Bull. Org. mond. Santé
Bull. Wld Hlth Org. } 1957, 17, 439-481

PROPORTIONAL MORTALITY OF 50 YEARS AND ABOVE

A Suggested Indicator of the Component "Health, including Demographic Conditions" in the Measurement of Levels of Living

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SYNOPSIS

In 1954 the United Nations Committee of Experts on International Definition and Measurement of Standards and Levels of Living suggested that for the measurement of levels of living quantifiable or potentially quantifiable components should be considered separately. An attempt is made in the present paper to evolve a single, comprehensive numerical indicator to quantify the component " health, including demographic conditions ".

The use of an objective statistical technique as a guide in the selection of such an indicator is suggested. From the application of this technique, it is concluded that the percentage of deaths at the ages 50 years and over to total deaths (proportional mortality) affords a fairly suitable yardstick by which broad inter-country comparisons may be made. This indicator has the advantages of simplicity of calculation, comprehensiveness, availability of data, possibility of international comparability despite the varying quality of basic statistical information, sensitivity for the purpose of inter-country comparisons, and validity for studying levels and trends.

Introduction

The need for a numerical measure of the term " standard of living " or, more precisely, " level of living " has been felt for a long time. In recent years, this problem has received considerable attention at the international level for the purpose of finding some suitable means of comparing levels of living of different countries or of the same country from one period to another. In 1952, the General Assembly of the United Nations, taking note of the stipulation made in the United Nations Charter that the United

Nations shall promote " higher standards of living ", requested the Economic and Social Council in Resolution 527 (VI)

" to continue to pay special attention to changes occurring in the standards of living of the working population, and to provide for the working out of adequate statistical methods and techniques so as best to facilitate the gathering and use of pertinent data in order to enable the Secretary-General to publish regular annual reports showing changes in absolute levels of living conditions in all countries . . ."

Accordingly, the Secretary-General of the United Nations convened a committee of experts to report on the most satisfactory method of defining and measuring the standards of living. This committee recommended that in future discussions the term " level of living " be employed instead of " standard of living " when referring to actual conditions of living as contrasted with future aspirations, the latter concept being covered by the term " standard of living ".[5]

The committee was not able to formulate a single index of the level of living as a whole which could be applied internationally, and suggested that the problem of measuring levels of living should be approached in a pluralistic manner, i.e., by considering separately the various components representing values which the committee thought were quantifiable or potentially quantifiable. The committee suggested the following list of twelve components as an acceptable international catalogue of the components of levels of living :

1. Health, including demographic conditions
2. Food and nutrition
3. Education, including literacy and skills
4. Conditions of work
5. Employment situation
6. Aggregate consumption and savings
7. Transportation
8. Housing, including household facilities
9. Clothing
10. Recreation and entertainment
11. Social security
12. Human freedoms

For each of these twelve components, statistical measures or indicators are to be sought for the purpose of international reporting.

Indicators suggested for the Component " Health, including Demographic Conditions "

For the component " health, including demographic conditions ", the United Nations Committee originally recommended a study of the following indicators:

1. Expectation of life at birth
2. Infant mortality rate (number of deaths of infants under one year of age per 1000 births per annum)
3. Crude annual death-rate (deaths per 1000 population per annum)
4. Number of hospital beds in relation to the population
5. Number of physicians in relation to the population.

The committee also considered the question of " synthetic indicators ", i.e., a single unified index which would present a picture of the level of living as a whole. Although the committee " agreed that such a single unified index of the level of living was neither possible nor desirable, for purposes of international comparison under the present circumstances ", it proposed at the same time " the use of certain indicators which, while subject to great limitations, would nevertheless provide in some measure for broad general comparisons of levels of living and might in this sense be considered to be ' synthetic ' ". In this connexion " it was proposed that average expectation of life at various ages might be used as a synthetic indicator, in view of the fact that this item may be regarded—under certain defined circumstances—as a resultant of many other factors in the level of living ".

In connexion with the indicators suggested by the United Nations Committee, it has to be observed that the last two indicators—No. 4 and No. 5—refer in actual fact not to health levels but to factors which influence health. It has been assumed in this paper that the indicators sought for were to represent health levels, rather than to measure public health activities conducive to health.

Observations by WHO Expert Committee on Health Statistics

In September 1954, the WHO Expert Committee on Health Statistics [6] examined the indicators suggested by the United Nations Committee and expressed the opinion that the indicators pertaining to the number of hospital beds and the number of physicians in relation to population suffered from lack of international comparability of quality of medical care facilities and could not be considered fully representative of the most decisive factors for determining health. These indicators concealed the existence of the relatively higher levels of medical care available in the urban centres of the under-developed countries. The WHO Expert Committee also felt that the value of the crude death-rate was limited because of variation in the sex/age structure of the population. Further, in so far as the expectation of life at birth is affected significantly by the level of the infant mortality rate, the WHO Expert Committee felt that in order to maintain a greater independence among the indicators, preference might be given to expectation of life at age 1 year (e_1^0) if the infant mortality rate is retained on the list. It was noted, however, that information on expectation of life was not available for many countries, particularly for the under-developed areas. Even for other countries, information in respect of expectation of life was generally available only at intervals of 10 or more years. As regards the infant mortality rate, the WHO Expert Committee noted that while this rate had been traditionally regarded as a good measure of the sanitary situation of a country or area, nevertheless the accuracy and reliability of the rate in numerous territories of the world—contingent as it was in its validity and significance on the completeness of the registration of births and infant deaths—might be open to some question.

Having thus noted the limitations of all the five indicators suggested by the United Nations Committee, the WHO Expert Committee reviewed other important demographic or public health indices which could eventually be used as indicators of the health component, such as " the number of deaths from infectious and parasitic diseases in relation to deaths from all causes " or " the number of deaths under 5 years of age in relation to deaths at all ages ", which would include a considerable proportion of the deaths caused by infectious diseases.

Search for a Single Comprehensive Indicator of " Health, including Demographic Conditions "

The WHO definition of health is indeed of wide coverage, embracing physical, mental and social well-being. This coverage is further widened by the inclusion of " demographic conditions " as well by the United Nations Committee in their first component.

While health statisticians have devised several indices to compare some of the aspects of physical health, it is to be noted that so far no suitable index has been put forward to quantify the status of national mental or social well-being. It may therefore seem a foregone conclusion that no single indicator to measure health in its broad sense is at present available. A study of the health component of levels of living therefore raises several difficult and as yet unsolved problems, necessitating perhaps an examination of many sub-components.

In this connexion it is pertinent to recall that a search for health indicators was initiated in the 1930's by the Health Organisation of the League of Nations. The objective then was to find health indices expressed in numerical terms which with some background information would give a picture of the health status of a community. An elaborate system of health indices was devised by Stouman & Falk,[4] falling into three main divisions:

1. Indices of vitality and health
2. Indices of environment
3. Indices of administrative activity.

These authors decided against any attempt to devise a single health index by which the general state of health of a community could be rated, as they considered that " such unit rating could have only a slight interest and might serve as much to obscure as to measure individuality of local problems ".

However, in spite of the enormous complexity of the study of the health level of a country or community in numerical terms, the problem that has to be faced, at least from the administrative point of view, is broadly to classify the countries according to their state of health. In the present state of knowledge perfection is, of course, impossible. But an administrator may well ask to what extent he could possibly make use of the available national statistical data to study various countries according to their level of health. In other words, do the existing data serve any useful purpose for broad inter-country comparisons? Such an administrative need arises from a recognition of the fact that such simple indices as infant mortality rate, crude death-rate, expectation of life, etc. do show considerable variation from one country to another or from one period of time to another. Various countries can be ranked according to any of these indices and such ranking has had, no doubt, some significance to health administrators in studying both levels and changes in health status. One of the important reasons for which each country maintains extensive statistical machinery, whereby vital events occurring in each single family are recorded, is to produce such objective indices. In recent years the methodology for the analysis and interpretation of these data has also been improved. One is naturally led, therefore, to enquire what maximum use can now be made of these national data for our present purpose. Is the time not yet ripe to re-examine the thought that has permeated these developments and to devise a more informative index than has so far been found, at least to serve the present needs?

Criteria for Selecting an Indicator of " Health, including Demographic Conditions "

Although certain limitations of the indicators already proposed for use have been noted and some preferences expressed by different committees, we feel that in choosing an indicator for the purpose in question some criteria should first be laid down so that the selection can then be made, as far as possible, on an objective basis. The criteria suggested are:

1. For international applicability, records should be available from as large a number of countries and territories as possible.

2. The indicator should relate as far as possible to each country or territory as a whole and not to any selected area or population group only.

3. Records needed to estimate the indicator should be of good quality, or the indicator should not be unduly affected by qualitative defects in the records such as those arising from under-registration or from differences in terminology, definitions, practices or procedures used for classifying and consolidating the data.

4. The indicator should be comprehensive in character, as stipulated in the term " health, including demographic conditions ". It implies that as far as possible various factors affecting health in the entire life-span should be taken into account.

5. As far as possible, the computation of the indicator should be simple enough to command international acceptance.

6. The indicator should possess high discriminatory power and validity so as to distinguish between countries at various levels of health and to indicate changes occurring from time to time.

Application of Discriminant Function Technique

Our approach to this study has been actuated by the desire to utilize statistical information already available so as to produce a single indicator which, in the present state of knowledge, could satisfy the above criteria and be used to discriminate between countries at different levels of health and with different demographic conditions. We were led into this study by the belief that, while the crude death-rate may enable us to rank various countries of the world, this ranking is better achieved by using the infant mortality rate. As a criterion by which such a comparison may be made, we have utilized the concept of the " generalized distance " or D^2, the statistical theory of which was developed by Mahalanobis (see Annex 2) in connexion with the study of two population groups. If several different measurements are available on each of the two groups, the measurements may be compared in the light of this criterion to find the one which best discriminates between the two groups. The greater the value of D^2, the better it is for discrimination.

Our purpose is not to allocate countries to the so-called " developed " or " under-developed " categories but to seek an appropriate ranking of them. The theoretical considerations involved in the use of D^2 values for our purpose are discussed in a later paragraph. For the moment it may be stated that in applying a similar concept to our search for a suitable indicator we begin by considering two groups of countries, Group A comprising the so-called " developed " countries and Group B the so-called " under-developed " countries from the point of view of health. The crux of the argument is that the countries chosen for these two groups are clearly different inasmuch as no country included in one group could possibly be considered to fall in the other from the health point of view. In other words, we have deliberately chosen two groups of countries which we know *a priori* to differ from each other in their levels of health. Ten countries were selected for each group, as follows:

Group A : Australia, Canada, Denmark, England and Wales, France, New Zealand, Norway, Sweden, Switzerland, USA;

Group B : Ceylon, Colombia, Dominican Republic, Egypt, India, Malaya (Federation), Mexico, Peru, Philippines, Thailand.

The reason for including only ten countries in each group was that for Group B national data were not available for a larger number. As a matter of fact, the data in respect of the expectation of life are available for only five countries out of the ten—Ceylon, Colombia, Egypt, India and Mexico.

Basic statistical data in respect of these 20 countries are shown in Annex 1 (Table X).

Our object then was to examine the various health indices proposed by the United Nations Committee of Experts or by the WHO Expert Committee on Health Statistics, to see which of these or what combination of some of them could provide the greatest value of D^2. A series of trial calculations was made of the values of D^2 for indices obtained by combining some of the measurements with proper weighting, according to the discriminant function technique developed by Mahalanobis [2] and Fisher.[1]

The values of D^2 corresponding to various indices or combinations of ome of them are given in Table I.

Discriminatory Values of Various Indices

Since, of the ten countries belonging to Group B, only half provided data for expectation of life, the D^2 values were computed first for ten Group A countries and five Group B countries in order to facilitate the comparison of the discriminatory value of expectation of life with other indices (part (*a*) of Table I). Except for the expectation of life, figures are generally available for other health indices for the ten countries in Group B also. Various values of D^2 recalculated for combinations of indices for ten countries in each group are shown in part (*b*) of Table I.

The value of D^2 was first calculated by including the four indices recommended by the WHO Expert Committee on Health Statistics—namely, crude death-rate, infant mortality rate, expectation of life at age 1 year and proportional mortality under 5 years to total deaths. Subsequently, values of D^2 were calculated separately by excluding from the four indices one index at a time. Items 2, 3, 4 and 5 and Table I show the values of D^2 thus obtained. An interesting observation is that the value of D^2 is considerably lowered when the proportional mortality index is excluded

TABLE I. VALUES OF D^2 FOR VARIOUS HEALTH INDICES OR THEIR COMBINATIONS

Index *	D^2
(*a*) Data based on 10 Group A countries and only 5 Group B countries for lack of figures relating to expectation of life	
1. CDR, IMR, $e^{o}_{1,m}$, PM < 5	98.5
2. CDR, IMR, $e^{o}_{1,m}$	21.4
3. CDR, IMR, PM < 5	42.5
4. CDR, $e^{o}_{1,m}$, PM < 5	91.5
5. IMR, $e^{o}_{1,m}$, PM < 5	69.6
6. CDR, IMR	14.6
7. CDR, $e^{o}_{1,m}$	15.5
8. CDR, PM < 5	40.1
9. IMR, $e^{o}_{1,m}$	15.8
10. IMR, PM < 5	31.2
11. $e^{o}_{1,m}$, PM < 5	36.6
12. CDR	3.7
13. IMR	10.2
14. PM < 5	29.1
15. $e^{o}_{1,m}$	15.1
16. Expectation of life at birth, male	16.6
17. Average expectation of life at 5-year intervals, from 0 to 75 years (males)	9.3
18. Average expectation of life at 5-year intervals, from 0 to 75 years (females)	14.5

Index *	D^2
(*b*) Data relating to 10 Group A and 10 Group B countries	
19. CDR, IMR, PM < 5	43.0
20. CDR, IMR	14.1
21. CDR, PM < 5	42.8
22. IMR, PM < 5	39.3
23. CDR	2.0
24. IMR	10.4
25. PM < 5	37.7
26. PM < 1	23.6
27. PM < 10	56.5
28. PM < 15	70.8
29. PM < 20	87.4
30. PM < 25	109.7
31. PM < 30	137.4
32. PM < 35	167.2
33. PM < 40	212.4
34. PM < 45	234.0
35. PM < 50	269.1
36. PM < 55	236.5
37. PM < 60	184.4
38. PM < 65	111.1
39. PM < 70	73.4
40. Mean age at death	156.6
41. Percentage of persons aged 65 and over to total population	49.6
42. Later infant mortality rate (i.e., infant deaths from age 1 month to under 12 months per 1000 live births)	7.6
43. Age-specific death-rate for 1-4 years	22.8

*** Index: CDR = crude death-rate; IMR = infant mortality rate; $e^{o}_{1,m}$ = expectation of life at age 1, male; PM <*x* = proportion of deaths under *x* years of age to total deaths (%).**

from these four indices, the value then being reduced to 21.4 as against such high values as 98.5, 42.5, 91.5 and 69.6. This seems to suggest that proportional mortality under 5 years by itself possesses high discriminatory value. Values of D^2 were also calculated by excluding two or three indices each time. These values are shown in items 6-15 in Table I. A study of the differences in D^2 values once again suggests that the value is considerably lowered when the proportional mortality indicator is excluded. As a matter of fact, a comparison of the figures appearing against items 12, 13, 14 and 15 indicates that the discriminatory value of proportional mortality under 5 years stands out well above that of the other three indices.

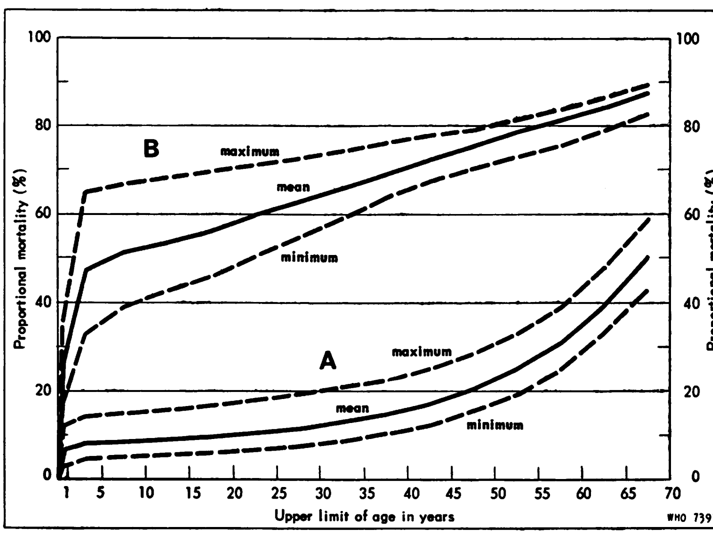
The crude death-rate is shown to have the poorest discriminatory value, as indeed is to be expected considering the fact that owing to the aging of the population the crude death-rate in certain well-developed countries is higher than in some under-developed countries. Expectation of life has about the same discriminatory value at age 0 or age 1 year, although it is better than either the crude death-rate or the infant mortality rate. Thus, out of these three indices it would seem that the " expectation of life " is to be preferred, although there appears no particular advantage in using expectation of life at 1 year alone in preference to expectation of life at age 0. Of course, as has already been stated, this index is not available for many countries, and where it is available it is usually calculated only at intervals of 10 or more years—a consideration that weighs heavily against its use as an indicator.

The high discriminatory power possessed by the proportional mortality under 5 years of age is evident also from part (*b*) of Table I. The three indices—namely, crude death-rate, infant mortality rate and proportional mortality under 5 years—together have a D^2 value of 43.0, while item 25 shows that proportional mortality under 5 years alone has as high a value as 37.7.

Having noted that the proportional mortality under 5 years possessed high discriminatory value, similar trial calculations were made for other age periods. Thus the proportional mortality under 1 year was found to have a lower D^2 value (23.6) than that for proportional mortality under 5 years (37.7). On the other hand, proportional mortality under 10 years appeared to have a higher value than that for under 5 years. This led us to investigate D^2 values of proportional mortality at higher age-groups by extending the period by 5 years each time. The corresponding values of D^2 are given in items 28-39 in Table I. It was found that the value of D^2 increased with age up to 50 years, attaining as high a value as 269.1. As a matter of fact the value of D^2 attained by proportional mortality under 50 years of age by itself far exceeds that attained by combining any of the other indices together into a single discriminatory function. After age 50, the value of D^2 shows a decrease. Of course, it is understandable that if this age limit is further extended to higher and higher ages, then the value of proportional mortality will approach 100 for all countries in both the developed and under-developed groups and accordingly this indicator will not be expected to differ for the two groups.

It is of interest to study how the actual values of proportional mortality gradually diverge to an increasing extent for the developed and under-developed countries as we calculate the values successively up to certain ages. Fig. 1 shows the average values of proportional mortality up to

FIG. 1. PROPORTIONAL MORTALITY WITH ADVANCING AGE FOR 10 DEVELOPED AND 10 UNDER-DEVELOPED COUNTRIES



A = 10 developed countries
B = 10 under-developed countries

various ages by unbroken lines, as well as the ranges of the maximum and minimum proportional mortality of individual countries belonging to each of these two groups. The gap between the lines 0A and 0B is seen gradually to widen with increasing age until age 50 is reached. Thereafter, it shows a tendency to narrow, as indeed is to be expected, because at higher ages the proportional mortality figure for both groups of countries will approach 100%. This diagram illustrates why proportional mortality with a split at age 50 emerges as the best on the basis of the discriminant value. A perusal of the figures set out in Table I in respect of several other possible indices of health shows that the only other index that appears to have a relatively high value of D^2 is mean age at death. For the calculation of mean age at death from the national tabulations of deaths by age, we were constrained to make an arbitrary assumption in regard to the average age at death for the highest age-group for which the maximum age limit is undefined. The calculation of mean age at death is no doubt more laborious than that of simple proportional mortality under 50 years of age. In any case, the value of D^2 for the mean age at death does not attain the same order of magnitude as that for the proportional mortality. In view of these considerations, we would prefer the use of proportional mortality to any of the other indicators whose D^2 values are set out in Table I.

The reasons why this proportion possesses the highest value of D^2 are not far to seek. Owing to the operation of past forces of mortality and natality, the population in the developed countries is in general relatively older than in the so-called under-developed countries, so that it is in the under-developed countries that there is a relative preponderance of persons under 50 years of age. Again, it is in the under-developed countries that mortality rates are particularly high among infants, children and mothers. Thus, both the demographic structure of the population and health conditions as reflected in the mortality pattern combine to produce a relatively larger number of deaths under 50 years in under-developed countries. The value of the proportional mortality under 50 years is thus considerably increased in these countries.

The values of proportional mortality as calculated so far, i.e., for the age-group *under 50 years* to total deaths, are relatively higher for the under-developed countries and lower for the developed countries. In other words, this index is related in an inverse manner with the level of health, decreasing in value as the level of health shows improvement. If, however, an indicator is needed that is directly related to level of health, we could use instead proportional mortality of *50 years and over* to total deaths. The value of proportional mortality of 50 years and over will of course be 100 minus the index so far discussed. It can be shown theoretically that it will possess the same discriminatory value as that of proportional mortality under 50 years. Inasmuch as proportional mortality of 50 years and over will have greater appeal than the index so far discussed because of its direct relationship to level of health, it is suggested for general use.

The study so far undertaken reveals, therefore, that for studying the health and demographic status of different countries by means of an indicator based on national statistical information already available, an appropriate indicator would appear to be the *percentage of deaths at 50 years and over to deaths at all ages.*

In the hypothetical case of a country where all persons live to a ripe old age and no death occurs under 50 years, the value of this indicator will obviously be 100%. On the other hand, if in a country adverse mortality conditions operate so heavily that no person survives to age 50, then the value of this indicator will be zero. These, of course, are the two extreme cases; the values of various countries will range between these two limits: the better the health conditions, the nearer will the indicator be to 100%.

Further Theoretical Considerations

It has already been mentioned that the values of D^2 on which the previous discussion is based would be likely to be somewhat different if in either of the two groups, i.e., developed and under-developed, some other countries were included. Because the number of available countries is rather small, it is difficult to estimate the sampling errors in D^2 values of various indices. Nevertheless, some idea of the nature of this variation can be obtained by drawing samples of countries from these 20 countries and recalculating D^2 values from repeated samples. Five random samples were drawn of 8 countries from each group. The values of D^2 obtained for various indices are shown in Table II.

TABLE II. VALUES OF D^2 FOR VARIOUS SAMPLES OF 8 COUNTRIES FROM EACH OF THE DEVELOPED AND UNDER-DEVELOPED GROUPS

Index *	Sample				
	1	2	3	4	5
CDR	2.3	2.5	2.2	2.0	1.4
IMR	9.2	11.2	13.7	10.3	9.1
$\overset{o}{e}_{0, m}$	17.5	16.5	12.4	13.9	33.9
$\overset{o}{e}_{1, m}$	15.0	13.9	11.2	12.6	41.2
PM < 1	24.3	30.3	23.3	25.5	18.8
PM < 5	35.6	46.9	54.6	33.0	29.2
PM < 10	51.8	68.2	81.0	51.1	43.7
PM < 20	73.0	101.9	130.0	84.7	69.3
PM < 30	113.2	149.3	178.8	150.8	112.0
PM < 40	171.9	215.3	244.8	273.7	181.8
PM < 50	214.3	270.9	261.2	389.2	253.8
PM < 60	141.7	222.3	168.4	215.0	188.9
PM < 70	59.6	95.3	62.2	71.4	83.6

* Index: CDR = crude death-rate; IMR = infant mortality rate; $\overset{o}{e}_{1, m}$ = expectation of life at age 1, male; PM<x = proportion of deaths under x years of age to total deaths (%).

It is realized that owing to the fact that the same country may happen to be included in different samples, the D^2 values from different samples would possess some similarity. However, even though differences occur from one sample to another, it is worthy of note that the D^2 value for the proportional mortality for 50 years and over stands out highest in each series. Further, no other index is found to approach a value as high as that of the proportional mortality indicator.

It can well be argued that this indicator may suffer from the disadvantages that are known to characterize a proportional mortality figure. For instance, by using the total deaths in the denominator we may be utilizing a figure that may show ordinarily a larger degree of fluctuation from year to year than a relatively more stable population as the base. However, it may be noted that since the total deaths are classified in two broad categories the value of this indicator will be disturbed only if in any particular year, owing to special age-selective factors, the deaths in these two age-groups happen to be distributed in an unusual manner.

In making use of the technique of the discriminant function, or the concept of the generalized distance, for this study we have been aware that from the methodological point of view there are certain shortcomings. In the first place, the theoretical assumptions on which the use of this technique is justified may not be altogether fulfilled by our data. Of course, it is known that in the application of such statistical techniques a certain departure from the theory is permissible. However, we possess no basis for making any claim as to whether or not the theoretical assumptions are reasonably fulfilled. Secondly, the technique of discriminant function and the concept of generalized distance are ordinarily employed for the purpose of developing a suitable indicator to discriminate between two (or in special cases a few more) population groups. We have proceeded by choosing two distinct groups of countries—A and B, namely, developed and relatively under-developed—and have shown that the proportional mortality indicator is better suited to this purpose than several of the other well-known indices. Thereafter, the proportional mortality indicator has been used for the purpose of broadly ranking individual countries. Whether or not such a use of a discriminator is justifiable may be a moot point on purely theoretical considerations.

In any case, we must point out that the application of the discriminant function technique has definitely served one purpose, in that it has focused attention on the proportional mortality figure as a possible comprehensive indicator. Even if this indicator happened to be suggested for use without the foregoing theoretical study, i.e., if it were suggested on purely empirical grounds, it would still merit study because of the many advantages it is shown to possess in the present context.

Proportional Mortality Indicator by Sex

In the previous discussion of proportional mortality we have considered the figures for both sexes together. However, values of D^2 have also been calculated separately for each sex by taking the same age-groups in increasing order up to 70 years; the figures are shown in Table III.

TABLE III. VALUES OF D^2 BY SEX FOR PROPORTIONAL MORTALITY BELOW CERTAIN AGES, 1949-51

Age-group	D^2			Difference between the D^2 values for both sexes and that for:	
	male	female	both sexes	males	females
Under 1 year	24.9	21.1	23.6	+1.3	—2.5
,, 5 years	39.3	35.1	37.7	+1.6	—2.6
,, 10 ,,	57.3	52.6	56.5	+0.8	—3.9
,, 15 ,,	70.6	66.8	70.8	—0.2	—4.0
,, 20 ,,	84.5	85.3	87.4	—2.9	—2.1
,, 25 ,,	97.1	116.4	109.7	—12.6	+6.7
,, 30 ,,	111.7	156.4	137.4	—25.7	+19.0
,, 35 ,,	129.0	194.2	167.2	—38.2	+27.0
,, 40 ,,	158.8	245.9	212.4	—53.6	+33.5
,, 45 ,,	182.7	253.8	234.0	—51.3	+19.8
,, 50 ,,	222.1	274.8	269.1	—47.0	+5.7
,, 55 ,,	203.6	229.6	236.5	—32.9	—6.9
,, 60 ,,	167.0	190.1	184.4	—17.4	+5.7
,, 65 ,,	100.7	124.8	111.1	—10.4	+13.7
,, 70 ,,	64.6	89.8	73.4	—8.8	+16.4

It is interesting to observe that in the case of both males and females the separate values of D^2 show increases up to the age of 50 years and that thereafter a decrease sets in, as has been observed in the case of figures for both sexes considered together. Further, up to the age-group 20 years (approximately corresponding to the pre-reproductive period for females) the difference between the male and female values is very small. Thereafter, females show higher D^2 values than those for the males throughout the life-span. In view of the higher D^2 values for females after 20 years, the point for consideration is whether it would be advantageous to use proportional mortality for females alone as an indicator of health and demographic conditions in preference to that calculated for both sexes together. The last two columns of Table III, showing the difference of each sex from the combined figures for both sexes, indicate that females have a higher value than the combined figures for both sexes during the age period 25 to 50 years. At age 50, however, the difference in magnitude is relatively small between the female proportional mortality and that for the two sexes together.

It could be argued that for purposes of international comparability the female population may indeed provide a better basis because the female population is generally more immune from the effects of such factors as war, migration, and certain occupations. On the other hand, to consider figures for both sexes together may seem to have the advantage that we study the sum total of health conditions affecting the entire population.

It is difficult to choose between one indicator and another on purely statistical grounds. We would suggest that for the time being, even though the D^2 values show some preference for female proportional mortality, and even though considerations of comparability also point in the same direction, yet for inter-country comparisons we may use the proportional mortality of 50 years and over for both sexes to total deaths as a suitable yardstick by which to compare broadly the health and demographic conditions of various countries, or of the same country from one period to another.

Effect of Inaccuracies in Basic Statistical Data on Proportional Mortality Indicator

One factor that usually detracts from the international comparability of almost all vital and health statistical indices is the varying degree of reliability in basic national statistical data. The proportional mortality indicator makes use of mortality statistics classified into only two broad age-groups. Errors in its estimation may therefore be expected to arise from two causes—either mis-statements of age or under-reporting of deaths. However, it will be clear from the following discussion that neither of these sources of error is likely to have an effect of any material magnitude on the proportional mortality indicator.

Effect of mis-statement of age

Reliability in estimating the proportional mortality indicator depends largely on how the deaths are recorded around the age of 50 years. If the age-recording around 50, even though grossly unreliable, is not subject to any special bias such as a consistent over- or understatement of age, then, because of the very large numbers of deaths involved, the errors on either side of 50 years will cancel each other out, and international comparability will not be affected. In some cases, however, bias may be present because there may occur, firstly, a preference for certain digits and, secondly, a consistent over- or understatement. Population census data, for instance, are well known to suffer from both these defects. In the case of deaths, however, we are dealing with a statement of age of the deceased made by another person so that to some extent the possibility of deliberate under- or overstatement of age is obviated. Nevertheless, the effect of a bias tending towards, say, a consistent overstatement of age at death, or a preference for certain digits, has been studied.

If the true age at death is 50 years or over and it is overstated, the death will still fall in the correct category for the purpose of this indicator. Therefore the overstatement of age of deaths occurring at ages 50 years and over (where, indeed, such overstatements are generally made in under-developed countries) would not make any difference whatever to the accuracy of the indicator. Again, if the true age at death was, say, below 40 years, and an overstatement of age was made up to a maximum of nine years, the death would still fall in the appropriate category of under 50 years, without in any way affecting the value of the indicator. Therefore, the effect of overstatement of age has to be considered only in respect of those deaths which occur at a few years below the age of 50 and which are overstated to such an extent as would wrongly classify them in the age-group 50 years and over.

TABLE IV. PERCENTAGE AMONG TOTAL DEATHS OF DEATHS IN AGE-GROUPS 45-49 YEARS AND 50-54 YEARS IN CERTAIN COUNTRIES, 1949-1951

Country	Percentage among total deaths of deaths in the age-group:	
	45-49 years	50-54 years
Ceylon	2.9	2.6
Colombia	2.7	2.4
Egypt	1.5	2.2
Malaya	4.1	5.3
Mexico	3.2	2.8
Peru	3.0	2.8
Philippines	2.7	3.1

Table IV shows the percentage of deaths in the age-groups 45-49 years, and 50-54 years in certain countries.

If we consider that, either owing to preference for certain digits or for deliberate reasons, an overstatement of age occurs to the extent of 5 years, then it would seem that some of the deaths actually occurring in the age-group 45-49 years would be wrongly classified in the next age-group 50-54 years. The figures given in Table IV show that the percentage of reported deaths in the latter age-group to total deaths is only of the order of 1 to 5. Of course, only a fraction of these deaths are likely to have been wrongly classified. We may therefore conclude that in actual practice an overstatement of age is not likely to bring about an error of more than one or two units in the proportional mortality indicator. Similar considerations also apply in the case where a consistent understatement of age occurs. However, the extent to which both understatement and overstatement of age occur together will naturally tend further to reduce this error to almost negligible proportions. It would seem, therefore, that error due to wrong reporting of age may be expected to be of almost negligible magnitude in the case of the proportional mortality indicator—an argument that weighs considerably in favour of its use, especially in areas where age recording is so poor as to invalidate the use of the infant mortality rate.

Effect of under-registration of deaths (especially infant deaths)

Another important defect in mortality statistics arises from the under-registration of deaths, especially in the less-developed areas. This under-registration is not likely to have any effect on the accuracy of the proportional mortality indicator if deaths happen to be under-registered almost uniformly at all ages. This is because, in the process of division, the common factor of under-registration will tend to cancel itself out. The national mortality totals are built up only when statistics have been received from all the individual subdivisions, such as provinces or states, which in their turn are compiled when returns from further subdivisions such as districts or counties, etc., have been received. In the process of compilation, a check is usually maintained on the receipt of returns from all such individual units, except perhaps at the periphery where returns from families or sometimes even small areas such as villages may be missed. Such defects, therefore, would cause the under-registration of deaths equally at all ages without disturbing the value of the indicator.

Under-registration of infant deaths. There exists, however, the possibility that in the country as a whole the under-registration of infant deaths may be of a higher order of magnitude than the under-registration of deaths at other ages. For instance, in some countries, because of differing legal provisions, liveborn infants dying before registration of their birth are not registered as infant deaths but as stillbirths. The effect of this differential under-reporting has been further examined in cases where the registration of total deaths may be in default by as much as 10%, 20% or 30%, and infant deaths even more so. A detailed discussion of this problem is given in Annex 3, in which the effect of 5%-30% under-enumeration of infant deaths is studied in relation to 5%-30% under-registration of remaining deaths, thus covering various possibilities to be met with in practice. The effect of this differential under-reporting depends on three factors: (1) the proportion of infant deaths to total deaths, (2) the rate of under-registration of infant deaths, and (3) the rate of under-registration of deaths at age

1 year and over. In so far as the reporting of infant deaths is generally more deficient than that of deaths at higher ages, the computed proportional mortality indicator overestimates its value. The analysis reveals (see Table XI) that in the rather extreme case where infant deaths may be under-registered to the extent of from 10% to 20% more than deaths at other ages, the proportional mortality indicator is overestimated by an average error of the order of from 2% to 8%. In other words, if the observed value of the indicator is 30%, it could be in error by from 0.6 to 2.4 units; that is, the true value of the indicator would lie between 29.4 and 27.6. In the more usual cases the error in the indicator is not likely to exceed 1 or 2 units and may be even less. It will be seen, therefore, that the effect of the differential under-reporting of deaths is to a considerable extent minimized when calculating the proportional mortality indicator.

Advantages of Proportional Mortality Indicator

In addition to possessing a high discriminatory value (see page 445) and precision in spite of the usual defects in national data (see page 453), another advantage of the proportional mortality indicator is that it is based exclusively on mortality statistics requiring the classification of total deaths into only two broad age-groups, (1) deaths under 50 years, and (2) deaths at age 50 years and over. It does not require a knowledge of the population size and can therefore be calculated even for countries for which census estimates of the population are not available. But even though its calculation does not require a knowledge of the population size or composition, the age composition of the population resulting from past demographic factors, such as trends in birth- and death-rates, has an influence on its value, thus lending it the status of a comprehensive indicator of the first component in the measurement of levels of living—" health, including demographic conditions ".

The indicator further distinguishes between the more serious and preventable deaths among infants, children and mothers on the one hand, and the rather inevitable deaths in old age on the other. Thus, quite apart from the theoretical advantages, the use of the proportional mortality indicator would appear to possess a logical appeal.

An additional advantage of this indicator is that it can easily be calculated separately from year to year or for any other time period (see page 464 and Fig. 4). The data for its calculation are available for a large number of countries.

To our knowledge, the indicator that best satisfies the criteria set out on pages 443 and 444 is the proportional mortality ratio. Indeed, it is of such a simple nature that it could equally well have been suggested for use on purely empirical grounds.

Demographic Factors likely to Influence Proportional Mortality Indicator

Even though, as stated in the preceding section, the proportional mortality indicator possesses theoretical merits and practical advantages, there are a number of demographic aspects which need further scrutiny.

The two factors which determine the level of this indicator are (1) age-specific death-rates, and (2) age distribution of the population. It may be argued that age distribution of a population may not be related to levels of living. This is not necessarily true, because the age distribution of a country unaffected by abnormal migration arises generally from the cumulative effect of past trends in fertility and mortality. As stated already, countries in an advanced stage of development usually have a relatively more aged population, i.e., a larger proportion of persons aged 50 years and over. In an under-developed country, the proportional mortality indicator is reduced in value on account of both high childhood mortality and the younger age distribution of the population.

It is not easy, however, to state what a good demographic condition is. We are aware that demographers generally comment on the unfavourable consequences of an increasingly aging population. But we may observe that they are concerned more with the economic and social implications of aging than with its relation to general mortality rates. The aging of the population in a country in the process of health development is a matter of observation, and we have seen that an indicator based on this phenomenon is a good discriminator between under-developed and highly-developed countries. Nevertheless, two particular situations may be mentioned.

(1) Several European countries have comparable age-specific mortality rates, but the proportional mortality indicator is slightly higher in those with the older population (compare, for instance, Sweden with the Netherlands). It is not our intention to attach much significance to such small differences in this indicator. Furthermore, as is shown below (see page 458), variations in the birth-rate among similarly developed countries do not affect materially the proportional mortality indicator.

(2) Some non-European developed countries are characterized by a rather young population and their proportional mortality indicator is accordingly generally lower than for European countries having more or less similar health conditions. For instance, as is seen from Table VIII, the indicator was lower in 1949-53 for New Zealand, Australia, Canada, the USA and Israel than for Sweden, England and Wales, Norway, Denmark and Switzerland. The former group of countries has recorded continuous immigration of considerable magnitude in the past. In these countries the age distribution of the population has been and is affected by the age structure of the immigrants and may not necessarily be the result merely of the operation of past forces of mortality and natality. The effect of migration in the proportional mortality indicator is discussed below.

Effect of migration

We have so far presumed that the age distribution of the population is not disturbed by factors other than past trends in natality and mortality. Important changes may nevertheless occur through migration. One of the recent examples of a country known to have been markedly affected by migration is Israel. Comparable annual figures in respect of Jewish migration and Jewish population for Israel are shown from 1948 onwards in Table V. The actual values of annual proportional mortality for the total population (including Jewish migrants) are shown in column 6. Against these values are shown in column 7 the computed values of the indicator on the assumption that no migration took place. For this computation we proceeded by using the 1948 age distribution of the population as the base and followed this cohort through successive years allowing for the recorded age-specific mortality rates and birth-rate. The differences between the actual and the theoretical values are shown in column 8, while in column 5 is shown the extent of annual migration. On the basis of this study it is apparent that even when the net annual immigration was of the order of 25% of the resident population, a most unusual if not unexcelled magnitude, the effect on the proportional mortality indicator was not in excess of 2 to 4 units. On the other hand, the increase in the actual value of the indicator from 1949 to 1955 was 12.8 units. The effect of migration, therefore, is not likely to alter in any material sense the broad level of the country as judged by this indicator or to mask the long-term trend in the value of the indicator. The details of computation are shown in Annex 4.

Effect of changes in birth-rate

The basic assumption in the use of this indicator is that countries with higher levels of health are generally the ones with relatively lower birth- and death-rates. Therefore, if one country has age-specific mortality rates lower than another but has a relatively higher birth-rate, the indicator may, because of a relatively younger population, seem to give a lower value. The effect of change in the birth-rate from one year to the next, or of its remaining at a high level, is examined below.

Change in birth-rate from one year to the next. In the first place we examine the extent to which a change in birth-rate occurring from one year to the next influences the value of the proportional mortality indicator. Theoretical analysis made in this connexion reveals that relative changes in the value of the proportional mortality indicator would depend on (1) the magnitude of the change in the birth-rate from one year to the next, r, and (2) the proportion of infant deaths to total deaths, q. The numerical values of the relative change in the indicator are set out in Table VI, corresponding to various combinations of the values of r and q (see Annex 5).

TABLE V. ANNUAL MIGRATION IN ISRAEL AND PROPORTIONAL MORTALITY INDICATOR, 1948-55, JEWISH POPULATION ONLY

Year	Average population	Immi-grants	Emi-grants	Percentage of net immigration among total population	Proportional mortality indicator		
					actually observed	under hypothesis of no migration	difference of columns 7-6
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1948	671 871	118 993	1 040	17.6	60.4	60.0	—0.4
1949	901 050	239 576	7 207	25.8	51.9	54.2	2.3
1950	1 103 005	170 249	9 463	14.6	51.2	54.7	3.5
1951	1 323 984	175 095	10 057	12.5	54.9	57.5	2.6
1952	1 429 772	24 369	13 000	8.0	56.2	58.5	2.3
1953	1 467 689	11 326	12 500	—0.1	61.7	63.5	1.8
1954	1 500 648	18 370	7 000	0.8	63.9	65.0	1.1
1955	1 553 000	...	...	...	64.7	65.6	0.9

... Figures not available

TABLE VI. PERCENTAGE CHANGE IN PROPORTIONAL MORTALITY INDICATOR DUE TO CHANGE IN BIRTH-RATE

Annual change in birth-rate (r) (%)	Proportion of infant deaths to total deaths (q)		
	10 %	20 %	30 %
—25	+2.6	+5.3	+8.1
—20	+2.0	+4.2	+6.4
—15	+1.5	+3.1	+4.7
—10	+1.0	+2.0	+3.1
—5	+0.5	+1.0	+1.5
0	0.0	0.0	0.0
5	—0.5	—1.0	—1.5
10	—1.0	—2.0	—2.9
15	—1.5	—2.9	—4.3
20	—2.0	—3.8	—5.7
25	—2.4	—4.8	—7.0

In a developed country the proportion of infant deaths to total deaths is generally less than 10% and the value of the proportional mortality indicator is of the order of 80%. Hence, even as high a change as ± 25% in the birth-rate would only affect the indicator by

$$80\% \times 2.6\% = 2.08\%,$$

or of the order of 2%. On the other hand, in the case of an under-developed country, the percentage of infant deaths is generally of the order of 30% and the value of the proportional mortality indicator is about 25% or lower. Therefore a change of ± 25% in the birth-rate would affect the value of the indicator by an amount of

$$25\% \times 8.1\% = 2.025\%,$$

i.e., again of the order of 2%. Thus it appears that even a ± 25% fluctuation in birth-rate will not affect the value of the indicator by more than 1 or 2 units.

Continuous change in the birth-rate

In the above discussion, we have examined the effect of an increase or decrease in birth-rate occurring from one year to another. If a difference in birth-rate level persists for a longer period, the value of the proportional mortality indicator may be further affected. In order to examine the magnitude of change in the value of the proportional mortality indicator caused

TABLE VII. EFFECT OF HIGH BIRTH-RATE ON SWEDISH PROPORTIONAL MORTALITY INDICATOR, 1945-53

Year	Birth-rate			Proportional mortality indicator for Sweden		
	Sweden	Nether-lands	percentage of column 3 to column 2	actually observed	under Netherlands birth-rates	difference of column 5– column 6
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1945	20.4	22.6	111	77.3	76.9	0.4
1946	19.7	30.2	153	80.5	78.4	2.1
1947	18.9	27.8	147	82.0	80.1	1.9
1948	18.4	25.3	138	82.7	81.1	1.6
1949	17.4	23.7	136	83.8	82.3	1.5
1950	16.4	22.7	138	85.1	83.7	1.4
1951	15.6	22.3	143	85.4	83.8	1.6
1952	15.5	22.4	145	86.1	84.5	1.6
1953	15.4	21.8	142	86.5	85.0	1.5

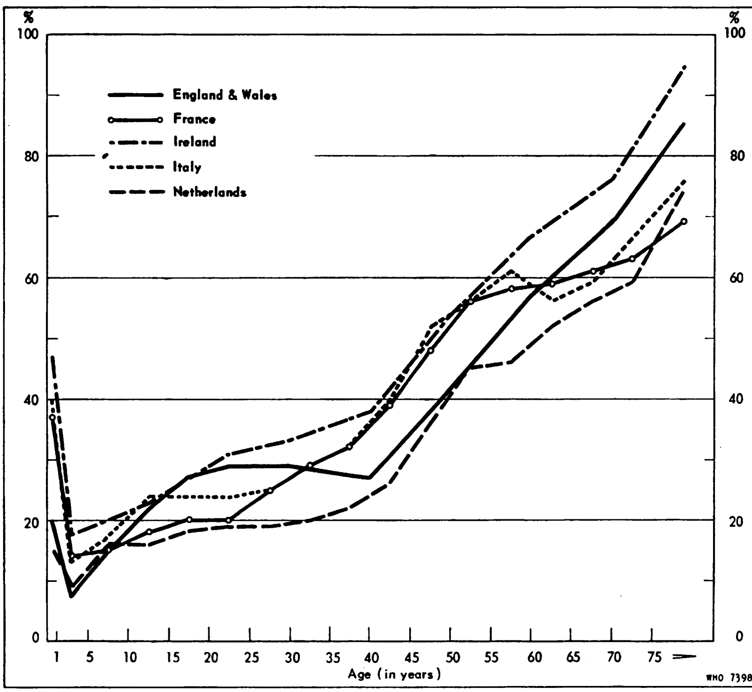
on this account, we consider the case of two countries, Sweden and the Netherlands. The reason for studying these two countries is that both are known to be well developed with regard to health conditions, although in recent years the age-specific mortality rates have generally been lower in Sweden than in the Netherlands. But the Netherlands birth-rate has been consistently considerably higher than the Swedish rate—almost 40% in excess (see column 4 of Table VII). We have studied what the value of the Swedish proportional mortality indicator would have been if Swedish birth-rates had been as high as in the Netherlands. The results of the computation from 1945 onwards are shown in column 6 of Table VII, while column 5 shows the values of the indicator actually observed for Sweden. The difference between these two series of values is shown in column 7. It is seen that the difference in the birth-rate of as high an order as 40% observed in these two countries does not affect the value of the indicator by more than 1 or 2 units.

Effect of uniform decrease in age-specific mortality rates

It can be argued theoretically that if proportionately similar decreases were to occur in deaths under 50 years of age and in deaths at age 50 years and over, then the proportional mortality indicator would not show any change in value. This criticism appears to us invalid because we would then be overlooking the fact that in actual experience such a uniform decrease in deaths does not take place. What usually happens is that an improvement in health conditions is followed by a relatively greater decrease in the death-rates among infants, children and adults than in the death-rates at the older ages. In Fig. 2 decreases in age-specific death-rates are shown during a 50-year period from 1900 (or 1901) to 1950 (or 1951) for a number of countries. It shows the ratios of the age-specific mortality rates around 1950-51 to what they were around 1900-01. Marked decreases occurred in the age-group 1 to about 40 years, while on the other hand, the age-group 50 years and over recorded relatively much lower decreases. A proportionately uniform drop in the age-specific death-rate is not recorded.

An exceptional case in which a uniform decrease may perhaps seem possible occurs when a campaign against mass disease is carried out in an area affecting the entire population. On biological grounds even this may not be expected to bring about a uniform decrease in mortality at all ages because mass diseases affect the susceptible young population, of whom some die following an attack and others develop immunity of a longer or shorter duration. Therefore, persons passing into the more advanced age-groups, being relatively more immune, will accordingly be expected to show less gain from control of mass diseases than those young ones still in the susceptible category. An interesting example of such a mass campaign

FIG. 2. PROPORTION (%) OF CURRENT AGE-SPECIFIC MORTALITY RATES (1950 OR 1951) TO CORRESPONDING RATES IN 1900 OR 1901 IN CERTAIN COUNTRIES

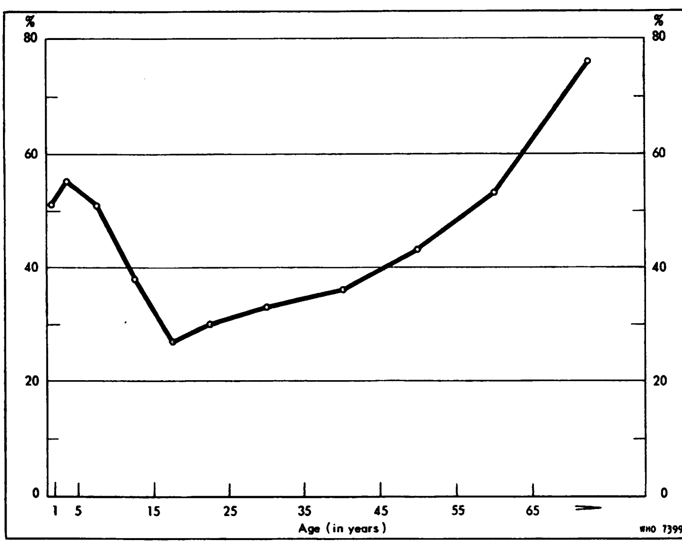


is that of the island-wide malaria control by DDT spraying in Ceylon, which began in the year 1946. It could be argued that once the disease is eradicated, the entire population may to an equal degree escape the risk of dying from malaria. In Fig. 3, the decrease in the specific mortality rates by age from 1946—the first year of DDT spraying—to 1954, has been shown for Ceylon. Here again, the decrease is most marked in the child and younger adult age-groups. Thus, while the age-group 25-34 years shows a decrease of 67%, the corresponding decrease in the age-group 65 years and over was only 24%, once again illustrating that specific public health measures such as mass control of malaria bring about relatively more marked reductions of mortality in children and younger adults.

Even granting, for the sake of argument, that mortality reduction did occur uniformly in some very special case, it has to be noted that such a reduction would lead to a relatively larger cohort crossing over from the age-group under 50 years to the age-group 50 years and over. A proportionately increased number in the age-group 50 years and over would therefore begin in succeeding years to give a higher figure for the proportional mortality indicator.

In previous paragraphs we have examined the proportional mortality indicator in the light of anticipated criticism. It is argued that this indicator does not materially suffer from imperfections of the basic statistical data usually met with in under-developed areas. It is also found that the effects of such factors as migration, change in birth-rate, or a uniform drop in age-specific mortality rates on this indicator are not likely to be of an important magnitude. It is therefore contended that this indicator possesses advantages over other indices when used for broad international comparison of the levels of " health, including demographic conditions ".

FIG. 3. 1954 AGE-SPECIFIC MORTALITY RATES FOR CEYLON AS PERCENTAGES OF CORRESPONDING 1946 RATES



It is, of course, admitted that perhaps no single indicator can possess all the required qualities. The proportional mortality indicator has to be used with caution, especially when studying levels of small population groups. For instance, this indicator may not be fully valid for comparing small population groups within the same country, because if there is a greater predominance of old people in an area (as would happen if people, after retirement, moved to selected zones), the value of this indicator for purposes of within-country comparability would be minimized. On this consideration, therefore, it would seem that the whole population of a country should be considered. If it is desired to compare subdivisions of any single country, a scrutiny of the factors that lead to peculiar age distribution should first be made.

Applicability and Validity of Proportional Mortality Indicator

Some of the applications or uses of the proportional mortality indicator are shown below.

Ranking of countries according to proportional mortality indicator

A broad classification of 55 countries for which relevant data are available has been obtained on the basis of the average value of this indicator for the five-year period, 1949-53, and is shown in Table VIII. The actual figures of this indicator for each of the countries are shown in parentheses. Not much significance can be attached to minor differences of only a few units observed among different countries. For this reason the countries in Table VIII are shown in four broad groups.

Trends of proportional mortality indicator

The variation in the proportional mortality indicator from year to year and the secular trends in certain countries from 1920 onwards are shown

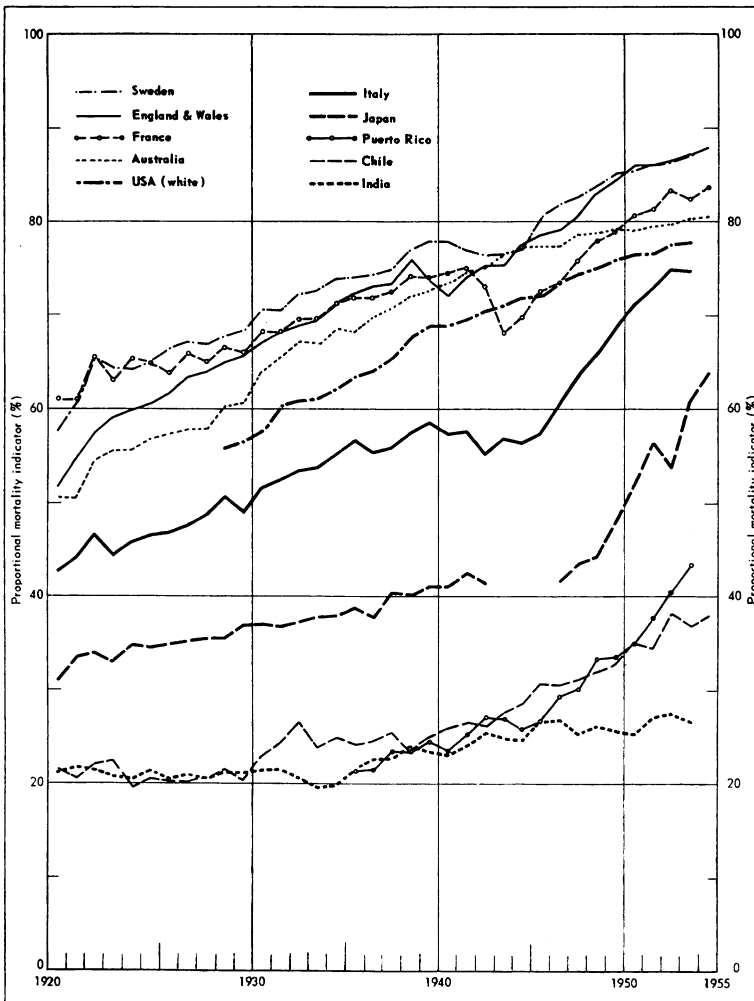
TABLE VIII. GROUPING OF COUNTRIES BY PROPORTIONAL MORTALITY INDICATOR, 1949-53

Proportional mortality indicator	Countries and value of proportional mortality indicator (in parentheses)
75 and over	Sweden (85.4), England and Wales (85.3), Norway (81.8), Denmark (81.6), Scotland (81.6), Switzerland (81.4), New Zealand (81.3), Belgium (81.3), Northern Ireland (80.0), France (79.8), Australia (79.3), Austria (79.3), Netherlands (79.0), USA (white) (78.9), Ireland (78.9), Germany (Fed. Rep.) (77.9)
50-74	Iceland (73.5), Hungary [a] (72.0), Canada (71.9), Finland (71.0), Italy (70.7), Union of South Africa (white) (68.9), Greece [a] (67.5), Uruguay (64.0), Spain (63.9), USA (non-white) (57.3), Israel (55.6), Argentina (53.8), Portugal (53.6), Japan (52.0)
25-49	Yugoslavia [b] (45.7), Brazil [c] (37.6), Paraguay [d] (37.5), Puerto Rico (35.8), Chile (34.5), Panama [e] (32.1), China (Taiwan) [f] (31.4), Ceylon (30.6), Costa Rica (27.2), Venezuela (27.2), Thailand (27.0), Malaya (Federation of) (26.9), India (26.3), Mexico (25.6)
Under 25	Peru (24.5), Colombia (24.3), Philippines (23.5), Jordan [g] (22.5), Pakistan [h] (22.5), Dominican Republic (21.9), El Salvador [e] (21.6), Nicaragua [i] (21.6), Honduras [j] (20.9), Egypt (20.9), Guatemala [d] (18.6)

[a] 1952 and 1953
[b] 1950-1953
[c] 1949-1952
[d] 1949, 1952 and 1953
[e] 1949, 1950 1952 and 1953
[f] 1951-1953
[g] 1953
[h] 1949-1951
[i] 1949 and 1950
[j] 1949, 1951-1953

in Fig. 4. The gradual increase in the value of the indicator is discernible in several countries.

FIG. 4. ANNUAL PROPORTIONAL MORTALITY INDICATOR FOR CERTAIN COUNTRIES, 1920-1955



Frequency distribution of proportional mortality indicator for subdivisions of a country

The United Nations Committee of Experts considered it highly desirable to study not only a single national figure for each country but also the frequency distribution obtained by studying the same index for subdivisions of each country. The underlying idea was to study the percentage of population falling below or above a given point on the scale of the indicator.

The proportional mortality indicator can, of course, be easily calculated for any population group within a country. But as stated already, it is affected by changes both in specific death-rates and in the age composition of the population. The within-country variations due to migration, as, for instance, between urban and rural areas, may perhaps produce differences of sizeable magnitude. When studying the proportional mortality indicator for subdivisions of any single country, the effect of such a variation has to be kept in mind.

With this reservation, a few frequency distributions of the proportional mortality indicator are shown in Fig. 5, 6, 7, 8 and 9. In the first two figures, the frequency distributions for country subdivisions are presented for the years 1925 and 1950 for the USA and Japan. In this period of 25 years

FIG. 5. DISTRIBUTION OF PROPORTIONAL MORTALITY INDICATOR FOR 40 STATES AND DISTRICT OF COLUMBIA, USA, 1925 AND 1950

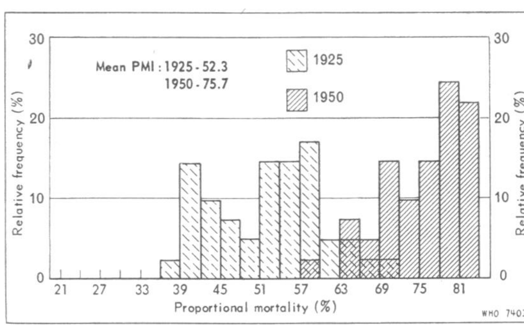


FIG. 6. DISTRIBUTION OF PROPORTIONAL MORTALITY INDICATOR FOR 46 JAPANESE PREFECTURES, 1925 AND 1950

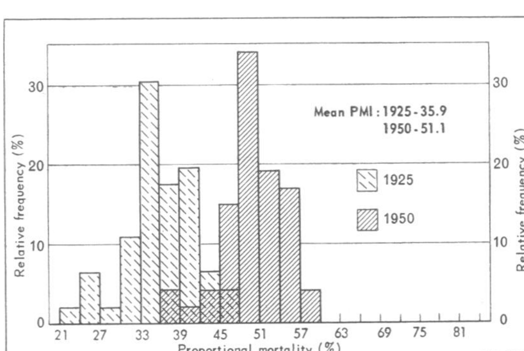
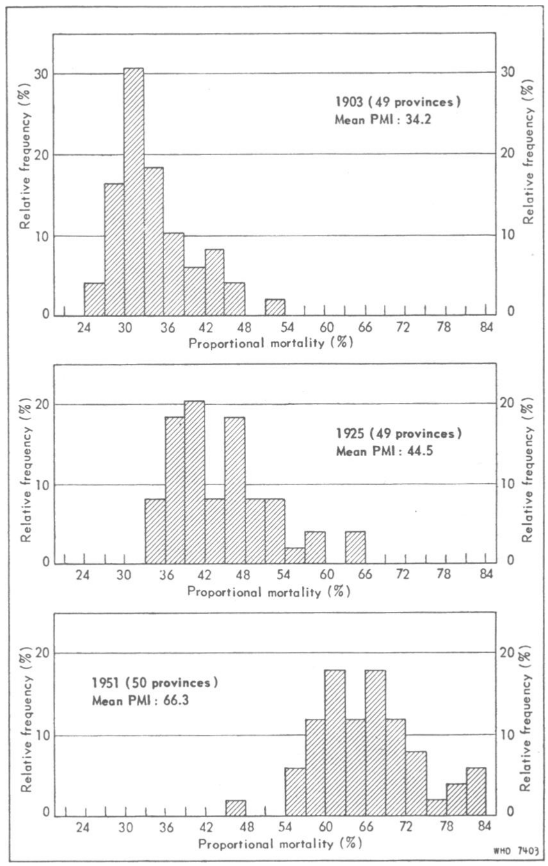


FIG. 7. DISTRIBUTION OF PROPORTIONAL MORTALITY INDICATOR FOR SPANISH PROVINCES, 1903, 1925 AND 1951



a shift of the entire distribution towards higher values of this indicator is clearly brought out. In Fig. 7 the frequency distributions for Spain are shown for three years (1903, 1925 and 1951), illustrating once again a shift of the distribution towards higher values of the indicator. In Fig. 8, comparison is made for England and Wales, not only between two years (1911 and 1950), but also between rural and urban areas. The striking features of this diagram are not only that the frequency distributions shifted materially towards higher values between 1911 and 1950, but also that there was a distinct change in the spread of the frequency distributions. Thus, the distributions for the year 1950 are much narrower than those for 1911, showing a tendency towards greater uniformity within the country with regard to this indicator. Fig. 8 can also be compared with Fig. 9, for the largest State in India, Uttar Pradesh, for which also both rural and urban distributions are shown for 1934 and 1950. Although the periods covered are not comparable, the frequency distributions for Uttar Pradesh do serve to indicate the relatively slower progress recorded.

Validity of proportional mortality indicator

In order to examine the validity of this indicator for purposes of ranking various countries in relation to the ranking obtained by using other health

FIG. 8. DISTRIBUTION OF PROPORTIONAL MORTALITY INDICATOR FOR URBAN AND RURAL AREAS OF COUNTIES IN ENGLAND AND WALES, 1911 AND 1950

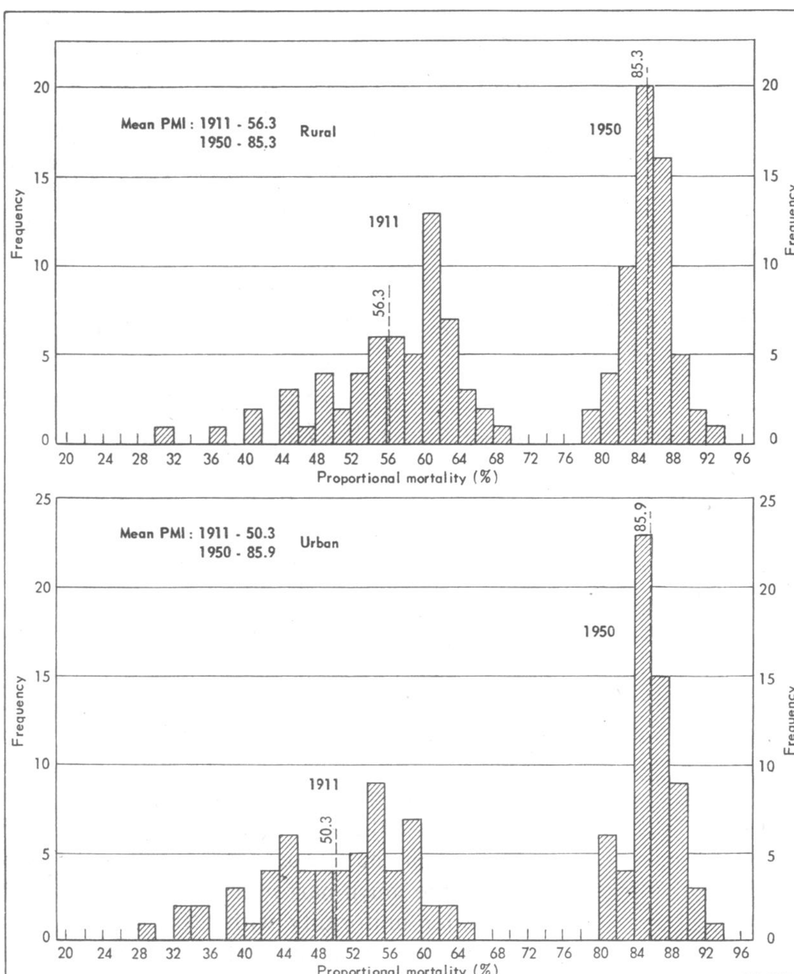
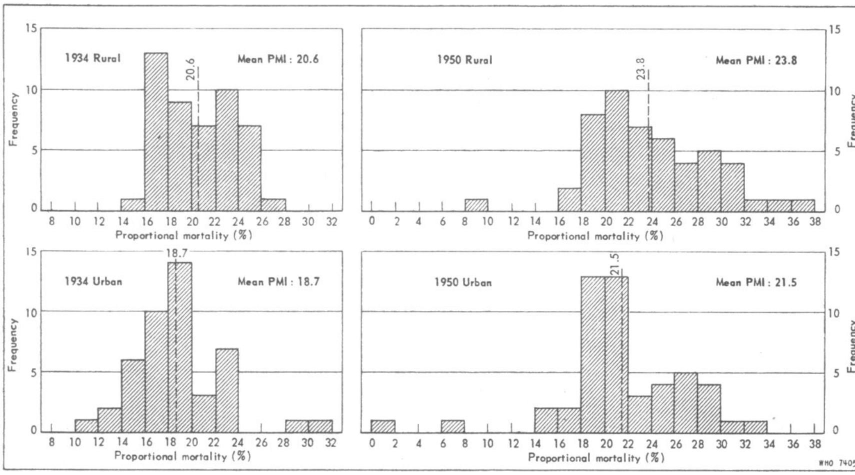


FIG. 9. DISTRIBUTION OF PROPORTIONAL MORTALITY INDICATOR FOR URBAN AND RURAL DISTRICTS OF UTTAR PRADESH, INDIA, 1934 AND 1950



indices, a comparison has been carried out in Table IX. It is only for 27 countries that we are able to obtain complete data in respect of the following five indices, the use of which has been suggested by the WHO Expert Committee on Health Statistics:

1. Crude death-rate.
2. Infant mortality rate.
3. Expectation of life at age 1.
4. Proportion of mortality from infectious and parasitic diseases in relation to deaths from all causes (comparable information was available and has been included for typhoid and paratyphoid fevers, typhus fever, malaria, smallpox, measles, scarlet fever, whooping cough and tuberculosis of all forms).
5. Proportion of mortality under 5 years to total deaths.

This table shows the rank each country occupies when each of the five indices is used separately for ranking, as well as the rank obtained by adding all the five ranks (column 6). The latter may be considered as the " over-all " ranking by the use of all five indices. The ranking of the same countries according to the proportional mortality indicator is also shown.

It is seen from the table that the ranking obtained by the use of the proportional mortality indicator is closely related to that of the first set of indices, with the exception of the ranking by the crude death-rate. The rank correlation coefficient worked out between the over-all ranking (column 6) and the proportional mortality indicator is 0.86, showing a high degree of correlation.

TABLE IX. RANKING OF 27 COUNTRIES ACCORDING TO VARIOUS HEALTH INDICES *

Country	Crude death-rate (1949-51)	Infant mortality rate (1949-51)	Expectation of life at age 1, male (around 1950 **)	Proportion of mortality from infectious and parasitic diseases (1951)	Proportional mortality under 5 years (1949-51)	Ranking by total ranks (columns 1-5)	Proportional mortality indicator (1949-51)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Israel	1	13	6	15	21	12	20
Netherlands	2	4	1	7	13	5	12
Norway	3	5.5	2	8	5	2.5	3
Denmark	4	8	3	1	8	4	6
Canada	5	11	7	9	17	9	16
New Zealand	6	2	5	4	6.5	2.5	4
USA (white)	7	5.5	10	2	9	7	9
Australia	8	3	11	3	6.5	6	10
Sweden	9	1	4	5	1	1	1
Switzerland	10	9	16	11.5	4	10	7
Germany	11	18	8.5	14	15	13	15
Finland	12	12	20	22	16	15.5	17
Japan	13	19	22	26	20	20	22
USA (non-white)	14	14	18	18	18	17	19
Spain	15	21	24	23.5	19	21	18
England and Wales	16	7	8.5	6	2	8	2
Scotland	17	10	12	11.5	3	11	5
Austria	18	20	13	17	13	15.5	14
Ceylon	19.5	22	19	20	24	22	24
Belgium	19.5	16	15	10	10	14	8
Portugal	21	24	21	21	22	23	21
Ireland	22.5	15	17	19	11	19	13
France	22.5	17	14	16	13	18	11
El Salvador	24	23	23	23.5	25	24	26
Chile	25	26	25	25	23	26	23
Mexico	26	25	26	27	26	27	25
Egypt	27	27	27	13	27	25	27

* The decimal part (.5) after certain ranks is due to averaging the ranks in case of a tie.
** Data for nearest available period to 1950.

Conclusions

In pursuance of the recommendation made by the United Nations Committee of Experts on International Definition and Measurement of Standards and Levels of Living to the effect that methods be studied to develop indicators of " health, including demographic conditions ", we have studied the relative merits of the various indicators proposed for this purpose. By applying an objective statistical technique to the data available, and on the basis of certain stipulated criteria for the selection of a suitable indicator, we come to the conclusion that the most suitable indicator for the specific purpose is the proportion of deaths at 50 years and over to total deaths. This paper summarizes the main findings as well as illustrates the applicability of the proportional mortality indicator to the study of levels and trends of different countries of the world. It is our hope that if a similar search is made for indicators in respect of other components of levels of living and if additional suitable indices are developed, it may be possible to combine such indices by appropriate statistical methodology into a single workable index of level of living. The proportional mortality indicator to quantify the component " health, including demographic conditions " is recommended for use in this context.

It is by no means implied that this indicator should in any way replace such indices as the infant mortality rate, expectation of life, etc., which are already in use. For purposes of inter-country comparisons each index suffers from certain limitations inherent in the quality and availability of data and in the method of computation involved.

We have emphasized that if a single indicator of " health, including demographic conditions," is needed, the selection of such an indicator should be made on an objective basis. We have presented one approach for this purpose, and this has incidentally revealed the value of the above-mentioned proportional mortality indicator. In spite of some weaknesses the proportional mortality indicator possesses the following advantages over other indices:

(*a*) simplicity of calculation,

(*b*) regular availability of data from a large number of countries,

(*c*) comprehensiveness of character reflecting the effects of a wide variety of factors influencing health and demographic conditions,

(*d*) possibility of international comparability in spite of the varying quality of the basic national statistical information,

(*e*) high degree of discriminatory power, and

(*f*) validity for ranking the countries and for studying levels and trends.

Annex 1

TABLE X. HEALTH INDICES FOR CERTAIN COUNTRIES, 1949-1951

Group A

Index *	Australia	Canada	Denmark	England & Wales	France	New Zealand	Norway	Sweden	Switzer-land	USA
1. Crude death-rate per 1000 population	9.6	9.1	9.0	12.0	13.3	9.3	8.8	10.0	10.4	9.7
2. Infant mortality rate per 1000 live-births	25.0	40.9	31.4	30.8	54.5	23.1	27.2	22.0	31.9	29.6
3. Later infant mortality rate per 1000 live-births	7.4	17.3	12.9	12.0	28.9	6.5	12.5	6.2	9.9	9.0
4. Expectation of life at birth (male)	66.07	66.33	67.8	66.5	61.9	68.29	69.25	69.04	62.68	65.47
For the period	(1946-48)	(1950-52)	(1946-50)	(1950)	(1946-49)	(1950-52)	(1946-50)	(1946-50)	(1939-44)	(1949-51)
5. Expectation of life at age 1 year (male)	67.25	68.33	70.0	67.8	65.4	69.03	70.70	69.92	64.75	66.73
For the period	(1946-48)	(1950-52)	(1946-50)	(1950)	(1946-49)	(1950-52)	(1946-50)	(1946-50)	(1939-44)	(1949-51)
6. Average of expectation of life at five-year intervals (0 to 75 years)										
Male	34.87	35.92	37.01	34.91	33.96	36.13	38.17	37.04	33.63	34.63
Female	38.20	38.89	38.18	38.53	37.81	39.04	39.99	38.48	36.35	38.51
For the period	(1946-48)	(1950-52)	(1946-50)	(1950)	(1946-49)	(1950-52)	(1946-50)	(1946-50)	(1939-44)	(1949-51)
7. Percentage of persons 65 years and over to total population at the latest census	8.0	7.8	9.1	10.9	10.9	9.6	9.6	10.2	9.6	8.1
For the census year	(1947)	(1951)	(1950)	(1951)	(1946)	(1951)	(1950)	(1950)	(1950)	(1950)
8. PM < 1	6.0	12.2	6.4	4.1	8.3	6.1	5.9	3.6	5.5	7.4
9. PM < 5	7.5	14.3	7.7	5.0	9.8	7.5	7.2	4.5	6.9	8.6
10. PM < 10	8.1	15.2	8.1	5.3	10.1	8.0	8.0	5.0	7.4	9.2
11. PM < 15	8.6	15.8	8.5	5.6	10.4	8.4	8.3	5.4	7.8	9.7
12. PM < 20	9.3	16.8	9.0	6.1	11.0	9.1	8.9	5.8	8.4	10.5
13. PM < 25	10.5	18.1	9.8	6.8	11.9	10.0	9.9	6.6	9.4	11.9
14. PM < 30	11.7	19.4	10.8	7.8	13.1	11.0	11.2	7.6	10.6	13.0
15. PM < 35	13.1	20.9	12.0	8.7	14.0	12.2	12.5	8.7	11.8	14.5
16. PM < 40	14.9	22.7	13.6	10.2	15.5	13.9	14.1	10.2	13.4	16.8
17. PM < 45	17.4	25.2	15.9	12.2	17.9	15.9	16.1	12.2	15.8	19.9
18. PM < 50	20.9	28.5	19.2	15.4	21.4	19.0	18.9	15.2	19.4	24.1
19. PM < 55	25.9	32.9	23.6	19.9	26.0	23.3	23.0	19.4	24.3	30.1
20. PM < 60	33.1	38.9	29.4	26.1	31.5	29.3	28.0	25.0	30.7	37.9
21. PM < 65	42.9	47.3	37.6	35.0	38.8	38.4	34.5	32.9	39.3	47.6
22. PM < 70	54.4	57.8	48.5	47.0	48.8	51.1	43.0	43.5	51.0	59.0
23. Mean age at death	63.45	57.66	65.20	67.47	64.57	64.27	66.96	68.06	65.35	61.12
24. Ages-pecific death-rate for 1-4 years per 1000 population	0.14	0.19	0.11	0.10	0.19	0.12	0.12	0.09	0.15	0.12

* $PM<x$ = proportion of deaths under x years of age to total deaths (%).

TABLE X. HEALTH INDICES FOR CERTAIN COUNTRIES 1949-1951 (continued)

Group B

Index *	Ceylon	Colombia	Dominican Republic	Egypt	India	Malaya	Mexico	Peru	Philippines	Thailand
1. Crude death-rate per 1000 population	12.7	14.2	10.1	22.5	15.4	15.1	17.0	12.0	11.7	10.3
2. Infant mortality rate per 1000 live-births	83.4	126.0	73.2	170.5	124.8	93.2	100.4	104.5	105.2	64.5
3. Later infant mortality rate per 1000 live-births	35.2	78.8	45.5	136.2	65.2	60.1	66.9	66.4	—	—
4. Expectation of life at birth (male)	56.36	—	—	35.65	32.45	—	37.92	—	—	48.7
For the period	(1950)			(1936-38)	(1941-50)		(1940)			(1947-48)
5. Expectation of life at age 1 year (male)	61.16	—	—	42.09	39.00	—	44.43	—	—	52.0
For the period	(1950)			(1936-38)	(1941-50)		(1940)			(1947-48)
6. Average of expectation of life at five-year intervals (0 to 75 years)										
Male	34.02	—	—	27.27	22.30	—	26.60	—	—	27.71
Female	33.23	—	—	32.00	22.76	—	28.03	—	—	30.10
For the period	(1950)			(1936-38)	(1941-50)		(1940)			(1947-48)
7. Percentage of persons 65 years and over to total population at the latest census	3.4	2.9	2.9	3.1	3.6	2.7	3.4	4.3	3.2	2.6
For the census year	(1946)	(1938)	(1950)	(1947)	(1951)	(1947)	(1950)	(1940)	(1948)	(1947)
8. PM < 1	25.9	32.1	32.6	36.4	20.6	26.6	26.5	26.1	26.5	18.0
9. PM < 5	46.5	51.2	51.0	64.9	28.3	41.5	49.6	47.4	47.6	32.9
10. PM < 10	50.9	55.3	55.0	66.9	43.9	46.0	53.7	51.6	51.7	38.9
11. PM < 15	52.3	57.1	57.4	68.3	47.9	48.2	55.5	53.8	54.0	42.4
12. PM < 20	54.0	59.4	60.1	69.6	52.3	50.6	57.8	57.0	56.6	45.8
13. PM < 25	56.8	62.6	63.8	71.0	—	53.9	60.6	61.0	60.1	50.2
14. PM < 30	59.6	65.5	67.1	72.6	59.6	57.3	63.5	64.4	63.4	54.5
15. PM < 35	62.1	68.2	70.2	74.1	—	60.9	65.9	67.3	66.7	58.9
16. PM < 40	65.0	71.0	73.1	75.8	67.0	64.7	69.1	70.4	70.8	63.7
17. PM < 45	67.3	73.5	76.2	77.4	—	69.1	71.9	73.2	73.8	68.4
18. PM < 50	70.1	76.2	78.7	78.8	74.3	73.3	75.1	76.2	76.5	73.1
19. PM < 55	72.8	79.0	81.5	81.1	—	78.5	78.0	79.0	79.5	77.6
20. PM < 60	75.4	81.5	83.5	82.4	82.1	—	80.5	81.3	82.2	81.7
21. PM < 65	78.7	—	86.4	84.8	—	—	84.2	84.9	85.5	85.8
22. PM < 70	82.4	88.2	88.3	87.0	—	—	87.5	87.5	88.0	89.3
23. Mean age at death	28.57	25.18	24.25	19.78	—	—	26.05	26.31	26.15	29.96
24. Age-specific death-rate for 1-4 years per 1000 population	2.52	2.69	1.84	2.63	2.42	2.25	3.92	2.37	1.73	1.53

— Not available * PM<x=proportion of deaths under x years of age to total deaths (%).

Annex 2

THEORETICAL EXPLANATION OF D² VALUES

Let us denote the two types of population—the developed and the under-developed—by the symbols A and B respectively. Let the various health indices be denoted by x_1, x_2 . . . For instance, x_1 may stand for the crude death-rate, x_2 for infant mortality rate, x_3 for neo-natal mortality rate and so on. If the number of countries in each group is 10, there will thus be 20 values of each of these several indices. Our purpose is to find a linear compound y of the type shown below, involving one or more of these indices, which will statistically minimize the misclassification of A and B when their function y is used for the purpose of discrimination.

$$y = w_1x_1 + w_2x_2 + w_3x_3 + \text{etc.},$$

where w_1, w_2, w_3 . . . are the weighting coefficients.

We may further denote the average value of discriminant function y for the developed countries by $\bar{y}_A$ and for the under-developed countries by $\bar{y}_B$. The difference between $\bar{y}_A$ and $\bar{y}_B$ is denoted by d. For the purpose of minimizing misclassification we choose the discriminant function y so as to make d^2 as large as possible with respect to the variance of $\bar{y}_A$ and $\bar{y}_B$. This is done by choosing appropriate values of w's, so as to maximize d^2/s. The quantity s is the pooled within-variance of the two groups given by the following equation :

$$s = \frac{\Sigma_A(y_A - \bar{y}_A)^2 + \Sigma_B(y_B - \bar{y}_B)^2}{n_A + n_B - 2}$$

The symbols Σ_A and Σ_B denote summations over all the values in groups A and B respectively where n_A and n_B are the numbers of countries included in each of the two groups.

Maximization of d^2/s is obtained by differentiating partially with respect to various w's, each time equating the partial differential coefficient to 0 and solving the simultaneous equations thus obtained. For the purpose of comparing the discriminatory values of various indices we have shown the maximized value of d^2/s or Mahalanobis's D^2 in Table 1 (see page 446).

Annex 3

EFFECT OF UNDER-REPORTING OF INFANT DEATHS AND DEATHS IN GENERAL ON PROPORTIONAL MORTALITY INDICATOR

Let d_i = actual number of infant deaths;
d'_i = reported number of infant deaths;
d = number of deaths at age 50 years and over;
d' = reported number of deaths at age 50 years and over;
D = total number of deaths;
D' = reported total number of deaths.

If we assume that p_i is the proportion of under-reporting of infant deaths and p is the proportion of under-reporting of deaths in the other age-groups, then:

$$d'_i = d_i (1 - p_i)$$
$$d' = d (1 - p)$$
$$D' = d_i (1 - p_i) + (D - d_i)(1 - p) = D(1 - p) - d_i(p_i - p).$$

The value of the proportional mortality indicator, computed on the basis of reported deaths, will involve the following error δ relative to the value of the indicator thus computed:

$$\delta = \frac{\frac{d'}{D'} - \frac{d}{D}}{\frac{d'}{D'}}$$

By substituting the values of d and D in terms of d' and D' respectively, we easily obtain

$$\delta = \frac{\frac{d'_i}{D'}\frac{p_i - p}{1 - p_i}}{1 + \frac{d'_i}{D'}\,\frac{p_i - p}{1 - p}}$$

This equation indicates that the error caused by under-reporting of infant deaths depends on three factors: (1) proportion of infant deaths to total deaths, (2) the rate of under-reporting of infant deaths, and (3) the rate of under-reporting of deaths at age 1 year and over. The numerical value of the error which will be involved in the proportional mortality indicator for countries in which infant deaths constitute 10%, 20% and 30% of total deaths is worked out by means of the above formula. In Table XI are shown the percentages of error of estimates in the indicator corresponding to various numerical values of p_i and $p_i - p$.

Thus, if the difference between p_i and p is between 5% and 20%, the percentage error in the indicator is expected to range from 0.5% to 7.9% of the value of the indicator.

TABLE XI. PERCENTAGE ERROR IN THE PROPORTIONAL MORTALITY INDICATOR DUE TO UNDER-REGISTRATION OF INFANT DEATHS

$p_i - p$ \ p_i	5 %	10 %	20 %	30 %
Case 1: Registered infant deaths are 10 % of total deaths				
0	0	0	0	0
5 %	0.5	0.6	0.6	0.7
10 %		1.1	1.2	1.4
20 %			2.4	2.8
Case 2: Registered infant deaths are 20 % of total deaths				
0	0	0	0	0
5 %	1.0	1.1	1.2	1.4
10 %		2.2	2.4	2.8
20 %			4.8	5.4
Case 3: Registered infant deaths are 30 % of total deaths				
0	0	0	0	0
5 %	1.6	1.6	1.8	2.1
10 %		3.2	3.6	4.1
20 %			7.0	7.9

p_i = percentage of under-reporting of infant deaths
p = percentage of under-reporting of deaths at age 1 year and over

Annex 4

EFFECT OF MIGRATION IN ISRAEL ON THE VALUE OF THE PROPORTIONAL MORTALITY INDICATOR

Computation was made of the expected values of the proportional mortality indicator for Israel (Jewish population only) on the assumption that no migration had taken place since 1948 (Table XII). The recorded age-specific death-rate, m_x, was converted into the life-table death-rate, q_x, by means of the formula:

$$q_x = \frac{2m_x}{2 + m_x}$$

by which the population by age was multiplied to obtain the deaths by age. Throughout the study period the birth-rate was assumed to be 30 per 1000 population, a figure closs to the average recorded during this period. The recorded infant mortality rate wae applied to the births thus computed to get infant deaths in each year. The population at the beginning of each year was obtained by deducting the deaths from the population at the beginning of the preceding year and adjusting for the carry-over of population from one age-group to the next.

TABLE XII. VALUES OF q_x AND AGE COMPOSITION OF THE POPULATION OF ISRAEL EXPECTED UNDER HYPOTHESIS OF NO MIGRATION

Age-group (years)	Values of q_x								Population at the beginning of each year							
	1948	1949	1950	1951	1952	1953	1954	1955	1948	1949	1950	1951	1952	1953	1954	1955
0	.0382	.0579	.0518	.0423	.0399	.0367	.0342	.0336	28 000	30 000	30 710	31 403	32 127	32 875	33 633	34 419
1-4	.0023	.0048	.0040	.0032	.0033	.0024	.0025	.0018	80 000	86 792	93 045	98 624	103 806	108 443	112 094	116 876
5-9	.0009	.0011	.0009	.0008	.0011	.0006	.0006	.0004	94 000	95 086	97 579	101 161	105 441	110 126	115 094	120 151
10-14	.0005	.0009	.0006	.0007	.0007	.0005	.0004	.0004	72 000	76 354	80 025	83 480	86 953	90 579	94 439	98 526
15-19	.0011	.0010	.0013	.0012	.0013	.0011	.0013	.0009	79 000	77 523	77 213	77 685	78 758	80 303	82 279	84 618
20-24	.0012	.0014	.0015	.0018	.0018	.0015	.0014	.0011	86 000	84 500	82 994	81 718	80 775	80 235	80 135	80 453
25-29	.0013	.0013	.0014	.0015	.0014	.0014	.0012	.0010	76 000	77 900	79 115	79 777	80 040	80 068	79 988	79 918
30-34	.0016	.0016	.0016	.0016	.0017	.0012	.0013	.0012	100 000	95 052	91 480	88 868	86 912	85 397	84 227	83 272
35-39	.0019	.0018	.0019	.0021	.0023	.0016	.0019	.0015	106 000	104 607	102 515	100 123	97 675	95 313	93 187	91 231
40-44	.0025	.0029	.0024	.0025	.0028	.0026	.0027	.0024	90 000	92 980	95 052	96 323	96 848	96 752	96 232	95 380
45-49	.0051	.0042	.0044	.0043	.0046	.0039	.0041	.0038	54 000	60 935	67 085	72 397	76 885	80 540	83 481	85 705
50-54	.0069	.0083	.0073	.0072	.0071	.0077	.0076	.0062	36 000	39 346	43 351	47 786	52 371	56 906	61 219	65 231
55-59	.0102	.0120	.0115	.0108	.0105	.0117	.0110	.0106	27 000	28 530	30 354	32 611	35 295	38 339	41 606	45 069
60-64	.0185	.0198	.0204	.0195	.0206	.0189	.0207	.0178	24 000	24 413	25 002	25 819	26 935	28 329	30 065	32 054
65-69	.0302	.0319	.0321	.0307	.0320	.0298	.0326	.0305	22 000	22 082	22 207	22 401	22 741	23 199	23 876	24 672
70-74	.0507	.0561	.0511	.0503	.0545	.0521	.0531	.0484	15 000	16 021	16 765	17 465	18 088	18 572	19 101	19 623
75+	.1273	.1191	.1008	.1027	.1015	.1090	.1106	.0951	11 000	11 560	12 277	13 251	14 193	15 133	15 925	16 672

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Annex 5

EFFECT OF CHANGE IN BIRTH-RATE ON PROPORTIONAL MORTALITY INDICATOR

Change in Birth-rate from One Year to the Next

Let

r = proportional increase in birth-rate from one year to the next;
d_i = annual infant deaths;
d = annual deaths at age 50 years and over;
D = total annual deaths before the change in birth-rate took place;
D' = total annual deaths after the change in birth-rate took place.

The relative change in the proportional mortality rate will be

$$\delta = \frac{\dfrac{d}{D'} - \dfrac{d}{D}}{\dfrac{d}{D}} = \frac{D - D'}{D'}$$

Substituting for D'

$$D' = D - d_i + d_i(1 + r) = D + d_i r,$$

we obtain:

$$\delta = \frac{- r\dfrac{d_i}{D}}{1 + r\dfrac{d_i}{D}} = - \frac{rq}{1 + rq}$$

where: $q = \dfrac{d_i}{D}$, i.e., the proportion of infant deaths among the total deaths before the change in birth-rate took place. Thus the relative change in the value of proportional mortality indicator depends on:

(1) the magnitude of change in the birth-rate from one year to the next;
(2) the proportion of infant deaths among the total deaths.

In Table VI (page 459) are tabulated the values of δ corresponding to the rate of change in birth-rate of 5%, 10%, 15%, 20% and 25% for the three levels of the proportion of infant deaths among the total deaths, i.e., 10%, 20% and 30%.

Continuous Change in Birth-rate

Computation was made to determine what the values of the proportional mortality indicator would have been if the Swedish birth-rate had been the same as that in the Netherlands during the period 1945-53. The annual number of births in Sweden was multiplied by the ratio of birth-rates for the Netherlands and Sweden to obtain the hypothetical number of births in Sweden. For children born since 1945, the Swedish expected deaths by age in each year were obtained by multiplying the recorded deaths of that age by the ratio of Netherlands' and Sweden's birth-rates for the year in which this cohort was born. The computation of the proportional mortality indicator is shown in Table XIII.

TABLE XIII. HYPOTHETICAL VALUES OF PROPORTIONAL MORTALITY• INDICATOR FOR SWEDEN BASED ON NETHERLANDS BIRTH-RATE FOR THE PERIOD 1945-53

Year	Item	Recorded figures	Expected figures
1945	Birth-rate	20.4	22.6
	Births	135 373	150 000
	Deaths at age 0-11 months	4 054	4 491
	Deaths at age 50 and over	55 592	55 592
	Total deaths	71 901	72 338
	Proportional mortality	77.3	76.9
1946	Birth-rate	19.7	30.2
	Births	132 597	203 300
	Deaths at age 0-11 months	3 516	5 390
	Deaths at age 1 year	299	331
	Deaths at age 50 and over	56 856	56 856
	Total deaths	70 635	72 541
	Proportional mortality	80.5	78.4
1947	Birth-rate	18.9	27.8
	Births	128 779	189 400
	Deaths at age 0-11 months	3 268	4 807
	Deaths at age 1 year	292	448
	Deaths at age 2 years	203	225
	Deaths at age 50 and over	60 326	60 326
	Total deaths	73 579	75 296
	Proportional mortality	82.0	80.1
1948	Birth-rate	18.4	25.3
	Births	126 683	174 200
	Deaths at age0-11 months	2 936	4 037
	Deaths at age 1 year	240	353
	Deaths at age 2 years	186	285
	Deaths at age 3 years	149	165
	Deaths at age 50 and over	55 972	55 972
	Total deaths	67 693	69 022
	Proportional mortality	82.7	81.1
1949	Birth-rate	17.4	23.7
	Births	121 272	165 200
	Deaths at age 0-11 months	2 823	3 845
	Deaths at age 1 year	251	345
	Deaths at age 2 years	137	202
	Deaths at age 3 years	139	213
	Deaths at age 4 years	131	145
	Deaths at age 50 and over	58 287	58 287
	Total deaths	69 537	70 806
	Proportional mortality	83.8	82.3

TABLE XIII. HYPOTHETICAL VALUES OF PROPORTIONAL MORTALITY INDICATOR FOR SWEDEN BASED ON NETHERLANDS BIRTH-RATE FOR THE PERIOD 1945-53 (continued)

Year	Item	Recorded figures	Expected figures
1950	Birth-rate	16.4	22.7
	Births	115 414	159 700
	Deaths at age 0-11 months	2 421	3 351
	Deaths at age 1 year	224	305
	Deaths at age 2 years	172	237
	Deaths at age 3 years	147	216
	Deaths at age 4 years	104	159
	Deaths at age 5 years	115	127
	Deaths at age 50 and over	59 820	59 820
	Total deaths	70 296	71 508
	Proportional mortality	85.1	83.7
1951	Birth-rate	15.6	22.3
	Births	110 168	157 500
	Deaths at age 0-11 months	2 378	3 399
	Deaths at age 1 year	229	317
	Deaths at age 2 years	160	218
	Deaths at age 3 years	115	158
	Deaths at age 4 years	96	141
	Deaths at age 5 years	87	133
	Deaths at age 6 years	102	113
	Deaths at age 50 and over	59 601	59 601
	Total deaths	69 799	71 111
	Proportional mortality	85.4	83.8
1952	Birth-rate	15.5	22.4
	Births	110 192	159 200
	Deaths at age 0-11 months	2 207	3 189
	Deaths at age 1 year	188	269
	Deaths at age 2 years	134	185
	Deaths at age 3 years	110	150
	Deaths at age 4 years	108	149
	Deaths at age 5 years	92	135
	Deaths at age 6 years	74	113
	Deaths at age 7 years	76	84
	Deaths at age 50 and over	58 752	58 752
	Total deaths	68 270	69 555
	Proportional mortality	86.1	84.5
1953	Birth-rate	15.4	21.8
	Births	110 144	155 900
	Deaths at age 0-11 months	2 064	2 922
	Deaths at age 1 year	182	263
	Deaths at age 2 years	116	166
	Deaths at age 3 years	101	140
	Deaths at age 4 years	79	108
	Deaths at age 5 years	83	114
	Deaths at age 6 years	89	131
	Deaths at age 7 years	83	127
	Deaths at age 8 years	60	66
	Deaths at age 50 and over	60 140	60 140
	Total deaths	60 553	70 733
	Proportional mortality	86.5	85.0

RÉSUMÉ

La nécessité d'introduire une mesure numérique des « niveaux de vie » s'est fait sentir depuis longtemps, et particulièrement au cours des dernières années, en raison de l'intérêt porté par les Nations Unies à ce problème. Un Comité d'experts convoqué à cet effet par le Secrétaire général des Nations Unies, devant l'impossibilité d'établir un indice unique du niveau de vie dans son ensemble, susceptible d'être appliqué à l'échelle internationale, suggéra de rechercher des indices représentatifs des diverses composantes, plutôt que de ces niveaux eux-mêmes. Dans la liste des douze éléments constitutifs établie par le Comité d'experts des Nations Unies, le facteur « santé y compris l'état démographique » figure en première place.

L'élaboration d'un ou de plusieurs indices relatifs à cette composante particulière a été étudiée à l'OMS par le Comité d'experts des Statistiques sanitaires et par un Groupe d'étude de la Mesure des Niveaux de Santé. Guidés par leurs commentaires et leurs observations, les auteurs ont tenté d'élaborer un indicateur numérique mesurant l'élément « santé y compris l'état démographique » et pouvant trouver sa place à côté des indicateurs représentant les autres éléments constitutifs des niveaux de vie suggérés par le Comité d'experts des Nations Unies. Le but poursuivi n'était donc pas de mettre au point des mesures spécifiques des problèmes de santé publique, qui peuvent revêtir d'innombrables aspects, dont beaucoup ne sont même pas numériquement mesurables dans l'état actuel des connaissances. Il eût fallu, pour cela, procéder à un examen analytique de la santé nationale — physique, mentale et sociale — et disposer, en conséquence, de toute une série d'indices. Les auteurs ont cherché, au contraire, à résumer numériquement le niveau de santé national sous une forme aussi concise que possible, en sacrifiant ainsi toute une diversité de détails en faveur d'un indicateur global unique des conditions sanitaires et démographiques.

Les auteurs ont employé une technique statistique objective pour choisir un tel indicateur: celle des fonctions discriminatoires. Les auteurs pensent que l'indicateur proposé, à savoir le pourcentage des décès survenant à 50 ans et au-dessus, par rapport au nombre total des décès (mortalité proportionnelle), fournit une base de comparaison assez satisfaisante entre pays. Des exemples sont donnés qui illustrent l'utilisation de cet indicateur. Celui-ci présente les avantages suivants: il est simple à calculer, il présente un caractère synthétique, il n'exige que des données très largement accessibles, il est sensible et permet des comparaisons valables sur le plan international, malgré les différences dans la qualité des données statistiques de base, enfin il permet une étude détaillée des niveaux et de leurs tendances. Il n'est pas, pour autant, parfait, et ses limitations sont clairement exposées.

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