International Union for the Scientific Study of Population

international population conference

FLORENCE, 5 - 12 JUNE 1985

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Union Internationale pour l' Etude Scientifique de la Population

congrès international de la population

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CAUSE OF DEATH PATTERNS IN LOW MORTALITY COUNTRIES: A CLASSIFICATION ANALYSIS

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With the conquest of the infectious diseases in Europe, North America and Australasia, health policies in these countries have been largely reorientated towards the control of the degenerative diseases of later life. This epidemiological transition is also evident in a handful of other countries in East Asia and Latin America. However, whereas the leading causes of death under the regime of the infectious diseases were common health problems in most countries, it is not at all clear that the transition to lower mortality has been accompanied by greater epidemiological uniformity. The objective of this paper is to explore the extent to which this has been achieved as reflected by data on causes of death.

It is worth emphasizing from the outset that any international assessment of this type is fraught with difficulties. To begin with, diagnostic practices vary widely from country to country. Not only will the interpretation of the rules for coding a cause of death as specified in the International Classification of Diseases vary from one country to another, but also the comparability of diagnosis is affected by such factors as religious and social constraints on the reporting of some diseases or injuries and even the very fashionableness of a particular diseases among the medical profession. The problem of comparability is confounded even further by changes to the International List of Diseases and Injuries at each decennial revision. This is of particular concern for the analysis proposed in this paper since the period to

* The views expressed and designations used in this paper are those of the author and do not necessarily reflect the opinions or policies of the World Health Organization.

which the data refer corresponds to the introduction of the Ninth Revision of the ICD in many countries. Of course, one has little choice but to use cause of death data for making international comparisons. However, provided they are interpreted prudently, analyses of these data can yield important insights into common health problems.

One should also not lose sight of the fact that in analyzing cause of death data, one is dealing merely with the immediate medical or "stated" cause of death. These data give no indication of the behavioural, environmental and/or biological circumstances which lead to death. This, of course, has much greater relevance for the formulation of health policy but is outside the scope of this paper.

In attempting to classify countries according to their mortality structure, one may choose many axes: level, age, sex, and cause of death are perhaps the most common. While the identification of patterns of causes of death is the main concern here, we have thought it worthwhile to briefly delineate age and sex patterns of mortality. These are described in the first part of the paper. The latter section of the paper focusses on causes of death within selected age groups (15-24, 45-54, and 65-74). These ages were selected for analysis since we believe that they represent periods of life when the composition of the leading causes of death is likely to change.

1. LEVEL OF MORTALITY AND AGE-SEX PATTERN

Table 1 shows the list of low mortality countries arranged in descending order of life expectancy at birth (column 2) as estimated by the United Nations for the period 1980-1985. We have defined a "low mortality country" as a country having a life expectancy of 70 years or more for this period. Columns (4) and (5) show the life expectancy for males and females separately based on the latest data available to WHO. Unfortunately, the reference period covered by these data is rather broad, ranging from 1976 for the GDR to 1983 for Scotland and Luxembourg. No further analysis was possible for those countries not reporting recent mortality data to WHO.

Columns (7) to (13) of Table 1 give the age-specific mortality rates separately for males and for females. These data are summarized in Figures 1 and 2. The vertical axis of Figure 1 represents a balance between a) high infant mortality and low mortality at older ages populations below the solid line and b) low infant mortality and high mortality at older ages (above the solid line). This axis is the second principal component of the analysis of data shown in Table 1. The first component, which gives the level, is more closely correlated to e_{10} than to e_0 .

Thus, on the right hand side of Figure 1 we find the lowest level of female mortality occurring in Japan, Sweden and Iceland (e_0 = 80 years) and at the left side of the figure one sees the highest level of mortality occurring among Polish males (e_0 = 66 years).

The male and female scatters are distinct and separated by a level of life expectancy roughly equal to 73.4 years. It is interesting to note that males in Iceland and females in Yugoslavia can expect to live on average to the same mean age (73.4 years) but that their age-specific risks of dying are very different (see Table 1). The former have a very low infant mortality compared with the latter (7.0 per 1000 compared with 28.6) and relatively high mortality at older ages (545.4 per 1000 at 45-54 against 399.3).

TABLE 1

Recent mortality levels and patterns in low mortality countries

Country	Life expectancy at birth				All causes of death							
	1980/ 1985 (UN esti- mate)	As calculated by WHO			Age-specific death rate per 100,000							
					Males				Females			
		Year	M	F	0-1	15-24	45-54	65-74	0-1	15-24	45-54	65-74
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Iceland	76.7	1982	73.4	79.9	705.5	92.5	545.4	3412.7	481.5	36.9	245.4	1785.7
Japan	76.6	1982	74.5	80.2	730.9	76.8	509.3	3041.8	580.9	29.4	247.4	1665.3
Netherlands	75.9	1982	72.8	79.7	930.6	72.0	510.7	3990.8	722.7	33.1	285.9	1800.8
Norway	75.9	1982	72.7	79.8	891.5	111.8	576.1	3740.6	715.3	31.8	244.7	1805.5
Switzerland	75.9	1981	72.5	79.4	866.9	141.8	527.4	3712.0	636.2	48.4	255.6	1762.0
Sweden	75.8	1982	73.5	79.6	710.2	70.3	514.5	3570.0	653.1	30.3	281.5	1856.8
Canada	74.9	1982	72.0	79.0	1036.2	123.5	583.4	3859.3	780.1	39.3	313.4	1987.5
Denmark	74.9	1982	71.8	77.9	949.6	92.5	643.0	4064.8	687.6	34.1	421.1	2137.4
France	74.5	1981	70.9	79.1	1118.1	140.6	782.8	3852.0	816.3	52.9	308.2	1744.0
Italy	74.4	1980	71.0	77.7	1641.3	105.7	664.0	4072.3	1242.0	37.7	297.6	2120.6
Australia	71.4	1981	71.4	78.7	1117.4	138.5	627.3	4039.6	865.9	46.0	323.3	2004.9
Spain	74.3	1981	71.8	78.0	1451.8	99.7	587.6	3703.8	1143.6	38.0	277.7	1971.2
U.S.A.	74.0	1980	70.1	77.8	1392.8	172.2	769.3	4085.6	1120.8	57.6	414.3	2135.3
Israel	74.0	1980	72.2	75.8	1728.1	95.4	552.3	3796.0	1312.3	32.1	325.6	2798.2
Greece	74.0	1982	73.6	78.3	1648.0	93.6	444.4	3352.0	1365.5	37.4	225.2	2058.0
Puerto Rico	73.9	1982	73.2	79.5	1844.0	120.4	626.3	2846.9	1566.2	34.5	302.2	1829.4
Hong Kong	73.9	1982	73.5	79.9	1023.8	64.0	631.2	3546.8	945.8	33.0	317.7	2054.9
England & Wales	73.7	1982	71.3	77.3	1218.0	82.1	587.2	4579.8	939.3	32.2	363.2	2433.9
Northern Ireland	73.7	1982	68.4	75.0	1511.6	111.4	690.1	5025.4	1151.4	34.5	429.1	2635.6
Scotland	73.7	1983	69.6	75.8	1141.1	32.1	758.6	5099.7	836.5	33.1	441.5	2989.7
Cuba	73.5	1978	72.0	75.0	2480.0	129.9	559.9	3124.7	2018.0	111.2	418.3	2557.4
New Zealand	73.4	1981	70.5	77.0	1316.7	152.6	658.5	4339.2	1033.7	66.9	391.6	2371.5
Belgium	73.3	1979	69.9	76.6	1332.5	126.6	684.7	4763.7	1116.7	53.8	371.1	2360.1
Fed. Rep. Germany	73.3	1982	70.5	77.2	1204.0	121.0	680.4	4586.8	972.2	44.8	335.1	2327.0
Finland	73.2	1980	69.2	78.0	843.9	113.3	836.6	5008.9	677.2	32.9	279.8	2296.3
Costa Rica	73.0	1980	71.0	76.0	2207.0	137.4	544.0	3807.7	1599.6	51.8	364.0	2432.1
Austria	73.0	1982	69.4	76.6	1508.3	165.8	798.6	4583.8	1042.0	47.8	359.7	2412.3
Ireland	73.0	1980	69.8	75.2	1202.1	90.7	707.4	4859.3	1008.5	37.9	415.7	2901.3
Luxembourg	72.8	1983	68.9	76.0	1230.6	142.8	746.9	4609.4	1282.0	70.2	365.9	2488.6
German Dem. Rep.	72.7	1976	68.9	74.5	1596.2	135.2	688.9	5217.0	1177.5	52.5	410.0	3098.6
Fiji	72.5	1978	–	–	3832.4	133.2	1286.4	4410.7	2761.3	121.5	949.2	3381.8
Bulgaria	72.3	1978	68.5	74.0	2048.3	116.3	786.4	4957.1	1579.1	50.4	370.1	3329.8
Singapore	72.2	1981	69.1	74.5	1150.2	99.3	837.7	5230.6	958.9	48.8	499.0	3121.1
Poland	72.0	1980	66.1	74.6	2434.3	145.7	1092.9	5327.9	1804.0	42.6	427.9	2813.9
Malta	71.7	1982	70.0	74.0	1459.9	58.8	679.7	6089.7	1587.3	40.0	328.0	3979.6
Czechoslovakia	71.6	1981	67.0	74.5	1969.7	111.2	977.4	5679.5	1397.9	41.0	420.6	3168.5
Kuwait	71.2	1982	69.0	73.8	2596.0	89.8	603.8	5239.4	1954.0	44.2	458.1	3287.9
Hungary	71.2	1982	65.6	73.2	2244.9	36.1	1242.5	5836.7	1747.4	45.1	522.2	3386.7
Yugoslavia	71.2	1981	67.6	73.3	3272.5	106.2	840.0	4691.1	2866.5	47.4	399.3	3056.3
Panama	71.0	1980	71.1	75.9	2314.8	163.6	491.2	3300.0	2076.0	73.1	368.9	2040.9
Albania	70.9	–	–	–	–	–	–	–	–	–	–	–
Romania	70.9	1982	67.1	72.5	3056.0	130.6	887.1	4598.8	2537.6	70.3	407.0	3131.1
U.S.S.R.	70.9	–	–	–	–	–	–	–	–	–	–	–
Portugal	70.8	1979	67.3	74.2	2912.0	172.2	774.9	4583.3	2272.3	56.5	347.2	2582.7
Qatar	70.6	–	–	–	–	–	–	–	–	–	–	–
United Arab. Emir	70.6	–	–	–	–	–	–	–	–	–	–	–
Jamaica	70.3	–	–	–	–	–	–	–	–	–	–	–
Uruguay	70.3	1978	66.8	73.7	4289.6	124.4	896.4	4602.6	3327.1	71.3	468.0	2561.7
Trinidad & Tobago	70.1	1977	–	–	2460.1	138.9	923.8	5344.8	1851.4	73.5	678.4	4134.5

By and large, the classification of countries according to mortality level is roughly the same for males and females. Typically, the Latin American and Mediterranean countries show the highest levels while the Nordic countries and Japan display the lowest levels. This pattern is emphasized by Figure 2. Previous studies (Ledermann and Breas, 1959; Coale and Demeny, 1966) have demonstrated that a realistic classification of countries can only be achieved on the pattern of mortality by age, *independently* of the level. This can be easily done with principal component analysis. The first component clearly specified the level (closer to e_{10} then e_0), the other components (primarily the next two components [1]) give the age pattern. As the classification of countries according to age pattern of mortality does not differ greatly between males and females, we have only presented the plane described by the second and third components resulting from an analysis of mortality rates for the four age groups but both sexes combined.

The four axes ${}_1M_0$, ${}_{10}M_{15}$, ${}_{10}M_{45}$, and ${}_{10}M_{65}$ corresponding to age specific mortality rates rotate round the center and highlight "balances" between ages, namely

- higher infant mortality seems to be associated with lower mortality at age 50
- higher mortality at age 20 seems to imply lower mortality at age 70.

The positions of countries in Figure 2 represent their actual age pattern. Thus, the mean age pattern for Norway is representative of the average pattern for all countries. The direction of the line from the center to a country indicates the age or ages for which mortality is higher than in other countries. Also, the farther a country is away from the center, the larger is the age deviation from the mean.

The most significant finding to emerge from Figure 2 is the cluster of the Mediterranean and Latin American countries: Uruguay, Panama, Cuba, Portugal, Costa Rica, Romania, Puerto Rico, Greece, Yugoslavia, Spain and Italy may be classified as countries whose infant mortality is, irrespective of the stage of their mortality decline, still higher than in other countries of the world (this corresponds to the updated "South" model).

Another specific cluster corresponds to the Anglo-Saxon countries (England and Wales, Northern Ireland, Ireland, and Scotland) and is characterized by a higher mortality at the very old ages (i.e. 65-74 years).

The Northern European sub-group (Norway, Denmark, Iceland) display a relative age pattern of mortality that is closer to Japan and Hong Kong.

Two others groups can be defined. The first contains countries of Eastern and Central Europe (Federal Republic of Germany, German Democratic Republic, Austria, Poland and Czechoslovakia) with higher mortality at age 50, and the second encompasses the overseas English-speaking countries (USA, New Zealand, Australia, Canada) as well as France and some neighbouring countries (Belgium, Luxembourg and Switzerland). This latter group is characterized by a higher mortality around age 20, almost surely due to elevated death rates from

1 Roughly 90 % of the total variance in mortality rates is explained by the first 3 components.

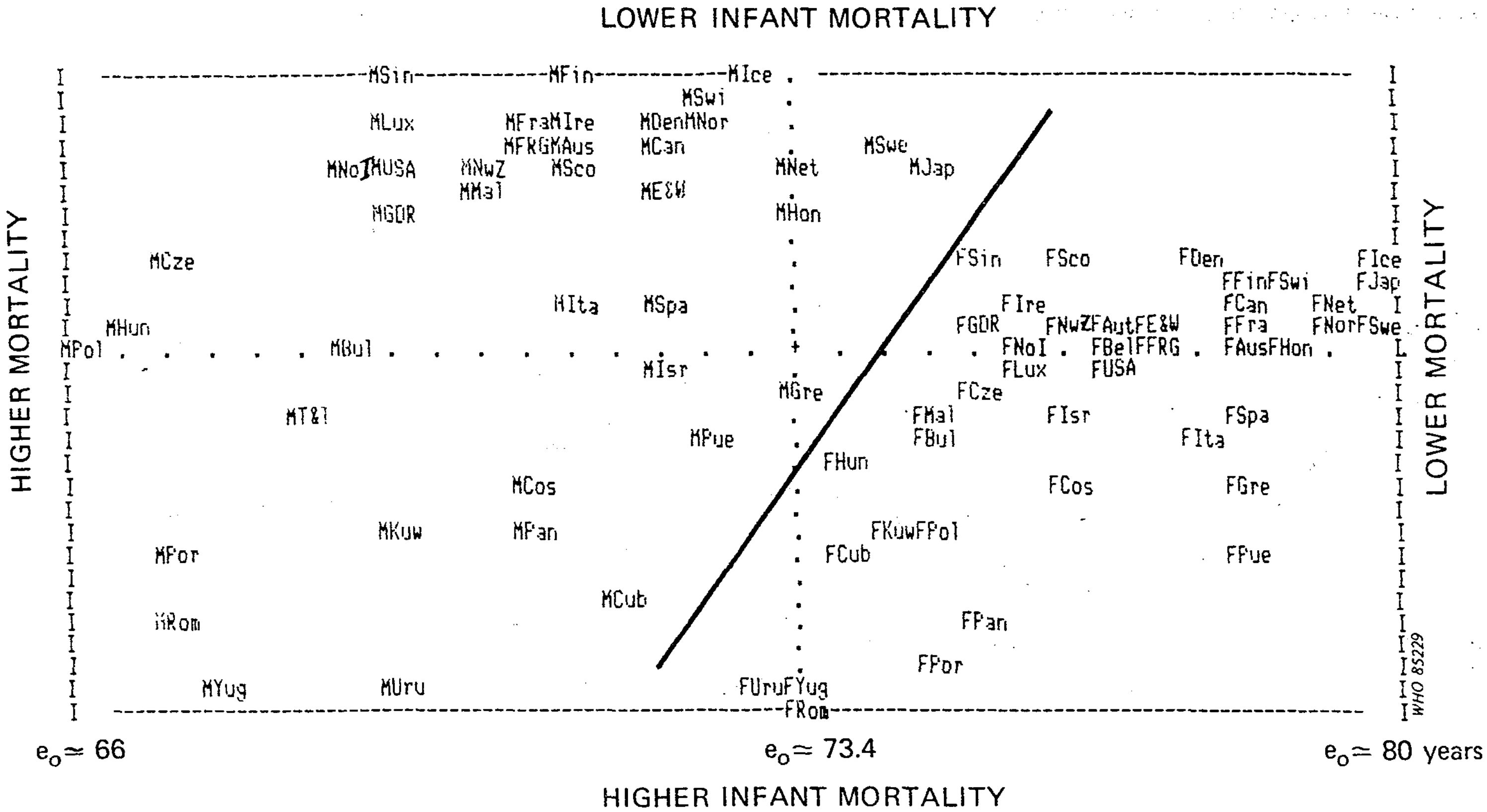

Figure 1

Principal component analysis of mortality levels in low mortality countries, by sex, latest available year

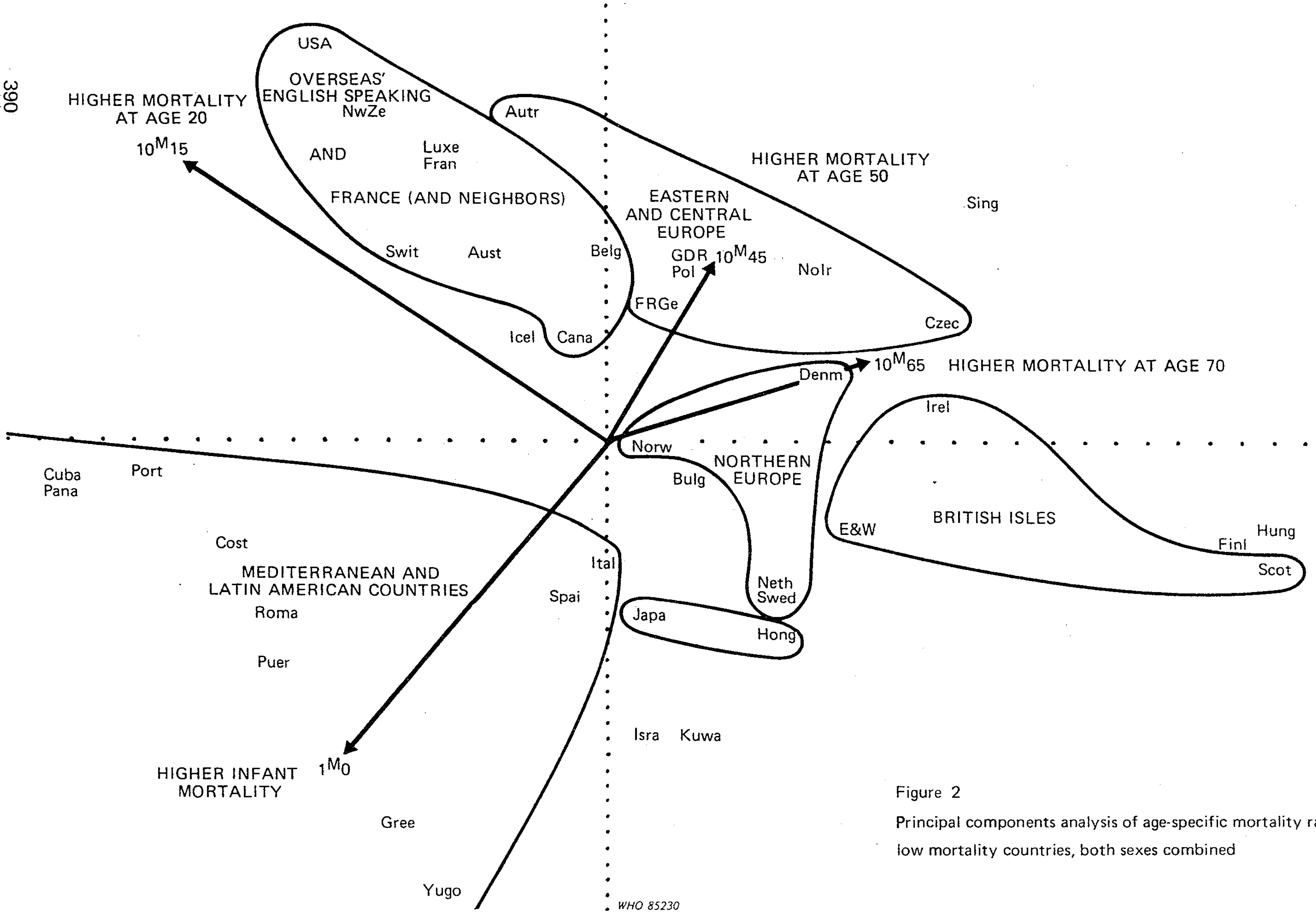

Figure 2

Principal components analysis of age-specific mortality rates, low mortality countries, both sexes combined motor vehicle accidents. At the same time, some perhaps unexpected groupings can be identifed such as Finland and Hungary, which are near Scotland, and Singapore which is quite distinct from the two other Asian countries, Japan and Hong Kong.

Following this preliminary classification based on age-specific rates from all causes combined, a cause-specific analysis will be attempted beginning with the age group 15-24 years.

2. CAUSES OF DEATH AMONG YOUNG ADULTS

Figure 3 shows the scatter of male and female mortality rates at ages 15-24 years on two axes, one is the *level* of the death rate and the second is a *balance* [2] between Motor Vehicle Accidents at the bottom and other causes at the top.

It is immediately obvious from Figure 3 that there is less absolute variation in mortality among females than among males at these ages. Interestingly, the British Islands have joined Sweden, Japan and the Netherlands where death rates are lower, whereas the overseas English-speaking countries now show much higher mortality along with Austria, Switzerland and France. Only slightly better off are the Eastern European group (Czechoslovakia, Bulgaria, Hungary).

If the first axis of Figure 3 focuses on the level of mortality for "all causes", the second axis and the Figure 4 deal with causes of death ignoring the level. To obtain Figure 4:

1) we have grouped the countries (via automatic classification) according to the khi^2 distance between distribution;
2) we have applied the "correspondence factor analysis" [3] method which is a variant of the general factor analysis.

Figure 4 is the principal plane of this factor analysis. The four groups resulting from the classification are circled on that figure.

The four causes (Motor vehicle accidents, Suicides, Other accidents and All other causes) taken into account "fix" the graph. One group including Japan, Sweden, Norway, Canada, Switzerland, Denmark, Finland and Hungary is characterized by relatively high mortality from motor vehicle accidents. For

[2] As for Figure 1, this axis corresponds to the second principal component in a principal component analysis involving the cause-specific death rates at ages 15-24. In fact, the variable Motor Vehicle Accidents does not correspond exactly to the second component and we have therefore rotated the subspace described by components 2 and 3 to obtain this correspondence.

[3] The factor analysis method using the khi^2 distance is called "correspondence analysis". This name comes from the property that the scatter of variables (causes) obtained by the "dual" analysis (i.e. khi^2 distance between variables) may be superimposed with the previous scatter of individuals (countries) to show the *correspondence* between causes and countries. This means that the name of a specific cause is placed (on Figure 4) near countries for which that specific cause is overrepresented. For a description of the technique, see Benzecri.

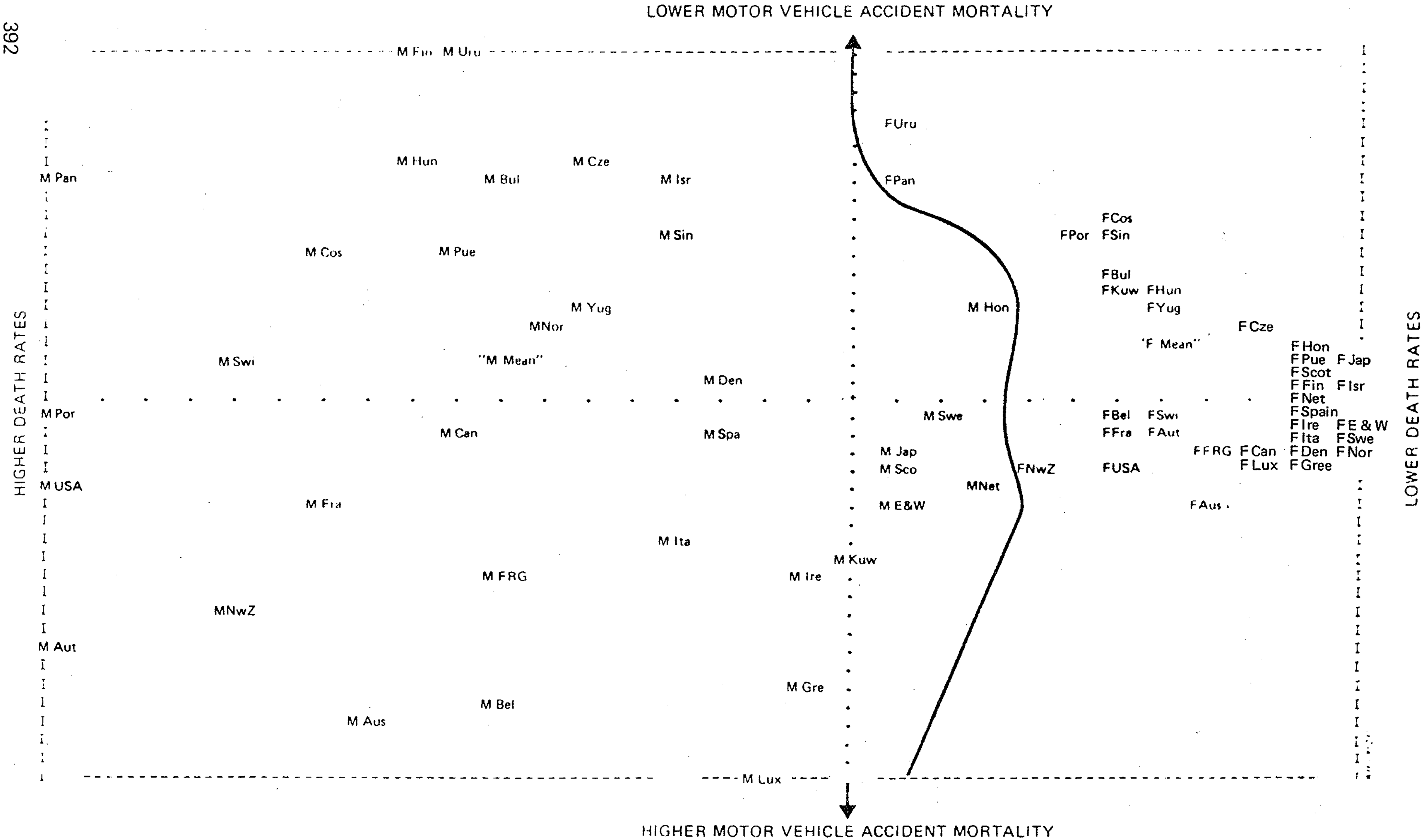

Figure 3

Principal component analysis of death rates at ages 15-24 years, low mortality countries

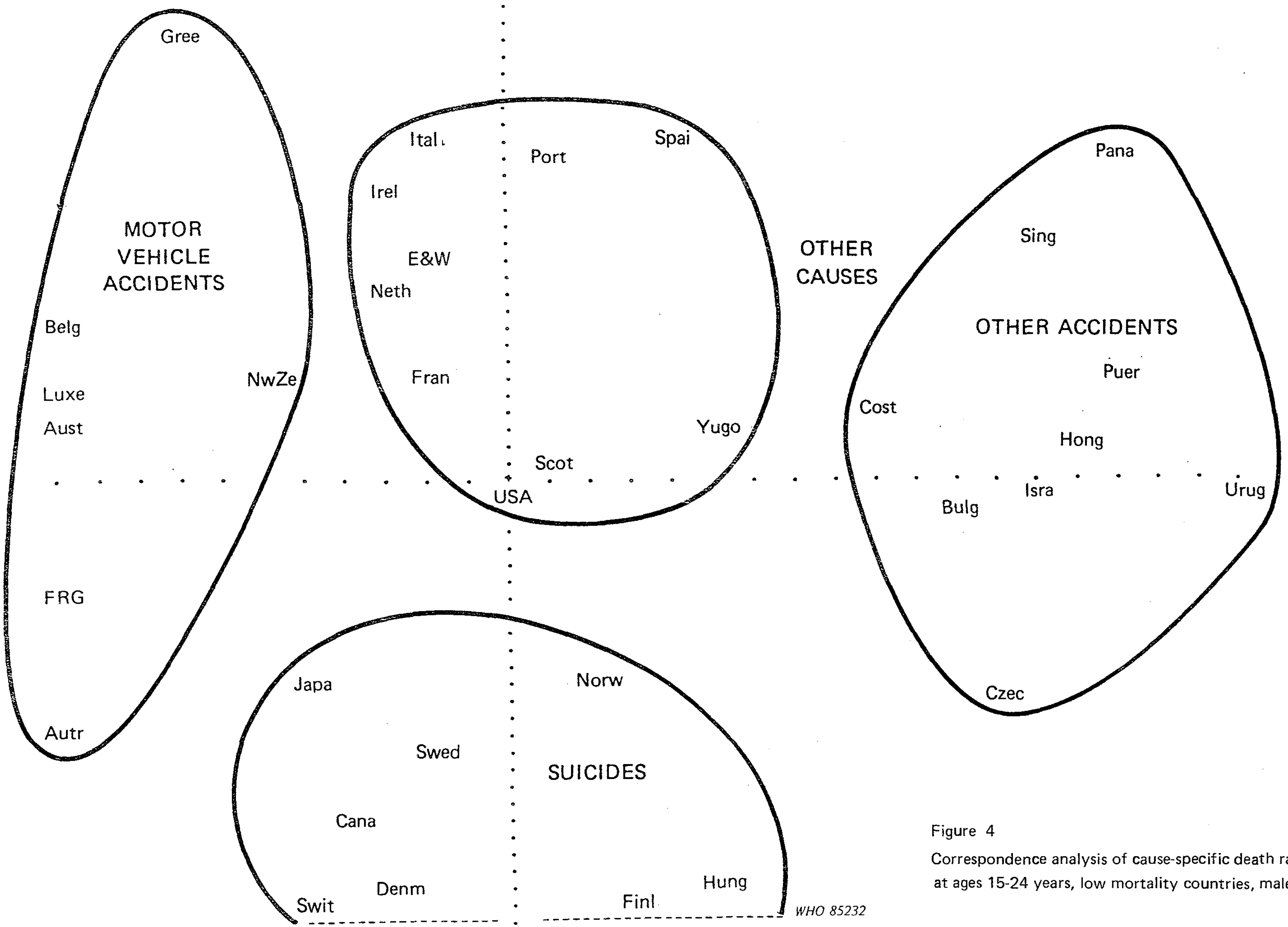

Figure 4
Correspondence analysis of cause-specific death rates at ages 15-24 years, low mortality countries, males

this latter group, the *level* of mortality is also the highest. The USA and France also show a high risk from Motor vehicle accidents but other causes are of importance too in these countries and hence they belong to a more "central" group including Scotland and Yugoslavia. Italy, Spain and Portugal belong to the same group as Ireland, England and Wales and the Netherlands but with a lower mortality from suicides.

3. CAUSES OF DEATH AT OLDER ADULT AGES

The cause of death comparability problems mentioned earlier are of much greater significance for mortality analyses at these ages in view of the difficulties of choosing an underlying cause in the presence of multiple pathologies. Similarly, the break in classification between the 8th and 9th Revisions of the ICD was of grater consequence for some of the leading causes of death at these ages, in particular for ischaemic heart disease. With this in mind, we have chosen a selection of causes of death which are intended to be at once epidemiologically meaningful, economical for analyses and also likely to effectively discriminate among countries. A list of the causes used in the analysis is given in Annex Table A. Ischaemic heart disease has been grouped with other forms of heart disease, despite their very different etiology, since there *would* seem to be strong national preferences in coding a death to one form rather than the other. Furthermore, since motor vehicle accidents and suicides are not declared in some countries, we have grouped them together with all other violent deaths.

With regard to the statistical method to analyse age, sex and cause-specific death rates, the problem is somewhat more complex at ages 45-54 and 65-74 than at ages 15-24, not the least because many more causes need to be considered. A first approach could be to classify countries according to the level of "all causes" mortality at the two age groups 45-54 and 65-74 into 4 or 5 groups and to compare the structure of causes between groups. This analysis is based on the assumption that as mortality declines, the structure of causes of death will change progressively to a structure reflected by the mortality pattern of Japan or Sweden. However, this notion of future uniformity is already inconsistent with previous findings that mortality may decline substantially yet still maintain a similar age profile.

Let us consider, for example, the countries with the lowest rates at age 65-74 for males. These include Cuba, Puerto Rico, Japan, Panama, Greece, Iceland, Hong Kong and Sweden. Do Cuba, Japan and Sweden have the same cause-specific rates? Japan has the lowest death rate for Cardiovascular diseases as a whole, Sweden one of the highest, yet the ranks are inverted for cancers of the buccal cavity, pharynx, oesophagus and larynx. Cuba has a relatively low mortality from stomach cancer yet the rate in Japan is the highest in the world. Evidently, the "all causes" rates mask very different cause-specific structures.

Shall we have more success with a single specific cause? Let us take the example of lung cancers at 65-74 for males. The lowest death rates are (rank order given in parenthesis): Puerto Rico (1), Costa Rica (2), Panama (3), Portugal (4), Romania (5), Sweden (6), Israel (7), Cuba (8), Norway (9) and Kuwait (10), while the highest occur in: the Netherlands (43), Scotland (42), Belgium (41), Luxembourg (40), England and Wales (39), Finland (38), Singapore (37), *Czechoslovakia (36)*, Denmark (35), and Canada (34). It we now compute the proportion of lung cancers among all deaths at these ages and compute the ranks again we find the following order: Costa Rica (1), Portugal (2), Puerto Rico (3), Romania (4), *Panama (5)*, *Kuwait (6)*, Bulgaria (7), Israel (8), Sweden (9), Norway (10), and *Cuba (30)* on the one hand, and the Netherlands (43), Belgium (42), Luxembourg (41), Scotland (40), England and Wales (39), Canada (38), Denmark (37), Hong Kong (36), Greece (35), Finland (34), USA (33), Switzerland (32), Czechoslovakia (25), on the other. Thus, the ranking of cause-specific *proportions* instead of *level* is an important correction as it reorders some countries and ejects others: *Czechoslovakia* is no longer characterized by high lung cancer mortality, nor is *Cuba* by a low rate.

Classification should therefore be based on the structure rather than the level of mortality even if high proportions often mean high rates. The same method as that used for age 20 can be applied, but here the multidimensional space cannot be summarized to a simple visible space (of dimension 2 or 3) because of the variety of distributions encountered. Automatic clustering is then used with the khi^2 distance and yields reasonable results. Clusters are identified and characterized afterwards by their mean profiles. For each cluster we have identified those causes which are either most or least prominent and arranged them in order of magnitude of the deviation from the general mean pattern.

For each sex, the numerous cluster analyses based on rates at ages 45-54 for different groups of causes did not differ substantially from those computed at ages 65-74. The analysis is therefore shown by sex, but for both ages combined. It might also be mentioned that the cluster algorithm ("Ward" method) takes into account the mass of the country (sum of the different age-cause-specific rates). Thus, a little more weight is given to high mortality countries, but only in the aggregation phase.

3.1. Patterns of Male Mortality

Hierarchical clustering yields a binary tree of the different aggregations of countries. Some countries like Japan, Bulgaria, Portugal have a very specific pattern and are often aggregated only at the last step. Our compromise to avoid having too many single countries and large, aggregated clusters was to cut the tree at node 11, obtaining 11 subgroups. These classes are listed below in increasing order of importance of heart disease which, in general, implied a corresponding decrease in importance of cerebrovascular diseases:

Group A	Japan
Group B	Singapore, Hong Kong
Group C	Puerto Rico, France
Group D	Portugal, Bulgaria
Group E	Panama, Costa Rica
Group F	Spain, Italy, Greece, Uruguay, Federal Republic of Germany, Switzerland
Group G	Romania, Yugoslavia, Hungary, Austria, Czechoslovakia
Group H	Poland, German Democratic Republic
Group I	Australia, New Zewland, USA, Canada, Denmark, Netherlands, Belgium

Group J	England and Wales, Scotland, Ireland, Northern Ireland, Finland, Cuba
Group K	Sweden, Norway, Israel.

The clusters as identified from the analysis are shown in Figures 5 and 6.

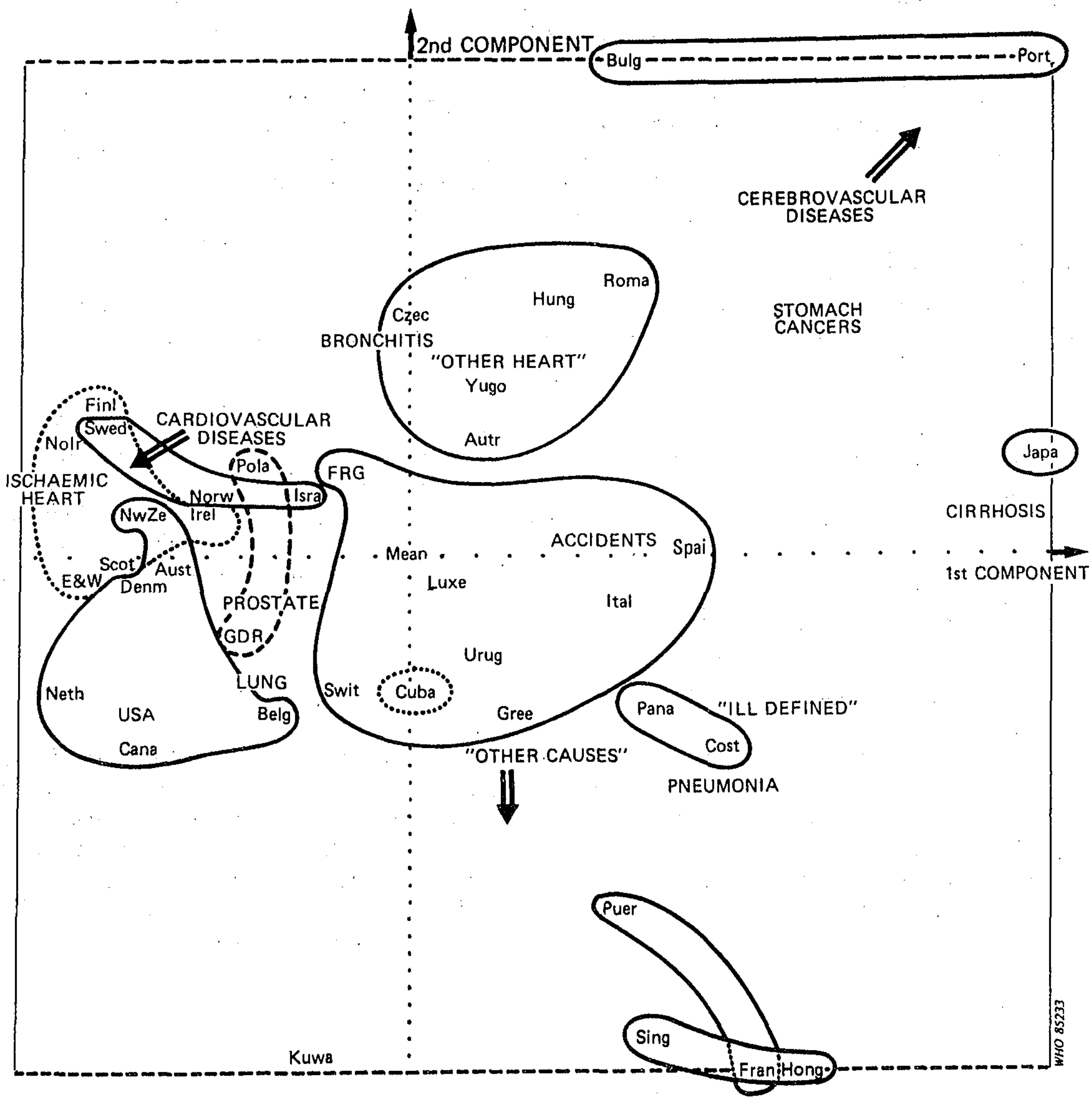

Figure 5

Classification of countries according to male mortality at ages 45-54 and 65-74.
First and second components

Figure 5 is the first principal plane in the Correspondance Analysis associated with the hierarchical classification. The intertwined clusters reveal the complexity of the relationship between the causes, with each successive component separating previously superimposed clusters. The first principal plane distinguishes on the left the Cardiovascular diseases, and opposite at the

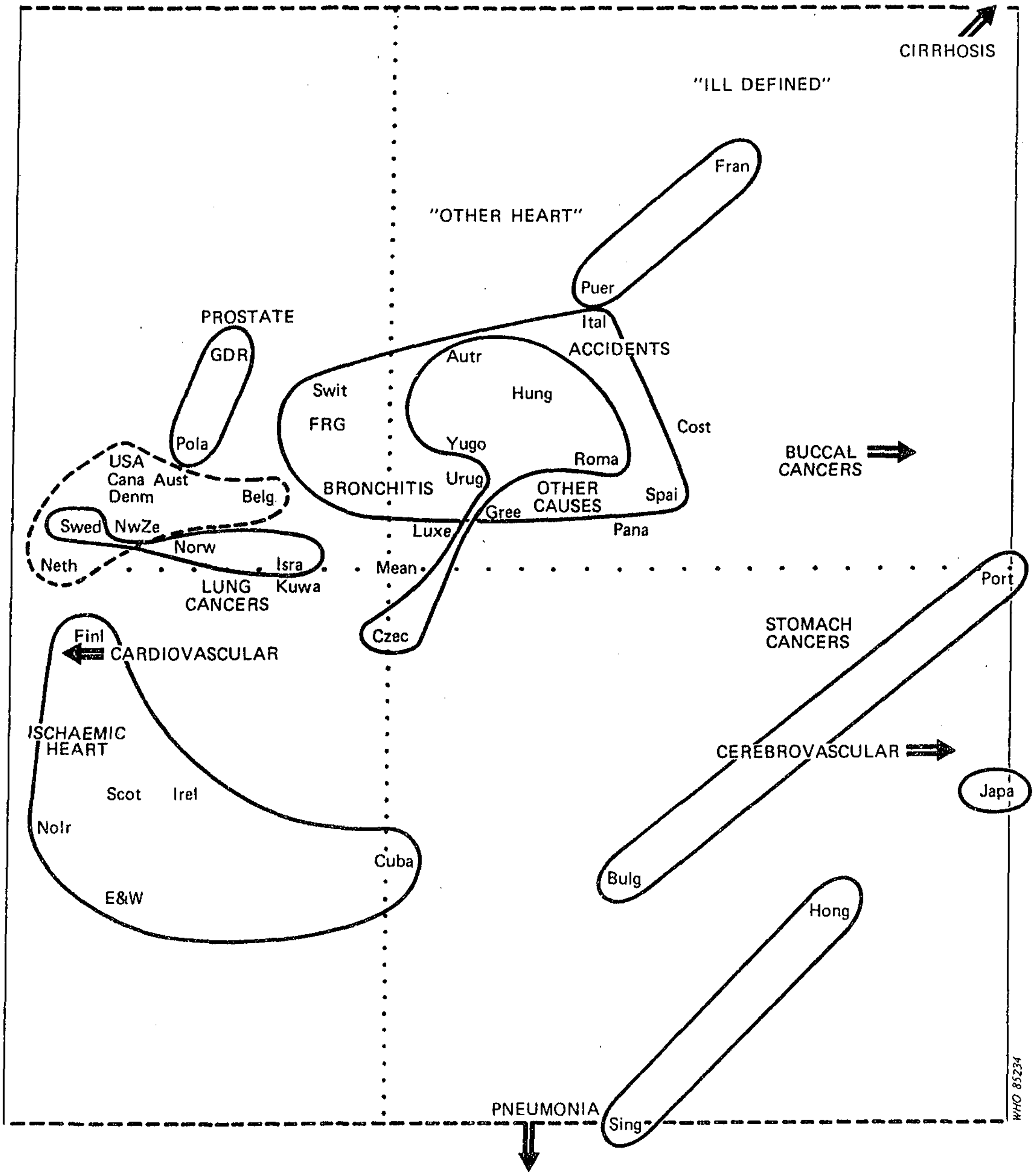

Figure 6

Classification of countries according to male mortality at ages 45-54 and 65-74.
First and third components.

North-East corner the Cerebrovascular diseases. The third component on Figure 6 (Figure 6 is the plane determined by the first and third components) discriminates Buccal cancers and Cirrhosis of the liver on top, and Pneumonia at the bottom. Some other causes are present on the two figures but if they are not extreme (i.e. far away from the center) they do not exert a major impact on that plane. Components of higher levels are too numerous to be shown here.

Japan could not be aggregated in the analysis with any other country, and in particular, with the two other Asian countries, Hong Kong and Singapore. The characteristics of the pattern for Japan are:

a) Very few deaths from heart diseases either at age 70 (17.8 % compared with 35.6 % for the general mean pattern) or at age 50 (13.6 % against 28.9 %).

b) High proportion of Stomach cancers (10.1 % against 3.2 % at age 70 and 9.3 % against 2.5 % at age 50).

c) Elevated mortality from Pneumonia at age 70 (5.0 % against 2.7 %) but much lower at age 50 (1.3 % against 1.6 %). This could well reflect a generation effect.

d) Very few cancers of the prostate (0.7 % against 2.1 % at age 70).

d) Lung cancer and Bronchitis are relatively unimportant in Japan although Cirrhosis of the liver is an important health problem.

Hong Kong and Singapore differ from Japan in their higher rate of infectious disease mortality (Pneumonia accounts for 8.3 % of deaths against 5.0 % for Japan and 2.7 % for the mean). Mortality from cancers of the buccal cavity, pharynx, oesophagus and larynx is also more common (3.7 % against 1.9 % for the mean), but cirrhosis of the liver is comparatively low in these two countries, as is bronchitis.

While it is perhaps not surprising to find France distinguished from the rest of the European countries, its inclusion with Puerto Rico is curious. The important difference between this group and the previous one relates to death from alcoholism. Both France and Puerto Rico have a higher proportion of deaths from cancers of the Buccal cavity (4.1 % against 1.9 % for the mean at age 70) and higher mortality from Cirrhosis of the liver (4.5 % of deaths against 1.8 %). Deaths from pneumonia in this group are also less common as are cancers of the prostate.

Let us now look at countries placed in the North-East quadrant of Figure 5. This position implies relatively few deaths from heart diseases but a much higher proportion from cerebrovascular diseases. At the top we find *Bulgaria and Portugal*, with extremely high proportionate mortality rates from Cerebrovascular diseases (28.4 % and 24.6 % at age 70 against 20.7 % for Japan and 11.3 % for the mean). Cirrhosis of the liver is a frequent cause of death in Portugal but not in Bulgaria. Below them, we have the Central European group: Romania, Yugoslavia, Hungary, Austria and Czechoslovakia. Here, cerebrovascular deaths are relatively frequent (14.9 % for the mean of this group against 11.3 % for the general mean). Cirrhosis of the liver is a very important cause of death too, particularly at age 70, with the exception of Czechoslovakia. Percentages vary from 2.8 up to 4, compared with 1.9 for the general mean.

Figure 6 shows the countries which are more affected by alcoholism (North-East corner corresponds to high proportion of deaths from Cirrhosis of liver and high Buccal cancer mortality). These include Italy, Puerto Rico, France, Portugal, Romania, Spain, Yugoslavia, Austria, Hungary and the Federal Republic of Germany. They differ from the Asian group by having relatively few Stomach cancer deaths, lower mortality from pneumonia and fewer deaths from Cerebrovascular diseases. In the previous list France and Puerto Rico were distinguished by the very low death rates from cardiovascular diseases.

The group consisting of Panama and Costa Rica is characterized by

a) high Stomach cancers (6.6 % against 10.1 % for Japan and 3.2 % for the mean)

b) high mortality from external causes (6.5 % against 3.4 %)

c) very few lung cancers (3.3 % against 8.0 %)

Stomach cancers are more deterministic for this group at age 70 than at age 50 (respectively, 6.6 % against 3.2 % and 4.2 % against 2.5 %).

Another group can be seen toward the centre of Figure 5. This is an aggregation of

1) Mediterranean countries: *Greece, Spain and Italy*
2) *Uruguay*
3) *Federal Republic of Germany and Switzerland.*

This centred position means that there were no substantial deviations from the mean. Nevertheless this group shows fewer Pneumonias (1.7 % against 2.7 %) lower average mortality from Cardiovascular diseases (32.1 % against 35.6 %), and slightly higher mortality from Cirrhosis of the liver (2.6 % against 1.8 %) and Cancers of the buccal cavity, pharynx, oesophagus and larynx (2.3 % against 1.9 %).

The group consisting of the German Democratic Republic and Poland differs from that just described in 3 ways: Cerebrovascular diseases are of less importance (5.8 % against 11.3 % at age 70, and 3.6 % against 5.8 % at age 50). Bronchitis mortality is more important (7.0 % against 3.8 %) and mortality from heart diseases is substantially higher (40.3 % against 35.6 %).

The three remaining groups are characterized by high mortality from Cardiovascular diseases. Furthermore, one of these groups is characterized by high proportionate mortality from lung cancers: the Netherlands (16.8 %), Belgium (13.5 %), Denmark (10.9 %), Canada (11.3 %), USA (9. 8 %), Australia (9.3 %) and New Zealand (8.6 %). This group has also the lowest proportion of deaths from cerebrovascular diseases (7.7 % against 11.3 %). There are also fewer deaths from Pneumonia, Stomach cancer and Cirrhosis of the liver.

A second class encompasses the British Isles (England and Wales, Scotland, Ireland, Northern Ireland), *Finland* and *Cuba*. Cardiovascular diseases are among the highest here (43.1 %). Cerebrovascular diseases, on the contrary, are relatively unimportant (9.6 % against 11.3 %). The other main characteristics are the absence of a significant impact from cirrhosis of the liver (0.5 % against 1.8 %), the relatively low mortality from violent deaths, a high proportion of deaths from lung cancers (9.8 % against 8.0 %), and few Stomach cancers (2.3 % against 3.2 %).

The third and last group contains Sweden, Norway and Israel. The proportion of deaths from cardiovascular diseases is the highest for this group (44.1 %) whereas lung cancers are rare (5.1 % against 8.0 %). Other characteristics are a low proportion of deaths from bronchitis (2.0 % against 3.8 %) and from cancer of the buccal cavity, pharynx, oesophagus and larynx.

3.2. Patterns of Female Mortality

Classification of countries on the basis of female mortality patterns was also undertaken since there was no a priori reason why breast cancer should be distributed among countries in the same way as for cancer of the prostate. Moreover, as the structure of mortality differed between the sexes, another analysis would serve to confirm the groups identified from the classification of male mortality. We applied the same algorithm as for males and decided to cut the tree to obtain the same number of classes, i.e. 11. These were as follows:

Group A	Japan
Group B	Singapore, Hong Kong
Group C	France
Group D	Panama, Costa Rica, German Democratic Republic, Puerto Rico
Group E	Portugal, Bulgaria
Group F	Spain, Italy, Greece, Uruguay, Federal Republic of Germany, Austria, Hungary
Group G	Romania
Group H	Yugoslavia, Czechoslovakia, Poland, Finland, Israel
Group I	Australia, New Zealand, USA, Canada, Denmark, Sweden
Group J	Belgium, Netherlands, Norway, Switzerland
Group K	England and Wales, Scotland, Ireland, Northern Ireland, Finland, Cuba.

By and large, the main groups remain intact and are characterized by the same specific causes as for men. Indeed, looking again at Figure 5, one sees that this new partition could have applied for males also. We therefore could have chosen a better partition common to males and females, but this would have involved a greater degree of subjectivity.

On the basis of these clusters, one may note that breast cancer is comparatively rare in:

1) Central America - the group with Costa Rica, Panama, Puerto Rico had 2.1 % proportionate mortality compared with a mean of 3.4 %.

2) Asian countries (1.1 % for Japan, 2.1 % for Hong Kong and Singapore).

3) Bulgaria and Portugal (2.0 %).

4) All European Socialist countries (2.5 % for the group including Czechoslovakia and Yugoslavia, and 1.4 % for Romania).

On the other hand, breast cancer is a relatively common cause of death in all Northern and North-West European countries, in all overseas

English-speaking countries, and in France (5.3 %). The highest proportions occur in the Netherlands and Switzerland (respectively, 2.7 % and 2.5 % against 1.5 % at age 50, and 5.8 % and 6.1 % against 3.0 % at age 70). We have seen that Hong Kong and the Netherlands had the highest death rates from lung cancer for males; Hong Kong has one of the lowest rates for breast cancer and the Netherlands one of the highest. This example emphasizes the large diversification of mortality from cancer in the world.

Whilst this observation strengthens our case for distinguishing among specific cancers, the following example illustrates the difficulties in distinguishing between Ischaemic heart disease and Other forms of heart disease. Both Poland and Sweden have cause-specific structures which are not too distinct (see Figure 5 and 6). Yet the death rate from Ischaemic heart disease is 95 per 100,000 in Poland and 307 per 100,000 in Sweden among males aged 65-74. For other forms of heart disease, the death rates per 100,000 are respectively 300 and 88. The gap between the two countries is too large to be credible. Yet aggregation of these two causes results in loss of information. We have, therefore, shown on Figure 5 the 2 points "Ischaemic heart disease" and "Other forms of heart disease" at the respective centre of gravity of the countries concerned to see if the distribution of Cardiovascular diseases for these 2 sub-causes differs among countries. We may note here that Ischaemic heart disease is much more important in those countries with a high proportion of total Cardiovascular diseases than in others.

In the same way, we did not take into account "Ill-defined" causes but it appears on Figures 6 and 7 as an illustrative variable. This point is not centred, but is in the direction of the less developed low mortality countries: Costa Rica and Panama.

3. SOME CONCLUDING REMARKS

Any attempt at classification of countries on the basis of their mortality patterns will involve a considerable degree of subjectivity. Certainly, the clustering algorithm permits the user to exercise some discretion in fixing group boundaries and it is here that subjective assessments based on socio-cultural expectations have influenced our choice. Moreover, it must be acknowledged that classification on a single axis (cause of death) need not necessarily encompass all the desirable elements of national mortality experience which could determine group membership. We have, for example, largely ignored the very important sex differences in mortality which exist among these countries and which themselves define distinct groups. Fortunately, the groupings so defined by sex do not differ substantially from the clusters identified by this analysis of cause-specific patterns (see Preston, 1976; Lopez, 1983). It may well be, therefore, that countries fall into broadly consistent groups irrespective of which parameter or parameters of their mortality pattern one is grouping on. We should also remark here that in the limited space available, we have emphasized the analytical aspects and have devoted very little attention to a discussion of the rates themselves. A good account of international levels and differentials in cause-specific mortality, for the European countries at least, can be found in the study by Caselli and Egidi (1981).

With regard to the groupings identified here, the consistency of clusters across male and female mortality patterns suggests that there may well be pervasive national circumstances which determine a particular mortality pattern and group membership. The extent to which diagnostic practices rather than pathology determine prevalence of a particular cause of death is, of course, very difficult to assess and consequently one must view the groupings with some prudence. Nonetheless, we believe that the clusters are not too different to what one might expect. Certainly, the socio-geographical clusters which group together the Southern European countries on the one hand, and the Anglo-Saxon, Latin American, or Asian countries on the other is strongly suggestive of a common influence on national mortality patterns. However, the extent to which this reflects similar behavioural traits across nations is still unclear. One may argue that the identification of specific disease characteristics of some groups (e.g. cirrhosis of the liver in the groups containing France, Italy, Austria, Yugoslavia and the Federal Republic of Germany, and heart diseases/lung cancer/bronchitis in the Anglo-Saxon and Northern European countries) is consistent with known risk factor distribution in these populations.

To profit from this kind of analysis, one must be able to demonstrate the close association of national health behaviours with common disease patterns. This replication of risk factor/disease outcome process in a number of countries will in itself provide further evidence for the reorientation of health policies to encourage greater health consciousness. But to persuade health policy will require greater clarification of this cause-effect relationship and in this sense, a much more concerted effort to improve the international comparability of cause of death data may prove at least as rewarding as further intensive research on the epidemiology of these diseases.

ANNEX TABLE A

Composition of cause of death categories, ICD-8 & ICD-9 *

Cause of death category	Rubrics in A-List of ICD-8	Rubrics in basic tabulation list of ICD-9
All causes	A00	B00
Lung cancer	A51	1011
Cancer of buc. cav & pha.	A45,A46,A50	08,090,100
Breast cancer (F)	A54	113
Cancer of the prostate (M)	A57	124
Cancer of stomach	A47	091
Ischaemic heart disease	A83	27
Other forms of heart disease and other circ. diseases	A84,A86,A87,A88	28,30
Cerebrovascular disease	A85	29
Bronchitis, emphy., asthma	A93	32
Pneumonia	A91,A92	321
Cirrhosis of liver	A102	347
Motor vehicle acc.	AE138	E471
Suicide and self-inflicted injury	AE147	E54
All other violent causes	AE139-146,148-150	E470,E472-E479 E48-E53,E55-E56
All other causes	Remainder	Remainder

* International Classification of Diseases and Injuries.

SUMMARY

Among low mortality countries (e_0 of at least 70 years) large differences exist in age, sex and cause specific patterns. The extent to which these differences are artefactual (arising from diagnostic preferences and other factors affecting comparability of causes of death) is difficult to determine. A principal component analysis of the age-sex pattern of mortality confirmed previous findings underlying the construction of regional model life tables.

Principal components analysis, as well as correspondence analysis in conjunction with a cluster algorithm, have been applied to cause of death data at selected periods of life (ages 15-24, 45-54 and 65-74) to identify groupings of countries with common mortality structures. At ages 15-24, the international variation among male mortality was substantially greater than for females. For males, Japan, Hungary, Canada and the Nordic countries are characterized by a high proportion of suicides. A second group including Austria, Belgium, Australia, New Zealand and the Federal Republic of Germany show the highest death rates at these ages and the highest proportionate mortality from motor vehicle accidents.

At the adult ages, the multivariate analysis suggested 11 distinct groupings. By and large, the membership of groups was similar whether based on male or female mortality patterns. Japan formed a single-nation cluster characterized by low proportionate mortality from heart diseases and a high proportion of deaths from stomach cancer. Hong Kong and Singapore were grouped together on the basis of higher death rates from pneumonia. France was distinguished on the basis of diseases causally related to alcohol consumption (cirrhosis of the liver, cancer of buccal cavity, oesophagus, pharynx and larynx). Portugal and Bulgaria are characterized by a very high proportion of deaths from cerebrovascular disease. The central European countries (Romania, Yugoslavia, Hungary, Austria, and Czechoslovakia) were also grouped together on the basis of higher than average mortality from cerebrovascular diseases, as well as for cirrhosis of the liver. Three further clusters of countries were distinguished on the basis of a high proportion of deaths from heart diseases. One group included the overseas English-speaking countries and the Netherlands where lung cancer deaths were comparatively important. A second group included the British Isles and Finland (low cerebrovascular disease contribution, low proportion of deaths from cirrhosis of the liver). Norway, Sweden and Israel comprised the final group with the highest proportion (44 %) of adult male deaths due to heart diseases.

RESUME

LES DECES OBSERVES DANS LES PAYS OU LA MORTALITE EST FAIBLE: UNE ANALYSE CLASSIFICATRICE

Il existe entre les pays à faible taux de mortalité (espérance de vie au moins 70 ans) d'importantes différences en ce qui concerne l'âge, le sexe et les causes. Il est difficile de déterminer dans quelle mesure ces différences sont

des artifacts résultant de préférences diagnostiques ou d'autres facteurs affectant la comparabilité des causes de décès. Une analyse des principales composantes du schéma de mortalité par âge et par sexe a confirmé les constatations précédentes sur la base desquelles ont été construites les tables de survie régionales.

L'analyse des principales composantes ainsi que l'analyse des correspondances en liaison avec une classification automatique ont été appliquées aux données sur les causes de décès à des périodes déterminées de la vie (âges 15-24, 45-54 et 65-74) pour identifier des regroupements de pays ayant des structures de mortalité communes.

Aux âges 15-24, les taux de mortalité masculine variaient beaucoup plus d'un pays à l'autre que les taux de mortalité chez les femmes. Le Japon, la Hongrie, le Canada et les pays nordiques se caractérisent par une proportion importante de suicides chez les hommes. Dans un second groupe réunissant l'Autriche, la Belgique, l'Australie, la Nouvelle-Zélande et la République fédérale d'Allemagne on trouve les taux de mortalité les plus élevés à ces âges et la mortalité par accidents de véhicules à moteur y est proportionnellement aussi la plus forte.

Aux âges adultes, l'analyse à variables multiples a fait apparaître 11 regroupements distincts. D'une manière générale, la composition des groupes était semblable qu'on utilise les schémas de mortalité masculine ou féminine. Le Japon constituait un groupe à elle seule caractérisée par une faible mortalité proportionnelle par cardiopathies et une proportion élevée de décès par cancer de l'estomac. Hong Kong et Singapour avaient en commun des taux élevés de mortalité par pneumonie. La France se distinguait par l'importance des maladies causées par la consommation d'alcool (cirrhose de foie, cancer de la cavité buccale, de l'oesophage, du pharynx et du larynx). Le Portugal et la Bulgarie se caractérisent par une très forte proportion de décès par maladies cérébrovasculaires. Les pays d'Europe centrale (Roumanie, Yougoslavie, Hongrie, Autriche, Tchécoslovaquie) sont rassemblés sur la base d'une mortalité par maladies cérébrovasculaires supérieure à la moyenne ainsi que par l'importance de la cirrhose du foie. Trois autres groupes de pays se distinguaient par une proportion importante de décès par cardiopathies. Un groupe incluait les pays anglophones d'Outre-Mer et les Pays-Bas où les décès par cancer du poumon étaient relativement importants. Un second groupe incluait les îles britanniques et la Finlande (rôle peu important des maladies cérébrovasculaires, faible proportion de décès par cirrhose du foie). Le dernier groupe réunissait la Norvège, la Suède et Israël avec la proportion la plus élevée (44 %) de décès d'hommes adultes par cardiopathies.

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