- 3.2	+ 1.9
60-64	- 1.0	- 5.1	+ 3.9
35-64	- 6.6	- 6.4	- 0.2

Table 2 :

CHANGE (%) IN OVERALL MORTALITY, WITH CHANGE DUE TO CHD AND NON-CHD MORTALITY, 1975-76/1981-82

Age	Overall mortality	Attributable to CHD mortality	Attribuable to non-CHD mortality
35-39	- 12.5	- 1.2	- 11.3
40-44	- 5.7	- 2.1	- 3.6
45-49	- 9.1	- 2.5	- 6.7
50-54	- 11.7	- 4.6	- 7.1
55-59	- 3.2	- 0.3	- 3.0
60-64	- 5.1	- 0.2	- 4.9
35-64	- 6.4	- 1.3	- 5.1

non-CHD mortality, one will get the estimated effect of CHD mortality decrease).

Note that the CHD mortality drop was not the leading cause of the overall decrease, and this was true for all age subgroups. For the age group as a whole, 1.3 % of the decrease is attributable to CHD mortality, and 5.1 % to the non-CHD mortality.

These figures are important, because they strongly suggest that some general forces acted on mortality : this leads to question the specificity of the CHD mortality drop. In order to deal with this question, attention has to be focused on the proportion of CHD deaths among all deaths, i.e. on the questionable part of mortality statistics which may depend on shifts between diagnostic categories.

A basic approach is to consider trends observed in some other diseases, which are most likely to be confused with CHD diagnoses. Table 3 provides data regarding four of them; it shows that mortality from other cardiovascular diseases (grouped here in two categories) declined in almost all age subgroups. Note that this decline was generally greater than the decline observed for CHD mortality.

The reverse was true for sudden deaths and some ill defined causes of deaths : an increase is observed in each age subgroup. The group of "selected accidents" (which certainly includes some CHD and/or sudden deaths as cause of the accident) shows striking differences between age subgroups, but, for the age group as a whole, mortality from these selected accidents didn't follow the general decline of overall mortality and CHD mortality.

A further step is to know how far the trends listed in table 3 (or trends of any other relevant diseases) could have influenced the observed CHD trends. Even if no actual data are available regarding accuracy of causes of death, this question can be answered indirectly by error models : one can compute some expected values of CHD mortality change under different hypotheses regarding shifts between diagnostics categories.

Very sophisticated models can be designed for such purpose, but let's make a simple example. One can pool CHD deaths with the conditions listed in table 3, and consider this pool as "possible CHD" (PCHD) deaths. The reason for doing this is that shifts regarding CHD are most likely to occur within this pool. Thus, CHD mortality can be expressed as follows :

CHD mortality =

overall mortaliy
x
proportion of PCHD deaths among all deaths
x
proportion of CHD deaths among PCHD deaths

Note that this is another way to consider CHD mortality, where two components of proportions of CHD deaths are used instead of one (as in table 1).

Table 4 shows how these proportions vary. For the age group as a whole, the proportion of PCHD deaths declined (2,8 %), and this can be regarded as an indirect evidence that the CHD mortality decrease was real during the period under observation. On the other

Table 3 : CHANGE (%) IN MORTALITY RATES FROM SELECTED CAUSES OF DEATH, 1975-76/1981-82

Age	Other Heart and Vascular Diseases	Cerebrovascular and other CV diseases	Sudden deaths and selected unknown causes	Selected accidents
35-39	- 12.4	- 102.9	+ 34.0	- 17.9
40-44	+ 10.6	+ 16.8	+ 57.6	+ 1.5
45-49	- 28.7	- 12.3	+ 30.9	+ 18.3
50-54	- 17.9	- 13.8	+ 51.2	+ 17.2
55-59	- 10.4	- 2.6	+ 29.3	+ 2.4
60-64	- 19.6	- 44.1	+ 44.6	- 17.9
35-64	- 17.6	- 26.7	+ 40.7	+ 0.1

Table 4 : CHANGE (%) IN CHD MORTALITY, OVERALL MORTALITY AND COMPONENTS OF PROPORTION OF CHD DEATHS,1975-76/1981-82

Age	CHD mortality	Overall mortality	Proportion of PCHD deaths among all deaths	Proportion of CHD deaths among PCHD deaths
35-39	- 13.4	- 12.5	- 18.8	+ 15.1
40-44	- 16.6	- 5.7	+ 5.8	- 17.1
45-49	- 14.7	- 9.1	- 0.1	- 4.9
50-54	- 21.8	- 11.7	- 3.7	- 5.1
55-59	- 1.2	- 3.2	+ 0.8	+ 1.2
60-64	- 1.0	- 5.1	- 5.4	+ 8.8
35-64	- 6.6	- 6.4	- 2.8	+ 2.3

hand, the proportion of CHD deaths among the pool of PCHD deaths increased (2,3 %), mainly because of the increase in older age groups (55-64 years). This might correspond to some real phenomenon (that is : CHD mortality declines slower than other related diseases), but might be also due to increased accuracy of medical diagnosis or shifts in cause of death assessment and/or coding.

Using table 4, one can further compute some possible values of CHD mortality trends, providing some hypothetical values for these proportions. Table 5 compares the observed CHD mortality trends (first column) with three hypothetical values :

- the second column gives the values of CHD mortality change, holding constant, in all age subgroups, the proportion of PCHD deaths among all deaths;
- the third column gives the values of CHD mortality change, holding constant the proportion of CHD deaths among PCHD deaths;
- the fourth column gives the values of CHD mortality change, holding constant the proportion of CHD death among all deaths (table 1); these values are of course equivalent to the overall mortality change.

Note that under all three hypotheses, the age-standardized CHD mortality declined. Thus, results presented in table 5 can be interpreted as follows : it is very likely that CHD mortality declined between 1975-76 and 1981-82 in this age group. The magnitude of the decrease was very probably situated between 3,9 % and 9,2 %, and probably between 6,4 % and 9,2 %.

Similar interpretation can be made for each age subgroup; note that for men aged 50-54 years, the decrease was more likely to be situated between 11.7 % and 17.5 %, rather than the observed value of 21,8 %.

These ranges of values are much more informative than any confidence interval provided by usual statistical procedures : the reason for this is that errors are most likely systematic and not random (as is supposed in usual statistical tests).

Several other values can be computed using different hypotheses, and other issues can be considered to assess the consistency of the CHD mortaliy decline. For example, possible shifts between causes stated as underlying versus immediate and/or concomitant causes can be included in error models (11). One can also compare the trends observed for different seasons, in order to take account of epidemics (12). Furthermore, comparisons can be made between probabilities of death (using generation life tables) rather than between usual cross-sectional mortality rates (9).

Reasons for the decline

If the change in CHD mortality rates is viewed as very likely, the next step is to find some (causal) association. Enormous emphasis has been laid on change in life style and/or therapeutics improvement to explain such trends (13). The implicit assumption is that, when controlling population size and age structure, two populations are at the same risk of death, except for some risk or protection factors (life style for example). It should be remembered that population structure differ in many other respects

Table 5 : CHANGE (%) IN CHD MORTALITY : OBSERVED VALUES VS. THREE EXPECTED VALUES,1975-76/ 1981-82

Age	Observed values	Expected values : PCHD / all deaths constant	CHD / PCHD constant	CHD / all deaths constant
35-39	- 13.4	+ 4.5	- 33.6	- 12.5
40-44	- 16.6	- 23.8	+ 0.4	- 5.7
45-49	- 14.7	- 14.5	- 9.3	- 9.1
50-54	- 21.8	- 17.5	- 15.9	- 11.7
55-59	- 1.2	- 2.0	- 2.5	- 3.2
60-64	- 1.0	+ 4.1	- 10.8	- 5.1
35-64	- 6.6	- 3.9	- 9.2	- 6.4

Table 6 : CHANGE (%) IN CHD MORTALITY, POPULATION SIZE AND NUMBER OF CHD DEATHS 1975-76/1981-82

Age	CHD mortality	Population size	CHD deaths
35-39	- 13.4	+ 24.2	+ 14.0
40-44	- 16.6	+ 1.6	- 14.7
45-49	- 14.7	+ 0.5	- 14.1
50-54	- 21.8	- 2.5	- 24.9
55-59	- 1.2	+ 7.5	+ 5.8
60-64	- 1.0	- 3.1	- 4.2
35-64	- 6.6	+ 5.7	- 5.6

Table 7 : CHANGE (%) IN CHD MORTALITY, POPULATION SIZE AND NUMBER OF CHD DEATHS 1975-76/1981-82

Age	CHD mortality	Population size	CHD deaths
35-44	- 22.2	+ 14.2	- 4.8
45-54	- 20.0	- 1.0	- 21.2
55-64	- 2.3	+ 2.2	- 0.1
35-64	- 8.0	+ 5.7	- 5.6

than population size and age structure : these are only the two most important factors for mortality. Thus, before considering any "desirable change", other aspects should be considered. Official statistics provide some information in this respect.

Table 6 shows the change for the two components of CHD mortality rates : population size and number of CHD deaths. Note that population size increased during the period under observation (5.7 %), mainly because of the striking increase in the age subgroup 35-39 years (24.2 %).

A first consequence of this pattern should be noted : such unequal increase among age subgroups makes age-standardized rates much more dependent on the definition of age subgroups. Table 7 makes it obvious : if 10 years subgroups had been defined (instead of 5 years as in table 1), the age-standardized drop would have been 8 % (instead of 6.6 %). The difference ist not striking in this case, but other combinations can be more confusing (including differences in trends sign). This kind of problem is well known, although a review of current literature suggests that little attention is paid to this basic bias when discussing, for example, downturn in trends, or differences between geographical areas.

One could ask why the population size increased in some age subgroups, and declined in some others. Since the data concerns Swiss citizens only, part of the answer is given by the variation in number of live births in each related birth cohort. Table 8 shows, for example, that the striking increase observed for the age subgroup 35-39 is related to the "baby boom" for the corresponding birth cohort (in Switzerland, the baby boom started in 1941). The relationship is, however, less clear for other age subgroups. The reason is that other factors influenced the number of live persons in each birth cohort, namely :

- the previous mortality experience of each generation, which influences the number of "natural losses";
- the previous naturalization rates of each generation, which increase the number of Swiss citizen;
- the previous emigration rates of each generation, which decrease the number of Swiss citizens;

Few published data on these effects are available in Switzerland, and the last column of table 8 ("other sources of variation") gives the aggregate effect of the three effects mentioned above. Since overall mortality declined since the beginning of the century, a positive sign is expected in the last column, with an increased magnitude in each age subgroup. This is not completely true, suggesting that the balance between naturalization, emigration and mortality rates was specific for each generation.

This should be kept in mind for two reasons :

- The first regards the structure of national population : a basic effect of naturalization of foreigners and emigration of Swiss citizen is to modify the population mix (in terms of ethnic differences as well as in life style differences) and, perhaps, to modify the risk of population

Table 8 : CHANGE (%) IN POPULATION SIZE AND RELATED SOURCES OF VARIATIONS, 1975-76/1981-82

Age at the time of the study (1975-76/1981-82)	Birth years of related birth cohorts	Variations of population size (1975-76/1981-82)	Variations number of live births	Variations from other sources
35-39	1936-41/1942-47	+ 24.2	+ 23.6	+ 0.8
40-44	1931-36/1937-42	+ 1.6	+ 1.8	- 0.2
45-49	1926-31/1932-37	+ 0.5	- 4.9	+ 5.1
50-54	1921-26/1927-32	- 2.5	- 8.2	+ 5.3
55-59	1916-21/1922-27	+ 7.0	- 1.0	+ 8.0
60-64	1911-16/1917-22	- 3.1	- 2.4	+ 0.8
35-64	1911-41/1917-47	+ 5.7	+ 2.4	+ 3.4

regarding CHD mortality and/or overall mortality (14,15). If population mix is dramatically different between birth cohorts, this could be a part of the explanation of observed trends.

- A second aspect regards the previous mortality experience of each generation. Recent papers (16) emphasized the importance of physiological age in mortality trend; Mc Laren (17) pointed out that part of the differences in CHD mortality between countries could be explained by differences in infant and childhood mortality, for each related birth cohort. These aspects may be important for present and future analysis of mortality trends.

Further research is needed to know how far these two aspects may influence CHD mortality trends within a country, or differences between countries or geographical areas. This point is mentioned here, because a greater emphasis should be made on heterogeneïty of populations compared at different times (18).

Comment

A major drawback regarding mortality statistics is the poor quality of cause of death information. But another drawback should not be overlooked : these statistics are still too frequently used to illustrate some opinion. This opinion might be sound or not, but a better use is clearly needed if some kind of epidemiological surveillance is expected from these statistics.

This means primarly that all available informations provided by these statistics are to be used (and possibly exhausted). This also means that a closer insight can be gained into mortality trends when doing more than simple age-standardisation, but without oversophisticated (and generally scarcely controllable) statistical procedures.

More attention paid to this basic descriptive step will certainly result in sounder comments on trends, better protection against overenthusiastic interpretation and will generate more fruitful hypotheses.

Summary

This paper comments on the drop in coronary heart disease mortality observed in Switzerland among middle-aged men since the mid-seventies. Several methodological points are made regarding the consistency of this decline (relationships with mortality from other causes), and the reasons for this drop (possible change in population mix). It is suggested that a more complete use of vital statistics is still possible and that this can provide useful clues for the assessment and the interpretation of mortality trends in the field of cardiovascular epidemiology.

L'analyse des tendances de la mortalité cardiovasculaire : quelques remarques méthodologiques

Cet article commente la baisse de la mortalité par coronaropathie observée en Suisse chez les hommes d'âge moyen depuis le milieu des années soixante-dix. Plusieurs aspects méthodologiques sont présentés, concernant la vraisemblance de cette diminution (relations avec la mortalité par d'autres causes), et les raisons de cette baisse (changement possible de la structure de la population). Il est suggéré qu'une utilisation plus complète des statistiques disponibles est souhaitable, et que cela peut fournir des indications utiles pour évaluer et interpréter les tendances de la mortalité cardiovasculaire.

Analyse der Trends der kardiovaskulären Sterblichkeit : ein paar methodologische Bemerkungen

Dieser Artikel kommentiert die Senkung der Sterblichkeit durch Koronaropathie, welche in der Schweiz bei den Männern seit 1975 zu beobachten ist. Mehrere methodologische Aspekte werden erwähnt, die die Wahrscheinlichkeit dieser Senkung (Zusammenhänge mit Sterblichkeit durch andere Todesursachen) sowie die Gründe dieser Senkung (mögliche Veränderung der Bevölkerungsstruktur) betreffen. Eine allgemein intensivere Auswertung der Bevölkerungsstatistik wäre wünschenswert, was wichtige Elemente für die Bewertung und die Auslegung der kardiovaskulären Sterblichkeitstendenzen liefern könnte.

Bibliography

1. Rose G. Strategy of prevention : lessons from cardiovascular disease. Br Med J, 1 : 1847-51, 1981.
2. W.H.O. Expert Committee. Prevention of coronary heart disease. W.H.O. Technical Report Series no 678, 1982.
3. Gillum R.F., Blackburn H., Feinleib M. Current strategies for explaining the decline in ischemic heart disease mortality. J Chron Dis, 35 : 467-474, 1982.
4. Pisa Z., Uemura K. Trends in mortality from ischaemic heart diseases and other cardiovascular diseases in 27 countries, 1968-1977, World Health Statistics, 35 : 11-47, 1982.
5. Havlik R.J., Feinleib, M.(ed). Proceedings of the Conference on the decline in coronary heart disease mortality. NHLBI, US-DHEW, NIH Publication no 70-1610, Washington DC, 1979.
6. Guberan E. Surprising decline of cardiovascular mortality in Switzerland : 1951-1976, J Epidemiol Community Health, 33 : 114-20, 1979.
7. Gass R. L'influence des facteurs géographiques, démographiques et socio-économiques sur la mortalité par cardiopathies ischémiques en Suisse. Rev Epidem Santé Publ, 27 : 315-29, 1979.
8. Neury J.-E. La mortalité due aux maladies ischemiques du coeur en Suisse de 1969 à 1978, Bull Med Suisses, 60 : 1874-1878, 1979.
9. Alexander J., Junod B., Wietlisbach V. Trend in coronary and cerebrovascular mortality in Switzerland, unpublished paper, 1981.
10. Wietlisbach V., Gutzwiller F. Mortalité cardiovasculaire en Suisse : évolution de 1970 à 1980. Med. et Hyg., 42, 430-4, 1984.
11. Wietlisbach V., Gutzwiller F. Analyse des tendances récentes de la mortalité cardio-vasculaire en Suisse. Sozial- und Präventivmedizin, 29 : 165-167, 1984.
12. Gordon T., Thom T. The recent decrease in coronary heart disease mortality. Prev Med, 4 : 115-25, 1975.
13. Levy R.I. The decline in cardiovascular disease mortality. Am Rev Public Health, 2 : 49-70, 1981.
14. Brahimi M. La mortalite des étrangers en France. Population, 35 : 603-27, 1980.
15. Marmot M.G. Adelstein A.M., Bulusu L. Immigrant mortality in England and Wales 1970-78. Studies of medical and population subjects, no 47. Office of Population Censuses and Surveys, London, HMSO, 1984.
16. Fries J.F. Aging, natural death and the compression of morbidity, N Eng J Med, 303 : 130-5, 1980.
17. Mc Laren D.S. Ischaemic heart disease mortality in Sweden. Lancet, 1 : 1446, 1983.
18. Shepard D.S., Zeckhauser R.J. Long term effects of interventions to improve survival in mixed population. J Chron Dis, 33 : 413-433, 1980.