Measurement and Analysis of Mortality

New Approaches

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Classification of Developed Countries according to Cause-of-Death Patterns: A Test of Robustness during the Period 1968–1974

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1. Introduction

The development of statistical theory originated in the study of mortality and measurement of death risk. Both were of interest to insurance companies and bankers. Indeed, a correct estimate of mortality by age makes it possible to wager on human life along insurance principles, and the service rendered by this insurance is a source of profit. Unlike literature on causes of death, the literature on estimates and modelling of mortality by age is abundant. For actuaries, it is less important to know what a client is going to die of than his date of death. However, knowledge of causes of death interests another sector, that of health organizations. There is little doubt that developments on modelling of mortality by causes of death are scarcer and less penetrating than the advances in modelling of mortality by age. This may be due to the combination of paucity and unreliability of the data and the intrinsic difficulties of the subject. We have already learnt, using the model tables by Ledermann (1959) and Coale and Demeny (1966), that two countries can have the same life expectancy and yet experience two very different age-specific death risk patterns. With causes of death the analysis becomes more complicated since two countries which have identical death rates at given ages, such as Japan and Sweden, may have radically opposed causal profiles.

In a recent paper (Brouard and Lopez 1985) we defined a typology of countries with low mortality according to causes of death. This typology was established on the basis of a cross-sectional analysis of 45 countries around 1980. One of the results of the analysis is that Sweden is characterized by a pattern dominated by cardiovascular diseases. This is a rather paradoxical fact since the death rate by cardiovascular disease in Sweden is presently one of the lowest in the world. But this is only because Sweden has the second-highest observed life expectancy in the world. When the bulk of countries reach comparable levels of life expectancy, Sweden will appear as a country where mortality from cardiovascular diseases is most significant.

In this chapter I will attempt to confirm the validity of the typology elaborated before by testing its robustness on a set of developed countries during and after 1968. The study uses all available WHO mortality data for developed countries where the deaths by cause are classified according to the Eighth and Ninth Revisions of the International Classification of Disease. The first year is usually 1968 and the last is 1984 and thus the study covers a period of roughly 15 years. I shall also try to assess the robustness of the method by analysing geographical variations within one country. Before presenting the results, I will briefly summarize the methodology and the nature of the data, and state the main hypotheses.

2. Nature of the Data and Method

2.1. Data

It should be remembered that only the initial cause of death is itemized in WHO statistics: the process, the multiple causes, the circumstances which led to the death are totally unknown to us. This is an important limitation of the study. We focus on 35 developed countries which regularly send their statistics to WHO (this excludes the USSR). While the statistics are available according to a list of 150 causes of death, we restrict our study to 16 specific causes (see Appendix 14.1). This reduction allows us to maximize simplicity: the intercorrelation between causes is complex enough to require minimization of the number of parameters to be estimated. The reduced list of causes of death also achieves parsimony in the sense that we preserve relevant information whenever desired. Thus, for example, in the case of tumours we gain simplicity by retaining only those items which are either quite frequent or of relevance to health. organizations, physicians, and epidemiologists. We gain in parsimony by not aggregating those items with frequencies that vary considerably across countries. Thus, tumours are broken up into four rubrics: lung, respiratory and digestive, breast (for women) and prostate (for men), and stomach.

2.2. The Statistical Method

In accord with the general goal of model tables, we are interested in the proportional distribution of deaths by causes. We want to show that countries have a cause-of-death profile that, without being completely invariant, remains very characteristic in the sense that the difference between two profiles of one country at two different dates is less marked than that of two different countries at the same date. Moreover, since it is too complicated to introduce the full age detail of these cause-specific profiles (Duchene 1980) we have chosen three broad age groups: 15–24, 45–54, and 65–74 years. Mortality in the first age group does not involve the same causes as does mortality in the other two and is dealt with separately. Causes of death in this group are reduced to four: (*a*) road accidents, (*b*) suicides, (*c*) other accidents, and (*d*) other causes. In the other age groups all 16 causes play an important role (see Figure 14.1). The average level of the death rate in the age group 45–54 for all 35 developed countries is six to seven times lower than that in the age group 65–74 and its cause-specific distribution is very different: in particular, cardiovascular diseases play a much more important role whereas accidents play a lesser one. Figure 14.1 also shows that there are marked differences in the distribution of causes of death by sex. The distributions calculated at the beginning of the observation period (1968–9) and at the end of the period (1983–4) show that, if the average level of mortality has decreased (from 475 per 100 000 to 432 for males in the age group 65–74, for example), the structure has not greatly changed. Admittedly, these average distributions hide significant variability between countries but we can show that age- and sex-specific peculiarities in the distribution of cause of death tend to be reproduced for other ages and the other sex.

We now describe the statistical method applied to understand the relation between the results of the longitudinal analysis and those of the cross-section. In Appendix 14.2 we give details on the calculations as well as additional numerical results. Consider a table where countries are placed in rows and the 16 chosen causes of deaths appear in the columns. Each cell on the table may represent the death rate in country *i* by cause *j* for a given sex and age. The sum of the cells in a row gives the total death rate. Dividing each of the cell values into the total death rate, yields a cause-of-death profile or the cause-of-death distribution. If we then define a distance between two profiles, calculate a table of distances between countries, and apply an automatic classification procedure to the table of distances, we will obtain a typology of countries. Admittedly, the procedure has limitations since: (*a*) there is no unique definition of distance, (*b*) there are multiple classification algorithms, and (*c*) the number of groups desired in the typology is arbitrary. Nevertheless, we have been able to assess the robustness of the typology by changing the definition of distance and altering the classification algorithm. Although the proximity between groups varies according to the methods used, the typology suggested here is robust and, without being optimal, is in all cases quite acceptable. Instead of summarizing the different typologies obtained, I will show the details of the method used so that its results can be replicated more easily.

As indicated in Appendix 14.2, instead of presenting two separate analyses, one for the age group 45–54 and the other for the age group 65–74, I have juxtaposed the tables corresponding to each of them. This was done only after having verified that the resulting typologies were consistent with each other. Thus the total for a row yields now the sum of the rates in the two age groups. To assign weight to causes of lesser significance and to

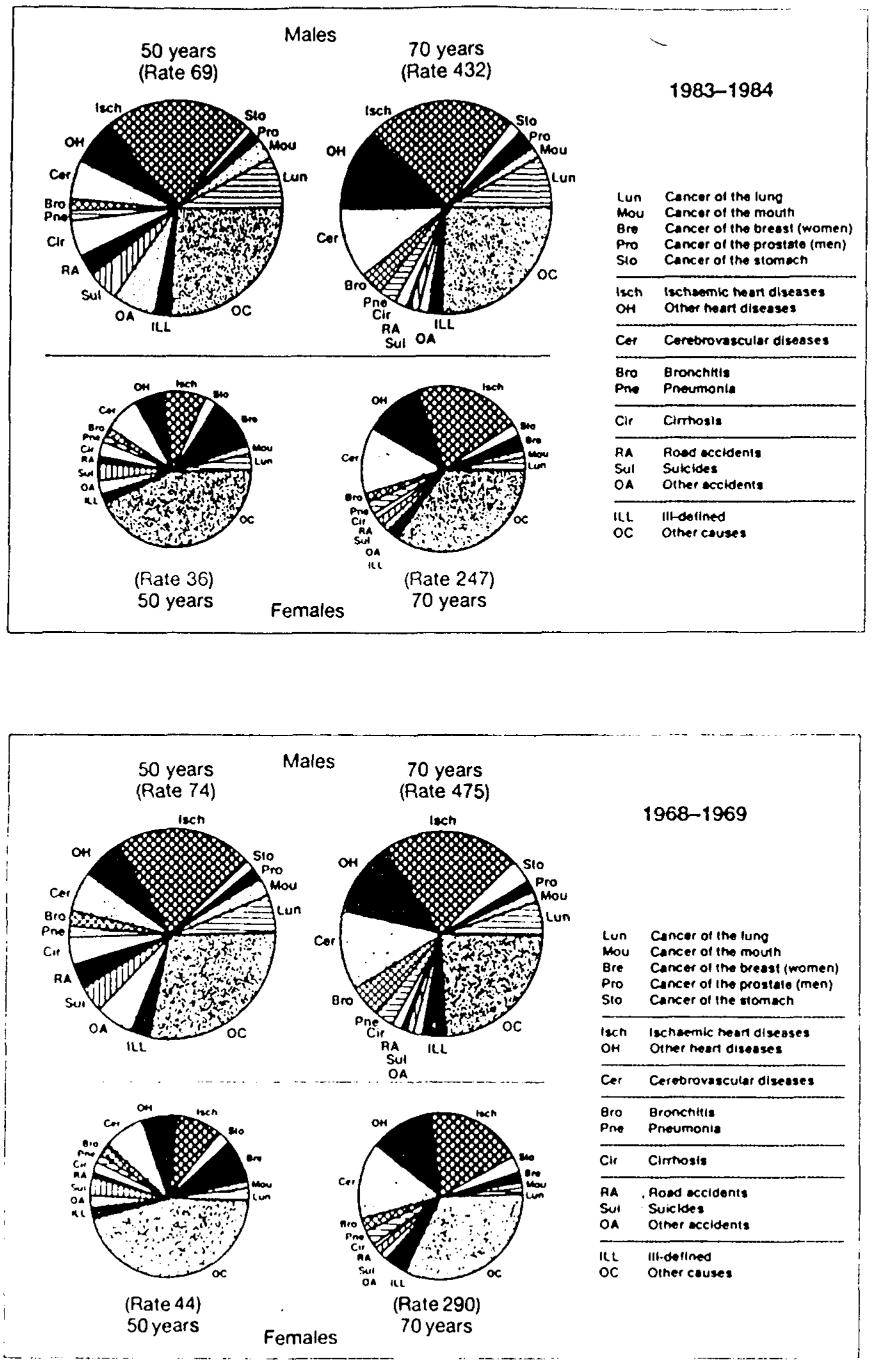

Fig. 14.1. Distribution of deaths by cause at 45–54 years and 65–74 years for males and females. Average from 35 countries in 1983–1984 and 1968–1969

re-establish the relative balance between rates in both age groups, I have chosen the distance x^2, which is defined as the total of the weighted square differences between the profiles of two countries. The weights are the reciprocal of the average death rate by cause (see Appendix 14.2). Although it would have also been possible to combine female and male tables into a global typology, it was thought that a sex-specific analysis was more informative. In fact, although the resulting typologies are quite similar, their graphical representation and their correspondence with causes of death are very different (this is especially true for breast cancers, which are clearly not distributed in the same way as cancers of the prostate). If indeed we choose the distance x^2, the associated factor analysis offers a possibility of performing an analysis of correspondence between the causes of death and the countries in the sample (Benzecri 1973).

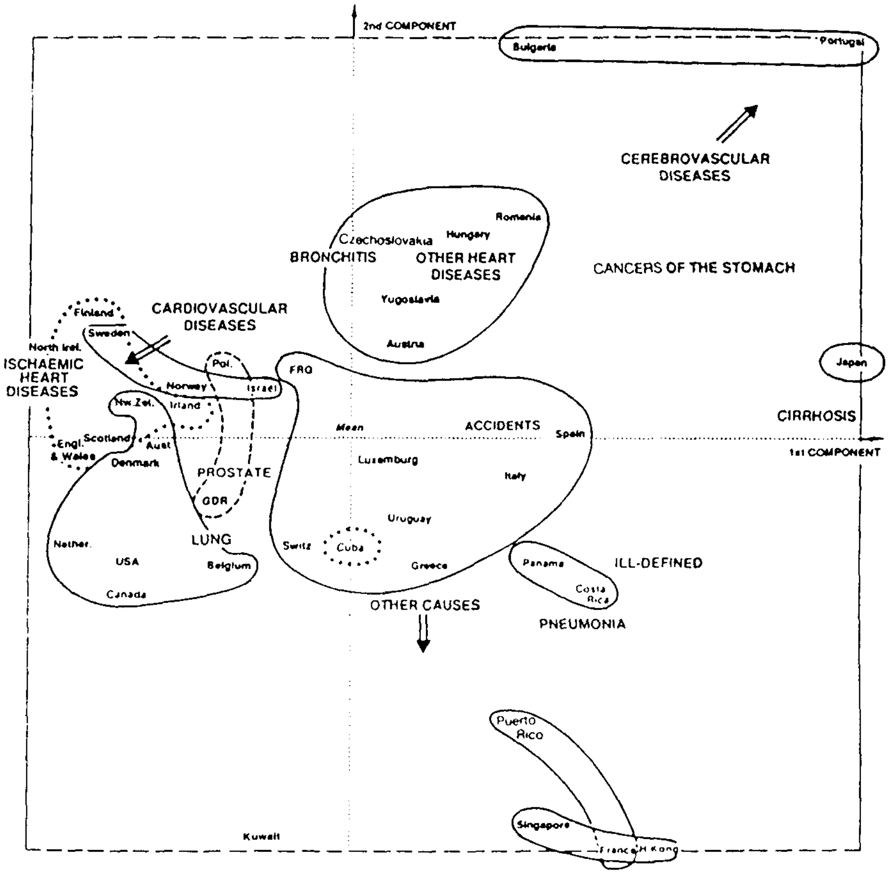

Fig. 14.2. Classification of countries according to their death-by-cause profile at 45-54 years and 65-74 years, men, first and second components

The typology consists of 11 groups. The developing countries which are listed (in parentheses) have been removed from subsequent analysis since our study is only concerned with developed countries. The list of countries in each group is presented below. The representation in the form of contours on two factorial planes intersecting components 1 and 2 and 1 and 3 appear in Figures 14.2 and 14.3 respectively. The groups are:

A: Japan;
B: Singapore, Hong Kong;
C: France, (Puerto Rico);
D: Portugal, Bulgaria;

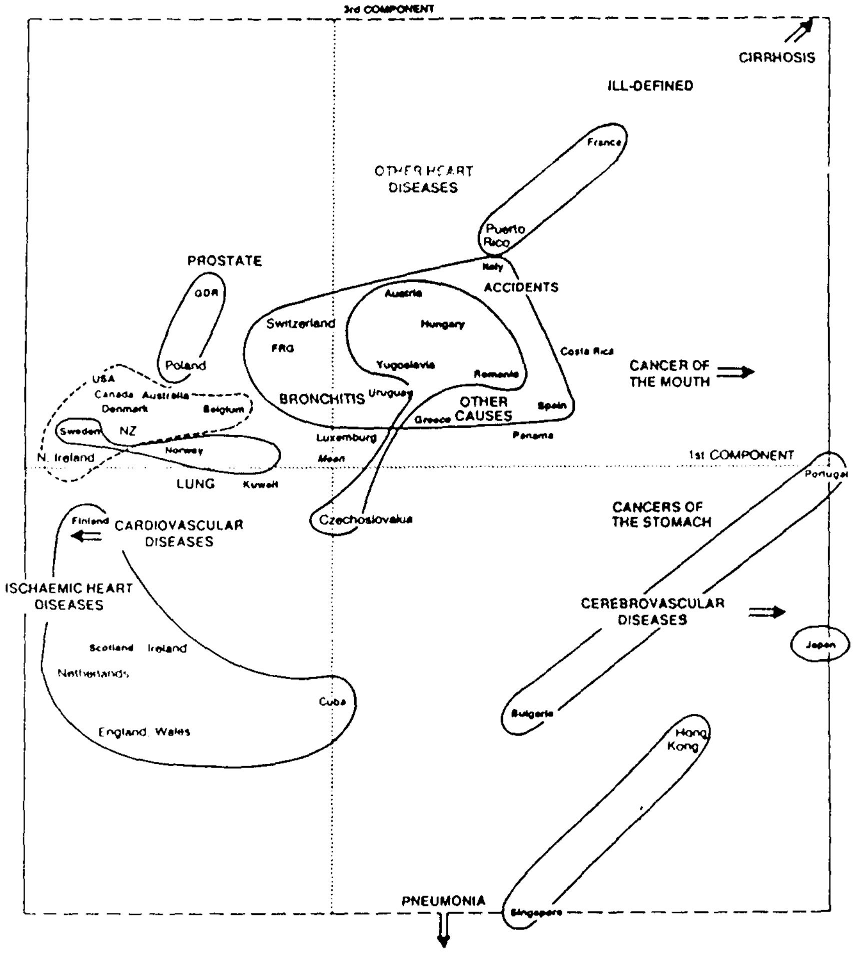

Fig. 14.3. Classification of countries according to their death-by-cause profile at 45–54 years and 65–74 years, men, first and third components

E: (Panama, Costa Rica);
F: Spain, Italy, Greece, Uruguay, Federal Republic of Germany (FRG), Switzerland;
G: Romania, Yugoslavia, Hungary, Austria, Czechoslovakia;
H: Poland, German Democratic Republic (GDR);
I: United States, Canada, Australia, New Zealand, The Netherlands, Denmark, Belgium;
J: England and Wales, Scotland, Northern Ireland, the Republic of Ireland, Finland, (Cuba);
K: Sweden, Norway, Israel.

The results of the factor analysis on the first two components leads to a contrast between countries with a high proportion of cerebrovascular diseases (upper right corner of Figure 14.2) and those having a high proportion of cardiovascular diseases (upper left corner of Figure 14.2). When we use the first and third component, the contrast is between those with a high proportion of deaths due to alcoholism (upper right corner of Figure 14.3) and those with a high proportion of pneumonias (bottom of Figure 14.3). Each new axis makes it possible to distinguish other diseases which are associated with more particular countries clearly; however, the multiplicity of

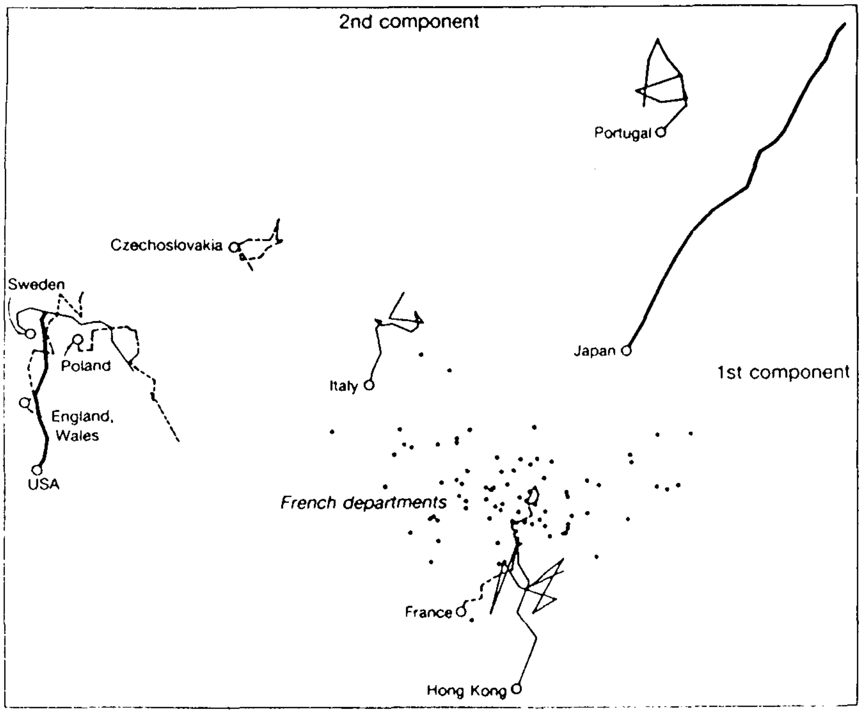

Fig. 14.4. Trajectories of representative countries from each group on the factorial plane (1,2) during the period 1968-1984, and position of the 95 French departments

planes complicates the accounting and synthesis a great deal. We should note that the factor analysis, whose objective is to summarize the initial information contributed by the 16 causes, can not lead to further reductions of the information, for the relations between causes and countries are very complex. In fact, 88% of the variance is explained by a total of six components. The graphic presentation of just two factorial planes in no way allows a correct translation of the initial information and only the final classification is valid. The graphs presented here are only an illustration of this classification.

The results of this factor analysis can be used to visualize the relative location of other countries or the same country at different periods of time in order to assess the evolution of the cause-specific distribution independently from the total level of mortality. It is this technique that we have used to visualize the trajectory of developed countries over the last 15 years or so.

3. Longitudinal Analysis

All the data from developed countries have been projected on to various factorial planes but, given that the projection of 640 or so points on to the

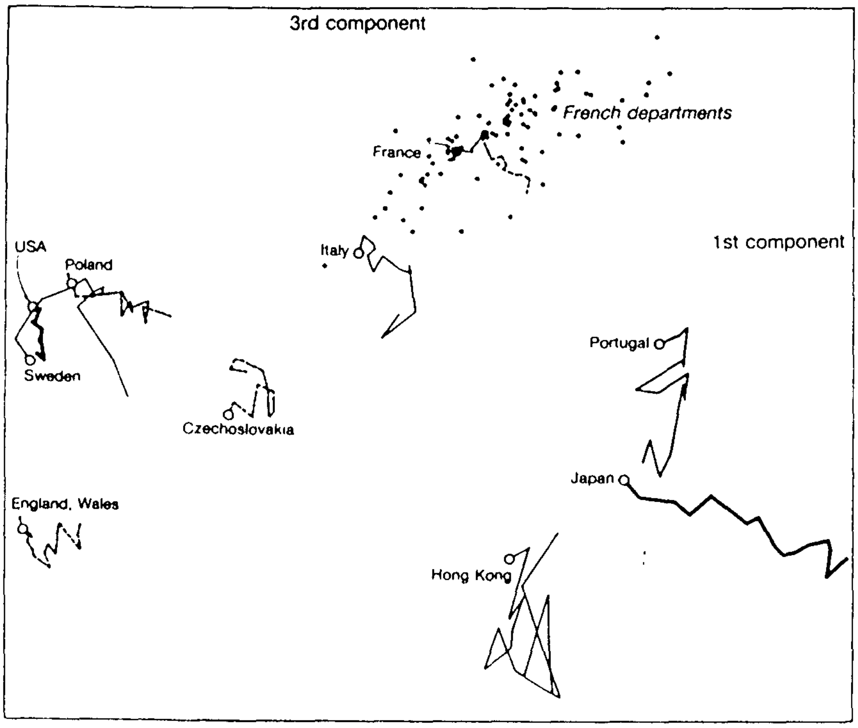

Fig. 14.5. Trajectories of representative countries from each group on the factorial plane (1,3) during the period 1968–1984, and position of the 95 French departments

same graph is illegible, we have chosen to display only one representative for each of the groups defined. Figures 14.4 and 14.5 show the trajectories of the countries on planes (1, 2) and (1, 3). Apart from Japan, where mortality decline has been particularly rapid, we observe that over 16 years the cause-of-death profiles are remarkably stable. The case of Japan is interesting as

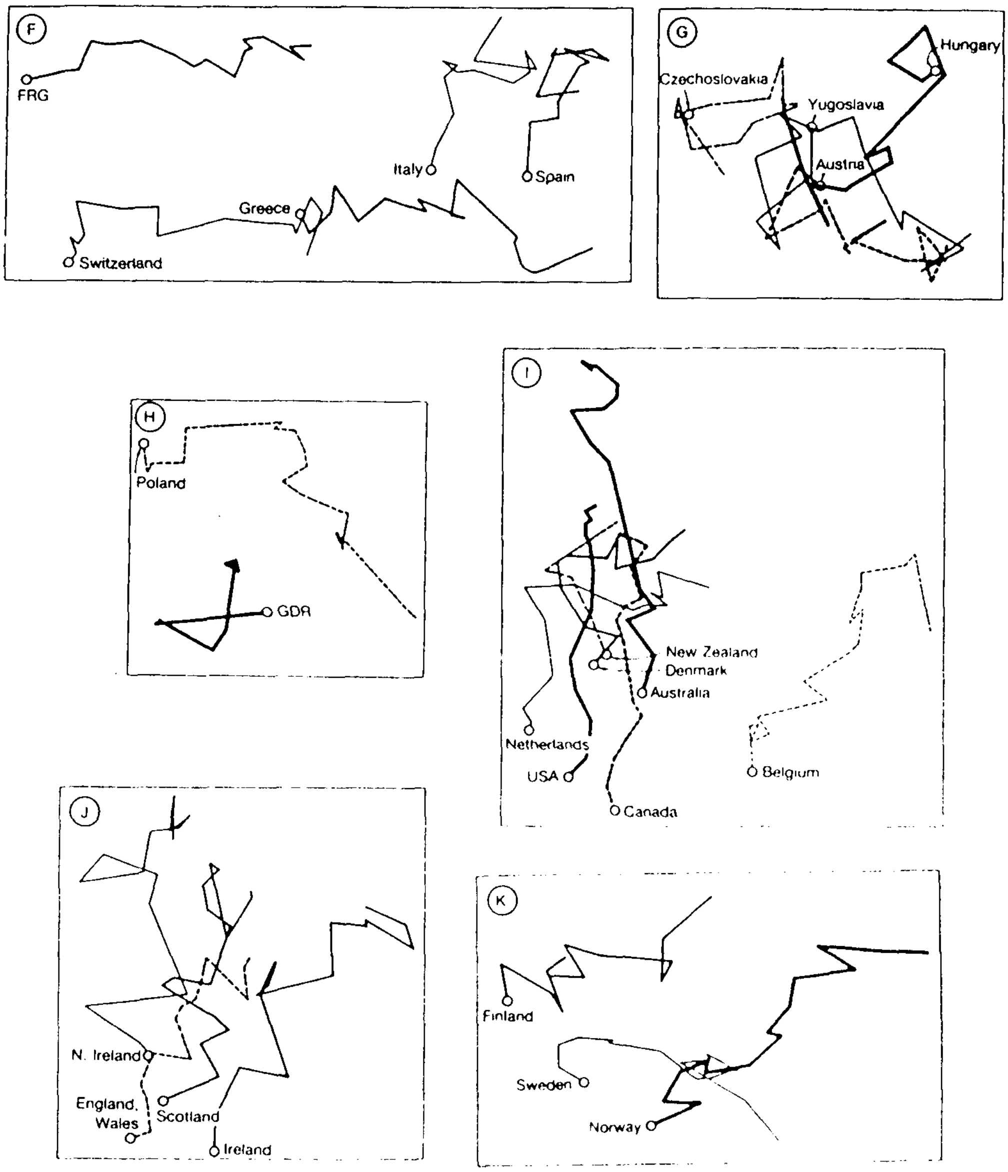

Fig. 14.6. Trajectories of various countries of a same group on the plane (1,2) during the period 1968-1984

its trajectory reveals a very clear decline in cerebrovascular diseases, which accompanies the general improvement in life expectancy between 1968 and 1984 (with gains of about four years for males and six years for females). The sloping trajectories like those of France or of Italy also reveal a decline in cerebrovascular disease.

In order to better analyse the development of countries within a group, we have drawn specific contours for each group (see Figure 14.6). In group I containing the overseas Anglo-Saxon countries (with Denmark, Belgium, and the Netherlands) one observes that the trajectories descend revealing a decline in cardiovascular and cerebrovascular disease and an increase in lung cancers. Group J (British Isles and Finland) reveals absolutely identical trends. Group K (other Nordic countries and Israel) is quite different as they show a very marked increased in the proportion of cardiovascular disease. Here it is possible to detect the recent turn-about of Sweden. In group F (the Mediterranean countries) Greece differs from Italy and Spain due to a higher proportion of cardiovascular disease. Trends are identical for Spain and Italy but different for Greece. The FRG and Switzerland, which were regrouped with these Mediterranean countries, tend to deviate from the group because of a steady increase in cardiovascular disease and lung cancers. The FRG is remarkably similar to the GDR. In group G (containing the Central European countries of Hungary, Czechoslovakia, Austria, Yugoslavia, and Romania) the most important and disturbing characteristic is the increase in the male death rates at given ages. Table 14.1 shows that, apart from Austria, male death rates increased at all ages between 1968 and 1984. For Austria, the death rate at ages 45–54

Table 14.1. *Death rates per 1000 in age groups 45–54 and 65–74 for Central European countries where male mortality stagnated or increased between 1968 and 1984* (per 1000)

Country	Year	Males		Females	
		45–54	65–74	45–54	65–74
Austria	1969	77	582	44	321
	1984	76	437	33	231
Bulgaria	1968	59	411	36	311
	1983	80	509	37	325
Czechoslovakia	1968	77	542	41	318
	1983	103	606	42	342
Hungary	1969	72	520	43	339
	1984	133	589	53	335
Poland	1969	77	507	42	302
	1984	108	514	41	284
Romania	1969	70	496	46	360
	1983	93	495	45	334
Yugoslavia	1968	70	470	44	340
	1982	86	500	40	314

Source: WHO, data bank.

has stagnated. The increase is less in the last age group and for females the trend is not systematic at all. The graphical representation reveals that the mortality increase in Central European countries is not due to any particular cause but is the outcome of a simultaneous increase of all causes. What we are witnessing in these countries is a general degradation of health conditions. Thus, for example, in the case of Hungary the trajectory is ascending according to component 3 (see Figure 14.7), which means that deaths by cirrhosis are increasing more than deaths by other causes. But the major role played by alcoholism in Hungary is not necessarily present in other countries. For example, it is not characteristic of the mortality increase in Czechoslovakia. And, since the case of Austria is not very favourable either, it is difficult to associate the Central European course of mortality with the political context. A complete explanation would require recourse to typical behaviours and practices in Central Europe. Table 14.1 also shows that mortality increases in Bulgaria and in Poland are attributable to cardiovascular diseases and lung cancers. These countries, together with the GDR, are part of group H. In the GDR mortality is decreasing rather than increasing.

In summary, this method of graphical representation makes it possible to detect major cause-specific mortality trends. It does not replace, however, classical quantitative work, which demands a return to basic data. We should also note that the method is unsuitable for a small country or for a country where the statistics are not very reliable for, by and large, the trajectories will be unclear and uninterpretable.

With this kind of graphical representation it is possible to look at the spread obtained when a country is divided into geographical sub-regions. Data are only shown for France and its 95 departments for the period

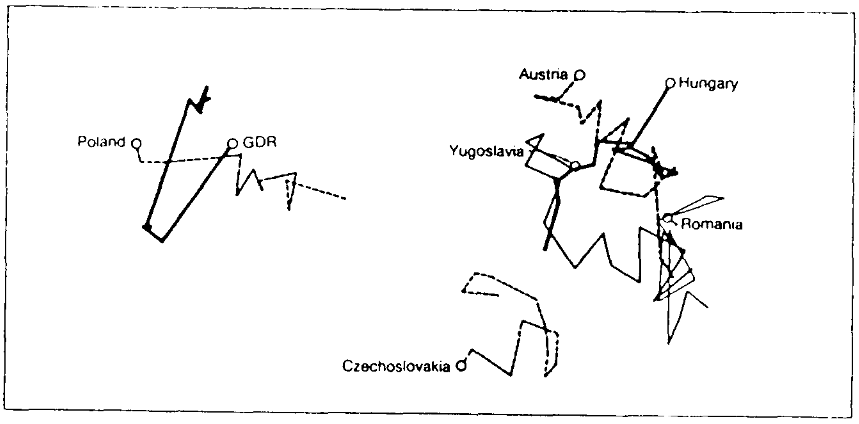

Fig. 14.7. Mortality increase in Central European countries, 1968-1984. Visualization on axes (1,3): the trajectory of Hungary moves towards the north-east quarter of cirrhosis of the liver

1974–6 (Figures 14.4 and 14.5). It may be noted that the scatter is relatively concentrated to only a small zone around the point 'France'. French departments which are geographically close to Italy (like Corsica) are close to the point 'Italy'. With this kind of statistical analysis and graphical representation we will be able to discover the structure of mortality by cause of death.

4. Death Risk in the Age Group 15–24

Although the two age groups we have chosen for analysis, 45–54 and 65–74, cover the majority of deaths, mortality in the age group 15–24 deserves special attention due to the increases in mortality experienced by some countries during the past decade. Figure 14.8 shows the position of all developed countries with regard to causes of death at this age and Figure 14.9 illustrates some remarkable national trajectories. Thus in Norway suicides have taken on an ever-growing proportion, Belgium is still particularly vulnerable to road accidents, and Italy, and especially Spain, depart from the characteristic profiles of developing countries (low proportion of suicides and road accidents) to join the other developed countries. Finally, Czechoslovakia draws away from the group of developed countries, while Bulgaria's position stagnates.

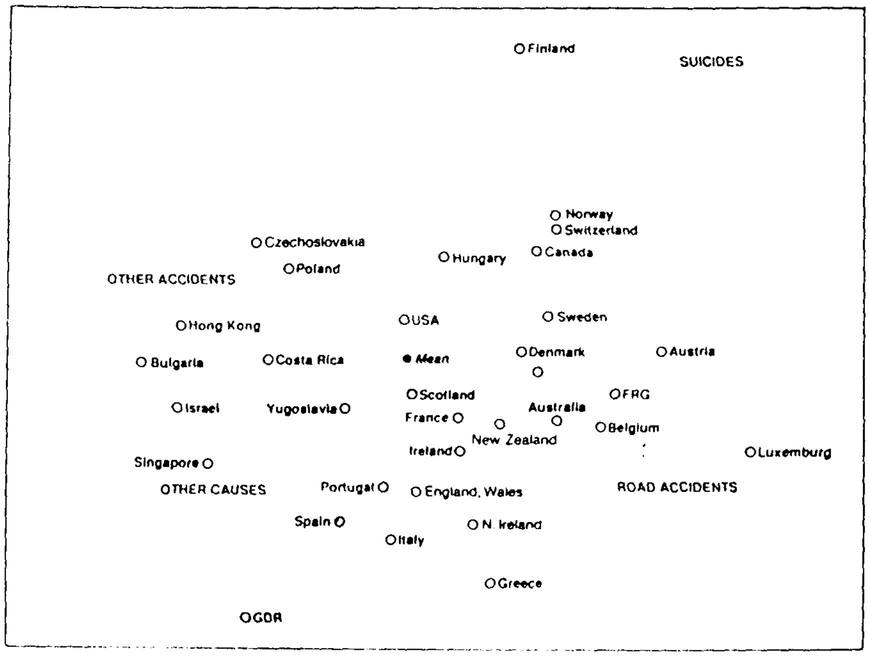

Fig. 14.8. Static position of countries according to causes of death at 15–24 years, men

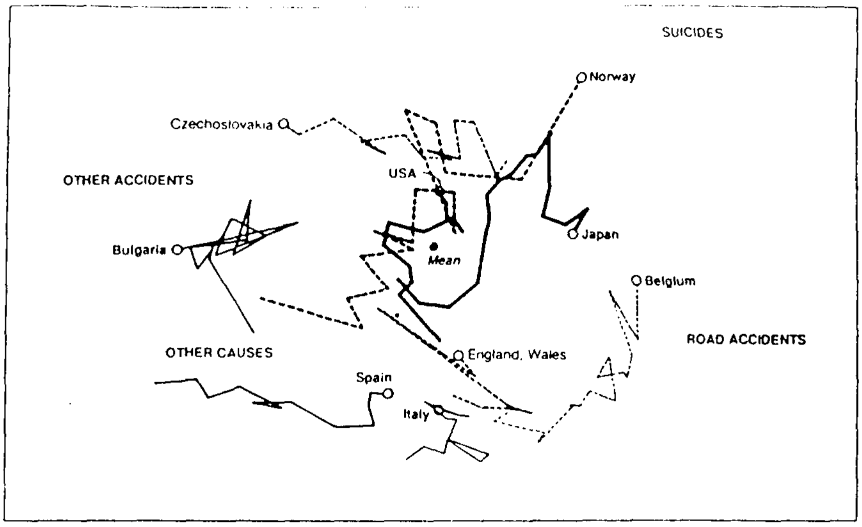

Fig. 14.9. Trajectories of certain countries within a causal interval at 15-24 years, men

5. Summary and Conclusion

Our objective in this chapter has been to validate a typology of countries according to their profile of causes of death by subjecting it to the test of a longitudinal analysis covering approximately 15 years (1968-84). The typology showed that countries with the same 'culture' had similar patterns of mortality by causes of death even if the *level* of overall mortality was very different. Now the longitudinal analysis confirms that over at least 15 years the typology remains the same, i.e. that each country stays at the same place and does not cross the universe of mortality by causes. It also shows that within the worldwide decline in mortality there is no standardization of the profile of causes of death. For example, Japan and Sweden, the two countries with the highest life expectancy in the world, are very far from each other in that universe: even though the proportion of deaths from cerebrovascular disease is declining in Japan, it is still much higher than in Sweden, which is characterized by a high and increasing proportion of cardiovascular disease.

Lack of standardization between profiles of causes of death does not imply a lack of trends within the profiles. But our finding again is that, most of the time, trends are in the same direction for all the countries of the same group. This means, for example, that cardiovascular diseases are increasing in all Nordic countries, while decreasing in overseas Anglo-Saxon countries.

Another finding concerns the increase in mortality in some countries of Central Europe during the period 1968 to 1978. This general increase does not have its origin in the increase of particular causes such as alcohol-related causes, but was the result of an increase in all causes: the health system in general has deteriorated over the period.

This study illustrates also the *dependency* of the causes of death: progress in particular fields of medicine have repercussions in all other fields. On the other hand, when health services are disorganized, mortality from any cause is increased.

At present, model life tables concern the universe of mortality *by age*, and not yet *by cause of death*, but we hope that these results will be helpful for the construction of model life tables by cause.

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Appendix 14.1

Table 14.A1. *ICD codes of chosen causes according to the Eighth and Ninth Revisions*

Causes	Eighth Revision rubrics of List A	Ninth Revision rubrics
All causes	A00	B00
Cancer		
Mouth, pharnyx, oesophagus	A45, A46, A50	08, 090, 100
Stomach	A47	091
Lung	A51	101
Breast	A54	113
Prostate	A57	124
Heart diseases		
Ischaemic	A83	27
Other	A84, A86, A87, A88	28, 30
Cerebrovascular diseases	A85	29
Bronchitis, asthma	A93	32
Pneumonia	A91, A92	321
Cirrhosis of the liver	A102	347
Ill-defined	AE136-7	46

Table 14.A1. *Continued*

Causes	Eighth Revision rubrics of List A	Ninth Revision rubrics
Other accidents	AE139-46, 148-50	E470, E472, E479
Road accidents	AE138	E471
Suicides	AE147	E54
Other causes	The rest	The rest

Appendix 14.2 Results of the Correspondence Factor Analysis

Consider the table for the age group 45-54 which provides the death rate for country $i(i=1, n)$ and for cause $k(k=1, e)$ between ages 45 and 54 as well as the table for ages 65-74 years. Place them side by side as shown in Figure 14.A1. Let m_{ij} be the complete matrix with j columns ($j\epsilon[1, 2c]$). Then, $m_{i.}=\Sigma_j m_{ij}$ is the total mortality rate within the age group 45-70 for country i. Similarly, $m.j=\Sigma_j m_{ij}$ is a measure of the average death rate by cause.

$$\begin{array}{cc} & \begin{array}{cccccc} & 45\text{-}54 & & & 65\text{-}74 & \\ & k & & & k & \end{array} \\ \text{Country} \quad i & \left[\begin{array}{cccccc} \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ \cdots & m^{50}_{ik} & \cdots & \cdots & m^{70}_{ik} & \cdots \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \end{array}\right] \end{array}$$

Fig. 14.A1. Matrix of death rates by age, country, and cause of death

We calculate the casual profile for the two age groups as the set of values $\frac{m_{ij}}{m_{i.}}$ and define a distance χ^2 between the profiles of two countries i and i' as

$$d^2(i,i')=\sum_j \frac{1}{m.j}(m_{ij}-m_{i'j})^2.$$

The weight m_j attenuates the contribution of frequent causes of death and re-establishes the relative distribution of deaths of both age groups.

This distance $\chi^2(i, i')$ can also be written as:

$$d^2(i,i')=\sum_j \left[\frac{m_{ij}}{m_{i.}\sqrt{(m.j)}}-\frac{m_{i'j}}{m_{i'.}\sqrt{(m.j)}}\right]^2,$$

and appears as the Euclidean distance between two points i and i' of coordinates x_{ij} and $x_{i'j}$ where x_{ij} is defined as:

$$I_{ij}=\frac{m_{ij}}{m_{i.}\sqrt{(m.j)}}.$$

Moreover, if we give weight m_l to each country where m_l equals the total death rates in both age groups, the correspondence factor analysis is a principal component analysis of table x_{ij} with weights m_{ij}. We thus seek the best possible representation of this balanced form of n countries in a two-dimensional space. The centre of gravity has as jth coordinate $\bar{x}_j = \sqrt{(m.j)}$. If $\vec{u}$ is a unitary vector of $\mathbf{R}^{2c}$, then

$$\psi_l = (\vec{x} - \bar{x}\ \vec{u}).\vec{u} = \sum_j \left(\frac{m_{lj} - m_{l}.m._j}{m_{l.\sqrt{(mJ)}}} \right)$$

is the coordinate of a country point on axis u. The vector $\vec{u}$ will be the major inertia vector provided it minimizes the quantity: $\sum_l m_{l.} \psi_l^2$ which, after simplification, corresponds to the diagonalization of the matrix $X'X$ where X is the common matrix:

$$X_{lj} = [m_{ij} - m_{i.} m_J / \sqrt{(m_{l.} m_J)}].$$

It is easy to show that this symmetrical matrix $X'X$ has the same eigen values as the matrix $X^{*\prime}X^{*}$. In simple terms:

$$X^*_{ij} = m_{ij} / \sqrt{(m_{l.} m_J)}.$$

The vector $\bar{x}\ \vec{u}$ is thus an eigen vector associated with the eigen value 1. Apart from this singular eigen value, there is also the eigen value of the order of α with eigen vectors $\vec{u}_\alpha$; the coordinate of a country i on the factorial axis of the order of α is then:

$$\psi_{\alpha l} = \sum_{j=1}^{2c} \left(\frac{m_{ij}}{m_{l.} \sqrt{m._j}} \right) u_{\alpha J} \tag{1}$$

Dual Representation

We can demonstrate (Benzecri 1973) that the matrix $X^*X^{*\prime}$ has the same non-void eigen values as the matrix $X^{*\prime}X^{*}$. If we take ν_α for the new eigen vector associated with the same eigen value $\lambda\alpha$, we get the following double relations:

$$\begin{cases} \nu_\alpha = \dfrac{1}{\sqrt{(\lambda_\alpha)}} x^* u_\alpha \\ u_\alpha = \dfrac{1}{\sqrt{(\lambda_\alpha)}} x^{*\prime} \nu_\alpha . \end{cases} \tag{2}$$

If instead of considering n country points in a $2c$th dimensional interval we consider $2c$ cause points in an nth dimensional interval with weight m_j, we obtain a relation which is symmetric to the relation $1/u\alpha i$, which gives the coordinates $\phi_{\alpha J}$ of the jth cause on the αth eigen vector connected with the eigen value $_\alpha$; this coordinate is:

$$\phi_{\alpha J} = \sum_{i=1}^{n} \left(\frac{m_{ij}}{m.j \sqrt{(m_{i.})}} \right) \nu_{\alpha l} \tag{3}$$

Relations 1, 2, and 3 lead to a fundamental barycentric correspondence relation between cause and country:

$$\phi_{\alpha j}=\frac{1}{\sqrt{(\lambda_\alpha)}}\sum_{i=1}^{n}(m_{ij}/m.j)\psi_{\alpha i}$$

$$\psi_{\alpha j}=\frac{1}{\sqrt{(\lambda_\alpha)}}\sum_{j=1}^{2c}(m_{ij}/m_{i.})\phi_{\alpha l}. \qquad (4)$$

Graphic Representation and Results

When cause points and country points are superimposed on the same graph, the barycentric correspondence is obtained. As in a principal component analysis, the percentage of inertia explained by the first components is associated with the eigen values. Table 14.A2 gives the eigen values as well as the percentages of inertia of each axis.

Table 14.A2. *Percentage of inertia of the first axes*

Axis	Eigen value	%	Accumulated (%)
1	0.03903	36.26	36.26
2	0.01926	17.90	54.16
3	0.01515	14.08	68.24
4	0.00967	8.99	77.23
5	0.00771	7.16	84.39
6	0.00423	3.93	88.32
7	0.00393	3.66	91.98
8	0.00196	1.82	96.75

We are restricted here to the representation of the first three axes (accounting for 68% of the variance). Starting with the causal groups of Table 14.A1, we have excluded all ill-defined causes and regrouped accidents on the one hand and all heart diseases on the other. We therefore had ten causes in all for each group or a total of 20 variables. For each of these variables, Table 14.A3 gives the weights $m._j$ and the coordinates on the first six axes ($\phi_{\alpha j}$).

Once the form of the causes is placed, the countries are positioned according to the barycentric relation 4. Table 14.A4 gives the coordinates on the three first factors of the 38 countries which have been used to build the form. In a previous paper, we selected the most recent data from countries having a life expectancy of over 70 years (Brouard and Lopez 1985). Here we have repeated this selection (thus diagonalizing the same matrix) and used these results to project either other countries or the same countries at different dates.

Take the example of a French department for which we know the male death rates according to the ten causes retained (Table 14.A1) and for the two age groups 45-54 and 65-74 years. Let $[j\epsilon(1,2\times 10)]$ be the death rates, and $t = \sum_i t_j$ the total death rates in both age groups (all causes included). The coordinate ψ_α, of this department on the axis α is given by the equation:

Table 14.A3. *Coordinates of cause points on the first factors*

Cause	Weight *mj*	Coordinates of the factors					
		1	2	3	4	5	6
45-54							
Lung	0.012	−0.09	−0.02	0.00	−0.21	0.01	0.01
Mouth	0.005	0.45	−0.39	0.13	−0.27	−0.18	0.17
Stomach	0.004	0.34	0.20	−0.07	0.17	0.21	−0.02
Cardiovascular	0.043	−0.21	0.05	−0.04	0.00	−0.09	0.02
Cerebrovascular	0.000	0.27	0.18	−0.16	0.01	−0.03	0.05
Bronchitis	0.002	0.04	0.13	0.00	−0.03	0.06	0.25
Pneumonia	0.002	0.31	−0.15	−0.35	0.15	−0.20	0.27
Cirrhosis	0.008	0.41	0.06	0.35	−0.06	−0.17	0.04
Other accidents	0.021	0.09	0.06	0.15	0.16	−0.05	0.08
Other causes	0.038	0.13	−0.09	0.06	0.04	−0.05	0.05
65-74							
Lung	0.072	−0.17	−0.12	−0.08	−0.22	0.12	−0.02
Mouth	0.017	0.27	−0.34	0.04	−0.08	−0.10	0.09
Stomach	0.028	0.29	0.09	0.00	0.23	0.29	−0.05
Cardiovascular	0.318	−0.20	0.05	0.02	0.04	−0.04	−0.01
Cerebrovascular	0.102	0.27	0.26	−0.11	−0.10	−0.04	−0.05
Bronchitis	0.034	−0.09	0.15	0.06	−0.07	0.21	0.23
Pneumonia	0.024	0.15	−0.20	−0.58	0.16	−0.08	0.13
Cirrhosis	0.016	0.46	0.05	0.37	−0.12	−0.15	0.09
Other causes	0.031	0.16	0.00	0.13	0.12	0.09	0.02
Other accidents	0.215	0.08	−0.15	0.03	0.02	0.01	−0.05

$$\psi_\alpha = \frac{1}{\sqrt{(\lambda_\alpha)}} \sum_{j=1}^{20} (t_j/t)\phi_{\alpha j}$$

For the first axis, we obtain (see Tables 14.A2 and 14.A3):

$$\psi_\alpha = \frac{1}{t\sqrt{0.03903}}\,(-0.09\,(\text{lung } 45\text{–}54) + 0.45\,(\text{mouth } 45\text{–}54)$$
$$+\,0.34\,(\text{stomach}) + 0.27\,(\text{brain}) + \ldots + 0.12\,(\text{lung } 65\text{–}74)$$
$$+ \ldots + 0.08\,(\text{all other causes } 65\text{–}74)). \tag{6}$$

By using this process it is also possible to visualize other causes or sub-causes. This is what we have done in Figure 14.2 by breaking up all cardiovascular diseases into 'ischaemic heart diseases' and 'other heart diseases'. For more detail on the method see Lebart *et al.* 1980.

Table 14.A4. *Coordinates of the 38 countries on the three first factors*

Country	Year	CIM	Weight	Axis 1	Axis 2	Axis 3
Mean	80		0.026	0.00	0.00	0.00
Australia	80	9	0.025	−0.16	−0.01	0.04
Austria	80	9	0.028	0.07	0.09	0.11
Belgium	78	8	0.028	−0.06	−0.07	0.01
Bulgaria	81	9	0.028	0.20	0.33	−0.22
Canada	78	8	0.024	−0.18	−0.04	0.06
Costa Rica	80	9	0.021	0.23	−0.10	0.09
Cuba	78	8	0.015	0.00	−0.10	−0.17
Czechoslovakia	82	9	0.036	0.01	0.15	−0.05
Denmark	81	8	0.024	−0.22	0.01	0.05
England, Wales	81	9	0.027	−0.21	−0.02	−0.19
Finland	79	8	0.031	−0.23	0.11	−0.04
France	81	9	0.023	0.28	−0.28	0.25
FRG	82	9	0.027	−0.03	0.04	0.09
GDR	76	8	0.031	−0.13	−0.05	0.13
Greece	82	9	0.019	0.09	−0.08	0.03
Hong Kong	82	9	0.022	0.35	−0.33	−0.21
Hungary	82	9	0.037	0.10	0.16	0.09
Ireland	82	9	0.028	−0.18	−0.05	−0.13
Israel	80	9	0.021	−0.07	0.02	0.00
Italy	80	9	0.025	0.16	−0.01	0.15
Japan	82	9	0.019	0.48	0.08	−0.16
N. Ireland	81	9	0.031	−0.25	0.05	−0.15
New Zealand	81	9	0.026	−0.21	0.01	0.02
Norway	82	8	0.021	−0.16	0.02	0.02
Panama	80	9	0.016	0.20	−0.08	0.04
Poland	80	9	0.033	−0.15	0.04	0.08
Portugal	79	8	0.026	0.46	0.31	−0.03
Puerto Rico	82	9	0.022	0.17	−0.22	0.20
Romania	82	9	0.029	0.15	0.16	0.06
Scotland	83	9	0.031	−0.20	−0.02	−0.14
Singapore	81	9	0.032	0.21	−0.30	−0.32
Spain	79	8	0.022	0.22	0.01	0.05
Sweden	82	8	0.021	−0.23	0.06	0.03
Switzerland	81	8	0.022	−0.04	−0.08	0.11
The Netherlands	82	9	0.023	−0.24	−0.08	−0.01
Uruguay	78	8	0.027	0.07	−0.06	0.05
USA	80	9	0.025	−0.20	−0.10	0.07
Yugoslavia	81	9	0.027	0.07	0.10	0.08