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NOTE

The *Population Bulletin of the United Nations* is intended to provide information of general international interest relating to population trends and problems, as well as technical material for the use, in particular, of governmental agencies, scientific institutions, and scholars engaged in social and economic research. Contributions of scientific articles on relevant topics will be welcomed. The editors will also be glad to receive information regarding national and international conferences relevant to population questions which are of interest to demographers in various parts of the world.

Opinions expressed in signed articles are not necessarily those of organs or Members of the United Nations.

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SPECIAL NOTICES

NEEDS FOR ANALYTICAL STUDIES OF CENSUS DATA

In the period between 1942 and 1952 censuses of population were taken in 155 areas of the world, covering about 60 per cent of the world's population. These figures represent a substantial increase in census activities over the preceding decades. In the three years 1950–1952 alone, 37 countries in various regions of the world had their populations enumerated. These censuses supply demographic data for a number of countries for which no such information has existed hitherto. The censuses were taken, in most cases, in general conformity with the recommendations made by international bodies to ensure international comparability of results. Considerable assistance was provided by the United Nations and other international agencies to the Governments less experienced in the census techniques.

It is only natural that the help extended by the U.N. agencies should not be restricted to the initial stages of the census taking, such as the designing of census schedules and the organizing of census machinery. A number of countries especially in the region of Latin America and in Asia have already asked for, and received considerable assistance in processing the census returns.

* * *

The work of the census, however, should not end with the tabulation and publication of the census statistics. Too often in the past, in the so-called advanced countries, voluminous compilations of census statistics have been allowed to moulder on library shelves, rarely utilized by government agencies and frequently inaccessible or incomprehensible to the public. It cannot be stressed too strongly that the census results represent a large national investment and it is in the national interest to realize maximum returns from this investment by applying the data to practical economic and social problems.

The understanding that economic and social problems are closely interrelated with population size and growth has been gaining ground in the last few decades. The rapid growth of populations in the under-developed areas of the world, the phenomenon of ageing of populations in the countries within the orbit of western civilization, the post-war " baby boom " occurring in a number of countries, can all be quoted as examples of experiences which made it clear that the demographic situation has to be taken into account as an important factor in economic and social development plans. If maximum success is to be achieved in any economic and social programme, the objectives have to be related to the present and future size of population, its composition and geographical distribution. Analyses of the results of recent censuses on the lines suggested in the following paragraphs will help materially in the effective planning of such programmes.

Sampling of census returns

Even in the economically advanced countries where demographic statistics are well developed, much of the information collected on census schedules remains unexplored on account of the high cost involved in the sorting and tabulating of millions of punch cards. Furthermore, the publication of the census reports is often delayed so long that many of the opportunities for practical applications of the data to current problems are lost. A comparatively new method of sampling of the census returns (or punch cards) and of analysing a small scientifically designed sample instead of the whole " universe " of cards has recently found application in a number of countries. This method, which saves both time and money and allows for a number of additional cross-tabulations to be made involving negligible expenditure, has rapidly grown in importance. It is one of the recommendations of the last session of the Population Commission that the applicability of this method be further tested.

Examples of analytical studies

The Population Commission has also decided to encourage governments, especially those of the under-developed countries, to undertake, in addition to the routine publication of census tabulations, an analytical appraisal of their demographic situation on the basis of the census results. It is important to realize that in the under-developed countries the registration of vital statistics is usually inadequate and often non-existent, and therefore the role of the census is more important in that it provides the only source of information on the trends, levels and differentials of fertility and mortality as well as on migration movements. In the field of fertility it is possible to employ,

for instance, the ratios of children to women of child-bearing age as the yardstick, or, if the question on the number of children born was asked, to evaluate the incidence of live births to successive cohorts of marriages or of women. Estimates of mortality and of the net volume of migration between the census dates can be made by comparing data on the native and foreign-born population classified by sex and age, at the two censuses. If data on place of birth have been obtained in the census, they can be used to analyse internal as well as external migration. The age structure can also be used to forecast the size and age distribution of the labour force in the not-too-distant future. These are only a few examples of problems which may be analysed within a framework of, and in addition to, the more general study of population size and density in relation to the natural resources available.

Topics proposed by Population Commission

The specific recommendations of the Population Commission contain a broad list of topics which may be profitably covered in the analytical studies. This list is reproduced below. The emphasis has been laid throughout on those topics which are of foremost importance to the programmes of economic and social development. In addition to the study of past, present and future trends of the components of population growth, an interpretation of census results is suggested with special reference to such problems as labour supply, housing, standard of living, and education. It must be borne in mind, however, that the relevance of various problems depends on the actual needs of the country under study. Moreover, the scope of the analysis must by necessity vary from country to country according to the type of information obtained.

The list of topics included in the recommendations of the Population Commission reads as follows : [1]

(1) Completeness and accuracy of census results and comparability with earlier censuses ;

(2) Size, density, and geographical distribution of population in relation to natural resources ;

(3) Trends and characteristics of urban and rural population ;

(4) Structure of the population with special regard to age groups, economically active and inactive groups, social classes and (where relevant) ethnic groups and nationalities ;

(5) Trends in mortality, fertility, and family size for the country and its subdivisions ;

(6) Fertility and mortality differentials between regions, economic groups, social classes and (where relevant) ethnic groups, nationalities, etc. ;

(7) Prospects for future population growth, with special reference to labour supply and employment ;

(8) Internal and external migration, and their effects on the age structure, labour force, and other demographic characteristics of the country and its subdivisions ;

(9) Composition of the population with reference to occupation, industry, status and social classes ;

(10) Economic and social conditions such as labour supply, housing, standard of living, education, and social welfare measures.

* * *

It is to be hoped that the initiative shown by the United Nations agencies in mapping out a programme for analytical studies of recent censuses will find a favourable response among the governments. This is one of the fields of work in which governments may request technical assistance from the United Nations. Such assistance may take the form of providing the services of expert demographers upon request. In addition, the Secretariat may be able to give advice and assistance in the planning stage of each national project as well as in carrying out some comparative studies on an international basis.

Plans for World Population Conference

The forthcoming world conference of experts for the scientific discussion of population problems will take place from 31 August to 10 September 1954 at the headquarters of the Food and Agriculture Organization in Rome. The Conference was authorized by the Economic and Social Council to be held under the auspices of the United Nations in close collaboration with the International Union for the Scientific Study of Population, and interested specialized agencies. (See *Population Bulletin*, No. 2, current items, p. iv.)

The tentative list of topics for discussion at the Conference, as adopted by the Preparatory Committee, is given below. One half-day meeting will be devoted to each topic, meetings in Series A being held simultaneously with those in Series B. In addition to the meetings on the topics listed, there will be an opening plenary meeting and two final plenary meetings, the latter being devoted to summaries of discussions of the more important topics with special reference to needs for further research. For each meeting the Secretary-General of the United Nations has appointed an organizer who will arrange for the preparation of papers and their discussion.

Invitations to attend the Conference will be sent by the Secretary-General to experts nominated

[1] United Nations. *Report of the Population Commission (seventh session)*. Document E/2359. New York, 1953, para. 41.

by governments, specialized agencies, and non-governmental scientific organizations interested in population. A preliminary list of international non-governmental scientific organizations which have been requested to submit nominations is given below.

Each person invited to attend the Conference will have the opportunity to contribute a scientific communication of not more than 2,500 words, on a topic relevant to population. Communications may be written in English, French, Spanish, Russian, Chinese or Italian, and must be accompanied by a summary of not more than 200 words. The papers should be in the hands of the Director of the Population Division, United Nations, New York, by 31 March 1954, in order to allow time for their use in preparing the programme for the Conference.

Financing of the Conference will be shared by the United Nations, the International Union for the Scientific Study of Population, the Italian Government and the co-operating specialized agencies. The International Union has appointed a financial committee with an international membership to collect funds for the Conference from interested individuals, foundations and private organizations.

Further information regarding arrangements for the Conference, including the participation of individuals, can be obtained from the Secretary of the Sub-Committee on Arrangements, Dr. Frank Lorimer, American University, 1710 Connecticut Avenue, Washington 16, D.C., U.S.A. Information regarding the activities and goals of the financial committee can be obtained from its Chairman, Dr. Louis I. Dublin, The Institute of Life Insurance, 488 Madison Avenue, New York, N.Y., U.S.A.

Preliminary list of international non-governmental scientific organizations requested to nominate individuals to attend the World Population Conference

A. *Organizations with major interest in population*

International Union for the Scientific Study of Population

B. *Organizations concerned with population in varying degrees*

Econometric Society
Inter-American Statistical Institute
International Biometric Society
International Economic Association
International Geographical Union
International Gerontological Society
International Political Science Association
International Sociological Association
International Statistical Institute
International Studies Conference
International Union of Anthropological and Ethnological Sciences
International Union of Biological Sciences
International Union of Scientific Psychology
Pacific Science Association
Permanent Committee for International Congress of Actuaries

Tentative list of substantive meetings

Series A

1. Mortality trends, with special attention to areas of lower death rates
2. Mortality trends, with special attention to areas of higher death rates
3. Fertility trends, with special attention to areas of lower fertility
4. Fertility trends, with special attention to areas of higher fertility
5. International migration, with special attention to areas of emigration
6. International migration, with special attention to areas of immigration
7. Prospects for future population changes
8. Variations in age composition, with special attention to effects of declining fertility and mortality
9. Economic and social consequences of ageing of population
10. Demographic aspects of economic and social development I. Population in relation to natural resources and agricultural development
11. Demographic aspects of economic and social development II. Population in relation to capital formation, investment, and employment
12. Demographic aspects of economic and social development III. Interrelations of population, economic development and social change
13. Population distribution and internal migration, with special attention to highly industrialized countries
14. Population distribution and internal migration, with special attention to countries in process of industrialization
15. Social aspects of population changes, with special attention to inter-disciplinary studies

Series B

1. Evaluation of quality of demographic statistics
2. Techniques of demographic measurement and analysis
3. Special topics I (selected contributed papers)
4. Special topics II (selected contributed papers)

5. Methods of making population projections
6. Design and control of demographic field studies
7. Special topics III (selected contributed papers)
8. Problems and methods in demographic studies of preliterate peoples
9. Special topics IV (selected contributed papers)
10. Relation of population changes to distribution of genetic factors
11. Methods of research on relations between intelligence and fertility
12. Concepts and definitions in demographic statistics
13. Demographic analysis relevant to problems of economic and social development
14. Legislation, administrative programmes, and services relevant to population, with special attention to the evaluation of their effects
15. Recruitment and training of personnel for demographic research and teaching

Population structure as a factor in manpower and dependency problems of under-developed countries

Paper presented by JOHN D. DURAND, *Acting Director of the Population Division of the United Nations, at the 1952 meeting of the American Sociological Society.*

The characteristically high birth rates in the under-developed countries create a " bottom heavy " age structure of the population, with excessive numbers of children in proportion to the numbers of adults. The heavy load of dependency and the relative deficiency of adult manpower that are inherent in such an age structure add to the handicap of low productivity of labour and increase the difficulties of social advancement.

The people of these countries compensate for these handicaps to some extent by the custom of employing children at an early age. Likewise, the old men continue to work as long as they are physically able, instead of retiring at age 65 or 70, as is customary in the highly developed industrial societies. Nevertheless, the economically active population of the under-developed countries is, as a rule, relatively small in proportion to the number of dependants. Further, the expectation of working life in these countries is typically rather short, because many infants and children die before they have reached working age, and many of those who begin their working careers are eliminated by death before they have completed the full span of their potentially productive years.

The reduction of death rates, which has become a general trend in the under-developed countries, lengthens the economically active life of each successive generation. Yet, without a corresponding reduction of birth rates, longer survival will not improve the balance between the productive and the dependent elements of the population; for it is primarily the birth rate, and not the death rate, which determines the age structure. In fact, the ratio of dependants to producers is likely to increase somewhat in the future in the majority of under-developed countries, in consequence of continuing urbanization and industrialization. It is typical of urban communities that the proportions of children and of old men engaged in economic activities are lower than in rural communities. The result will be to take away a part of the gain resulting from increased production per worker; this seems practically inevitable unless the birth rates of these countries are reduced.

Some of these demographic facts and tendencies have been taken for granted by writers on the population problems of the under-developed countries, without much effort at statistical verification. In some cases, more has been taken for granted than appears justified in the light of the data to be presented here. This statistical analysis, however, is far from being definitive. It is based on rather old data, of dubious comparability, with many gaps in the geographical coverage of the under-developed regions of the world. A more comprehensive, up-to-date, and more firmly based analysis will be possible when the results of the censuses taken in 1950 and 1951 are fully tabulated.

" Productive " and " dependent " age groups

The unfavourable age distribution which characterizes most under-developed countries has been brought out in many studies by a rather simple technique of analysing census statistics, in which the population is divided into three broad age groups intended to represent children who have not reached working age, adults of working age, and persons past working age. These three groups are usually defined as under 15 years, 15 to 60 or 65 years, and 60 or 65 years and over. It is found that in the under-developed countries the children typically make up a very large proportion of the population, and although there are relatively few people past working age, the proportion of adults in the intermediate, or so-called " productive " age group is rather low.

An example is furnished by the latest figures for Thailand (1947 census) and the United Kingdom (1950 estimates).[1] Children under 15 years of age make up 42 per cent of the population in Thailand, but only 22 per cent in the United Kingdom. Persons over 60 account for 4 per cent of the total in Thailand and 16 per cent in the United Kingdom. When these two " dependent " age groups are combined and their numbers expressed as a ratio to the population in the " productive " age group 15–59 years, the ratio works out to 85 dependants per 100 producers in Thailand, but only 61 per 100 in the United Kingdom.

United Nations estimates of population by age groups for the regions of the world [2] indicate that ratios of " dependent " to " productive " age groups close to the one for Thailand—ranging from about

[1] The statistics of population by age groups are shown in United Nations, *Demographic Yearbook, 1951.* New York, 1951, table 4.

[2] United Nations, *Demographic Yearbook, 1949–50.* New York, 1950, p. 15.

80 to 85 dependants to 100 producers—are characteristic of Asia, Africa, and Latin America; that is, the economically least developed parts of the world. On the other hand, ratios close to that of the United Kingdom—ranging from about 55 to a little over 60 dependants per 100 producers—are typical of northern, western and central Europe, northern America, and the British Dominions in Oceania. Intermediate ratios, in the neighbourhood of 70 dependants per 100 producers, are found in the regions of southern and eastern Europe, which are also intermediate between the other two groups of regions in the degree of their economic advancement. So there is a strong correlation, throughout the world, between economic retardation and a heavy dependency load as measured by the age structure of the population.

The regional differences in the age structure were even larger a decade ago, and they will probably be larger again a decade from now. In the regions where the ratio of children to adults is now lowest, it was lower still before the war and the well-known " baby boom ". The crude birth rates in these regions have fallen off from the post-war peak and are expected to drop lower in the future, bringing down with them the percentages of children in the population. No such trend is generally expected in the economically retarded, poverty-ridden, and dependency-laden regions. In most cases the present high birth rates of peoples in these regions can be expected to remain high for some time to come, and to keep up the burdensome ratio of children to adults.

It would be a mistake to dismiss the age structure as a factor of only minor importance hindering the economic development of the under-developed countries.[3] The necessity of providing for a large brood of dependent children accentuates the difficulty of sparing even a modest share of an inadequate income for investments in capital goods and progressive social services. The achievement of a satisfactory standard of education, which is probably the most important key to social and economic progress in the long run, is severely hampered by the excessive numbers of children in proportion to the numbers of adult workers who can help to foot the educational bill.

The relation between age and dependency

The assumption that all persons between certain age limits are producers and that all those outside the specified age range are dependants is obviously useful only for a first approximation. In each age group except the very young and the extremely old, there are some individuals who take part in the production of goods and services and some who only consume what is produced by others. The proportions of producers and dependants are not the same, age for age, in different countries. In particular, children go to work much younger, as a rule, in retarded agricultural countries than they do in advanced industrial countries. The kind of comparisons illustrated above therefore understate the manpower resources and exaggerate the dependency burdens of the under-developed countries by comparison with the advanced ones. This remains true even in view of the fact that many of the child workers are only partly self-supporting.

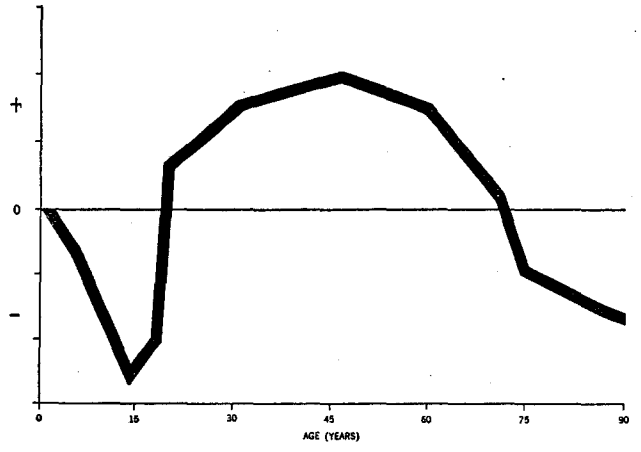
It would be interesting to know the average value of what the people of each age, in each country, produce by way of goods and services having an economic value to the community, and the value of what they consume. Dependency could then be measured in relation to age by means of an index which could be called the " average net product " of each age group: that is, the positive or negative difference between *per capita* production and consumption on the part of persons in the given age group. The variation of this index from age to age would describe a curve, the form of which would differ from country to country and from time to time, and which would not be the same for the two sexes. To avoid misunderstanding, it should be pointed out that dependency is here considered not as the individual sees it with regard to his finances, but from the point of view of the nation or the community.

In a modern industrial society, the average net product of a generation of males probably falls from zero at birth to a maximum negative figure at an age in the teens when most of the boys have not yet begun to earn a living and are drawing heavily on the community for their maintenance and education. From that point the net product probably rises quickly into positive values as the young people enter the labour market, and goes on increasing gradually until some age, perhaps around 40 to 50 years, when men reach the economic prime of their lives.[4] After that age the men move toward dependency; their average net product falls, gradually at first and rapidly later, to zero and then to lower and lower negative values as the survivors of the generation move on into old age. A curve based on hypothetical values for average net product of males at different ages in industrial countries is shown in figure 1.

[3] United Nations, " Implications of population trends in under-developed countries ". In *The determinants and consequences of population trends.* Document ST/SOA/Ser.A/17 (New York, 1953), Chapter XV.

[4] In the United States, according to the 1940 census results, the median wage or salary income in 1939 of males who earned any such income but who had less than $50 of other income reached a maximum of $1,322 in the age group 35–44, and was $1,302 in the group 45–54 years old. United States, Bureau of the Census, *Sixteenth Census of the United States, 1940, Population, The labour force (Sample statistics): Wage or salary income in 1939,* Washington, 1943, table 6. The age at which men earn most may not be the same as the age at which they produce the most, and the latter age may differ, because of variations in their consumption, from the age of maximum net product.

FIGURE 1. AVERAGE NET PRODUCT OF MALES IN INDUSTRIAL COUNTRIES (HYPOTHETICAL)



In the case of women, if only gainful work were considered as production, the average net product would reach a maximum somewhere around the age of 20, and even at that age it would be far below the average net product of men. To be realistic, however, it would be necessary to take account of the value of women's services as housewives and mothers; and with this item included it is hard to say at what age women's average net product is greatest, or how it compares with the average for men at any age.

In agricultural countries, where the majority of production is in the hands of family enterprises, the age-to-age variation of the average net product is undoubtedly smaller than in industrial countries. The negative balance for children is not so pronounced, because children are employed to a greater extent in productive work, and also because the outlays for children's education, medical care, and even for their food are necessarily less lavish than in industrial countries. The negative net products of old men are not so large, for the same reasons, and the range of ages at which the average net product is below zero is narrower, at both ends of the scale.[5]

It would be worth while to follow out this line of analysis with some actual data or estimates of production and consumption in relation to age, for those countries which possess any relevant statistics. It is not feasible, however, for a comparison of economically advanced and underdeveloped countries; the available data for the latter are entirely inadequate. For this purpose, the best that can be done with the available materials is to take the census statistics for persons reported as "economically active"—that is, following gainful occupations—to represent producers, and the remainder of the population to represent dependants.

As Moore has shown,[6] these census statistics leave much to be desired as a basis for international comparisons. The data for females, especially, would lead anyone far astray who accepted them at their face value. For the present purpose, the numbers of economically active females would not be very useful even if they were exactly comparable from country to country, since they do not include the housewives, who must be considered realistically as producers, although their product does not find its way into conventional national accounts. For these reasons, attention will here be confined to the statistics for the male population.

The ages of economic activity of males

The first question to consider is, how do the age at which boys begin to be economically active and the age at which men cease to be active differ between economically advanced and under-developed countries?

Table 1 gives the percentages of economically active persons among the male population of each age group for a number of countries.[7] In order to indicate approximately the degree of economic

[5] For further speculations of some other writers on this subject, see A. Sauvy's *Théorie générale de la population.* Paris, 1952, Vol. I, Chapter XXIV. Sauvy arrives at estimates of the economic value of a man at various ages by multiplying the average net product for each age group by the life-table population in that age group, cumulating the results from each age to the end of life, and dividing by the numbers of survivors in the life table at the given ages.

[6] W. E. Moore, "The exportability of the 'Labor force' concept". *American Sociological Review,* Vol. 18, No. 1, February 1953, pp. 68–72.

[7] For this analysis, the relevant census statistics have been assembled for those countries of Asia, Africa, and Latin America for which data could be obtained; for four countries in southern and eastern Europe that were not very highly developed from an economic point of view at the date to which the figures relate, namely, Portugal, Italy, Greece, and the Soviet Union; and for four countries economically much more advanced, namely, the United States, France, Sweden, and Australia. Where data were available for several census years, figures for a year near 1940 were chosen. In some cases, the latest available figures are rather old; those for Greece are from the 1928 census and those for the USSR from the 1926 census. Their antiquity is not very damaging, because the purpose of this paper is more to investigate relationships between the degree of economic advancement and the manpower-dependency situation than to describe the conditions which exist at present in any particular country. It is more important to emphasize that coverage of the under-developed regions of the world is rather narrow, especially in Asia and Africa, and that the effective definitions of the economically active population differ from country to country. In some cases, comparability has been improved by re-grouping the categories tabulated in the census reports, but the feasible adjustments were not sufficient to put the statistics on an internationally comparable footing. It is important to remember this when drawing conclusions from these figures. Some errors have been introduced also by interpolating figures for diverse age groups in order to obtain the grouping shown in table 1.

TABLE 1. PERCENTAGES OF ECONOMICALLY ACTIVE MALES AMONG ALL MALES IN EACH AGE GROUP, FOR SELECTED COUNTRIES, RECENT CENSUS YEARS

(Percentages obtained by interpolation of figures for different age groups are shown in italics)

Country and date	Age in years							
	10–14	*15–19*	*20–24*	*25–34*	*35–44*	*45–54*	*55–64*	*65 and over*
Industrial countries :								
United States, 1940 [a]	1.2 [b]	40.4	88.1	95.1	94.6	92.0	83.9	41.8
Australia, 1933 [c]	3.1	73.4	96.6	98.2	97.1	96.1	90.4	43.4
Sweden, 1940	1.9	82.2	92.5	96.9	97.2	95.7	86.1	42.6
France, 1936	14.2 [d]	72.4	93.7	97.0	96.3	92.9	79.0	53.7
Semi-industrial countries :								
Japan, 1930	14.1	78.5	91.8	97.3	98.0	94.1	*88.5*	*64.0*
Italy, 1936	26.9	*81.6*	*92.1*	97.7	97.1	94.7	88.6	61.8
Greece, 1928	*21.4*	*85.3*	*93.8*	*97.2*	*97.5*	*96.7*	*94.0*	*78.8*
Portugal, 1940	26.2	75.4	*94.4*	*97.5*	*98.0*	*96.8*	*93.7*	*87.0*
Jamaica, 1943	4.0 [e]	56.6	85.3	95.4	*96.4*	*94.8*	*88.0*	*62.3*
British West Indies (except Jamaica), 1946	9.0	77.4	97.8	98.7	98.1	96.2	88.9	60.7
Puerto Rico, 1940	[f]	*53.0*	88.4	93.1	93.9	91.4	82.0	51.1
Panama, 1940 [g]	19.7	77.6	96.4	98.1	*98.4*	*97.5*	*95.0*	*82.9*
Agricultural countries :								
Peru, 1940 [h]	22.8 [i]	63.0	*92.6*	*96.7*	*97.2*	*96.5*	*95.3*	82.6
Brazil, 1940	*30.4*	*88.7*	*93.7*	*96.0*	*96.9*	*95.7*	*91.5*	*75.1*
Turkey, 1945	48.7 [d]	79.9	90.9	93.0	93.6	93.0	88.9	79.0
Egypt, 1937	63.4	82.4	90.7	*96.6*	*98.0*	*97.0*	*94.0*	*85.6*
Philippines, 1939	26.5	69.3	90.4	96.7	97.5	95.9	87.6	53.1
USSR, 1926	58.0	88.4	97.7	99.0	99.2	98.8	94.8	69.3

[a] Statistics based on tabulations of a 5 per cent sample of the census returns.

[b] Tabulations on economic activities were limited to the age group 14 years and over. The percentage for age 10–14 was calculated on the assumption that no children 10–13 were economically active, and is therefore a minimum figure. The true figures must have been much less than 5.8 per cent, which was recorded for age 14 alone.

[c] Excluding full-blooded aborigines.

[d] Data were tabulated for the age group under 15 without sub-division. It was assumed that all economically active children under 15 were 10-14; hence the percentage for this age group is slightly overstated.

[e] In the Jamaica census publications, data were presented for the age group under 15 without sub-division. The percentage 4.0 was obtained by assuming that all economically active children under 15 years were 10–14; hence the percentage for this age group is probably slightly overstated. A summary table in the British West Indian Census volume cites a figure of 3.4 as representing the proportion of males 10–14 years of age in Jamaica who were economically active in 1943. This figure, however, is not strictly comparable with those for the other age groups presented here, since it is based on figures for the economically active from which a small number of unpaid helpers in domestic service have been excluded. See British West Indies, *West Indian Census 1946. Part A. General report on the census of population.* Kingston, 1950, pp. 45–46.

[f] The data tabulated do not permit an approximation of the percentage for this age group, but it was probably not far from that for Jamaica.

[g] Excluding tribal Indians.

[h] Enumerated population, excluding jungle population.

[i] Data were tabulated for the age group 6–14 without sub-division. It was assumed that all economically active children 6–14 were 10–14; hence the percentage for this age group is somewhat overstated.

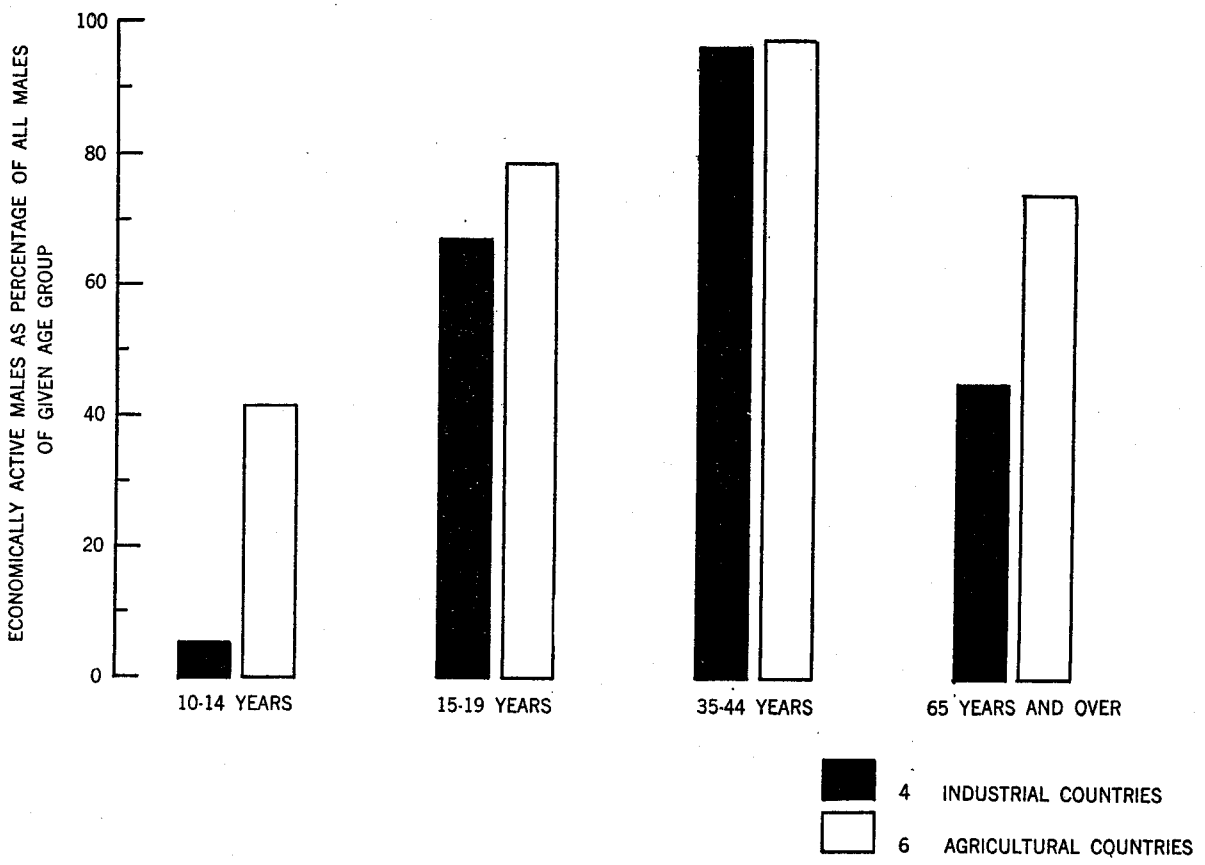
Sources: See the list of census publications at the end of this paper.

advancement of the countries, they are classed as "industrial", "semi-industrial", or "agricultural" on the basis of the percentage of the male workers who were engaged in agriculture and related employments at the time of the census. In the "industrial" countries this percentage was below 35; in the "semi-industrial" countries it was 40–60 per cent, and in the "agricultural" countries it exceeded 60 per cent.

The figures confirm that children in the underdeveloped, agricultural countries go to work at a younger age than those in the advanced industrial countries (see also figure 2). In three of the six countries listed in the table as "agricultural", some 50 or 60 per cent of the children 10–14 years old were reported in the census as economically active, and in the other three this proportion was 20–30 per cent. By contrast, three of the four "industrial" countries had only about 3 per cent or fewer of the children of this age reported as economically active, and in the fourth country, France, the figure was perhaps 14 per cent. The percentages for the "semi-industrial" countries taken as a group were intermediate, those for the Caribbean territories ranging from about 3 to 10 per cent,[8] while those in the other "semi-industrial" countries varied from about 15 to 25 per cent.

[8] The table contains no estimate of the percentage for Puerto Rico, but the data for the age group 10–15 years, together with the statistics on school attendance, suggest that the proportion of economically active children 10–14 may have been about the same in Puerto Rico as it was in the British West Indies.

FIGURE 2. PERCENTAGE OF MALES ECONOMICALLY ACTIVE IN SELECTED AGE GROUPS
(Unweighted averages for industrial and agricultural countries)



Two principal explanations of the differences in these percentages suggest themselves. First, the people of the under-developed, agricultural countries are too poor to afford the long education which is customary in the economically more advanced countries. Second, agriculture is a type of employment in which it is comparatively easy for children to work, at least in part-time or intermittent activities, especially on the home farm.

The relatively high proportion of French children classified as economically active, by comparison with the children in the other "industrial" countries, may be related to the fact that France has a larger proportion of agricultural population than these other countries. The agriculture of the Caribbean territories is conducted to a large extent on plantations with hired labour rather than on family farms, and this fact, together with a standard of education that is unusually high for under-developed countries, may help to explain the relatively low percentage of economically active children there. But it would be futile to seek far for explanations of such deviations from the general rule, beyond the fact that the statistics vary with the details of the definitions and procedures followed in the censuses, and with the shades of meaning attached to the same terms in communities with different cultures. It is hardly likely, for example, that child labour is really almost twice as common in Turkey as in the Philippines, and nearly three times as widespread in Egypt as in Peru.

The statistics on economic activities of children 15–19 years old also show some correlation with the degree of economic advancement of the nation, but the relationship is less consistent than that which appears in the figures for the younger children. The country with the lowest proportion of gainfully occupied boys 15–19 years old was the United States, that is, the most industrialized of all the countries listed in the table. Also, the Soviet Union, which was the least industrialized of these countries at the time of the census (a quarter of a century ago, it will pay to emphasize, in this case), reported the highest proportion of economically active boys at this age. Rather high percentages for age 15–19 were shown also for Brazil, Egypt and Turkey, but not for Peru or the Philippines; and rather low percentages were recorded in France and Australia, but not in Sweden. It seems that the

true relationships are largely hidden by the vagaries of the statistics.[9]

It should not be necessary to point out that a nation which allows its children to go to work before they reach maturity pays a penalty in the form of lost opportunities for economic and cultural advancement through education, if not in the form of impaired health. In the long run this penalty may annul completely, and perhaps several times over, the immediate gain represented by the output of the working children. Young people in school can be regarded as national assets, the value of which, in terms of their potential future product, increases with each addition to the investment in their schooling.

The problem of childhood dependency in the under-developed countries can be summarized in these terms: with a high ratio of children to adults and a low *per capita* income for the adult population, the people of these countries can ill afford to keep their children long in school. They lighten the burden by putting the children to work early, and thus they sacrifice the welfare of the next generation.

It is only in this way that they compensate for the relative shortage of adult manpower. In addition, as the data in table 1 bring out, and as illustrated by figure 2, the men in the under-developed countries continue working in old age to a greater extent than they do in the economically more favoured countries. In five of the six countries classed as " agricultural ", the proportion of men over 65 reported in the censuses as economically active was in the range from about 70 to 85 per cent. (The exception was the Philippines, with 53 per cent.) On the other hand, in three of the four " industrial " countries this proportion was about 40–45 per cent, France being the exception with 54 per cent. The majority of the " semi-industrial " countries had percentages of economically active men over 65 lying in the range from 50 to 70 per cent, though Greece, Portugal, and Panama recorded larger percentages.

Without doubt the old men in the under-developed countries are under a compulsion to continue working as long as they are physically able to earn a living and perhaps contribute something to the support of their numerous grandchildren. Furthermore, since they are for the most part independent farmers, they have the opportunity to remain in their occupation beyond the age at which the wage-earners in industrial countries are commonly forced to retire by the pressure of competition from younger men. Thus, in the peasant-agricultural societies, the span of the working years is increased both in youth and in old age by economic necessity operating in the framework of a social organization that facilitates the employment of relatively inefficient workers.

Sometimes it is said that men in the economically retarded countries tend to become dependent earlier than those in more advanced countries, where health conditions are better.[10] It is difficult to reconcile this statement with the figures which we have presented. To be sure, the men in the under-developed countries who continue working after age 65 or 75 may be woefully inefficient on account of poor health, but only rather extreme estimates of the degree of their disability would be consistent with the hypothesis stated. The point can be illustrated by referring to the statistics for the United States in 1940 and Egypt in 1937, which show 42 per cent and 86 per cent, respectively, of the men over 65 engaged in economic activities. If it is assumed that the American workers over age 65 produce just enough, on the average, to balance their consumption, then the Egyptian workers of this age would have to produce less than half of the pittance which they consume in order to make the degree of dependency of the male population over 65 in Egypt higher than in the United States.

In fact, there are practically no data available regarding either the prevalence of disabilities among the workers in the under-developed countries or the degree of such disabilities. Here is one of the worst gaps in existing statistical information about the conditions of life in these countries.

The ratio of dependants to producers

The evidence presented above shows that the employment of children and old men tends to moderate the high proportion of dependants and the low proportion of producers which result from the age structure of the population in the under-developed countries. In most cases, however, this is not enough to bring the numerical relation-

[9] The census tabulations for some of these countries show the numbers of boys classified as students, or as attending school during a certain period, in addition to the numbers engaged in economic activities. In several of the under-developed countries it appears that rather large numbers of boys were reported to the census-takers as neither economically active nor in school. For example, in Portugal, 1940, the number economically active plus the number in school added to only 69 per cent of the male population 10–19 years old. The corresponding figure for Brazil was about 78 per cent, and for the Philippines, 85 per cent. For Puerto Rico, in the age group 15–19 years, the economically active and the boys in school accounted for about 75 per cent of the male population. There may be some truth in these figures, for schools in some of the countries mentioned are few and far between and those boys who are not lucky enough to be in school may not easily find steady jobs. The data suggest, however, that in the censuses of these countries many young people who were only partially or intermittently employed were not reported as economically active, and that the true numbers of boys engaged to any extent in gainful work were substantially greater than the numbers recorded, the amount of under-reporting varying from country to country.

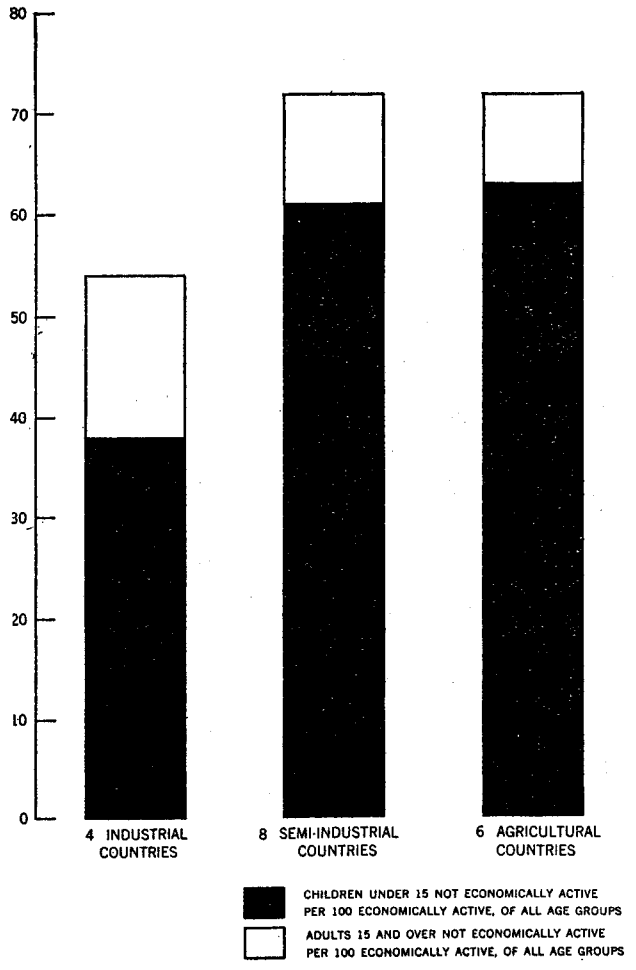
[10] See, for example, P. A. Wadia and K. F. Merchant, *Our economic problem*. Bombay, 1946.

ship between the dependent and the productive population in under-developed countries into line with that which is found in the economically advanced countries. This fact is illustrated by figure 3 and by the data in table 2, where the dependent male population, defined as the number of males of any age not classified as economically active, is expressed as a ratio to the productive male population, that is the total number of economically active.

In the four " industrial " countries, this ratio varies from 44 dependants per 100 producers in the case of Sweden to 65 per 100 in the case of the United States. Ratios ranging from about 70 to 105 dependants per 100 producers are shown for five of the eight " semi-industrial " countries, and ratios between about 70 and 90 per 100 for four of the six " agricultural " countries. In these cases, clearly, the dependency load remains heavy in spite of the premature employment of young people and the prolonged economic activity of the aged.

FIGURE 3. PERSONS NOT ECONOMICALLY ACTIVE PER 100 ECONOMICALLY ACTIVE

(Unweighted averages for 3 groups of countries)



The exceptional cases in the " semi-industrial " group are the three southern European countries, Italy, Greece, and Portugal. There, as we have said, the age structure of the population is not so unfavourable as it is in most countries of Asia, Africa, and Latin America. When allowance is made for the children and the old men who are economically active, their dependency ratios come down close to the average for the economically most advanced countries. In the group of " agricultural " countries, Egypt and the Soviet Union have similarly low dependency ratios, in these cases because of extremely high percentages of workers within the various age groups, which are sufficient to counterbalance a very adverse age structure.

The counteracting influences of the two factors, age structure of the population and proportions of economically active males within various age groups, may be shown more clearly by the standardized dependency ratios in table 3. The ratios " standardized for percentages of economically active males " are computed as if these percentages, for each age group, were the same in all the other countries as they were in the United States. The absolute values of these standardized ratios have no meaning, but the differences between countries show the effects of the variations in age structure upon the dependency ratios, other factors being held constant. The figure for Portugal, which is higher by about one-third than that for the United States, reflects the moderately unfavourable age structure which is characteristic of the southern European region. The ratio for Japan is somewhat higher, and the ratios for Peru, the Soviet Union, Turkey, Egypt, Puerto Rico, and Brazil, where the age structure is most conducive to a heavy dependency load, are higher yet.

The variations of the ratios " standardized for age distribution of the male population " show only the effects of differences in the proportions of males in the various countries who are classified as economically active, within age groups that are made to conform to the structure of the United States population. Standardized in this way, the dependency ratio for Puerto Rico is somewhat lower than that for the United States. For Japan, Peru, Turkey, Portugal, and Brazil it is considerably lower, and for the USSR and Egypt it is only one-half as high as the United States ratio. In other words, early employment of young people and prolongation of the active life of old men cut down the dependency ratio slightly in Puerto Rico, considerably in Japan, Peru, Turkey, Portugal, and Brazil, and greatly in Egypt and the Soviet Union.

In some under-developed countries the effect of this factor is sufficient to bring the number of dependants per 100 producers down to the level which is typical of the industrial countries; it does not follow, however, that the weight of the dependency load is no heavier. The productive

efficiency of the very young and the very old workers is certainly below the average for the workers in the middle age groups. How far below, it is impossible to say; and consequently it is uncertain how high the dependency ratio would be if it were calculated in proportion to an equivalent number of workers in the prime of life. It seems likely, however, that, on this basis, it would be higher in all the under-developed countries than in the advanced countries.

TABLE 2. NUMBER OF MALES NOT ECONOMICALLY ACTIVE, IN THREE AGE GROUPS, PER 100 ECONOMICALLY ACTIVE MALES OF ALL AGES, FOR SELECTED COUNTRIES, RECENT CENSUS YEARS

Country and date	Age of males not economically active (years)			
	All ages	Under 15	15–54 [a]	55 and over
Industrial countries :				
United States, 1940 [b]	65	42	15	9
Australia, 1933 [c]	55	42	6	7
Sweden, 1940	44	30	5	9
France, 1936	53	38	6	9
Semi-industrial countries :				
Japan, 1930	70	60	7	4
Italy, 1936	57	46	5	6
Greece, 1928	55	49	4	2
Portugal, 1940	57	49	6	2
Jamaica, 1943	86	70	13	4
British West Indies (except Jamaica), 1946	76	67	5	3
Puerto Rico, 1940	105	83	17	5
Panama, 1940 [d]	68	62	5	1
Agricultural countries :				
Peru, 1940 [e]	88	76	10	2
Brazil, 1940	75	68	5	1
Turkey, 1945	70	59	9	2
Egypt, 1937	54	47	5	1
Philippines, 1939	91	78	9	4
USSR, 1926	54	49	3	2

[a] Including persons whose age was not stated.

[b] Statistics based on tabulations of a 5 per cent sample of the census returns.

[c] Excluding full-blooded aborigines.

[d] Excluding tribal Indians.

[e] Enumerated population, excluding jungle population.

Source : See the list of census publications at the end of this paper.

TABLE 3. STANDARDIZED AND UNSTANDARDIZED NUMBERS OF MALES NOT ECONOMICALLY ACTIVE PER 100 ECONOMICALLY ACTIVE MALES, FOR SELECTED COUNTRIES, RECENT CENSUS YEARS

(Age distribution and age-specific percentages of economically active persons in the male population of the United States, 1940, taken as standard)

Country and date	Unstandardized	Standardized for percentages of economically active males	Standardized for age distribution of male population
Standard :			
United States, 1940	65	65	65
Semi-industrial countries :			
Japan, 1930	70	96	46
Portugal, 1940	57	89	39
Puerto Rico, 1940	105	111	61
Agricultural countries :			
Peru, 1940	88	121	44
Brazil, 1940	75	117	39
Turkey, 1945	70	113	41
Egypt, 1937	54	103	32
USSR, 1926	54	106	32

The length of working life

The paper has thus far been concerned with a cross-sectional view of the population of each country at the date of the census, inquiring how many of the people living in the country at that time were producers and how many dependants. It is also of interest to take what may be called the "life-table" view, and consider how many years are spent working and how many years in a state of dependency during the average lifetime of a generation. These averages are independent of the age structure of the population; they depend only on the conditions of mortality and the ages at which the people begin and cease to work.[11]

Mortara has made an extensive study of the variations in the expectation of working life, so far as they depend on differences in mortality rates.[12] For this purpose he assembled life tables from 35 countries and 5 Latin-American cities or states, where the total expectation of life at birth (for both sexes) ranged from less than 27 years (in India, 1921–1930) to nearly 67 years (in New Zealand 1934–1938). Defining the period of economically active life as the interval between the fifteenth and the sixtieth birthday, Mortara undertook to calculate from the life tables the average numbers of years within that age range which groups of newborn infants in the various countries could expect to live. Of course, the expectation of working life defined in this way was much longer in the areas of low mortality than in those of high mortality. It ranged from slightly less than 16 years in India to nearly 40 years in New Zealand. (The maximum value, if there were no deaths at all before age 60, would be 45 years). The ratio of working life to the total life expectancy, however, varied within a fairly narrow range, from 62 per cent to a little over 70 per cent in the areas covered by Mortara's tables. Its variations were not closely correlated with the total expectation of life nor with the degree of economic advancement of the areas.[13]

It is possible to compute a more refined measure of the length of working life for a few countries, by using data on economic activities of males in various age groups in place of the assumption that the active ages are always from 15 to 60 years. The measure calculated in this way is shown in table 4, for the four "industrial" countries, four of the "semi-industrial" countries, and two of the "agricultural" countries—these being the ones for which the necessary life tables could be obtained. Here the expectation of working life is defined as the average number of years of economic activity to which a new-born cohort of baby boys could look forward, under the conditions of mortality and economic activities of males at various ages which prevailed during the time-periods indicated.[14]

Among the four "industrial" nations, the expectation of working life ranged from 37 years for the French to 44 for the Swedes. Working life for the people in the "semi-industrial" and "agricultural" countries was distinctly shorter, ranging from 26 years for the Egyptians to 35 for the Greeks and Portuguese. These findings are generally similar to Mortara's. Both the total life span and the productive years are short in the

[11] The generations which we consider here are not real generations but imaginary ones which are assumed to be subject at each age to a certain risk of mortality and a certain probability of being economically active. The mortality risks are calculated from cross-sectional data on deaths occurring among the population of each age during a period of years near the census date. The probabilities of being economically active are calculated from the cross-sectional data on the population of each age enumerated in the census. This is the conventional approach to the analysis of life-table functions. For discussions of method and rationale see J. D. Durand, *The labor force in the United States, 1890–1960.* New York, 1948; U.S. Bureau of Labor Statistics, *Tables of working life.* Bulletin No. 1001, Washington, 1950. For countries having long historical series of the relevant statistics it would be possible to use the generation-life-table approach, which would give measures of the average numbers of economically active and inactive years in the life-time of actual generations traced through successive censuses.

[12] G. Mortara, *Durée de la vie économiquement active suivant la mortalité.* Rio de Janeiro, 1951.

[13] Mortara also presented some other interesting functions, including the average number of years to be lived within the age range 15–60 by persons surviving to age 15, and the per cent distribution of the total years lived by the life-table cohort among the age groups under 15, 15–59, and 60 years and over. He made historical analyses of the data for some countries, and analysed generation life tables for a few countries.

[14] The following short-cut method of calculation was used because of the limitations of the data:

(1) The stationary male population (L_x) was estimated, for the age groups under 10, 10–14, 15–19, 20–24, 25–34, 35–44, 45–54, 55–64, 65 and over, from the numbers of survivors (l_x) and expectations of life for males at exact ages 0, 10, 15, 20, 25, 35, 45, 55 and 65. This was necessary because L_x values were not given in the sources from which the life-table functions were obtained.

(2) The "stationary economically active population" (males) was derived by applying to the results of step (1) the percentages of economically active males in the corresponding age groups, as shown in table 1.

(3) The sum of the results of step (2) for all ages was divided by the radix of the life table (100,000) to obtain the average number of economically active years.

(4) To obtain the corresponding figures for males at ages 10 and 20, which appear in table 5, the stationary economically active populations at ages over 10 and over 20 years were divided by the numbers of survivors (l_x) at ages 10 and 20, respectively.

It is believed that the errors due to the use of grouped data and to estimating L_x values are of minor importance by comparison with the uncertainties due to lack of exact comparability in the statistics on economic activities for different countries.

The values shown in tables 4 and 5 for the United States are not comparable with those given in the sources cited in footnote 11, for the latter were based on adjusted and the former on unadjusted census figures.

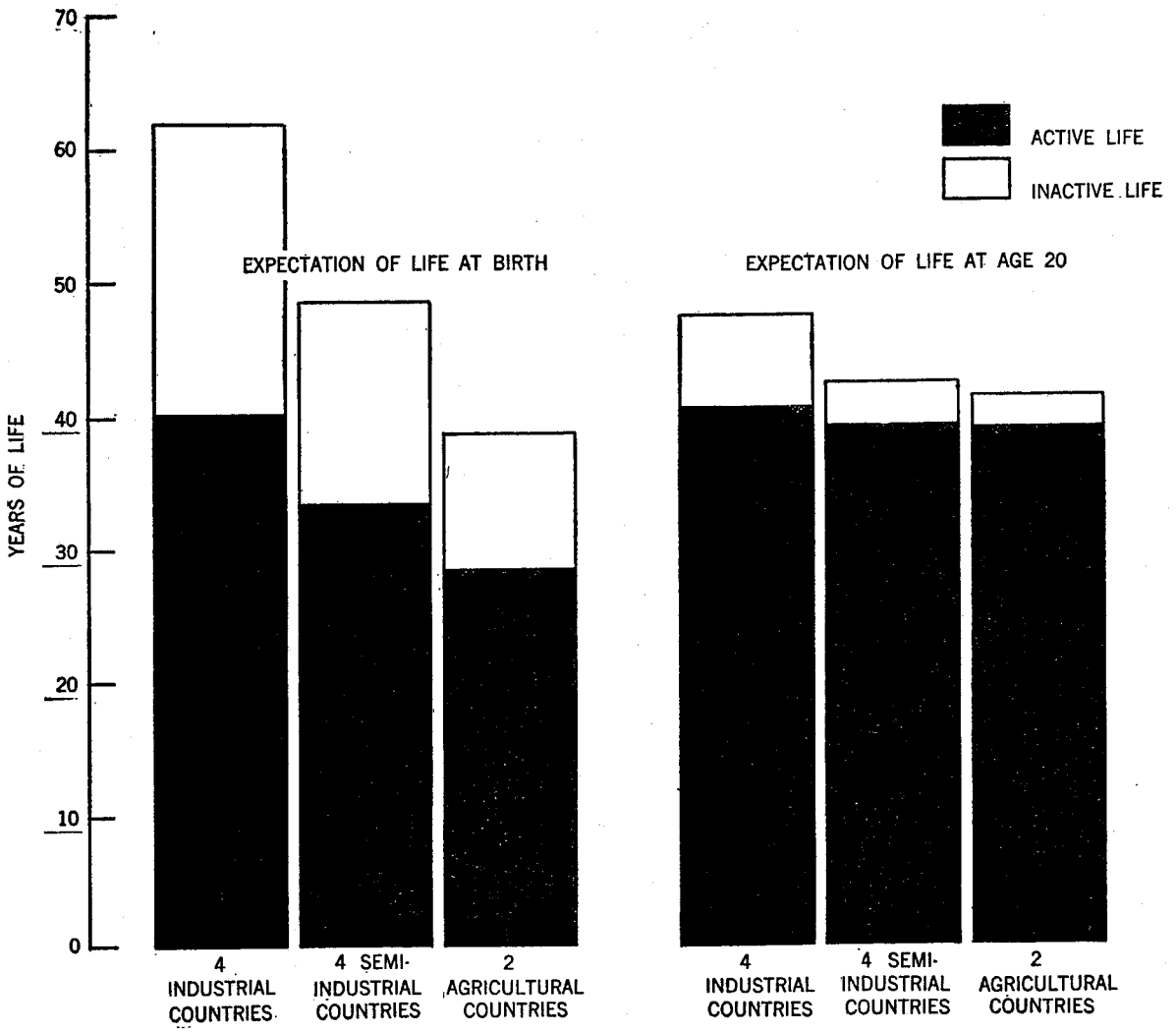
under-developed countries, especially those like Egypt where the toll of mortality is very heavy.

To what extent is the short expectation of working life due to losses of life in infancy and childhood, before the age at which the boys begin to make a productive contribution ? Some information on this point can be obtained from table 5, which shows the average numbers of economically active years after ages 10 and 20 for males who survive to these ages. These figures do not differ very greatly from country to country ; in fact the averages for the three groups of countries are nearly the same. It appears that already after age 10 the relatively high mortality in the under-developed countries is more or less counter-balanced by the tendency of the survivors to continue working at a ripe old age. Figure 4 shows the average expectation of active and inactive life at birth and at age 20 for males in the three groups of countries.

The inactive years for men in the under-developed countries are few. In Egypt or Russia, a boy at birth might look forward to a total of only 10 or 11 years of inactive life in childhood and old age, whereas the corresponding figure for Sweden or the United States was 23 or 24 years.

Mortara, with his assumption that economic activity begins at age 15 and ends at age 60, found that the expectation of working life constituted about the same fraction of the total life expectancy in different countries. The more sensitive measure of working life used in the computations for table 4 gives a somewhat different result, namely that the fraction of man's lifetime spent in economic activity tends to be larger in the under-developed than in the advanced countries. In the four " industrial " countries this fraction was below 67 per cent, whereas in the two " agricultural " countries and in three of the four " semi-industrial " countries it was between 67

FIGURE 4. EXPECTATION OF ECONOMICALLY ACTIVE AND INACTIVE LIFE FOR MALES
(Unweighted averages for 3 groups of countries)



and 75 per cent. But it would not be wise to attach much weight to this comparison, for the differences are not very large, the countries are few, and the data are not entirely trustworthy.

The effect of falling death rates

Death rates are falling in almost all the underdeveloped countries where there are any statistics on population changes, and there is reason to

TABLE 4. EXPECTATION OF LIFE AND AVERAGE LENGTH OF ECONOMICALLY ACTIVE LIFE, FOR MALES AT BIRTH, IN SELECTED COUNTRIES, RECENT YEARS

Country and time-period [a]	*Expectation of life* [b] *(years)*	*Economically active years*		*Average number of inactive years* [d]
		Average number [c]	*Per cent of expectation of life*	
Industrial countries :				
United States, 1939–41	61.6	37.9	61.5	23.7
Australia, 1932–34 [e]	63.5	42.5	66.9	21.0
Sweden, 1941–45	67.1	44.3	66.0	22.8
France, 1933–38	55.9	37.0	66.1	19.0
Semi-industrial countries :				
Japan, 1926–30	44.8	30.2	67.4	14.6
Greece, 1926–30	49.1	35.0	71.4	14.1
Portugal, 1939–42	48.6	35.2	72.4	13.4
Jamaica, 1945–47	51.3	33.1	64.5	18.2
Agricultural countries :				
Egypt, 1936–38	35.7	26.0	72.9	9.7
USSR, 1926–27 [f]	41.9	31.2	74.5	10.7

[a] The time-periods indicated are those to which the mortality schedules of the life tables refer. Years to which data on economic activities refer are indicated in table 1.

[b] Except for Portugal, figures from United Nations, *Demographic Yearbook, 1951, op. cit.*, table 29. Figures for Portugal from United Nations, *Demographic Yearbook, 1952*. New York, 1952, table 28.

[c] Computed by the method explained in footnote 14, from data presented in the sources mentioned in note *b*, and in table 1.

[d] Obtained by subtraction.

[e] Excluding full-blooded aborigines.

[f] Life tables refer only to the European territory.

TABLE 5. EXPECTATION OF LIFE AND AVERAGE LENGTH OF ECONOMICALLY ACTIVE LIFE, FOR MALES AT 10 AND 20 YEARS OF AGE, IN SELECTED COUNTRIES, RECENT YEARS

Country and time-period [a]	*Expectation of life (years)* [b]		*Average number of active years* [c]		*Average number of inactive years* [d]	
	At age 10	*At age 20*	*At age 10*	*At age 20*	*At age 10*	*At age 20*
Industrial countries :						
United States, 1939–41	56.1	46.9	40.7	39.2	15.4	7.7
Australia, 1932–34 [e]	58.0	48.8	45.6	42.4	12.4	6.4
Sweden, 1941–45	60.5	51.2	46.6	43.0	13.9	8.2
France, 1933-38	52.6	43.6	41.5	38.0	11.1	5.6
Semi-industrial countries :						
Japan, 1926–30	47.9	40.2	39.3	36.7	8.6	3.5
Greece, 1926–30	52.4	44.3	44.9	41.3	7.5	3.0
Portugal, 1939–42	52.6	44.0	45.6	41.8	7.0	2.2
Jamaica, 1945–47	50.8	41.9	39.4	37.3	11.4	4.6
Agricultural countries :						
Egypt, 1936–38	46.9	39.8	42.1	37.6	4.7	2.2
USSR, 1926–27 [f]	51.7	43.2	46.5	40.6	5.2	2.6

[a] The time-periods indicated are those to which the mortality schedules of the life tables refer. Years to which data on economic activities refer are indicated in table 1.

[b] Except Portugal, figures from United Nations, *Demographic Yearbook, 1951, op. cit.*, table 29. Figures for Portugal from United Nations, *Demographic Yearbook, 1952, op. cit.*, table 28.

[c] Computed by the method explained in footnote 14, from data presented in the sources mentioned in note b, and in table 1.

[d] Obtained by subtraction.

[e] Excluding full-blooded aborigines.

[f] Life tables refer only to the European territory.

expect that they will continue to fall in the future, if peace can be maintained in the world and if the wherewithal can be found to feed the growing population. What are the effects of lower mortality and longer survival upon the dependency situation and manpower resources of the under-developed countries ?

So far as the length of working life is concerned, evidently the effect is to increase it. But in order to know the effect on the cross-sectional ratios of dependants to producers, it is necessary to consider the effect of the lower death rates on the age structure of the population.

The results of Lorimer's recent calculations are pertinent here.[15] He considered a hypothetical population with a stable age distribution and fertility and mortality rates similar to those of India during the period 1921–1931. He calculated the changes in the age distribution of this population which would occur during a period of 30 years if the mortality rates were much reduced with or without simultaneous reductions in the fertility rates. The changes in mortality which he assumed were enough to lengthen the expectation of life for males at birth from about 27 to 45 years, during the 30-year period. His assumed change in the fertility rates amounted to a reduction of about one-third during the period.

On the assumption of mortality declining with fertility constant, Lorimer found that the percentages of both children and old people in the population increased somewhat throughout the 30-year period, while the percentage of persons 15–64 years old fell off. When he assumed simultaneous declines of fertility and mortality, he found that the proportion of children was cut down sharply and the proportion of old people raised by a lesser amount, so that the percentage of the population in the so-called " productive " age group was increased.

It is interesting also to calculate the changes in the ratio of male dependants to male producers which are implied by shifts in the age distribution. This can be done by assuming certain proportions of economically active males in the various age groups and keeping these rates constant over time. If, for example, it is assumed that in Lorimer's hypothetical population the percentage of economically active males among all males in each age group is constantly the same as it was in Egypt in 1937, the ratio of male dependants to male producers is found to stand initially at 58. If mortality declines alone, the ratio rises slightly, by the end of the 30-year period reaching 62 dependants per 100 producers ; if both mortality and fertility decline, it falls to 49 per 100.[16]

This illustration probably describes fairly well, in general terms, the kinds of effects which falling death rates are likely to have on the dependency ratios in under-developed countries during the next few decades. The magnitude of the effects, like the magnitude of the mortality changes, will of course differ from country to country.

The assumption of mortality declining alone is probably the more realistic one for the majority of the under-developed countries. Except in southern and eastern Europe, Japan, and some parts of the South American continent, there is little evidence as yet of falling birth rates in most of the under-developed countries. So long as their birth rates remain as high as they now are, there is little prospect of cutting down their high ratios of dependants to producers, and the effect of lower death rates, if anything, will probably be a tendency to raise those ratios a little.

An historical example of this tendency can be found in the demographic statistics of Japan during the period before the 1920's, when the decline of Japanese fertility first became evident. As Dr. Irene Taeuber has shown,[17] between 1888 and 1918—while Japanese mortality rates were being reduced progressively in the course of modernization of the country—the percentages of both children and old people in the population increased gradually so that the percentage of adults 15–64 years old dropped slightly, from about 61 to 59 per cent. If it is assumed that the percentage of economically active males among each age group of the male population was the same both in 1918 and 1888 as it was in 1920, the ratio of male non-workers to workers would have risen from 58 per 100 in 1888 to 62 per 100 in 1918.

The examples cited above indicate that the increase in the dependency ratio brought about by falling mortality is not likely to be very great. Moreover, the favourable effects of improved health for the surviving population, which goes hand in hand with lower death rates, should not be over-looked. Better health may ease the dependency load by improving the productivity of the workers—especially the elder ones—and making some of the partial dependants fully self-supporting. These favourable effects may outweigh the tendency toward a higher ratio of

[15] F. Lorimer, " Dynamics of age structure in a population with initially high fertility and mortality ", *Population Bulletin* (United Nations), No. 1. Document ST/SOA/Ser.N/1. New York, December 1951, pp. 31-41.

[16] If instead, the percentages of economically active males shown by the 1943 census of Jamaica—which were much lower than those for Egypt—are assumed, the result shows higher dependency ratios but about the same changes in these ratios. Lorimer's calculations referred to a population of both males and females, and his results are here applied in a computation relating to males only ; but the error on this account is not great.

[17] The author is grateful to Dr. Taeuber for permission to use here some of the materials which are to be presented in her forthcoming work on Japanese demography.

dependent to productive population which results from falling mortality with constantly high fertility rates. But in this field, as we have already said, statistics fail us and no measures of the relative strength of the opposing tendencies are possible at present.

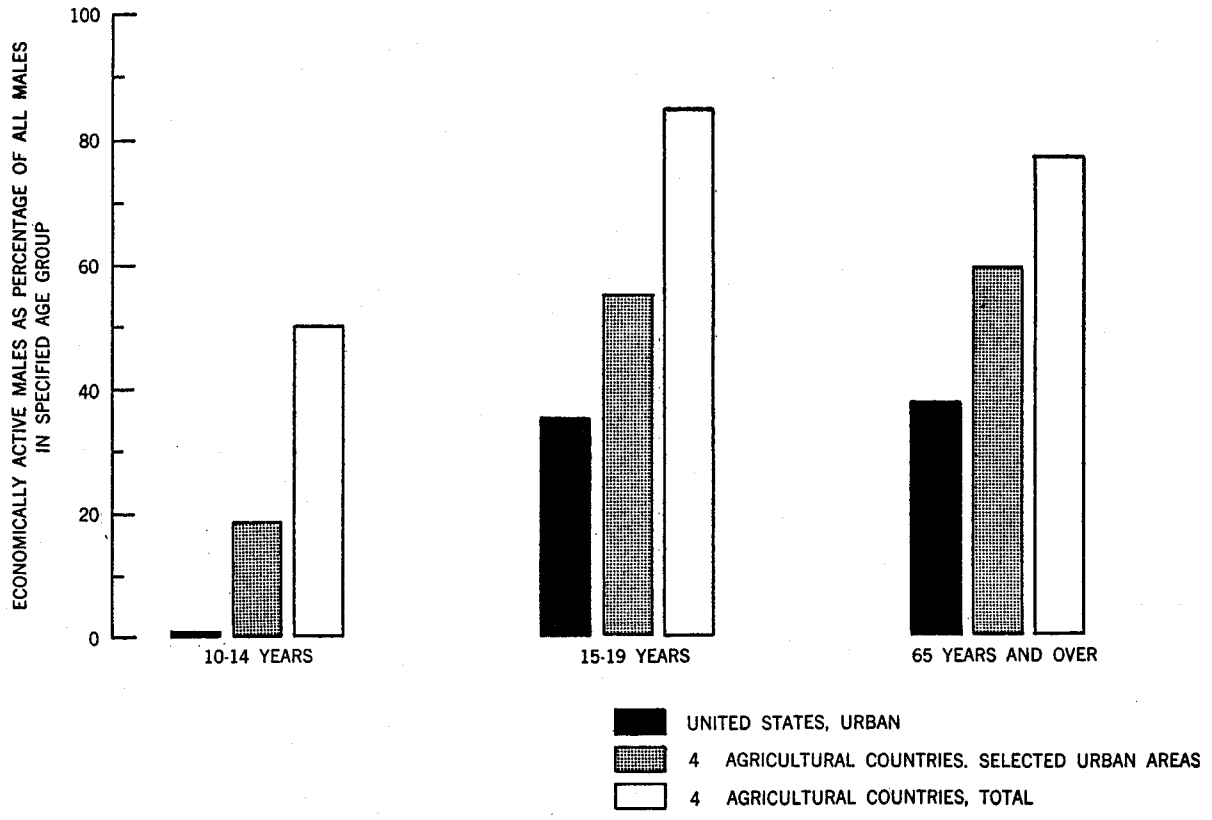
The effects of industrialization and urbanization

Shifts in the age structure, due to falling mortality rates, are not the only factors likely to raise the ratios of dependants to workers in the population of the under-developed countries during the next few decades. In addition, the proportions of children and elderly men who are economically active are likely to fall, in consequence of economic development and urbanization. We have suggested that rurality and low income are the main factors keeping these proportions high in the majority of under-developed countries. If this conclusion is correct, it follows that the development of non-agricultural industries, the growth of cities, and the increase of output per worker will probably be accompanied by shrinking proportions of workers among the population at both ends of the age scale.

There has not been very much study of the relationships between economic development and associated social changes, on the one hand, and the evolution of customs relating to gainful employment, on the other hand. One way of investigating this matter would be to analyse differences in the proportions of workers among the population in various age groups, in different localities of the same country, as shown by census statistics, and to relate these differences to the social and economic characteristics of the localities. Such an analysis could be carried out both for underdeveloped and advanced countries. No doubt it would be found that in some of the more prosperous and highly industrialized sections of certain under-developed countries the patterns of school attendance, employment of young people, and retirement resemble those of economically advanced countries. It has not been possible here to assemble all the necessary data and perform the required computations for such a study. However, the data are shown in table 6 for some cities or groups of cities in some of the under-developed countries, and some interesting relationships that are worth more study can be seen in these figures.

FIGURE 5. PERCENTAGE OF MALES ECONOMICALLY ACTIVE IN SELECTED AGE GROUPS

(Unweighted averages for total population and selected urban areas in 4 agricultural countries compared with urban United States)



Both table 6 and figure 5 indicate very clearly that the percentages of boys under 20 and men over 65 who were classified as economically active were higher in these urban segments of under-developed countries, on average, than they were in the urban part of the United States. Perhaps it was so because the economic situation of the people in even the most prosperous cities of the under-developed countries listed was less favourable than that of the urban population of the United States.

On the other hand, when the figures for the urban areas are compared with the national averages for the countries in which they are located, it appears almost without exception that the percentages of economically active males are lower, age for age, in the urban areas. The differences are most remarkable in the age group 10–14 years, but they are large also in the groups 15–19 and over 65 years of age. Even in the age groups 20–24 and 55–64, the urban percentages are in all cases substantially below the national averages. The inference can be drawn that further urbanization would have a strong tendency to cut down the national percentages of both young and old males engaged in economic activities. This would be the result, not only of the higher levels of living and standards of education which industrialization would make possible, but also of the loss of ready opportunities for gainful employment of children which the shift to an urban social organization involves.

Dependency ratios—numbers of males not economically active per 100 economically active males—for the selected urban areas are shown in table 7. On average, the ratios of dependants are about the same for the urban areas as for the national totals. This similarity is explained, however, only by the fact that the urban areas have a favourable age structure of population, because of the migration of young adults from the countryside to the cities. When the dependency ratios are standardized for age distribution of the male population, they are higher in all cases for the urban areas than the national totals. The amounts by which the standardized urban ratios exceed the national figures indicate how greatly urbanization on a large scale might raise the dependency ratios in some of the under-developed countries, unless the birth rate were reduced.

Here again the Japanese statistics compiled by Dr. Taeuber furnish an instructive historical

TABLE 6. PERCENTAGES OF ECONOMICALLY ACTIVE MALES AMONG ALL MALES IN EACH AGE GROUP, FOR SELECTED COUNTRIES AND SELECTED URBAN AREAS, RECENT CENSUS YEARS

(Percentages obtained by interpolation of figures for different age groups are shown in italics.)

Country and date	Age in years							
	10–14	15–19	20–24	25–34	35–44	45–54	55–64	65 and over
Industrial countries :								
United States, 1940 [a]	1.2 [b]	40.4	88.1	95.1	94.6	92.0	83.9	41.8
Urban areas [a]	.4 [b]	35.6	87.5	95.6	95.2	92.4	82.9	37.6
Semi-industrial countries :								
Portugal, 1940	26.2	75.4	*94.4*	*97.5*	*98.0*	*96.8*	*93.7*	*87.0*
Lisbon city	16.8	65.3	*90.0*	*97.0*	*98.3*	*96.6*	*91.4*	*83.3*
Puerto Rico, 1940 ..	[c]	*53.0*	88.4	93.1	93.9	91.4	82.0	51.1
San Juan city	[c]	*47.4*	85.2	93.0	93.9	90.4	77.3	41.0
Agricultural countries :								
Brazil, 1940	*30.4*	*88.7*	*93.7*	*96.0*	*96.9*	*95.7*	*91.5*	*75.1*
Federal District ..	*13.0*	*48.1*	*82.5*	*91.8*	*92.4*	*88.4*	*78.7*	*46.3*
Turkey, 1945	48.7 [d]	79.9	90.9	93.0	93.6	93.0	88.9	79.0
Cities of 30,000 + .	15.5 [d]	54.3	81.4	90.0	91.3	88.7	77.6	50.8
Egypt, 1937	63.4	82.4	90.7	*96.6*	*98.0*	*97.0*	*94.0*	*85.6*
Cairo Governate, 1947 [e]	31.6	63.8	83.0	94.4	97.0	*95.7*	*87.7*	*71.4*
USSR, 1926	58.0	88.4	97.7	99.0	99.2	98.8	94.8	69.3
Urban areas	13.3	56.4	94.9	98.4	99.0	98.0	91.2	68.3

[a] Figures based on tabulations of a 5 per cent sample of the census returns.

[b] Tabulations on economic activities were limited to the age group 14 years and over. The percentages for age 10–14 were calculated on the assumption that no children 10–13 were economically active, and are therefore minimum figures.

[c] The data tabulated do not permit approximations of the percentages for this age group.

[d] Data were tabulated for the age group under 15 without sub-division. It was assumed that all economically active children under 15 were 10–14; hence the percentages for this age group are slightly over-stated.

[e] In the sources consulted, statistics could not readily be obtained for the Cairo Governate in 1937 nor for all Egypt in 1947.

Sources : See the list of census publications at the end of this paper.

example. They show a downward trend in the percentages of Japanese males under 20 and over 55 years of age engaged in economic activities during the period 1920-1940, when Japan's programme of industrial expansion was proceeding at full speed. These are the figures :[18]

Age group	Percentage of males classified as economically active		
	1920	1930	1940
10–14 years	20.6	14.1	10.1
15–19 years	83.5	78.5	77.8
20–24 years	93.7	91.8	92.9
50–54 years	96.9	95.3	95.5
55–59 years	94.6	91.9	90.7
60 years and over	75.3	71.6	70.9

It is remarkable that the trend for the groups under 20 and over 55 years of age continued downward even between 1930 and 1940, although during this period Japan mobilized her manpower for a major war.

TABLE 7. NUMBER OF MALES NOT ECONOMICALLY ACTIVE PER 100 ECONOMICALLY ACTIVE MALES ; FOR SELECTED COUNTRIES AND URBAN AREAS, RECENT CENSUS YEARS

Country and date	Unstandardized		Standardized for age [a]	
	National total	Urban areas	National total	Urban areas
Industrial countries :				
United States, 1940	65	58 [b]	65	67 [b]
Semi-industrial countries :				
Portugal, 1940	57	39 [c]	39	45 [c]
Puerto Rico, 1940	105	85 [d]	61	67 [d]
Agricultural countries :				
Brazil, 1940	75	72 [e]	39	65 [e]
Turkey, 1945	70	64 [f]	41	64 [f]
Egypt, 1937	54	66 [g]	32	47 [g]
USSR, 1926	54	56 [b]	32	47 [b]

[a] Age distribution of the male population of the United States, 1940, taken as standard.
[b] All urban areas.
[c] Lisbon city.
[d] San Juan city.
[e] Federal District.
[f] Cities of 30,000 and over.
[g] Cairo Governate ; figures for 1947.

[18] Taeuber, I. " Population and labor force in the industrialization of Japan, 1850–1950 ". Prepared for a conference on economic growth in selected countries held on 25–27 April 1952, by the Committee on Economic Growth of the Social Science Research Council. A volume containing the papers prepared for this conference is to be published during the coming winter. The labour force data discussed here will also be presented in Dr. Taeuber's forthcoming book on Japanese demography.

As for the dependency ratio, it rose from an already high figure of 65 inactive per 100 economically active males in 1920 to 70 per 100 in 1930, and was near 71 per 100 in 1940, in spite of the mobilization.

Social and economic significance of the shifting balance of active and dependent population

The data which have been reviewed above point to the conclusion that the numerical relationship between the productive and the dependent population in most of the under-developed countries will become more and more unfavourable in the years to come—unless the trend is halted by falling birth rates. The more progress they make in economic development through industrialization and urbanization, it would seem, the higher the ratio of dependants will rise, at least so far as the male population is concerned.

Of course it does not follow that the governments of these countries should adopt any extreme policies for the sake of enlarging their labour force by bringing dependants into productive employment. It is worth repeating that the dependent students embody a social investment which can be expected to yield future dividends in productivity of labour and in many other ways. In so far as the rising ratio of inactive to active population is due to an increase in the length of school attendance, it is certainly advantageous in the long run. Earlier retirement, within limits, may also contribute to the welfare of the people. Furthermore, in many of the under-developed countries, an enlargement of the labour force would be a dubious advantage so long as the means have not been found to employ their existing labour supply to good advantage.

These things being said, it remains true that the prospect of having to support in the future a still larger number of dependants on the product of each worker has implications for employment policy. It increases the importance of efforts to avoid undue waste of manpower, not only through total or partial unemployment, but also through wasteful employment (for example, excessive employment of domestic servants), voluntary idleness of certain social classes, and traditional restrictions on the activities of women. Equally obvious is the bearing on population policy. Clearly the economic progress of these peoples would be easier if they kept the increase in the number of dependent children to a more moderate size, while adding to their investment in education and health *per capita* of the rising generations. This point seems often to be forgotten in the controversies which arise over the question whether or not various under-developed countries are over-populated.

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Census statistics of the population dependent on various types of economic activities

By JAMES W. NIXON

In this article Mr. Nixon, a former Chief Statistician of the International Labour Office, reviews the difficulties in census enumerations of classifying the economically inactive population by the industry, occupation and status of the persons upon whom they are dependent; and evaluates the recent international recommendations for obtaining such data.

INTRODUCTION

A classification of persons enumerated at a population census into the " economically active " (or the " occupied ", " gainful workers ", " labour force ", etc.) and the " economically inactive " (or the " not gainfully occupied ", " not in the labour force ", etc.) is carried out in most countries, and recommendations have been made by various international bodies to ensure uniformity of definition and comparability of data in this field. In some countries the population is also divided into those dependent on others for support or for their means of livelihood, and those who are not dependent on others. This concept is confined almost entirely to the countries of continental Europe, which not only classify the whole population by dependency, but give the numbers dependent on different industries or occupations and on different status groups (employers, employees, etc.). Such data are usually derived from the census schedules, not by means of a special question on dependency, but by tabulating the replies to the questions on economic activity and inactivity according to certain rules and conventions.

The Population Commission of the United Nations attached importance to the question of obtaining data on persons dependent on various economic activities, and adopted recommendations on the subject both at its third session in May 1948 and at its fourth session in April 1949.[1] The text of these recommendations is given later.

Since the adoption of these recommendations the United Nations has issued two general studies in which this subject is discussed.[2] These studies, while giving some useful information on the problems involved and on the methods adopted in different countries, do not deal with all the methodological aspects of the subject and are inclined to minimize the difficulties encountered; nor do they give any statistics in illustration of the methods proposed, or of the practices adopted in the different countries.

The objects of this article are to discuss, in greater detail than has been done hitherto, the problems involved in classifying the population by dependency; to examine the methods proposed by the Population Commission, particularly for classifying the inactive population according to the activities on which they are assumed to be dependent; and to illustrate these by using the actual statistics on this subject, compiled by the different countries.[3]

Concept of dependency

It is desirable, at the outset, to discuss the meaning of " dependency ", owing to the different uses of the terms " dependant ", " independent ", etc., in the census statistics of various countries and in different languages. In the English language, the term " dependant " in population studies generally refers to one who derives his support or means of livelihood from some other person and not from his own exertions. The complementary term " independent ", however, does not mean one who derives his means of livelihood from his own efforts, but is confined to those who derive it from property, pensions and the like. For the class of persons who are not dependants, there is no accepted term in English. The term " earner " is not satisfactory, as the class includes persons living on so-called " unearned " income, though the terms " earners " and " dependants " are sometimes used, especially in family living surveys where they are more appropriate. The

[1] United Nations. *Report of the Population Commission (third session)*. Document E/805. New York, 1948; *Report of the Population Commission (fourth session)*. Document E/1313. New York, 1949.

[2] United Nations. *Population census methods*. Document ST/SOA/Ser.A/4. New York, 1949; *Application of international standards to census data on the economically active population*. Document ST/SOA/Ser.A/9. New York, 1951.

[3] Listed below are the countries which compile dependency statistics for different economic activities along with the date of the latest census from which tabulations were available at the time of writing: Austria (1934), Bulgaria (1934), Czechoslovakia (1930), Denmark (1940), Finland (1940), Germany (1939), Hungary (1941), Italy (1936), Luxemburg (1935), Norway (1946), Poland (1931), Portugal (1940), Romania (1930), Sweden (1945), Switzerland (1941), Yugoslavia (1931), and Chile (1940). With one exception, all are in Europe.

term " income-recipients " is also not acceptable, since dependants may receive an income; the term " breadwinners " is used in one English-speaking country (Australia).[4,5]

Dependency in the sense of being supported by others is not a definite attribute like economic activity. The definitions being given, a person usually can be classified as either " active " or " inactive "; differences of classification may arise, for example, in the case of members of a family engaged both in domestic duties and in assisting the head in his undertaking, or persons engaged both in domestic duties and part-time paid activity, and other small groups, but the majority can be attributed to one group or the other, without great difficulty.

A person is not necessarily either a supporter or a dependant, however; there are degrees of dependency. Many parents help support active children during years when the children's earnings are low; on the other hand, children often contribute towards the upkeep of ageing parents whose incomes are declining. Elderly persons, for example widowers, although in receipt of ample means of support from pensions, capital, etc., may live with their married or unmarried children and contribute to their support. Many part-time workers are partially dependent on others though " active ".[6] The financial and economic characteristics of members of a household which contains persons other than the simple family of parents and dependent children are interrelated. Family incomes may be pooled, and children may be dependent on the collective activity of the family members. Only for the group of children of pre-school age is the notion of dependency unambiguous —the number of children in receipt of incomes in their own right being negligible—and this is perhaps the reason why reports on dependency in the censuses of certain countries have been confined to dependent children (e.g., England and Wales census of 1921, Australian census of 1933). The statistics of the total population divided into those who are and those who are not dependent must be regarded, therefore, as approximations if they are based solely on answers to questions regarding economic activity (e.g., whether engaging in an occupation). If questions relating to income are also asked at the census, the replies may enable doubtful cases to be put into one group or the other with more certainty, but few countries ask this question, and those which do (e.g., Canada 1941, Australia 1933, United States 1940) do not use the replies for this purpose.

By an extension of the notion of dependency on an individual for support, the term dependant is also used to mean those " dependent on an economic activity ", or in the words of the Population Commission those who " derive support from various economic activities ". A classification of the population of this nature involves determining the activity in which each active person is engaged and allocating inactive persons to the economic activity of those on whom they are dependent.

The word " dependant " or its equivalent in the different censuses may thus mean dependence of one person on another for support, dependence of an individual (active or inactive) for support on a given economic activity, or dependence for means of livelihood on receipt of wages or salary. This paper is concerned only with the statistics which correspond to the first two meanings. In the following paragraphs the term " non-dependant " is used in the absence of an accepted term in English to include those who are excluded by the term " dependant "; " non-dependants " thus consist of the economically active and persons who derive their income or means of support from pensions, interest, rent or independent sources.

Object and scope of census statistics on dependency

General statistics

The object of statistics of dependency is nowhere mentioned in the recommendations of the Population Commission, nor is much light to be found on the subject in the population census publications. Classifications of the *total* population into dependants and non-dependants (where the question of classifying dependants by economic activities does not arise)[7] are of use in showing the extent to which part of the population is supported by others at different census dates and in different regions of the country; and if the dependants are

[4] Australia, it might be added, classifies both breadwinners and dependants into " with income " and " no income ".

[5] The term " independent " is used in a completely different sense in some censuses. In a large number of European countries, it is assigned to the group consisting of employers and persons working on their own account to differentiate them from persons dependent on wages and salaries. Thus, in the census of Germany the term *Selbständig* is used to refer to the self-employed group, while in the census of Italy (1936), the terms used are *indipendenti* and *dipendenti*—the former covering employers, artisans, and the liberal professions, and the latter employed persons.

[6] In Great Britain, according to the census of population of 1951, over 600,000, or about 25 per cent, of the total number of economically active married women (approximately 2½ million) were part-time workers. These figures may be understated, however, since the statistics of national insurance for the same date include 3 million married women employees. It is possible that many married women failed to report their part-time employment on the census forms.

[7] Two countries, Australia and the Union of South Africa, classify the total population into dependants and non-dependants, without any further classification of dependants according to the economic activities on which they depend.

TABLE 1. TERMINOLOGY FOR STATISTICS ON DEPENDENCY USED IN VARIOUS POPULATION CENSUSES *

Country and date	*Non-dependants*	*Dependants*
Austria (1934)	Berufsträger und selbständige Berufslose	Hausfrauen und sonstige Angehörige
Bulgaria (1934)	Active	Passive
Chile (1940)	Activa	Inactiva (y desocupados)
Czechoslovakia (1930) .	Actifs dans la profession et membres aidants de la famille	Membres de famille sans profession et domestiques
Denmark (1940)	Active	Service domestique privé ; enfants non établis
Finland (1940)	Chefs de famille, personnes indépendantes, autres membres de la famille	Autre population sans profession et domestiques
Germany (1939)	Erwerbspersonen und selbständige Berufslose	Angehörige ohne Beruf
Hungary (1941)	Active	Passive
Italy (1936)	Produttivi	Improduttivi ; Domestici
Luxembourg (1935) ...	Individus actifs et chômeurs	Membres de famille
Norway (1946)	Personnes principales	Personnes secondaires
Poland (1931)	Active	Passive
Portugal (1940)	Chefs de famille	Personnes à leur dépens
Romania (1930)	Active	Passive
Sweden (1945)	Not given a collective title	Not given a collective title
Switzerland (1941)	Ayant une activité économique	Personnes qui en dépendent sans activité économique.
Yugoslavia (1931)	Personnes exerçant la profession et gens de maison	Personnes entretenues
Australia (1933)	Breadwinners	Dependants
Union of South Africa (1936)	Gainfully occupied and Independent	Dependent

* The terms are given in French for those countries which show French titles in their census publications.

Sources : See list of sources of census data at the end of this paper.

classified by sex and age, the statistics are useful in indicating the burden of childhood and old age dependency, as well as in suggesting the probable trends of such burdens. Approximate data can be obtained from the classification by " active " and " inactive " if the latter are subdivided so as to show who may be considered as " non-dependent " and who are " dependent ".

The classification of the population into " non-dependants " and " dependants ", as well as into " active " and " inactive " involves, therefore, a fourfold classification which may be represented as follows :

Non-dependants :		Dependants :	
Active	(A)	On active ...	(C)
Inactive	(B)	On inactive ..	(D)

The usual classification into active and inactive, as adopted by many countries and as recommended by the Population Commission, is into A (active) on the one hand, and the rest of the population (B + C + D) on the other. The classification of the population into non-dependants and dependants, however, is into A + B and C + D and therefore requires that the inactive be split into three groups, B, C and D.

The totals A + B, and C + D are given in all except one of the countries covered by this survey ; the terms used for these concepts in each of the countries are given in table 1 and the actual figures for six countries are given in table 2.

It will be noted from table 1 that the term " active " is used for the entire group of non-dependants (including those not exercising an occupation) in about half the countries. Table 2 shows that the size of group B (inactive non-dependants) is not negligible, amounting to about 18 per cent of all non-dependants in Austria, about 14 per cent in Germany, Denmark, Norway and Sweden, and about 8 per cent in Switzerland.

TABLE 2. STATISTICS ON DEPENDENCY FOR CERTAIN COUNTRIES

(Figures in thousands)

	Non-dependants	*Dependants*	*Total*
Germany 1939			
Total	46 491.4	30 816.3	77 307.7 [a]
Active	39 792.3	27 920.0	67 712.3
Inactive	6 699.1	2 896.3	9 595.4
Switzerland 1941			
Total	2 156.0	2 020.1	4 176.1 [b]
Active	1 992.5	1 935.4	3 927.9
Inactive	163.5	84.7	248.2
Austria 1934			
Total	3 753.6	3 006.6	6 760.2
Active	3 066.8	2 676.5	5 743.3
Inactive	686.8	330.1	1 016.9
Denmark 1940			
Total	2 052.3	1 792.0	3 844.3
Active	1 754.7	1 669.9	3 424.6
Inactive	297.6	122.1	419.7
Sweden 1945			
Total	3 514.5	3 159.3	6 673.8
Active	2 987.9	2 944.4	5 932.3
Inactive	526.6	214.9	741.5
Norway 1946			
Total	1 526.4	1 614.4	3 140.8
Active	1 308.1	1 532.6	2 840.7
Inactive	218.3	81.8	300.1
Condition unknown	8.1	8.0	16.1

[a] Plus 764.5 thousand inmates of institutions, etc., not classified.

[b] Plus 89.6 thousand inmates of institutions (and others) not classified.

Sources : See list of sources of census data at the end of this article.

Dependency on different economic activities

The problem of classifying the population according to dependency on various economic activities—the chief subject of this article—is more complex than that of dividing the population into the broad categories discussed above. Little has been said in the census publications of countries compiling such statistics regarding the purposes these data are intended to serve, and few countries, so far as can be ascertained, compare and analyse the figures for different economic activities or attempt to explain the differences, some of them very great, in the dependency ratios for different industrial or occupational groups. With regard to the uses of the data, the United Nations has stated as follows :

> " It is useful . . . to have information on the number of people who derive their livelihood from each type of economic activity, including dependants as well as the workers themselves. Such data can readily be obtained as a by-product of a census enumeration of the economically active population, and are valuable for a variety of economic, sociological and demographic analyses. As a means of characterizing the population of a country or area from an economic or social point of view, these data are more appropriate than statistics limited to the economically active population . . . The data have also certain specific uses to which statistics for the economically active population are not at all applicable ; for example, they may be used to compare the average number of dependants per worker in different industries or occupations, in connexion with investigations of the adequacy of earnings." [8]

In a later United Nations publication it was also stated :

> " The purpose of applying the three classifications [industry, occupation and status] to the inactive population, in addition to the active population, is to obtain information on the number of persons who depend for their livelihood upon different types of economic activities. Such data, for certain purposes, can provide a better description of the population's economic and social characteristics than statistics on the economically active population alone. The average number of dependants per worker is likely to differ among the various branches of activity, and it is important to know how living standards, educational status, fertility and mortality, patterns, etc., may differ among the families of workers in various occupations and industries." [9]

The purposes of the dependency statistics are thus stated for the most part in very general terms,[10] the only specific uses mentioned being

[8] United Nations. *Population census methods, op. cit.*, p. 145.

[9] United Nations. *Application of international standards to census data on the economically active population, op. cit.*, p. 28.

[10] These studies of the United Nations also give special attention to the desirability of statistics of persons dependent on agriculture. In this branch of economic activity, there are undoubtedly special circumstances which make it desirable in many countries to compile statistics of this nature. The distinction between " active " and " inactive " is much less marked in this branch where all members of the family may to some extent be engaged in agricultural activities in addition to their domestic duties. Some countries have confined their statistics on dependency to agriculture, or have adopted special methods of approach through agricultural censuses, enumeration of the number of persons living on farms, of the rural population, etc. Information on these methods is given in United Nations, *Population census methods, op. cit.* Ch. XIV. The Population Commission, moreover, made separate recommendations on the subject of dependency on agriculture. This article, however, is confined to questions of method and tabulation common to all economic activities and therefore does not deal with problems peculiar to agriculture.

" to compare the average number of dependants per worker . . . in connexion with investigations of the adequacy of earnings ", and " for studying living standards, educational status, fertility and mortality patterns " among workers' families in various industries and occupations.[11] It is no doubt of value to have information on the average number of dependants per worker for different social and economic groups and perhaps still more valuable to have information on the number of dependants which a household head (rather than a " worker ") has to support. How far the data available can and do in fact supply this information is discussed below.

Methods of compiling dependency statistics

The usual method of compiling these statistics is to consider all the active population grouped by industries or occupations as non-dependent and to identify among the inactive those who are non-dependent and those who are dependent, classifying the latter according to the economic activity of the head of the household in which they are living. The recommendations on this subject made by the Population Commission in 1948 and 1949 are as follows :

> " Statistics on this subject should include the economically active population classified by industry, occupation, and industrial status, and dependents classified by industry, occupation, and industrial status of the workers upon whom they depend. Classifications by industry are recommended as especially important in data of this type.[12]
>
> " For this tabulation [i.e., the number of persons of each sex, including persons economically active and their dependants, who derive support from various economic activities] persons not economically active should be allocated to the industry and . . . status of the head of the household . . . Persons not dependent on any industry should be shown separately and divided into at least three categories :
>
> " (i) Inmates of penal, mental, and charitable institutions.
>
> " (ii) Household heads who are unemployed and have not previously been in work, together with their dependants.
>
> " (iii) Other independent persons with their dependants.
>
> " When the questions on the schedule permit it, category (iii) may be divided into (iii–a) persons living on interest, dividends and rent and (iii–b) others (i.e., pensioners, etc.)." [13]

According to the Commission's proposal, the activity of the head of the household is the key to the classification of the household members, and the method therefore assumes (1) that the head of the household is readily identified on the census schedule, (2) that all inactive persons returned on the same schedule are dependent on the head of the household and (3) that all active persons who are not heads of households have no persons dependent on them. This method, which apparently has been used by most of the countries compiling such statistics, is arbitrary, but simple to apply, as United Nations studies have pointed out.[14] In fact, the simplicity of the method probably explains its adoption by the Population Commission.[15] No special questions are required on the census schedule, since the proposed tabulations can be based on the data collected from the usual questions on composition of the household and economic activity. It is doubtful, however, whether such a simplification of the problem gives meaningful results. Difficulties may be encountered in applying the recommended methods to some of the following groups.

1. *Heads of households.* It is often difficult to determine which member of a household should be designated as the head ; and, in addition, the definition of a census household or census family differs from country to country. " Lodgers " and married children living with their parents—both important groups in some countries—may or may not be counted as separate households. The nominal head may not be the chief breadwinner, but may even be dependent on others in the household (for example, an elderly father with adult children). These difficulties are to some extent recognized in the United Nations studies and need not therefore be enlarged upon ; but there are others which are not fully recognized.

2. *Persons living in non-private households.* The recommendations assume that all persons live in " households ", whereas a number of people both active and inactive live in hotels and boarding houses, in schools and colleges, in institutions, in barracks, on ships and barges, and census schedules are completed for these units. The concepts of household and head of household are normally not applicable to such units. This group of persons is not insignificant in number.[16] In certain types

[11] As regards mortality, it is difficult to see how the census data on dependency can throw any light on these subjects unless data are also available on dependants who have died classified by the economic activity on which the deceased were dependent.

[12] United Nations. *Report of the Population Commission (third session), op. cit.*, p. 20.

[13] United Nations. *Report of the Population Commission (fourth session), op. cit.*, p. 36.

[14] United Nations. *Population census methods, op. cit.*, p. 149.

[15] United Nations. *Application of international standards to census data on the economically active population, op. cit.*, p. 29.

[16] In Great Britain (census of 1951) 2,404,000 persons were, it is estimated, enumerated in such establishments, known as non-private households. Great Britain,

of non-private households, moreover, employed persons frequently live on their employer's premises and appear on his census schedule ; their dependants who are living elsewhere will therefore appear on another census schedule. In establishments such as hotels, inactive residents, as distinct from the staff, cannot be classified to the economic activity of the " head of the household ", even if such a person could always be identified.[17] The method of dealing with this group of persons is not explained, so far as can be ascertained, in any of the census reports, and it is therefore difficult to interpret the figures shown for the group " hotels, etc. " which appear in table 3 later in this article.

3. *Lodgers.* This category of persons has already been referred to above. Economically active lodgers may have dependants living elsewhere and, hence, shown on a different census schedule. On the other hand, the person responsible for the support of inactive lodgers (students, for example) is usually not the head of the household in which they are living, but rather a relative living elsewhere and shown on a different schedule. The category of lodgers is not insignificant in number.

4. *Domestic servants.* Domestic servants residing in the households of their employers are usually tabulated, in the censuses of the countries with which we are concerned, according to the economic activity of their employers, and included either with the group of " dependants " or shown as a separate group. These persons are, in fact, a special case ; they are economically active and yet are dependent for board and lodging on their employer, and are considered in some countries as engaged in domestic duties, along with the housewife. According to the recommendations of the Population Commission, they are to be included in the active population and classified as dependent on domestic service industry.

The method followed in most censuses for distributing dependants by economic activity is thus to allot them to the economic activity of the person adjudged to be the head of the household in which they are enumerated on the census day. This method has simplicity to recommend it but little else. Accurate classifications may be achieved through this method in the case of families consisting of an economically active head and a dependent wife and children, or in families where the active members other than the head have no dependants, or where the active family members (other than heads of households) follow the same economic activity as the head, as often happens in agriculture and among artisans and shopkeepers who employ only members of their family. But such families, except perhaps in predominantly agricultural and under-developed countries, are in a minority. A large proportion of households contains, in addition to the head, other active members and their dependants [18] and the economic activity of these other workers is frequently different from that of the head of the household. The United Nations studies admit that " in a country where the employment of members of the same household in different industries is very common, the result may be a considerable distortion ".[19] In the earlier study of census methods, however, it was stated that :

> " The validity of the results depends largely on the proportion of cases in which two or more members of the same household are engaged in different types of economic activities. This proportion is likely to be fairly small in most areas, and in many areas it can be considered insignificant. " [20]

This last statement is surely too sweeping and is not borne out by the evidence available. Statistics on the economic activities of the different members of a household are not available in population census reports, but indirect evidence is available as well as evidence from social surveys, and family living studies. Statistics on the occupations and industries of males and females are available for many countries, and in some of them married males and married females are separately distinguished. For example, in the 1940 census in the United States, occupation statistics are given for married males living with their wives

General Register Office, England, and General Registry Office, Scotland. *Census 1951. Great Britain. One per cent sample tables.* Parts I and II. London, 1952. In Germany (census of 1939) 3,477,000 persons are not included in the statistics of households. Germany, Statistisches Reichsamt. *Volks-, Berufs- und Betriebszählung vom 17. mai 1939. Berufszählung. Die Berufstätigkeit der Bevölkerung des Deutschen Reichs.* Statistik des Deutschen Reichs, Band 556. Berlin, 1942. In the case of both Great Britain and Germany, the proportion of persons outside private households amounted to about 5 per cent of the population.

[17] In Switzerland, however, " temporary guests in hotels, and patients in hospitals although enumerated at the place they stayed at on census day are transferred home and figure in the household they usually belong to " (Letter from Swiss Federal Statistical Office). It is doubtful, however, if other countries adopt this practice which requires the exact permanent address of the person temporarily absent (or of the person temporarily present) to be given on the census schedules.

[18] In all countries, the number of active persons is much greater than the number of households. In England and Wales, at the time of the census of 1931, the " average household ", it is estimated, contained 1.86 non-dependants (and 1.87 dependants) ; the census of 1951 shows that nearly 50 per cent of all households contained 2 or more earners. Great Britain, General Register Office, England, and General Registry Office, Scotland. *Census 1951. Great Britain. One per cent sample tables, op. cit.,*

[19] United Nations. *Application of international standards to census data on the economically active population, op. cit.,* p. 29.

[20] United Nations. *Population census methods, op. cit.,* p. 149.

and for married wives living with their husbands; in Great Britain, statistics are available from the national insurance scheme on the number of married female employees and adult male employees by industries. These statistics are too detailed to reproduce, but both show considerable differences in occupational and industrial distributions of the wives and husbands. In the United States, 12.0 per cent of the employed married men were classified as clerical and sales workers, whereas 26.0 per cent of the married women belonged to this group; 16.6 per cent of the married men were classified as craftsmen, and only 1.3 per cent of the married women were so classified. In Great Britain, 5½ per cent of the married female employees were in building transport, vehicles and mining activities, whereas about 33 per cent of the adult male employees were so engaged; 16½ per cent of the women and 4.5 per cent of the men were employed in textiles and clothing. No information is available to indicate to what extent children follow the occupation or industry of their fathers. It is more than likely, however, that in most non-agricultural households containing several active members, the wife and active daughters and probably the active sons do not follow the same activity as the head.

Another consideration is that of the increasingly important part played by women in the economic activity of many countries. In the United States, about 17 per cent of all married women were in the labour force at the time of the 1940 census, and by 1951 the proportion had increased to more than one-fourth.[21] In Great Britain, the statistics of national insurance show that 25 per cent of the married women are working for wages or salaries.[22]

In the allotting of all inactive persons in the household to the economic activity of the head of the household, the result must therefore necessarily be a " considerable distortion ". These persons are in many cases dependent for support on the joint resources of the household, which determine its standard of living.

The method usually adopted gives rise to another distortion, which has already been mentioned, namely that all persons in a given economic activity are grouped together, irrespective of whether they have dependants or not. The number of persons dependent on the clothing industry, for example, is arrived at by adding together (1) the identifiable heads of households who are enumerated in this industry; (2) the inactive persons in these households who appear on the same census schedule; and (3) all persons other than household heads enumerated as economically active in the clothing industry. It therefore follows that the number of dependants is inflated in those activities in which there are fewer active persons who are not heads of households and diminished in those activities in which there are many active persons not heads of households. It should be noted that in each occupational or industrial group, the majority of adult males classified to that activity are active, while the proportion of adult females who are active varies considerably in the different industries—from a very low figure in mining and building, for example, to a very high figure in textiles, clothing, education. Therefore, the relative number of dependants on an economic activity should show an inverse correlation with the relative number of active females in that activity.

Average number of dependants per worker

It will be remembered that one of the chief uses of statistics of dependency on economic activities as stated in United Nations publications was to show the differences among the various branches of activity of the average number of dependants per worker, and a specific use of these figures was stated to be " to compare the average number of dependants per worker in different industries or occupations, in connexion with investigations of the adequacy of earnings ".[23] It is therefore of interest to examine the available data from this point of view.

The statistics cannot yield a precise measure of the average number of dependants per worker, in a given industry, since the denominator of this fraction is the total number of active persons, and the numerator is the number of inactive persons only in the households whose head is in the given industry.

The ratio of dependants to non-dependants on this basis, however, is of interest, but it is noteworthy that very few countries use their data to compute this ratio. Austria, Germany and Norway express their data in various forms of percentages, but do not apparently comment on the differences; the other countries make no calculations of ratios or percentages. The basic data are available in great detail for many countries, and any attempt to give a full analysis would be prohibitive. Figures were therefore selected for this purpose for six economic activities, three in which female employment is very low (mining, transport and construction), two in which it is high (textiles and clothing), and one, the hotel industry, which is subject to the difficulties of census treatment as

[21] The 1940 figure is based on revised census figures published in United States Bureau of the Census, " Marital and family characteristics of the labor force in the United States: April 1949 ". Series P-50, No. 22. Washington, 1949. Data for 1951 are from a sample survey of the population. See United States Bureau of the Census, " Marital and family characteristics of the labor force in the United States: April 1951 ". Series P-50, No. 39. Washington, 1951.

[22] Great Britain, Ministry of Labour. *Ministry of Labour Gazette.* Vol. LX, No. 9. August 1952.

[23] United Nations. *Population census methods, op. cit.*, p. 145.

TABLE 3. RATIO OF " DEPENDANTS " TO 100 " NON-DEPENDANTS " IN CERTAIN INDUSTRIAL OR OCCUPATIONAL GROUPS

Country and date of census	*Mining*	*Construction*	*Transport and communications*	*Textiles*	*Clothing*	*Hotels, etc.*
Austria, 1934	171	138	156	55	59	64
Bulgaria, 1934	176	170	218	68	111	—
Chile, 1940	180	176	233	81	73	205
Czechoslovakia, 1930	196	136	189	50	51	92
Denmark, 1940	—	148	118	38		47
Finland, 1940	207	136	140	38	51	27
Germany, 1939	172	122	130	48	42	33
Hungary, 1941	201	160	168	62	85	—
Italy, 1936	181	150	176	90	117	89
Luxembourg, 1935	200	154	195	62	69	39
Norway, 1946	—	—	120	—	—	32
Poland, 1931	221	175	239	98	113	83
Portugal, 1940	313	284	274	237	237	—
Romania, 1930	—	158	192	93		—
Sweden, 1945	156	139	106	49		28
Switzerland, 1941	152	136	148	66	49	37
Yugoslavia, 1931	154	154	194	66	86	115

Sources : Computed from census data given in the sources listed at the end of this article. A series of tables showing the actual census figures on which these computations are based is available in mimeographed form and will be supplied by the Population Division of the United Nations upon request.

a " household ", as described above. Table 3, above, shows the number of " dependants " per 100 " non-dependants " in each of these groups. A number of factors adversely affect the comparability of the data for different countries. In some countries, domestic servants are included with dependants; in others they are not. The treatment of the unemployed is likewise not the same in all the countries. Furthermore, the scope of the activities also may differ from country to country. For example, under the column heading " transport and communications " the actual industrial coverage varies—the ratios for some countries referring only to transport, while those for other countries cover both transport and communications. Other differences in coverage result from the fact that for some countries the data relate to industrial groups, but for other countries to occupational groups. The figures for each country, however, are comparable horizontally.

These percentages bring out clearly the high ratios of dependants to non-dependants in mining, construction and transport, and the lower ratios in textiles and clothing. It will be noted that for each country the figures for the first three groups are higher—usually considerably higher—than the figures for the other two. It is to be expected that the dependency ratio would be high for the first group—mining—since employment opportunities for women are likely to be few in an area where mining is the major industry. On the other hand, the ratios for textiles and clothing are expected to be low, since employment opportunities for women are plentiful in these activities. That the number of " dependants per worker " is two to three times as high in mining, construction and transport as in textiles and clothing, however, is open to doubt, and it seems likely that the differences are exaggerated by the methods used in compiling the statistics. It is interesting to note, however, that the ratios for Hungary follow substantially the same pattern as those for the majority of other countries although a more exact procedure whereby each dependant was asked to state the activity of the person who supported him, was used in the 1941 census of that country.

For Germany, the report on the census of 1933 gives a table showing for each industrial group the percentage of active female employees to active male employees, and the percentage of inactive family members to active members (roughly dependants per 100 non-dependants). The table is too detailed to present here, but figures are shown below for the six industries having the highest percentages of active females and the six having the lowest percentages : alongside these are given the proportion of inactive to active family members. It will be seen that the two lists are almost identical.

TABLE 4. GERMANY : CENSUS OF 1933

Female employees per 100 employees (in ascending order)		*Inactive members of the family per 100 employees (in descending order)*	
Construction	1.0	Coal mining	180.4
Coal mining	1.1	Post and railways	170.6
Iron mining	2.6	Gas, water, electricity	158.8
Gas, water, electricity	3.4	Iron mining	147.8
Post and railways .	3.9	Earth and stone ..	132.5
Earth and stone ...	11.4	Construction	125.8
Food, etc.	25.0	Food, etc.	60.0
Agriculture	35.2	Agriculture	54.0
Health services	42.6	Health services ...	49.2
Textiles	56.3	Textiles	51.5
Hotels, etc.	57.1	Hotels, etc.	35.3
Clothing	58.3	Household services	34.5

Sources : Germany, Statistisches Reichsamt. *Volks-, Berufs- und Betriebszählung vom 16. Juni 1933. Die berufliche und soziale Gliederung des Deutschen Volkes.* Statistik des Deutschen Reichs, Band 458. Berlin, 1937, p. 43.

The figures for the hotel industry are given in table 3 to illustrate the case of " non-private households " already referred to, where active employees may live on the employers' premises while their dependants live elsewhere, and where the residents (active or inactive) may be temporarily absent from their usual dwelling places. As is to be expected, the numbers of dependants per 100 non-dependants are very low, with the exception of those for Chile and Yugoslavia. It would seem that the usual method has not been applied in these cases, but unfortunately details of the methods adopted for enumerating and tabulating this category of persons are not available for any country other than Switzerland.

The figures for Portugal, it will be noted, are exceptionally high for all groups of activities, owing to the fact that they show the number of dependants in relation only to the number of household heads, other active members of the household being excluded from the computations. The figures for Italy, moreover, are not compiled according to the usual method : they include members of the family temporarily absent and exclude those temporarily present.[24]

Treatment of special categories of the population

The unemployed. No reference has yet been made to one class of the population—and numerically a very important one in many pre-war censuses—the unemployed. Persons reporting themselves as unemployed at a population census are usually included in the active population, and in many censuses are classified according to their former occupation and industry ; this procedure has also been recommended by international bodies. In applying the concept of dependency, however, it might be argued that since the majority of the unemployed probably have very small resources of their own to fall back upon, and may depend for their livelihood on relatives, or on public or private relief, they should be considered as dependent. Perhaps for such reasons at least two of the countries—Chile and Portugal—included all of the unemployed in the inactive or dependent group, and Italy included part of the unemployed in this group. In the census of 1933 in Australia where " dependants " are defined as " all persons dependent on public and private support ", the 481,000 persons recorded as unemployed are included with " breadwinners ". Yet, of these, 213,000 reported no income during the previous twelve months.[25]

No specific reference to the treatment of the unemployed in dependency tabulations is contained in the recommendation of the Population Commission, except for the group of unemployed who have never worked before. However, since the Commission recommended that the unemployed are to be included in the active population, and the United Nations studies suggest that those with previous work experience be classified according to the occupation, industry and status of their " usual, most recent, or last regular employment ",[26] it is the intention that they be classified with non-dependants and distributed by economic activities in dependency tabulations. As the unemployed who have never worked before cannot be allocated to any occupational or industrial group, the Population Commission proposed that they be shown as a separate group.[27]

The practice followed by most countries in past censuses has been either to include the inexperienced unemployed in a residual group, such as " occupation (or industry) indefinite or not stated ", or, if the unemployed are tabulated separately by economic activity, to include them under a heading such as " unemployed, occupation (or industry) not stated ". Very few censuses show separately the unemployed who have not previously worked ; two censuses which do are those of the United States (1940) and Italy (1936). The former includes them in the labour force (i.e., the active

[24] Italy includes in the classification of dependants by economic activity only the members of those families whose heads were present at their usual residences on census day.

[25] Australia, Commonwealth Bureau of Census and Statistics, *Census of the Commonwealth of Australia, 30th June 1933.* Vol. II, Part XXVI. Canberra, 1937.

[26] United Nations. *Application of international standards . . ., op. cit.*, p. 26.

[27] The Commission actually proposed that " household heads who are unemployed and have not previously been in work, together with their dependants " be shown as a separate group, but the Secretariat, noting that this recommendation failed to take account of the unemployed without previous work experience who were *not* household heads, suggested that it be expanded to cover all unemployed who had not previously worked and their dependants.

population), while the latter includes them in the inactive (and " unproductive ") population. This category of persons consists very largely of persons who have just left school or college and are awaiting their first jobs. In the United States census they are defined as having " not previously worked full-time for one month or more and seeking work ", and numbered 767,000, of whom 488,000 were under 20 years of age.[28] In the census of Italy, they are described as " persons awaiting their first jobs ", and numbered 767,000, of whom 373,000 were under 20 years of age; of these 1,549 are given as " family heads ".[29]

From the above figures it is clear that only a small proportion of the first job seekers are likely to be heads of households. Most of these persons are dependent on others for support. For example, a youth who has just left school and is hoping to find employment is very often dependent on his father for support to the same extent as are his brothers still in school. Therefore, the shortcomings of international recommendations in dealing with this group are obvious. It would seem that a more accurate classification could be obtained by classifying those inexperienced unemployed who are not household heads according to the activity of the head of the household.

Persons of independent means. Some questions can also be raised regarding the third group of persons not dependent on any industry or occupation which the Population Commission proposed to identify separately, namely " other independent persons with their dependants ". Strictly speaking, this group should be confined to heads of households with independent income and their dependants, since the Commission recommended that all inactive persons (including those of independent means) who are not heads of households are to be allocated to the economic activity of the head of the household in which they live.[30] This proposal assumes that the latter group, i.e., those who are not household heads, have no dependants.

The treatment of persons who state that they are retired, in receipt of a pension, living on capital, rents, etc., is, in fact, difficult. A retired person may have no income of his own, or he may have a substantial pension or other income; a pensioned person may have a pension ample for support of himself and dependants, or he may have a small private or state old-age pension, necessitating his being supported by relatives or through other means. Such terms as " retraités ", " pensionnés ", etc., which occur frequently in the census reports of the countries here considered, may connote any degree of dependency and non-dependency from the affluent and " well-off " (completely non-dependent) to the poor or even destitute (completely dependent). The recommendation of the Population Commission is that all persons of these categories, whatever their income (unless they are identified as heads of households) should be treated as dependent on the head of the household with whom they are living, although, in fact, they may be helping to support other family members. As censuses do not inquire into the amount of the resources of persons who return themselves as retired, or whether they have any resources at all, the resulting classification is arbitrary.

None of the countries covered in this article indicates the procedure it has adopted in classifying persons of independent means who are not reported as heads of households, and no statistics are available in any country on the numbers of persons of independent means who are heads of households and those who are not. It is possible that in some censuses all persons of independent means are considered automatically as household heads, a rather arbitrary assumption, since many of these persons (for example, pensioned widows living with their married children) are unlikely to be regarded as heads of their households by the other family members.

It might also be argued that persons who draw pensions from their former employment (banks, railway companies, corporations, etc.) should be considered, for the purpose of these statistics, as dependent on these economic activities along with the present employees of these establishments. Special questions would, of course, be required in the census to obtain the information necessary to apply this procedure.

In view of the large number of persons who now, in many countries, receive State old-age pensions, the concept of persons living on their own means or on retirement pensions is changing. Persons in receipt of State old-age pensions under a social insurance scheme are sometimes classified as in receipt of relief, charity, or State support; sometimes they are classified with persons on private pensions or those living on their own means from capital, property, etc. A retired government employee drawing his pension is not always grouped with the non-government employee drawing a pension from the State, though from the point of view of dependency there is little to choose between the two, except that the latter is more likely to be partially dependent on others. To describe " pensioners " as part of the group of " independent persons ", as is done in the Population Commis-

[28] United States, Bureau of the Census. *Sixteenth census of population.* Vol. III, *The labor force*, Part I. Washington, 1943.

[29] Italy, Istituto Centrale de Statistica. *VIII censimento generale della popolazione, 21 aprile 1936.* Vol. IV, *Professioni*, Part 2. Roma, 1939.

[30] The Population Commission's proposals regarding the classification in dependency statistics of persons of independent means who are not household heads is illustrated by the codes shown for members of a hypothetical family in the United Nations study, *Application of international standards . . ., op. cit.*, p. 29.

sion's recommendations, is, in many cases, a euphemism.

Dependency by status (as employer, employee, etc.)

In addition to classifications of the population dependent on the various branches of economic activity (or occupations), the Population Commission also attaches importance to a classification of the total population by status (as employer, employee, etc.). Many of the countries covered give such a classification, usually cross-classifying status by industry or occupation.

The problems and difficulties which arise in the classification of the total population by status are, on the whole, the same as those already discussed. The census schedule usually contains a question to ascertain whether each active individual is an employer, own-account worker, employee (sometimes distinguishing between salaried employees and wage earners), unpaid family worker, etc. According to the Population Commission's recommendations, the number of persons attached to each status group includes active heads of households and their dependants, along with other active persons belonging to that status.

International recommendations regarding tabulations of the population by status are thus subject to the same shortcomings as are those relating to industry and occupation, owing to the fact that active persons in the same household may not all belong to the same status group. However, since there are fewer status groups than there are industries or occupations, this problem is not likely to be so serious. Furthermore, in households where the head is an employee, it is likely that other active members will, in the majority of cases, also be employees. On the other hand, in households where the head is an employer or own-account worker, other active members are more likely to be employees or unpaid family workers. If these assumptions are correct, the ratios of dependants to non-dependants are likely to be somewhat inflated for the self-employed group, consisting of employers and workers on own account. Another reason for expecting higher ratios for this group is that employers are probably more likely to employ domestic servants than are household heads of other statuses, and in many of the census tabulations domestic servants have been counted as dependants.

The ratios of dependants to 100 non-dependants have been computed for the countries for which such data are available, and are given in table 5. Few conclusions can be drawn from these data. The statistics are not comparable vertically, owing to different methods of compilation, for example, with respect to the inclusion of domestic servants with dependants, and with regard to the treatment of unpaid family workers. In every census covered, the group "employers and workers on own account" is shown to have the highest number of dependants; and in nearly every census, the ratios are higher for "salaried employees" than for "wage earners". These results are to be expected, partly for the reasons indicated above, and also because the proportion of active women is likely to be lower (and the proportion of dependants therefore higher) in households in which the head is an employer, or a salaried employee, than in households in which the head is a wage earner.

TABLE 5. RATIO OF DEPENDANTS TO 100 NON-DEPENDANTS BY STATUS

Country and date of census	*Employers and workers on own account*	*Unpaid family workers*	*Salaried employees and officials*	*Wage earners*
Bulgaria, 1934	163	21	136	109
Czechoslovakia, 1930	138	—	128	90
Denmark, 1940	190	—	79	82
Germany, 1939	100	3	84	79
Hungary, 1941	170	—	85	101
Italy,* 1936	135	—	166	140
Luxembourg, 1935 .	140	—	121	121
Poland,* 1931	162	—	122	
Sweden, 1945	163	—	79	83
Switzerland, 1941 ..	177	19	103	80
Yugoslavia, 1931 ..	209	—	142	76

* Excluding agriculture.

Sources : Computed from census data given in the sources listed at the end of this paper. A series of tables showing the actual census figures on which these computations are based is available in mimeographed form and will be supplied by the Population Division of the United Nations upon request.

SUMMARY AND CONCLUSIONS

This survey of the methods of compiling dependency statistics is admittedly incomplete. It is based on the published census reports which in no case indicate how the problems raised in this article have been solved.[31] Questionnaires addressed to the different governments on the problems here raised would undoubtedly have thrown much

[31] In the German census of 1933, for example, full explanations are given of the methods adopted for classifying the population into such groups as "active" and "inactive", and for classifying active persons by industry and occupation, but the only reference to the subject of how family members are allotted to the various economic activities is the following statement: "Die betriebliche Gliederung wird auch für die Angehörigen ohne Hauptberuf durchgeführt und zwar auf grund der Art des Betriebes dem der Erhährer angehört". Germany, Statistisches Reichsamt. *Volks-, Berufs- und Betriebszählung vom 16. Juni 1933. Die berufliche und soziale Gliederung des Deutschen Volkes. Textliche Darstellung der Ergebnisse. Statistik des Deutschen Reichs, Band 458, p. 8. Berlin, 1937.* No definition is given of "Ernährer" (breadwinner), nor is it explained how such persons are identified on the census schedule. This term does not appear in any of the census tables or in the census reports.

further light on the subject, had it proved feasible to use them. But sufficient information is available to show that the object and value of such statistics do not, and, in fact, cannot, conform to the desiderata laid down by the studies on this subject.

The classification of the *total* population into non-dependants and dependants, irrespective of economic activities, does not present too many difficulties. However, it is doubtful whether inactive dependants can be accurately separated from inactive non-dependants on the basis of census information, unless special questions on the census schedule are directed to this end. Information such as " retired ", " in receipt of pension " or " no occupation " for adult males, for example, gives little indication as to whether the individual is self-supporting or dependent on others. The portion of the inactive population that is potentially non-dependent is a large one in most countries and is increasing in importance.

As regards the classification of the population according to the numbers dependent on various economic activities, the problems of defining the " household ", and the " head of household ", become of great importance, and it has been shown that these terms are often difficult to define. In the first place, not all of the population lives in private households. Moreover, households are differently defined in the various countries and variously composed, and what may be considered as one household in one country, may be considered as two or more in another country. Also, the head of household for census purposes may be identified by reason of age, seniority, or degree of relationship, rather than in economic terms as the person on whom the inactive members depend.

The problem of households with some members temporarily absent, either in other private households or in non-private households on census day, also gives rise to difficulty. Some countries obtain information on persons temporarily present, or temporarily absent, and use these data for obtaining *de jure* population figures, but it is doubtful if any country [32] obtains *de jure* households by transferring all persons temporarily present in the households where they are enumerated to their permanent households. Students, lodgers, and persons who live on the premises of their employer are other examples of groups which may often appear on a different census schedule from their dependants or supporters, as the case may be.

Finally, the assumption that the very large part of the active population who are not heads of households have no persons dependent on them must place a serious limit on the value of the statistics.

The assumptions implicit in the accepted procedures for obtaining data on this subject, namely, that the population resides in easily defined households, that each household has an easily identifiable head, that the great majority of active wives and children follow the same activity as the head of the household, and that inactive persons can be readily separated on the census schedule into non-dependants and dependants—all have the effect of making the statistics of limited value. It is little wonder that many important countries compile no dependency statistics from their population census data, but confine their tabulations on economic activities to the active population. Households vary widely in their composition and differ with respect to the mutual relations and dependency of their members; it would seem that questions of dependency and non-dependency cannot be satisfactorily answered by a census inquiry directed primarily toward distinguishing the economically active from the inactive population. Various types of social surveys or family living studies might provide more appropriate means for obtaining data on this complex question.

[32] See footnote 17.

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The measurement of infant mortality

By W. P. D. LOGAN, M.D., Ph.D.

Various methods of calculating infant mortality rates, designed to avoid the main sources of error in measuring infant mortality, are described and evaluated in this article by Dr. Logan, who is the Chief Medical Statistician of the General Register Office of England and Wales. One of the methods evaluated in this article was set forth in detail in "An analysis of infant mortality" by Bourgeois-Pichat which appeared in the second issue of the Population Bulletin.

I. GENERAL CONSIDERATIONS AFFECTING THE MEASUREMENT OF INFANT MORTALITY

Infant mortality comprises deaths occurring during the first year of life, and is customarily expressed as a ratio of the number of infant deaths in a given period to the number of live births during the same period or related in some other way to the infant deaths. From the medical aspect more attention is paid to the infant mortality rate than to any other single index of mortality, and this for several good reasons. The mortality rate in infancy is higher than at any other age of childhood or early adult life, being surpassed only by the rates attained in old age; and whereas a death at say age 65 represents the loss of few years of expected life, a death in infancy may entail a loss of life of perhaps 60 years or more. In addition, the infant mortality rate has long been recognized as a sound index of sanitary conditions: high in unfavourable circumstances, in association with poverty, overcrowding, ignorance and neglect, and declining as socio-economic conditions improve. So invariable is this relationship that the standard of living of a community or nation from the hygienic viewpoint can be estimated with fair accuracy from a glance at its prevailing levels of infant mortality; and the effectiveness of a health administration in improving the general salubrity of its area can be judged by how rapidly the infant mortality rate declines.

The health official, therefore, has two inducements to achieve a low infant mortality rate in his area—the saving of infant life that it represents and the indication it gives of sanitary well-being; and he looks at the rate from a number of angles. He compares the level of infant mortality recorded in his area with the rates achieved elsewhere; he studies the trend of mortality in his area from year to year, and perhaps from month to month, compared with the trends reported from other areas; and he examines the constitution of the infant mortality rate of his area, particularly its age distribution within the first year of life and the reported medical causes of death.

A mortality index to which so much importance attaches must be reasonably accurate; the statistical facts used to compute the infant mortality rate must be trustworthy, and the method of computation sound. However, the degree of accuracy need be no higher than is necessary for an interpretation of the prevailing situation from the practical viewpoint of drawing attention to real trends and variations when they exist, and of not indicating those that do not exist. Therefore, although accuracy is necessary, absolute precision will seldom be needed; and the degree of accuracy necessary in any specified circumstances will depend entirely upon these circumstances and upon the type of judgment concerning infant mortality that is called for. There can be no advantage in striving after a meticulously accurate index if the realities of the situation are such that a relatively less precise, but possibly more readily attainable, index will suffice for all practical medical purposes. The problem, however, is to know how accurate, for these purposes, the index needs to be.

A. THE CONVENTIONAL INFANT MORTALITY RATE AND ITS MAIN SUB-DIVISIONS

The infant mortality rate, in its simplest form, is usually expressed as the number of infant deaths in a given period per 1,000 live births during the same period. The period usually considered is a year, but quarterly or monthly rates are also frequently calculated.

The total rate for all infant deaths under one year can be broken down according to *age at death*, yielding a neonatal mortality rate (deaths under four weeks or deaths under one month) and a postnatal mortality rate (deaths between four weeks, or one month, and 12 months). The advantage of a four-week limit for neonatal mortality is that it is invariable, whereas a one-month limit varies from month to month throughout the year, but a one-month limit is still probably the one more generally used. For closer study, infant mortality is sometimes subdivided in considerable detail of age, and the World Health Organization Nomenclature Regulations No. 1

stipulate (Article 8) : " If special statistics of infant mortality are published by age, the following age grouping shall be used :

" by single days for the first week of life (under one day, 1, 2, 3, 4, 5, 6, days)
" 7-13 days
" 14-20 days
" 21-27 days
" 28 days to 2 months
" by single month of life from 2 months to one year (2, 3, 4,... 11 months) ".[1]

For certain purposes, deaths during the neonatal period are combined with foetal deaths to yield a *perinatal* mortality rate. There is no general agreement as to which deaths should be included under this title : e.g., intermediate plus late foetal deaths plus infant deaths under four weeks ; or late foetal deaths (stillbirths) plus infant deaths in the first week, or first month of life ; or stillbirths plus the " endogenic " component of infant mortality as suggested by Bourgeois-Pichat (see page 53). Meantime, until a generally accepted usage emerges, it is advisable when using the term *perinatal* mortality to indicate what range of foetal and infant mortality it is intended to cover.

A distinction between deaths of male and female infants is usual, and occasions no difficulties of calculation or interpretation. In many countries, distinction is also made by colour and/or race.

It is less easy to achieve a valid distinction between legitimate and illegitimate infant mortality. The denominators are the numbers of children indicated as being legitimate or illegitimate at birth, and the numerators are the numbers legitimate or illegitimate at death. There is, however, possibly greater concealment of illegitimacy at the registration of the death of an infant than at the registration of birth ; and in addition a proportion of infants born illegitimate, and registered as such, become legitimated by the subsequent marriage of their parents, and if they die will be properly registered as legitimate infants. Both of these effects tend to reduce the recorded illegitimate infant mortality rate, and on occasion, at the later ages of the first year of life, the illegitimate rates may be apparently lower than those of legitimate infants. For example, England and Wales, 1947 (rates per 1,000 births) :

	Under 4 weeks	*4 weeks–3 months*	*Months 3–6*	*6–9*	*9–12*
Legitimate	22.1	6.7	5.9	3.6	2.1
Illegitimate	33.4	10.9	8.1	3.8	1.8

[1] World Health Organization. *Regulations No. 1 regarding nomenclature (including the compilation and publication of statistics) with respect to diseases and causes of death.* Official Records No. 13, Annex I, Geneva, 1948, p. 350.

Solutions to this problem would be to ascertain, for each infant death, the legitimacy status at birth from the birth registration record, and classify accordingly ; or to estimate, e.g., by an *ad hoc* sample investigation, the probable degree of error in the crude figures, and hence derive and apply a correcting factor ; but this adjustment has seldom or never been done.

Infant mortality rates are also calculated for local administrative areas ; in this connexion the main precaution is to ensure that deaths and births have been transferred from place of occurrence to place of usual residence (of parents). If this is not done, the areas in which maternity or children's hospitals are situated may record quite abnormal rates.

In some countries, attempts have been made to analyse infant deaths by such biological factors as maternal age and parity, and this may require linkage between birth and death registration details.

The relationship between infant mortality and socio-economic status has been repeatedly demonstrated by the British tabulations of infant mortality by social class and by parent's occupation.

Analysis of infant mortality by the reported medical *causes of death* and the interpretation of these findings present probably the most difficult of current problems in the study of infant mortality. The problems, and steps being taken to solve them, can be summarized as :

(i) Accuracy of diagnosis. It is notoriously difficult even for experienced physicians to tell with accuracy the cause or causes of death of newborn children, and autopsy findings are not always conclusive. Special studies to assess the validity of certified statements have emphasized the imperfections of these statements in certain directions, but the effects of these imperfections should not be over-estimated. Despite the known inaccuracies of the reported causes of infant death, analysis of these causes has provided profitable material for study and research.

(ii) Form of Death Certificate. A useful step towards better international comparability of cause of death statistics, including causes of infant death, has been the introduction, and widespread adoption of the International Form of Medical Certificate of Cause of Death, which provides for the statement of :

" I the disease or condition directly leading to death, together with such antecedent morbid conditions as may exist, so that the underlying cause of death will be clearly indicated, and

" II such other significant conditions contributing to the death but not related to the disease or condition causing death."[2]

[2] *Ibid.*, p. 351.

(iii) In accordance with Article 12 of the WHO Nomenclature Regulations No. 1, the main cause to be selected for the tabulation of mortality statistics shall be the underlying cause, defined as (*a*) the disease or injury which initiated the train of morbid events leading directly to death or (*b*) the circumstances of the accident or violence which produced the fatal injury.[3] This constitutes a departure from the former widespread practice, when multiple causes were certified, of selecting one of these causes for assignment on the basis of arbitrary rules of cause selection, and will lead to more realistic measures of the relative importance of different causes of death at each age. Article 2 of the same Regulations provides that coding shall be in accordance with the *International Statistical Classification of Diseases, Injuries, and Causes of Death.*[4]

B. Definition of infant death and live birth

The errors in the measurement of infant mortality that derive from this source are of two kinds :

(i) Differences from place to place in legal definitions and registration procedures ;

(ii) Departures in actual practice from the definitions prescribed.

The fundamental issue, and it is one that affects both the infant deaths and the live births, is the distinction between foetal death on the one hand, and live births followed by early infant death on the other.

A legal definition or registration procedure which leads to a case being classed as a foetal death instead of as a live birth followed by infant death results in the exclusion from the infant mortality rate of one unit both from numerator and denominator and hence reduces the recorded infant mortality rate. That there are great variations in the statutory definition of foetal death is widely recognized, and in several countries, including Belgium, France and Spain, children born alive but dying before birth registration are classed as stillborn. General adoption of the definitions proposed by the World Health Organization, and their application in relation to registration, will go far to improve the present confused state of affairs. The definitions are :

" Live birth is the complete expulsion or extraction from its mother of a product of conception, irrespective of the duration of pregnancy, which, after such separation, breathes or shows any other evidence of life, such as beating of the heart, pulsation of the umbilical cord, or definite movement of voluntary muscles, whether or not the umbilical cord has been cut or the placenta is attached ; each product of such a birth is considered live born. "

" Foetal death is death prior to the complete expulsion or extraction from its mother of a product of conception, irrespective of the duration of pregnancy ; the death is indicated by the fact that after such separation the foetus does not breathe or show any other evidence of life, such as beating of the heart, pulsation of the umbilical cord, or definite movement of voluntary muscles. " [5]

Even when uniform legal definitions have been internationally accepted, there still remains the problem of acquainting obstetricians with these definitions and of persuading them to classify their cases accordingly. Definitions that do not get applied in actual practice, however theoretically sound they may be, can do nothing to improve the accuracy of mortality indices. The WHO definitions do not, however, differ radically from definitions already in use in a number of countries, and which have proved reasonably acceptable and useful in practice.

C. Completeness of registration of births and infant deaths

Infant mortality can only be measured accurately if the registration of births and of deaths is complete, or if not complete is deficient to the same relative degree both for births and for deaths. The completeness of birth registration is improved where there is duplicated reporting of the birth by the medical attendant as well as by the parents. It is further improved where there are financial inducements to register the birth, e.g., maternity grants, family allowances and income tax rebates as in Britain at the present time, or where food rationing or schemes of supplementary food for infants make it advantageous to register the birth so that the child qualifies for these benefits. Apart from these positive advantages, a long established and widely known registration system, associated with penalties for failure to comply with registration requirements, makes for practically complete birth registration.

To some extent, the completeness of birth registration can be tested against census results (though more usually the test is carried out for the reverse purpose) and can be further tested by routine or occasional attempts, when an

[3] *Ibid.*, p. 351.

[4] *Ibid.*, p. 349.

[5] World Health Organization, Expert Committee on Health Statistics. *Report on the second session.* Technical Report Series, No. 25, Geneva, 1950, p. 12 ; World Health Organization, Third World Health Assembly. *Resolutions and decisions.* Official Records, No. 28, Geneva, 1950, pp. 16-17.

infant death is registered, to trace the relevant birth registration record. In a recent investigation of this kind in England, 99.2 per cent of the birth registrations were traced of children dying under one year of age ; and many of the untraced proportion, 0.8 per cent, were not necessarily, and in fact were probably not, unregistered.

Incompleteness of death registration presents no practical problem in countries where authority for burial is obtained only after the death has been registered.

In places where registration is known or believed to be grossly deficient, and where the recorded infant mortality rate must necessarily be no more than an approximate measure of the true rate, it would be a misdirected effort to carry out refined techniques of computation of the kinds now to be discussed, in order to improve the accuracy of the rate.

II. CALCULATION OF THE INFANT MORTALITY RATE

The infant mortality rate is customarily expressed as a q_x function, in contradistinction to the m_x functions that are used to express death rates at other ages ; that is to say, the infant mortality rate expresses the proportion dying out of those alive at the beginning of the period of observation (i.e., the number of live births), instead of, as at other ages, the proportion dying out of the average number alive during the period. Moreover, it is customary to use the same denominator, the number of live births, for infant mortality rates at different stages throughout the first year, e.g., under one month, one to three months, three to six months and so on.

There is usually a difference between the number of births or deaths *registered* in a year and the number of births or deaths *occurring* in the year as estimated on the basis of the registration records. The difference arises partly because of variations from year to year in the average time-lag between the occurrence of the events and their registration, and partly because of variations in the levels of the birth rate, and similarly of the death rate, during the registration time-lag period at the end of one year and at the end of another. In most countries, the average time-lag between the occurrence of a death and its registration is very short and does not tend to vary from year to year. There is little difference, therefore, between numbers of infant deaths registered and numbers occurring in a given calendar year, so that either may be used as the numerator for the infant mortality rate. The time-lag before the registration of births is longer and more variable ; thus in England and Wales the average time-lag at the beginning of 1939 was just over a month but had declined to nine days by the beginning of 1947. The number of births registered in 1940 was 607,000 but the number that occurred that year was only 590,000. The infant mortality rate per 1,000 births registered was 55.8, but the rate per 1,000 births occurring was 57.4, a sizable difference. In 1950, however, the difference was much less ; the rates were 30.1 per 1,000 births registered and 29.9 per 1,000 births occurring. Whenever the tabulation arrangements allow a choice, it is advisable to use birth occurrences as the denominator rather than birth registrations, since greater accuracy can thereby be achieved ; but as the advantage is less, the same course need seldom be followed in regard to deaths.

Although the infant mortality rate can be, and usually is, expressed as the number of infant deaths per 1,000 live births *during the same period*, the fact that an interval of up to a year may elapse between the birth and death of some of the infants represented in the rate means that this simple method of expression can be no more than a rough and ready, though convenient, approximation. For more accurate calculation of the rate, allowance must be made for the time-interval between the births and deaths ; that is to say, either the number of deaths must be adjusted so as to correspond with the number of births occurring during the stated period, or the number of births must be adjusted to correspond with the deaths during the period. It follows that there are two fundamentally different methods of expressing the infant mortality rate for a given period, e.g., calendar year. The births occurring during the year may be taken as the denominator, and the numerator found by following this cohort of infants forward during their first 12 months of life, and recording the number who died under 12 months, whether in the same or in the next calendar year. This yields a " cohort " mortality rate. The alternative method is to take as numerator the infant deaths recorded during the selected calendar year and to take as denominator suitable proportions of the births occurring in the same and in the preceding calendar year. This latter method yields a " calendar year " mortality rate and is the method of choice for health statistics purposes since it conforms to the general practice in this field of measuring mortality at any age on the basis of the deaths recorded in a specified calendar year. Although it is reasonable and, on occasion, convenient to express infant mortality on a cohort basis, the methods of calculation to be described in this paper will express the rate on the basis of calendar year mortality.

That there is need for some adjustment of the conventional infant mortality rate so as to relate deaths more accurately to the births from which

they were derived can be illustrated by the following hypothetical situation :

Year	Rate per 1.000 live births in the same year	Number of infant deaths	Number of live births	Rate adjusted to allow for variations in births *
1	60	60 000	1 000 000	
2	60	60 000	1 000 000	60
3	56	70 600	1 250 000	60
4	67	50 000	750 000	60
5	55	55 400	1 000 000	60

* Whole year numerator separation by factor, f = 0.25 (see page 43).

From the rates in the second column, a health officer would have grounds for believing that improvement had been achieved in year 3, that a serious setback was sustained in year 4, but that all the lost ground was recovered in year 5 and that by then the situation was better than at the beginning of the five-year period. When account is taken, however, of the large changes in numbers of births from year to year and a simple adjustment of the rate is made to allow for these changes, the rates remain constant throughout the period.

The next section is devoted to the description of the various practical computational methods whereby adjustments of this nature can be performed. In general, points that have to be kept in mind in considering the relative advantages of the different methods are :

(*a*) the availability of the data required ;

(*b*) the amount of detailed tabulation required ;

(*c*) the computational labour involved ;

(*d*) the theoretical justification for the method ;

(*e*) the gain in accuracy achieved, looked at from the viewpoint already stated that reasonable but not meticulous accuracy is all that is needed for practical medical purposes.

A. Methods of calculation

It will clarify subsequent discussion to present now a summary indicating the various methods available for calculating rates that make allowances for the proportion of deaths in the selected periods that relate to births in an earlier period. The usual periods for which rates are calculated are years, quarters and months, yielding annual, quarterly and monthly infant mortality rates. The following scheme is applicable to each of these rates :

I. Exact matching of births and deaths
   - (*a*) whole year matching — (*b*) part year matching
   - (1) multiplicative technique — (2) additive technique

II. Approximate matching of births and deaths
   - (*a*) whole year matching — (*b*) part year matching
   - (1) numerator separation — (2) denominator adjustment

III. Factor methods
   - (1) i by numerator separation factor (f)
     ii by denominator adjustment factor (r)
     iii by denominator adjustment utilizing numerator separation factor (f used as r)
   - (2) separation factor based on postnatal/total infant mortality ratio
   - (3) separation factor estimated from total infant mortality rate by regression formula.

B. Annual rates

1. Exact matching of births and deaths

(a) *Whole year matching*

For this method, knowledge is needed of the year of birth of each infant who dies in the selected year and in the preceding year.

	Live births	Infant deaths
Year 0	b_0	d_0 / d_1
Year 1	b_1	d_2 / d_3

The diagram above represents a situation where in year 0 there were b_0 live births and $d_0 + d_1$ infant deaths ; and in year 1 there were b_1 live births and $d_2 + d_3$ infant deaths. Of the deaths in year 0, d_1 were of infants known to have been born in the same year, i.e., from among the b_0 births ; and of the deaths in year 1, d_2 were of infants born in year 0 (i.e., from b_0 births) and d_3 were of infants born in year 1 (i.e., from b_1 births).

The probability of an infant surviving to one year of age is the product of the separate probabilities of its surviving to the end of the year in which it is born and, having done so, of its surviving

to one year of age in the next year. Bearing in mind that what is wanted is a "calendar year" and not a "cohort" mortality rate, the rate for year 1, in which there were $d_2 + d_3$ deaths, can be calculated as follows:

Let p_1 represent the first probability, and p_2 the second. Let $p = p_1 \times p_2$.

$$\text{Then} \quad p = \frac{b_1 - d_3}{b_1} \times \frac{b_0 - d_1 - d_2}{b_0 - d_1}$$

Let q represent the probability of dying under 1 year of age, so that $q = 1 - p$.

The infant mortality rate per 1,000 births = q/1,000.

In this method the two component probabilities of survival have been combined by multiplication. An alternative technique would be to calculate q as equal to

$$\frac{d_3}{b_1} + \frac{d_2}{b_0},$$

whereby the two component probabilities of dying are combined by addition. This additive method is theoretically unsound, but in practice it usually gives almost the same result as the multiplicative method. It will, in fact, give precisely the same result either if $d_2/b_0 = 0$, which is never likely to happen, or if $d_3/b_1 = d_1/b_0$. Unless the level of infant mortality is changed drastically from year to year, the latter situation is likely to hold sufficiently closely for the additive method to yield almost the same adjusted rate as the multiplicative method, with the advantage of somewhat less labour of computation.

The two techniques are compared in the following hypothetical example:

	Live births	Infant deaths
Year 0	$b_0 = 800\,000$	$d_0 = 5\,800$ / $d_1 = 30\,400$
Year 1	$b_1 = 900\,000$	$d_2 = 8\,300$ / $d_3 = 21\,900$

The conventional infant mortality rate for year 1 =

$$\frac{d_2 + d_3}{b_1} \times 1{,}000$$

$$= \frac{30{,}200 \times 1{,}000}{900{,}000} = 33.56$$

However, by the multiplicative technique:

$$q = 1 - p_1 p_2$$

$$= 1 - \frac{900{,}000 - 21{,}900}{900{,}000} \times \frac{800{,}000 - 30{,}400 - 8{,}300}{800{,}000 - 30{,}400}$$

$$= 1 - 0.9757 \times 0.9892$$

$$= 0.03484$$

Hence the infant mortality rate per 1,000 = 34.84.

By the additive technique:

$$q = \frac{d_3}{b_1} + \frac{d_2}{b_0}$$

$$= \frac{21{,}900}{900{,}000} + \frac{8{,}300}{800{,}000}$$

$$= 0.03471$$

Hence the infant mortality rate per 1,000 = 34.71.

The two adjusted rates agree fairly closely, and each is about one unit higher than the conventional rate.

(b) *Part year matching*

The method of whole year matching just described takes account only of the differences in the total number of births between one year and the next. No account is taken of possible differences between the two years in the distribution of births throughout each year, the assumption being that the distribution remains unchanged. Such an assumption may well be untenable, for the circumstances that cause the total number of births to change between one year and the next may cause alteration in the seasonal distribution. For example, the total births occurring in England and Wales in 1946 and 1947 and the percentage distribution of those births over the four quarters each year are shown in the table below:

Year	*Total number of births*	*Percentage distribution by quarters*				
		1st	*2nd*	*3rd*	*4th*	*Total*
1946 ...	820 719	*22*	*25*	*26*	*27*	100
1947 ...	881 026	*27*	*27*	*24*	*22*	100

Theoretically, the "correct" infant mortality rate would be obtained by relating the deaths in the selected year not merely to the total births either in the same or the previous year but to the finest subdivision of those years that could be achieved, e.g., single days. The computational labour involved in such a refined calculation would be very great even if the tabulated data were available. None the less, the full benefit of the correction of the rate cannot be achieved unless some account is taken of the births at different parts of each year, and in fact, unless this is done, the adjusted rate may be not merely wrong but may in certain circumstances be even less accurate than the crude conventional rate.

TABLE 1. HYPOTHETICAL DISTRIBUTION OF BIRTHS AND DEATHS BY QUARTERS AND BY AGE OF DEATH

Year	Period	Number of births	Number of deaths at ages in months			
			0-	3-	6-	9-12
Year 0	1st quarter	$1b_0$ = 100 000	3 000			
	2nd quarter	$2b_0$ = 200 000	2 000 / 6 000	400		
	3rd quarter	$3b_0$ = 220 000	2 000 / 6 000	400 / 400	200	
	4th quarter	$4b_0$ = 280 000	2 000 / 6 000	600 / 600	300 / 300	200
Year 1	1st quarter	$1b_1$ = 240 000	2 000 / 6 000	900 / 900	500 / 500	300 / 300
	2nd quarter	$2b_1$ = 230 000	1 000 / 3 000	600 / 600	400 / 400	300 / 300
	3rd quarter	$3b_1$ = 220 000	1 000 / 3 000	500 / 500	300 / 300	200 / 200
	4th quarter	$4b_1$ = 210 000	1 000 / 3 000	600 / 600	300 / 300	200 / 200

In the hypothetical example given in table 1, the same total numbers of births and deaths are assumed to have occurred in years 0 and 1 as in the previous (whole year matching) example, but the deaths have been subdivided by ages 0-, 3-, 6-, 9-12 months and related to the exact quarter year in which birth occurred.

From these data, the cumulative total of deaths occurring age by age, quarter by quarter, in relation to each quarter's cohort of births (i.e., cumulative along the diagonals) are as shown in table 2. The aim is to compute not a " cohort " mortality rate but a " calendar year " rate based on deaths in year 1. The probability of survival to age one year, as estimated in relation to births in each quarter of the year, is as shown below, where p_1 is the probability of surviving to the end of the calendar year of birth and p_2 is the probability of surviving to age one in the following calendar year.

TABLE 2. CUMULATIVE TOTALS OF DEATHS FROM SUCCESSIVE BIRTH COHORTS (HYPOTHETICAL DATA GIVEN IN TABLE 1)

	Cumulative total of deaths from each birth cohort							
Quarterly births	c_1	c_2	c_3	c_4	c_5	c_6	c_7	c_8
$1\ b_0 = 100\ 000$	3 000	5 000	5 400	5 800	6 000	6 300	6 500	6 800
$2\ b_0 = 200\ 000$	6 000	8 000	8 400	9 000	9 300	9 800	10 100	10 400
$3\ b_0 = 220\ 000$	6 000	8 000	8 600	9 500	10 000	10 400	10 700	10 900
$4\ b_0 = 280\ 000$	6 000	8 000	8 900	9 500	9 900	10 200	10 400	10 600
$1\ b_1 = 240\ 000$	6 000	7 000	7 600	8 100	8 400	8 700	8 900	—
$2\ b_1 = 230\ 000$	3 000	4 000	4 500	5 100	5 400	—	—	—
$3\ b_1 = 220\ 000$	3 000	4 000	4 600	—	—	—	—	—
$4\ b_1 = 210\ 000$	3 000	—	—	—	—	—	—	—

$$p_1 \times p_2 = p.$$

1st qtr. $\dfrac{1\ b_1 - c_7}{1\ b_1} \times \dfrac{1\ b_0 - c_8}{1\ b_0 - c_7} = 0.959827$

2nd qtr. $\dfrac{2\ b_1 - c_5}{2\ b_1} \times \dfrac{2\ b_0 - c_8}{2\ b_0 - c_5} = 0.970889$

3rd qtr. $\dfrac{3\ b_1 - c_3}{3\ b_1} \times \dfrac{3\ b_0 - c_8}{3\ b_0 - c_3} = 0.968438$

4th qtr. $\dfrac{4\ b_1 - c_1}{4\ b_1} \times \dfrac{4\ b_0 - c_8}{4\ b_0 - c_1} = 0.969166$

Average of 4 quarters, $p = 0.967080$

Hence, $q = 0.032920$,

and infant mortality rate per 1,000 live births = 32.92.

This exemplifies the multiplicative technique but, as for the " whole year matching ", the simpler though theoretically less accurate additive technique may be substituted on the assumption that the age specific mortality risks for corresponding quarterly birth cohorts of the two calendar years have not changed.

Application of the additive technique to these data is illustrated in table 3.

Again the multiplicative and additive techniques have given similar results, 32.92 and 32.79, in contrast with the crude rate of 33.56. It is to be noted, however, that both of the " part year matching " methods have produced an appreciable lowering of the crude rates, whereas the " whole year matching " methods previously applied to the same hypothetical data resulted in the crude rate being appreciably increased. This divergence of results derives from the very marked difference in the quarterly distributions of births in the two calendar years. Although there were fewer total births in year 0 than in year 1, the births in year 0 were so heavily concentrated in the 4th quarter of the year as to produce a reduction in infant mortality for year 1 when proper

TABLE 3. CALCULATION OF INFANT MORTALITY RATE BY DIRECT MATCHING PART YEAR ADDITIVE METHOD (HYPOTHETICAL DATE GIVEN IN TABLE 1)

	Cohort of birth							
	Year 0				*Year 1*			
Age at death (months)	*1st qr.*	*2nd qr.*	*3rd qr.*	*4th qr.*	*1st qr.*	*2nd qr.*	*3rd qr.*	*4th qr.*
0–	—	—	—	2 000	7 000	4 000	4 000	3 000
3–	—	—	900	1 500	1 100	1 100	600	—
6–	—	500	900	700	600	300	—	—
9–12	300	600	500	400	200	—	—	—
Total	300	1 100	2 300	4 600	8 900	5 400	4 600	3 000
Number of births (thousands)	100	200	220	280	240	230	220	210
Infant mortality rate per 1,000 births	3.000	5.000	10.455	16.429	37.083	23.478	20.909	14.286

Total of rates = 131.140

Hence, annual infant mortality rate (average of rates for four quarters) = 32.79

allowance was made for the distribution of births throughout each year. A sub-division of each year into the four quarters was used in the above example of " part year matching ". There would be no practical difficulty, though a trebling in computational labour, to have used separate months instead of quarters, but the additional gain in accuracy would probably be small.

2. APPROXIMATE MATCHING OF BIRTHS AND DEATHS

When no exact information is available about year of birth in respect of each infant death, matching of births and deaths can be achieved approximately by noting age at death, and by making simple but reasonable assumptions there from about the probability of birth having been in one year or the other.

For the purpose of exemplifying the various methods of calculation available, the actual data of infant deaths registered in England and Wales in 1950 and of births occurring in 1949-50 will be used. There were 20,817 infant deaths in 1950 and 697,097 birth occurrences, yielding a crude infant mortality rate of 29.86.

(a) *Whole year matching*

(1) *Numerator separation*

For this method, it is necessary to know only the number of deaths at various ages under one year in the selected year (1950) and the total number of births in the preceding and the same year (1949 and 1950). In respect of the number of deaths at each age, an assumption is then made about the numbers that probably related to children born in the same year or those born in the preceding year. Thus, for children dying under one day of age in 1950, all would be born in 1950 except perhaps half of those dying on the first day of the year. To allow for this half of 1/365, approximately .001 of the deaths in 1950 should be allocated to births in 1949. Similarly, for infants dying aged 9–12 months, it may be assumed that three quarters must have been born in 1949, and that of the remaining quarter, probably half were born in 1949 and half in 1950. Hence seven-eighths of these deaths can be assigned to births in 1949 and the remainder to 1950. The details of the full calculation are shown in table 4.

Out of a total of 20,817 infant deaths in 1950, 3,273 were assigned to births in 1949 (730,518) and 17,544 were assigned to births in 1950 (697,097). The numerator has thus been separated into two component groups of deaths; hence the technique has been labelled " numerator separation ". Adding together the death rates given by the two groups of deaths yields an infant mortality rate of 29.65.

If details of deaths at the suggested range of ages are not available but the tabulations distinguish neonatal from postnatal deaths, a highly simplified but less accurate numerator separation calculation can be carried out as follows :

TABLE 4. CALCULATION OF INFANT MORTALITY RATE, ENGLAND AND WALES, 1950, BY APPROXIMATE MATCHING WHOLE YEAR NUMERATOR SEPARATION METHOD

Age at death	*Number of deaths*	*Proportion assigned to 1949*	*Number of deaths assigned to births*	
			1949	*1950*
Under 1 day ...	5 027	.001	5	5 022
1 day–	5 579	.011	61	5,518
7 days–	1 180	.029	34	1 146
14 days–	633	.048	30	603
21 days–	498	.067	33	465
28 days–	3 012	.164	494	2 518
3 months–	2 631	.375	987	1 644
6 months–	1 383	.625	864	519
9–12 months ...	874	.875	765	109
Total	20 817		3 273	17 544

	1949	*1950*
Births	730 518	697 097
Infant mortality rate	4.480 +	25.167
	= 29.65	

Age at death	*Number of deaths*	*Deaths assigned to births in*	
		year 1	*year 2*
Under 4 weeks	x	—	x
4 weeks–1 year	y	½ y	½ y
Total	x + y	½ y	x + ½ y

Applying actual data for 1950 :

Age at death	*Number of deaths*	*Deaths assigned to births in*	
		1949	*1950*
Under 4 weeks	12 917	—	12 917
4 weeks–1 year	7 900	3 950	3 950
Total	20 817	3 950	16 867
Births		730 518	697 097
Infant mortality rate per 1,000 births		5.407 +	24.196
		= 29.60	

(2) *Denominator adjustment* (" *related births* ")

In this method, no attempt is made to separate the numerator, but the "crude" denominator, number of births in the current year, is adjusted by increasing or diminishing it a certain amount so as to make allowance for a different number of births in the previous year. Again it is necessary to know only the number of deaths at various ages in the current year, and the total births in that and the previous year.

For deaths under four weeks, it is assumed that the related births are all those in the current year with the exception of half of those in the last four weeks of the year, but with the addition of half of the births in the last four weeks of the previous year. Similar assumptions are made for deaths at other infant ages. Taking births in the preceding year as b_0 and in the current year as b_1, numbers of related births can be calculated as follows :

Under 4 weeks	$b_1 + 14/365\ (b_0 - b_1)$
4 weeks–3 months	$b_1 + 60/365\ (b_0 - b_1)$
3–6 months	$b_1 + 137/365\ (b_0 - b_1)$
6–9 months	$b_1 + 228/365\ (b_0 - b_1)$
9–12 months	$b_1 + 319/365\ (b_0 - b_1)$

Applying actual data for 1950 :

$b_0 = 730{,}518$; $b_1 = 697{,}097$

Age at death	*Number of deaths*	*Number of related births*	*Infant mortality rate per 1,000 related births*
Under 28 days	12 917	698 379	18.496
28 days–3 months	3 012	702 591	4.287
3–6 months	2 631	709 641	3.708
6–9 months	1 383	717 974	1.926
9–12 months	874	726 306	1.203
Total			29.62

As for the numerator separation method, a simplified and again less accurate method of calculation is available if details of age of death distinguish neonatal and postnatal deaths only :

Age at death	*Number of related deaths*
Under 4 weeks	$b_1 + 14/365\ (b_0 - b_1)$
4 weeks–1 year	$b_1 + 393/730\ (b_0 - b_1)$

Applying the 1950 data :

Age at death	*Number of deaths*	*Number of related births*	*Infant mortality rate per 1,000 related births*
Under 28 days	12 917	698 379	18.496
28 days–1 year	7 900	715 089	11.048
Total			29.54

(b) *Part year matching*

As explained in the section dealing with exact matching methods, whole year matching involves the assumption that the seasonal distribution of births was the same in each of the two years concerned, an assumption which is not always justifiable and which may on occasion lead to serious error. Therefore, for approximate matching methods, it is advisable where practicable to take into consideration the distribution of births throughout the two years. Again, the alternative techniques of numerator separation or denominator adjustment are available.

(1) *Numerator separation*

This method was adopted by the Registrar-General of England and Wales in 1920 and was applied to the infant mortality rates for years 1911-25. The method is fairly laborious and requires tabulation of deaths in each quarter of the selected year by single weeks of age up to four weeks, and by single months thereafter up to one year. Quarterly totals of births are required for the current and the preceding year. The deaths in each quarter are assigned to the births in one or the other of two possible quarters in varying proportions according to age at death, thus :

Age at death	*Proportion assigned to earlier of two possible quarters of birth* *	*Age at death*	*Proportion assigned to earlier of two possible quarters of birth* *
0 day–	—	4 months–	.50
1 day–	.02	5 months–	.83
7 days–	.11	6 months–	.16
14 days–	.19	7 months–	.50
21 days–	.27	8 months–	.83
28 days–	.46	9 months–	.16
2 months–	.83	10 months–	.50
3 months–	.16	11 months–	.83

* E.g., all infants dying at ages 14–20 days must have been born in the same quarter as that in which they died, with the exception of those dying during the first 14 days of the quarter and perhaps half of those dying during the next seven days. Hence $14/91 + 1/2 \times 7/91 = 0.19$ of the deaths are assignable to births in the previous quarter.

TABLE 5. CALCULATION OF ADJUSTED INFANT MORTALITY RATE, ENGLAND AND WALES, 1950, BY APPROXIMATE MATCHING PART YEAR NUMERATOR SEPARATION METHOD

(Registrar-General's method, 1920)

Age at death	Number of deaths	Deaths assigned to births in quarters of each year							
		1949				1950			
		1st qr.	2nd qr.	3rd qr.	4th qr.	1st qr.	2nd qr.	3rd qr.	4th qr.
Deaths in 1st quarter of 1950									
0 day-	1 339	—	—	—	—	1 339	—	—	—
1 day-	1 516	—	—	—	30	1 486	—	—	—
7 days-	341	—	—	—	38	303	—	—	—
14 days-	218	—	—	—	41	177	—	—	—
21 days-	182	—	—	—	49	133	—	—	—
28 days-	591	—	—	—	272	319	—	—	—
2 months-	561	—	—	—	467	94	—	—	—
3 months-	446	—	—	74	372	—	—	—	—
4 months-	337	—	—	168	169	—	—	—	—
5 months-	259	—	—	216	43	—	—	—	—
6 months-	200	—	33	167	—	—	—	—	—
7 months-	151	—	75	76	—	—	—	—	—
8 months-	138	—	115	23	—	—	—	—	—
9 months-	119	20	99	—	—	—	—	—	—
10 months-	95	47	48	—	—	—	—	—	—
11 months-	82	68	14	—	—	—	—	—	—
Total	6 575	135	384	724	1 481	3 851	—	—	—
Deaths in 2rd quarter of 1950									
0 day-	1 250	—	—	—	—	—	1 250	—	—
1 day-	1 476	—	—	—	—	30	1 446	—	—
7 days-	302	—	—	—	—	33	269	—	—
14 days-	144	—	—	—	—	27	117	—	—
21 days-	113	—	—	—	—	31	82	—	—
28 days-	403	—	—	—	—	185	218	—	—
2 months-	294	—	—	—	—	245	49	—	—
3 months-	245	—	—	—	41	204	—	—	—
4 months-	174	—	—	—	87	87	—	—	—
5 months-	120	—	—	—	100	20	—	—	—
6 months-	124	—	—	21	103	—	—	—	—
7 months-	96	—	—	48	48	—	—	—	—
8 months-	77	—	—	64	13	—	—	—	—
9 months-	74	—	12	62	—	—	—	—	—
10 months-	80	—	40	40	—	—	—	—	—
11 months-	62	—	52	10	—	—	—	—	—
Total	5 034	—	104	245	392	862	3 431	—	—
Deaths in 3rd quarter of 1950									
0 day-	1 233	—	—	—	—	—	—	1 233	—
1 day-	1 220	—	—	—	—	—	24	1 196	—
7 days-	235	—	—	—	—	—	26	209	—
14 days-	133	—	—	—	—	—	25	108	—
21 days-	72	—	—	—	—	—	19	53	—
28 days-	287	—	—	—	—	—	132	155	—
2 months-	205	—	—	—	—	—	171	34	—
3 months-	146	—	—	—	—	24	122	—	—
4 months-	142	—	—	—	—	71	71	—	—
5 months-	122	—	—	—	—	102	20	—	—
6 months-	90	—	—	—	15	75	—	—	—
7 months-	82	—	—	—	41	41	—	—	—
8 months-	65	—	—	—	54	11	—	—	—
9 months-	62	—	—	10	52	—	—	—	—
10 months-	41	—	—	20	21	—	—	—	—
11 months-	41	—	—	34	7	—	—	—	—
Total	4 176	—	—	64	190	324	610	2 988	—

TABLE 5 *(continued)*

Age at death	Number of deaths	Deaths assigned to births in quarters of each year							
		1949				1950			
		1st qr.	2nd qr.	3rd qr.	4th qr.	1st qr.	2nd qr.	3rd qr.	4th qr.
Deaths in 4th quarter of 1950									
0 day-	1 205	—	—	—	—	—	—	—	1 205
1 day-	1 367	—	—	—	—	—	—	27	1 340
7 days-	302	—	—	—	—	—	—	33	269
14 days-	138	—	—	—	—	—	—	26	112
21 days-	131	—	—	—	—	—	—	35	96
28 days-	333	—	—	—	—	—	—	153	180
2 months-	338	—	—	—	—	—	—	282	56
3 months-	230	—	—	—	—	—	38	192	—
4 months-	209	—	—	—	—	—	104	105	—
5 months-	201	—	—	—	—	—	167	34	—
6 months-	137	—	—	—	—	23	114	—	—
7 months-	129	—	—	—	—	64	65	—	—
8 months-	94	—	—	—	—	78	16	—	—
9 months-	73	—	—	—	12	61	—	—	—
10 months-	80	—	—	—	40	40	—	—	—
11 months-	65	—	—	—	54	11	—	—	—
Total	5 032	—	—	—	106	277	504	887	3 258
Total for year	20 817	135	488	1 033	2 169	5 314	4 545	3 875	3 258
Number of births		186 228	192 968	182 220	169 102	180 774	182 109	171 374	162 840
Infant mortality rates		0.725	2.528	5.669	12.827	29.396	24.958	22.611	20.007
Aggregate		118.721							
Infant mortality rate, 1950 ..		29.68							

To exemplify the computational procedure, a worked example is given in table 5, again utilizing the actual data for England and Wales, 1950, yielding a rate of 29.68 per 1,000 births.

A comparison between the crude rates in England and Wales in 1911 to 1925 (registered deaths per 1,000 registered births in the same year) and rates calculated by the method just described is given in table 6. The crude rate increased from 91.2 in 1916 to 96.5 in 1917, while the adjusted rate remained at 91.1. An increase in the crude rate from 79.9 in 1920 to 82.8 in 1921 was replaced by a decline in the adjusted rate from 84.5 to 81.2. Another smaller divergence in the direction of change indicated by the two methods occurred between 1924 and 1925 when the crude rate declined from 75.1 to 75.0 while the adjusted rate rose from 74.2 to 74.5.

(2) *Denominator adjustment* (" *related births* ")

This is the method that has been in official use in England and Wales since 1941. It requires numbers of deaths in the selected year at various ages of infancy, numbers of births in each quarter of the selected and the preceding year, and (if available) numbers of births in the month of December of each year.

TABLE 6. NUMBER OF BIRTHS AND INFANT MORTALITY RATES, ENGLAND AND WALES, 1911 TO 1925 : CRUDE RATE AND RATE ADJUSTED BY APPROXIMATE MATCHING PART YEAR NUMERATOR SEPARATION METHOD

Year	Number of live births registered	Crude infant mortality rate per 1,000 live births registered	Adjusted infant mortality rate
1911	881 138	130.1	129.2
1912	872 737	94.8	94.7
1913	881 890	108.4	108.9
1914	879 096	104.6	104.4
1915	814 614	109.7	105.8
1916	785 520	91.2	91.1
1917	668 346	96.5	91.1
1918	662 661	97.2	97.9
1919	692 438	89.1	93.2
1920	957 782	79.9	84.5
1921	848 814	82.8	81.2
1922	780 124	77.1	74.7
1923	758 131	69.4	69.2
1924	729 933	75.1	74.2
1925	710 582	75.0	74.5

The number of related births at each age of death is calculated as follows :

Age period of deaths	Related births: Total live births occurring in the calendar year of death experience, increased by the amounts indicated below (where "excess" signifies the excess of births occurring in the specified period of the previous year over the number occurring in the corresponding period of the experience year). If there was a deficiency instead of excess, the amount is deducted instead of added.
Under 4 weeks [a]	0.452 × excess in December
4 weeks–3 months [b]	0.654 × excess in October-December
3–6 months	Excess in October-December + ½ excess in July-September
6–9 months	Excess in July-December + ½ excess in April-June
9–12 months ...	Excess in April-December + ½ excess in January-March

[a] 0.452 = 1/2 × 28/31

[b] 0.654 = 28/91 + 1/2 × 63/91. This is the "official" factor. 0.652 = 28/92 + 1/2 × 64/92 would be preferable (there are 92 days in October-December) but the difference is of negligible consequence.

A worked example, utilizing actual data for England and Wales, 1950, is given in table 7, and yields a rate of 29.65. Should the number of births in December months not be available, the expression 0.452 × excess in December may be replaced by 0.152 × excess in October–December. If the substitution is made in the worked example for 1950, the adjusted rate declines from 29.65 to 29.64. To test the effect of further refinement of this method, the infant mortality rate was calculated on the basis of deaths at the same infant ages as for the numerator separation method (under one day, under one week, single weeks to four weeks, single months to 12 months), and numbers of births in single months of 1949 and 1950. The result was 29.67, compared with the rate of 29.65 given by the official method, thus suggesting that the more refined technique would not yield an advantage commensurate with the more detailed data and greater computational labour required.

Infant mortality rates for England and Wales from 1939 to 1950 calculated by the denominator adjustment method are compared with crude rates per 1,000 births occurring each year in table 8. The only divergence between the trends indicated by the two series was between 1946 and 1947 when the crude rate increased from 40.87 to 41.83 while the adjusted rate declined from 42.85 to 41.37, a large increase in births in 1946 having emphasized the effect of adjustment upon the 1946 rate. The table also includes rates per 1,000 births registered each year, the method customarily adopted in England and Wales for presenting unadjusted rates.

Bringing together the results for 1950 given by each of the approximate matching methods gives the following comparison with the crude rate of 29.86 :

	Numerator separation	*Denominator adjustment*
Whole year matching	29.65	29.62
Part year matching ...	29.68	29.65

It is evident that in this particular year there is

TABLE 7. CALCULATION OF ADJUSTED INFANT MORTALITY RATE, ENGLAND AND WALES, 1950, BY APPROXIMATE MATCHING PART YEAR DENOMINATOR ADJUSTMENT

(Registrar-General's method, 1941)

	Live births occurring in 1949 and 1950						
	1949	*1950*	*1949 minus 1950*	*Previous column cumulated upwards*	*½ (1949 minus 1950)*	*0.452 × December excess*	*0.654× 4th qr. excess*
1st quarter	186 228	180 774	5 454	33 421	2 727	—	—
2nd quarter	192 968	182 109	10 859	27 967	5 429	—	—
3rd quarter	182 220	171 374	10 846	17 108	5 423	—	—
4th quarter	169 102	162 840	6 262	6 262	—	—	4 095
December	55 744	54 813	931	—	—	421	—

Age at death	*Number of deaths*	*Number of related live births*	*Infant mortality rate per 1,000 related live births*
Under 4 weeks	12 917	697 097 + 421 = 697 518	18.519
4 weeks–3 months	3 012	697 097 + 4 095 = 701 192	4.296
3–6 months	2 631	697 097 + 6 262 + 5 423 = 708 782	3.712
6–9 months	1 383	697 097 + 17 108 + 5 429 = 719 634	1.922
9–12 months	874	697 097 + 27 967 + 2 727 = 727 791	1.201
Total	20 817		29.65

TABLE 8. NUMBERS OF BIRTHS AND INFANT MORTALITY RATES, CONVENTIONAL AND ADJUSTED, ENGLAND AND WALES, 1939 TO 1950

Year	Number of live births occurring	Infant mortality rate per 1,000 live births occurring	Infant mortality rate per 1,000 related live births	Infant mortality rate per 1,000 live births registered
1939	614 479	50.76	50.57	50.36
1940	590 120	57.43	56.77	55.83
1941	579 091	59.66	60.04	58.84
1942	651 503	49.51	50.62	49.32
1943	684 334	48.85	49.12	48.93
1944	751 478	44.52	45.44	44.92
1945	679 937	47.00	46.00	46.64
1946	820 719	40.87	42.85	40.91
1947	881 026	41.83	41.37	41.55
1948	775 306	34.52	33.93	34.45
1949	730 518	32.69	32.37	32.66
1950	697 097	29.86	29.65	30.09

little difference between the results from the four methods of adjustment, and this can be readily understood if the distributions of births in 1949 and 1950 are compared.

	Total	1st qr.	2nd qr.	3rd qr.	4th qr.
1949 :					
Number ..	730 518	186 228	192 968	182 220	169 102
Per cent ..	*100*	*26*	*26*	*25*	*23*
1950 :					
Number ..	607 097	180 774	182 109	171 374	162 840
Per cent ..	*100*	*26*	*26*	*25*	*23*

It was shown on page 35 above that the quarterly distributions of births in England and Wales in 1946 and 1947 were dissimilar. In 1947, the crude infant mortality rate per 1,000 births occurring was 41.83, and adjustment by the part year denominator adjustment method yielded a rate of 41.37. If the whole year instead of the part year method of denominator adjustment had been used, the adjusted rate would have been 42.40, that is to say, the rate would have been apparently increased as a result of the adjustment instead of being reduced. To avoid misleading results such as this, it is advisable, whenever the available data allow, to use one of the part year matching methods Of these, the denominator adjustment method ("related births") as used by the Registrar-General since 1941 demands less detailed data and somewhat less laborious computation than the numerator separation method used during 1920–25, but gives no less accurate results.

3. FACTOR METHODS

As an alternative to carrying out a more or less laborious computation in order to match births and infant deaths as accurately as possible, the infant mortality rate can be adjusted quite simply by utilizing a factor, determined *a priori*, in order either to separate the numerator or to adjust the denominator.

(a) *Numerator separation by factor f*

Let us suppose that there were d deaths in a selected year, and that there were b_1 births in that year and b_0 births in the previous year. Then the adjusted infant mortality rate can be expressed :

$$\text{Infant mortality rate} = \left(\frac{fd}{b_0} + \frac{(1-f)\ d}{b_1}\right) \times 1{,}000,$$

where fd is the number of deaths in the current year of infants born in the previous year, and the remaining deaths, $(1-f)\ d$, are those of infants born in the current year.

Providing the value of f is known, the calculation of the adjusted rate is a simple matter, and methods of determining the value of f will be described after two other factor methods have been mentioned.

(b) *Denominator adjustment*

Using the same symbols, d, b_0 and b_1, the adjusted infant mortality rate can be expressed :

$$\text{Infant mortality rate} = \left(\frac{d}{rb_0 + (1-r)\ b_1}\right) \times 1{,}000,$$

where rb_0 and $(1-r)b_1$ represent for each of the two years the proportions of the births relating to the deaths d.

Again the calculation is simple providing the value of r is known.

(c) *Denominator adjustment using numerator separation factor*

In practice, the values of f and r are very close to each other.[6]

Therefore, with very little error, the factor r in the denominator adjustment formula may be replaced by the factor f, the numerator separation factor, giving

$$\text{Infant mortality rate} = \left(\frac{d}{(fb_0 + (1-f)\ b_1)}\right) \times 1{,}000$$

Values of f or of r can be obtained in a number of ways. Thus, the approximate matching whole year numerator separation calculation of the infant mortality rate for England and Wales in 1950 (table 4) indicated that of the 20,817 infant deaths in that year 3,273 were of infants probably born in 1949. Hence $f = \frac{3{,}273}{20{,}817} = 0.16$.

[6] Let $b_1/b_0 = n$. Then if n is not equal to 1 it can be shown that $1/f = 1 - n + n/r$.

Hence f approximates to r when n approximates to 1.

Alternatively, taking the adjusted infant mortality rate for 1950 as that given by the part year denominator adjustment method, viz. 29.65 (table 7), f can be evaluated from the equation :

$$\frac{20{,}817\,f}{730{,}518} + \frac{20{,}817\,(1-f)}{697{,}097} = 29.65/1{,}000,$$

giving $f = 0.16$.

Similarly, r can be derived from the equation

$$\frac{20{,}817}{r\,(730{,}518) + (1-r)\,697{,}097} = 29.65/1{,}000,$$

giving $r = 0.15$

Substituting f (= 0.16) for r (= 0.15) in the denominator adjustment formula gives :

$$\text{Infant mortality rate} = \frac{20{,}817 \times 1{,}000}{(.16 \times 730{,}518) + (.84 \times 697{,}097)}$$

$= 29.64,$

i.e. substitution of f for r makes negligible difference to the result.

If data are available to allow exact matching of births and deaths in any year, this will provide a more accurate value of f than can be obtained from approximate matching methods. Whatever way f or r is determined, it can then be used for several years without recalculation unless the age distribution of infant mortality is changing greatly. The whole point of the factor method is, in fact, to avoid the labour of calculating a fresh factor each year. The data required and the computation involved in an *ad hoc* calculation of f or r are precisely the same as those for any of the adjustment methods for matching births and deaths; the factor emerges during the process of adjusting the rate, or can be calculated from the adjusted rate—in either case the adjustment process is unavoidable.

A further advantage of the factor methods is that the factor f or r need not be estimated precisely, considerable latitude being permissible without any serious error being introduced in the adjusted rate. For example, with a crude infant mortality rate of 30 per 1,000 and the number of births changing by 10 per cent or 25 per cent from one year to the next, adjusted rates given by different values of f are as shown in the next table.

Annual percentage change in number of births	*f = .20*	*f = .25*	*f = .30*
+ 25 per cent	31.50	31.88	32.25
+ 10 per cent	30.60	30.75	30.90
− 10 per cent	29.40	29.25	29.10
− 25 per cent	28.50	28.13	27.75

With up to about 10 per cent annual variations in births, the adjusted rates given by the different values of f do not differ to an extent that is likely to be of any practical importance. For example, the reduction in births in England and Wales from 1939 to 1940 was by 12 per cent. Infant mortality rates for 1940 given by values of f differing by ± 10 per cent and ± 20 per cent from the calculated value of .29 were as follows :

f =	.23	.26	.29	.32	.35
Infant mortality rate	56.91	56.84	56.77	56.70	56.64

A comparison is given in table 9 of infant mortality rates in England and Wales, 1940 to 1950, by the official related births method (part year

TABLE 9. INFANT MORTALITY RATES, ENGLAND AND WALES, 1940 TO 1950, ILLUSTRATING RESULTS OF VARIOUS METHODS OF ADJUSTMENT

Year	*Infant mortality rate per 1,000 births occurring*	*Infant mortality rate per 1,000 related live births*	*Infant mortality rate by 1940 factor f = .29*	*Infant mortality rate by 1940 factor r = .28*	*Infant mortality rate by 1940 factor f for r*	*Infant mortality rate by regression method*
1940	57.43	56.77	56.77	56.78	56.75	56.75
1941	59.66	60.04	59.34	59.35	59.34	59.34
1942	49.51	50.62	51.31	51.10	51.16	51.09
1943	48.85	49.12	49.57	49.52	49.54	49.48
1944	44.52	45.44	45.79	45.66	45.70	45.58
1945	47.00	46.00	45.71	45.66	45.61	45.88
1946	40.87	42.85	43.32	42.93	43.01	42.78
1947	41.83	41.37	42.72	42.64	42.67	42.54
1948	34.52	33.93	33.32	33.25	33.21	33.63
1949	32.69	32.37	32.14	32.14	32.12	32.30
1950	29.86	29.65	29.47	29.47	29.45	29.60

denominator adjustment) and by the three factor methods, using constant values of f and r calculated from the official adjusted rate for 1940. The results for each year as given by the three factor methods do not differ appreciably among themselves, but on several occasions diverge considerably from the more accurately calculated rate. For example, the factor methods gave an adjusted rate lower than the crude rate in 1941, whereas the " related births " method gave a higher rate. A divergence of opposite type occurred in 1947 when the official method reduced the crude rate and the factor methods increased it. These discrepancies occur because the factor methods are essentially " whole year " adjustment methods, i.e., they do not take account of possibly dissimilar distributions of births in the years to which they are applied from the year on which the factor was estimated.

(d) *Checking the value of f*

The simplified whole year numerator separation method of adjustment mentioned on page 38 based on neonatal and postnatal deaths, provides a rough but very simple method for checking the value of f, provided the data allow distinction of neonatal and postnatal deaths. By this method, half of the postnatal deaths in the current year are assigned to the previous year's births from which it follows that :

$$f = 0.5 \times \text{postnatal/total deaths.}$$

Thus for England and Wales, 1950

$$f = 0.5 \times 7{,}900/20{,}817 = 0.19,$$

which corresponds fairly well with the value of f already estimated for 1950.

(e) *Regression method of determining separation factor*

Another method of deriving a numerator separation factor, which has been suggested recently by Valaoras, requires neither the data for exact or approximate matching of births and deaths nor an adjusted rate based on such matching. The method is based on the experience of Scandinavian countries over a number of decades, during which the infant mortality rate declined from about 85 to about 30 per 1,000 live births. A numerator separation factor was calculated for each year by exact matching of births and deaths, and the value of the factor was found to increase as the infant mortality rate declined. On the assumption that this relationship between the infant mortality rate and the separation factor held at levels of the rate above 85 per 1,000 the following formula was developed :

$$\log (y - 50) = 1.490173 - 0.005153\, x$$

where y = the separation factor and represents the percentage of infant deaths in the current year to be assigned to the births in the same year, i.e., $y = 100\ (1 - f)$, and x = the conventional infant mortality rate per 1,000 live births.

According to Valaoras, the separation factor thus calculated should be increased or decreased by about one-fifth of the per cent increase or decrease of the number of births from the first to the second of the two calendar years under consideration.

Table 10 gives separation factors at various levels of the infant mortality rate.

On the assumption that the formula based on Scandinavian experience is of general applicability, a separation factor and hence an adjusted infant mortality rate can be calculated whenever annual total infant deaths and live births are known. The assumption is probably a reasonable one for Western countries where the level and trend of infant mortality has been similar to that in Scandinavia, but for most Western countries there is no need for such a simplified factor method since data are usually tabulated in sufficient detail to allow a more accurate adjustment.

The last column of table 9 gives infant mortality rates for England and Wales adjusted by this regression method, and it is clear that for the particular series of years shown the results are as good as those given by other factor methods and similarly diverge from the results given by the official " related births " method in years when the seasonal distribution of births was abnormal (i.e., 1940–41, and 1946–47). The regression factor method is not as accurate as an exact or approximate part year matching method, but is obviously a useful approximate method. Nevertheless, it may give misleading results in countries where the age distribution of infant deaths at a given level of infant mortality does not conform to the standard (Scandinavian) pattern. That this is more than a theoretic danger can be demonstrated by

TABLE 10. SEPARATION FACTORS AT SELECTED RATES OF INFANT MORTALITY DERIVED FROM THE FORMULA LOG $(y - 50) = 1.490173 - 0.005153\, x$

Infant mortality rate (x)	*Separation factor*	*Infant mortality rate* (x)	*Separation factor*
30	80.6	120	60.5
40	77.2	130	59.3
50	74.1	140	58.3
60	71.4	150	57.4
70	69.0	160	56.5
80	66.9	170	55.8
90	65.0	180	55.2
100	63.3	200	54.1
110	61.8		

TABLE 11. INFANT MORTALITY RATES, NEONATAL AND POSTNATAL RATES, AND SEPARATION FACTORS ESTIMATED BY REGRESSION METHOD AND BY POSTNATAL/TOTAL RATIO, VARIOUS COUNTRIES, 1948

Country	Total infant mortality rate	Approximate separation factor by regression method	Neonatal rate	Postnatal rate	$f = .5 \times$ postnatal/total ratio	$100 \times (1-f)$
Austria ..	76	68	39	37	.24	76
Chile ...	160	57	59	101	.32	68
India ...	130	59	61	69	.27	73
Portugal.	100	63	34	66	.33	67

comparing the age distribution of infant deaths in a few selected countries in 1948 on the basis of the neonatal, postnatal and total infant mortality rates (table 11).

In Austria and India, the neonatal and postnatal proportions were about equal, whereas in Chile and Portugal, there were roughly two postnatal deaths to each neonatal death. Hence, although the total rate for India was higher than for Portugal, and therefore had a smaller separation factor by the regression method, the corresponding factor yielded by the postnatal/total ratio was larger for India than for Portugal. In view of possibly abnormal age distribution of deaths, some dubiety must be felt about applying the regression method to those very countries where lack of detailed data would otherwise make it the method of choice.

C. QUARTERLY AND MONTHLY RATES

If it is inaccurate to use for the denominator of annual infant mortality rates the number of births in the same year, it is still more inaccurate to use for the denominator of quarterly or monthly rates the number of births in the same quarter or month. For annual rates, the proportion of deaths assignable to births in the same year is considerable, e.g., 80 per cent, and the number of births usually does not change violently from year to year. For quarterly rates, and still more for monthly rates, the proportion of deaths assignable to births in the same quarter or month as the deaths is much smaller (for quarters, about 65 per cent, and for months about 40 per cent), and the number of births usually changes much from quarter to quarter and from month to month.

A simple method of calculation that goes some way, but not nearly far enough, towards meeting these difficulties is to use as denominator the average quarterly or monthly births in the 12-month period ending with the current quarter or month. Thus for England and Wales in the first quarter of 1950, when there were 6,575 infant deaths, the denominator would be 1/4 (192,968 + 182,220 + 169,102 + 180,774) = 181,266, giving the infant mortality rate for the quarter as 36.27 per 1,000 births so estimated, compared with the

TABLE 12. CALCULATION OF QUARTERLY INFANT MORTALITY RATES BY EXACT MATCHING MULTIPLICATIVE TECHNIQUE (HYPOTHETICAL DATA GIVEN IN TABLES 1 AND 2)

Age at death	Quarters of death: 1st qr. $p_1 \times p_2$	2nd qr. $p_1 \times p_2$	3rd qr. $p_1 \times p_2$	4th qr. $p_1 \times p_2$
Under 3 months (1) ..	$\frac{1b_1 - c_1}{1b_1} \times \frac{4b_0 - c_2}{4b_0 - c_1}$	$\frac{2b_1 - c_1}{2b_1} \times \frac{1b_1 - c_2}{1b_1 - c_1}$	$\frac{3b_1 - c_1}{3b_1} \times \frac{2b_1 - c_2}{2b_1 - c_1}$	$\frac{4b_1 - c_1}{4b_1} \times \frac{3b_1 - c_2}{3b_1 - c_1}$
3–6 months (2)	$\frac{4b_0 - c_3}{4b_0 - c_2} \times \frac{3b_0 - c_4}{3b_0 - c_3}$	$\frac{1b_1 - c_3}{1b_1 - c_2} \times \frac{4b_0 - c_4}{4b_0 - c_3}$	$\frac{2b_1 - c_3}{2b_1 - c_2} \times \frac{1b_1 - c_4}{1b_1 - c_3}$	$\frac{3b_1 - c_3}{2b_1 - c_2} \times \frac{2b_1 - c_4}{2b_1 - c_3}$
6–9 months (3)	$\frac{3b_0 - c_5}{3b_0 - c_4} \times \frac{2b_0 - c_6}{2b_0 - c_5}$	$\frac{4b_0 - c_5}{4b_0 - c_4} \times \frac{3b_0 - c_6}{3b_0 - c_5}$	$\frac{1b_1 - c_5}{1b_1 - c_4} \times \frac{4b_0 - c_6}{4b_0 - c_5}$	$\frac{2b_1 - c_5}{2b_1 - c_4} \times \frac{1b_1 - c_6}{1b_1 - c_5}$
9–12 months (4)	$\frac{2b_0 - c_7}{2b_0 - c_6} \times \frac{1b_0 - c_8}{1b_0 - c_7}$	$\frac{3b_0 - c_7}{3b_0 - c_6} \times \frac{2b_0 - c_8}{2b_0 - c_7}$	$\frac{4b_0 - c_7}{4b_0 - c_6} \times \frac{3b_0 - c_8}{3b_0 - c_7}$	$\frac{1b_1 - c_7}{1b_1 - c_6} \times \frac{4b_0 - c_8}{4b_0 - c_7}$
$\prod_{i=1}^{i=4} p_{1i} \times p_{2i}$ =	0.951211	0.971799	0.973735	0.971716
q =	0.048789	0.028201	0.026265	0.028284
Infant mortality rate =	48.79	28.20	26.27	28.28

crude rate of 36.37 per 1,000 births in the same quarter. This method is in fact a factor method of denominator adjustment (see below) in which the same factor, .25, has been applied to each of the four quarters' births that were taken into consideration. Both in practice and theory, it is an unsound method, the practical objection being that it yields an inaccurate rate and the theoretic objection being that it fails to apply anything like the proper distribution of weights to the related birth periods, underweighting the current quarter, overweighting the first three preceding quarters, and giving no weight at all to the fourth preceding quarter (in practice, however, not a serious omission).

Another simple method sometimes used is to take as denominator the average quarterly or monthly number of births for the whole of the calendar year in which the selected quarter or month is situated. This method cannot be applied, therefore, until the end of that year. For the first quarter of 1950, the rate for England and Wales by this method would be

$$\frac{6{,}575 \times 1{,}000 \times 4}{697{,}097} = 37.73.$$

TABLE 13. CALCULATION OF QUARTERLY INFANT MORTALITY RATES BY EXACT MATCHING ADDITIVE TECHNIQUE (HYPOTHETICAL DATA GIVEN IN TABLE 1)

Quarterly infant mortality rate for year 1		*Under 3 months*	*3–6 months*	*6–9 months*	*9–12 months*	*Total*
1st quarter .	Deaths ...	2 000	900	500	300	
	Births/1000	280	220	200	100	
	Rate	7.143	4.091	2.500	3.000	
	Deaths ...	6 000	900	500	300	
	Births/1000	240	280	220	200	
	Rate	25.000	3.214	2.273	1.500	
	Total					48.72
2nd quarter	Deaths ...	1 000	600	400	300	
	Births/1000	240	280	220	200	
	Rate	4.167	2.143	1.818	1.500	
	Deaths ...	3 000	600	400	300	
	Births/1000	230	240	280	220	
	Rate	13.043	2.500	1.429	1.364	
	Total					27.96
3rd quarter	Deaths ...	1 000	500	300	200	
	Births/1000	230	240	280	220	
	Rate	4.348	2.083	1.071	0.909	
	Deaths ...	3 000	500	300	200	
	Births/1000	220	230	240	280	
	Rate	13.636	2.174	1.250	0.714	
	Total					26.19
4th quarter	Deaths ...	1 000	600	300	200	
	Births/1000	220	230	240	280	
	Rate	4.545	2.609	1.250	0.714	
	Deaths ...	3 000	600	300	200	
	Births/1000	210	220	230	240	
	Rate	14.286	2.727	1.304	0.833	
	Total					28.27

TABLE 14. QUARTERLY INFANT MORTALITY RATES CALCULATED BY VARIOUS METHODS (HYPOTHETICAL DATA GIVEN IN TABLE 1)

	1st qr.	*2nd qr.*	*3rd qr.*	*4th qr.*
Rate per 1,000 births in same quarter	47.50	28.70	27.27	29.52
Rate per 1,000 births in same and 3 previous quarters	48.51	27.22	24.74	26.38
Rate per 1,000 births in same calendar year ...	50.67	29.33	26.67	27.56
Rate adjusted by exact matching (multiplicative technique)	48.79	28.20	26.27	28.28
Rate adjusted by exact matching (additive technique)	48.72	27.96	26.19	28.27

None of these methods is good enough, particularly during periods of exceptionally fluctuating fertility, and more precise methods of matching the births and deaths are necessary. The methods available are the same in principle as those already described for annual rates and it will suffice simply to mention the methods and to illustrate their application by means of worked examples.

1. EXACT MATCHING OF BIRTHS AND DEATHS

Tables 12 and 13 illustrate the multiplicative and additive techniques of calculation of quarterly infant mortality rates based on the hypothetical data given earlier, and the results are compared in table 14.

Monthly rates can be calculated in the same way, providing deaths at single months of age are tabulated by exact month of birth.

2. APPROXIMATE MATCHING OF BIRTHS AND DEATHS

(a) *Numerator separation*

Almost the whole of the calculation required for quarterly rates by this method has already been carried out in table 5 in obtaining the adjusted annual rate, and the very simple additional steps —the conversion of the separated totals of deaths for each quarter into rates and their summation —are shown in table 15.

The calculation of monthly rates by this method follows the same general principle of separating out the deaths at each age according to the months in which birth probably occurred. The relative proportions to be assigned to the preceding months vary slightly with the length of the month of experience, and in addition it is advisable,

TABLE 15. CALCULATION OF QUARTERLY INFANT MORTALITY RATES, ENGLAND AND WALES, 1950, BY APPROXIMATE MATCHING NUMERATOR SEPARATION METHOD

	Deaths assigned to births in quarters of each year								
	1949				*1950*				
	1st qr.	*2nd qr.*	*3rd qr.*	*4th qr.*	*1st qr.*	*2nd qr.*	*3rd qr.*	*4th qr.*	*Total*
Number of births	186 228	192 968	182 220	169 102	180 774	182 109	171 374	162 840	
1st quarter 1950									
Deaths	135	384	724	1 481	3 851	—	—	—	
Infant mortality rate.	0.725	1.990	3.973	8.758	21.303	—	—	—	36.75
2nd quarter 1950									
Deaths	—	104	245	392	862	3 431	—	—	
Infant mortality rate.	—	0.539	1.345	2.318	4.768	18.840	—	—	27.81
3rd quarter 1950									
Deaths	—	—	64	190	324	610	2 988	—	
Infant mortality rate.	—	—	0.351	1.124	1.792	3.350	17.436	—	24.05
4th quarter 1950									
Deaths	—	—	—	106	277	504	887	3 258	
Infant mortality rate.	—	—	—	0.627	1.532	2.768	5.176	20.007	30.11

though hardly essential, to make some correction for disparity between the length of the month of death and of birth.

The deaths in a 31-day month may be assigned to months of birth in accordance with the following scheme :

Age at death	*Proportion of deaths assigned to*	
	Same month	*Preceding month*
Under 1 day	.984	.016
1 day-	.952	.048
2 days-	.919	.081
3 days-	.839	.161
7 days-	.661	.339
14 days-	.435	.565
21 days-	.210	.790
28 days-	.048	.476 to each of the two preceding months
2 months-	.5 to each of the second and third preceding months	
3 months-	.5 to each of the third and fourth preceding months	

and so on

A worked example illustrating the method is given in table 16, using partly hypothetical numbers of deaths in England and Wales in March 1947, the actual deaths not having been tabulated for single months. The example incorporates a simple correction for differences in the length of months of birth from that of the month of death.

The resulting infant mortality rate is 52.66, compared with a crude rate of 50.43 per 1,000 births in the month of March 1947, and a rate of 57.06 per 1,000 births between April 1946 and March 1947.

A simplified separation technique, utilizing neonatal and postnatal deaths only, provides a much easier, and reasonably accurate, method for the calculation of monthly adjusted rates (De Porte, 1946). By this method all the neonatal deaths are assigned to births in the current month, and all the postnatal deaths are assigned to the monthly average number of births during the preceding 11 months.

Thus, for England and Wales in March 1947, the procedure is as follows :

Age at death	*Number of deaths assigned to births in*	
	March 1947	*Monthly average, April 1946–February 1947*
Under 4 weeks	2 234	—
4 weeks–1 year	—	1 953
Number of births ..	83 021	72 496
Infant mortality rates	26.909	26.939
Total rate	53.85	

A correction for length of month can be easily introduced if desired.

TABLE 16. CALCULATION OF MONTHLY INFANT MORTALITY RATE, ENGLAND AND WALES, MARCH 1947, BY APPROXIMATE MATCHING NUMERATOR SEPARATION METHOD

(The break-down of deaths for the single month to the ages shown is hypothetical)

	Number of deaths	1947			1946									
		March	February	January	December	November	October	September	August	July	June	May	April	March
Births	—	83 021	73 693	82 913	78 345	72 382	72 373	73 256	70 967	70 002	68 031	70 820	64 677	65 627
Adjusted to 31 days ...	—	—	81 589	—	—	74 795	—	75 698	—	—	70 299	—	66 833	—
Under 1 day .	614	604	10	—	—	—	—	—	—	—	—	—	—	—
1 day–	238	227	11	—	—	—	—	—	—	—	—	—	—	—
2 days–	204	187	17	—	—	—	—	—	—	—	—	—	—	—
3 days–	412	346	66	—	—	—	—	—	—	—	—	—	—	—
7 days–	372	246	126	—	—	—	—	—	—	—	—	—	—	—
14 days–	232	101	131	—	—	—	—	—	—	—	—	—	—	—
21 days–	162	34	128	—	—	—	—	—	—	—	—	—	—	—
28 days–	481	23	229	229	—	—	—	—	—	—	—	—	—	—
2 months– ..	320	—	—	160	160	—	—	—	—	—	—	—	—	—
3 months– ..	243	—	—	—	122	121	—	—	—	—	—	—	—	—
4 months– ..	213	—	—	—	—	107	106	—	—	—	—	—	—	—
5 months– ..	151	—	—	—	—	—	76	75	—	—	—	—	—	—
6 months– ..	137	—	—	—	—	—	—	69	68	—	—	—	—	—
7 months– ..	120	—	—	—	—	—	—	—	60	60	—	—	—	—
8 months– ..	86	—	—	—	—	—	—	—	—	43	43	—	—	—
9 months– ..	81	—	—	—	—	—	—	—	—	—	41	40	—	—
10 months– ..	71	—	—	—	—	—	—	—	—	—	—	36	35	—
11 months– ..	50	—	—	—	—	—	—	—	—	—	—	—	25	25
Total	4 187	1 768	718	389	282	228	182	144	128	103	84	76	60	25
Infant mortality rate		21.30	8.80	4.69	3.60	3.05	2.51	1.90	1.80	1.47	1.19	1.07	.90	.38

Total = 52.66

TABLE 17. MONTHLY INFANT MORTALITY RATES PER 1,000 LIVE BIRTHS, CALCULATED BY VARIOUS METHODS, U.S. 1942 [a]

Month	Conventional rate	Adjusted rate (Full numerator separation method)	Adjusted rate (De Porte method)
January	43.4	47.5	47.0
February	44.4	47.5	47.2
March	42.4	45.3	45.3
April	38.6	42.2	42.4
May	36.9	40.7	40.6
June	37.2	39.9	39.8
July	39.1	40.5	40.2
August	37.9	37.9	37.8
September	40.2	38.4	38.3
October	40.5	38.2	38.4
November	40.4	38.7	39.0
December	43.9	42.4	42.7

[a] Extracted from Moriyama, I. and Greville, T., " Effect of changing birth rates upon infant mortality rates ". *Vital Statistics—Special Reports*, Vol. 19, No. 21, United States, Bureau of the Census, Washington, November 1944, pp. 399-412.

Table 17 (from Moriyama and Greville, 1944) compares conventional monthly infant mortality rates in the United States, 1942, with the adjusted rates given by a full numerator separation method and by the simplified neonatal/postnatal method of De Porte, and shows that the latter is a useful approximate method.

(b) *Denominator adjustment*

As for annual rates, the method used officially in England and Wales since 1941 for the calculation of quarterly rates is that of denominator adjustment (related births). A worked example of the method is given in table 18 for the four quarters of 1950. The method is applicable also to the monthly rates.

3. FACTOR METHODS

In the same way that an annual adjusted rate can be calculated utilizing a numerator separa-

TABLE 18. CALCULATION OF QUARTERLY INFANT MORTALITY RATES, 1950, BY APPROXIMATE MATCHING DENOMINATOR ADJUSTMENT (" RELATED BIRTHS ") METHOD

		Quarters			
		1st	2nd	3rd	4th
Infant deaths					
Under 4 weeks		3 596	3 285	2 893	3 143
4 weeks–3 months		1 152	697	492	671
3–6 months		1 042	539	410	640
6–9 months		489	297	237	360
9–12 months		296	216	144	218
Birth occurrences					
(Current qr.)	A	180 774	182 109	171 374	162 840
(Preceding qr.)	B	169 102	180 774	182 109	171 374
(Preceding qr.)	C	182 220	169 102	180 774	182 109
(Preceding qr.)	D	192 968	182 220	169 102	180 774
(Preceding qr.)	E	186 228	192 968	182 220	169 102
Related births					
Under 4 weeks [a]	.846A + .154B	178 977	181 903	173 027	164 154
4 weeks–3 months [b]	.346A + .654B	173 141	181 236	178 395	168 421
3–6 months	.5B + .5C	175 661	174 938	181 442	176 742
6–9 months	.5C + .5D	187 594	175 661	174 938	181 442
9–12 months	.5D + .5E	189 598	187 594	175 661	174 938
Infant mortality rates per 1,000 related births					
Under 4 weeks		20.092	18.059	16.720	19.147
4 weeks–3 months		6.654	3.846	2.758	3.984
3–6 months		5.932	3.081	2.260	3.621
6–9 months		2.607	1.691	1.355	1.984
9–12 months		1.561	1.151	0.820	1.246
Total		36.85	27.83	23.91	29.98

[a] $A + 1/2 \times 28/91\ (B-A) = A + .154B-.154A = .846A + .154B$

[b] $A + (28/91 + 1/2 \times 63/91)\ (B-A) = A + .654B - .654A = .346A + .654B$

TABLE 19. QUARTERLY INFANT MORTALITY RATES, ENGLAND AND WALES, 1950, CALCULATED BY VARIOUS METHODS

1950	(1) Rate per 1,000 births occurring in same quarter	(2) Rate per 1,000 births occurring in same and 3 preceding quarters	(3) Adjusted rate by numerator separation method (Table 15)	(4) Adjusted rate by denominator adjustment method (Table 18)	(5) Numerator separation by 1950 f factors	(6) Denominator adjustment by 1950 f factors
1st quarter	36.37	36.27	36.75	36.85	36.66	36.63
2nd quarter	27.64	28.19	27.81	27.83	27.85	27.83
3rd quarter	24.37	23.75	24.05	23.91	23.97	23.96
4th quarter	30.90	28.87	30.11	29.98	30.13	30.08

tion factor to allocate proportions of deaths to the births in the current and preceding year, a series of factors can be used to allocate proportions of a quarter's deaths to the births in the current and the four preceding quarters. Taking d as the deaths in the current quarter, f_0, f_1, f_2, f_3, f_4 as the separation factors for assigning deaths to the current and four preceding quarters' births, and b_0, b_1, b_2, b_3, b_4 as the births in these five quarters, the adjusted quarterly infant mortality rate is given by the formula :

Infant mortality rate =

$$\frac{df_0}{b_0} + \frac{df_1}{b_1} + \frac{df_2}{b_2} + \frac{df_3}{b_3} + \frac{df_4}{b_4} \times 1{,}000.$$

Alternatively, the numerator separation factors may be used to adjust the denominator, and the adjusted infant mortality rate is then given by the formula :

Infant mortality rate =

$$\frac{d}{f_0 b_0 + f_1 b_1 + f_2 b_2 + f_3 b_3 + f_4 b_4} \times 1{,}000.$$

In practice, the results do not differ to a material extent, but computation is somewhat easier by the second formula.

The numerator separation calculation for 1950 (table 5) gave the following distribution of the 20,817 deaths in the year, according to the quarter of birth :

	Deaths	Proportions	= Factors
Total	20 817	1.00	
Current quarter	13 528	.650	f_0
1st preceding quarter .	3 840	.184	f_1
2nd preceding quarter.	1 944	.093	f_2
3rd preceding quarter .	1 096	.053	f_3
4th preceding quarter .	409	.020	f_4

These factors represent the *average* quarterly separation of the deaths in 1950 and slightly different factors would be derived from each of the four quarters. It is simpler, however, and introduces negligible error, to use one set of average factors than to use different sets of factors for deaths in the different quarters of the year.

Table 19 compares the quarterly rates in England and Wales in 1950 calculated by various methods, including the two factor methods just described, utilizing the average quarterly factors derived from the 1950 experience. As the factors have been derived from the same year's experience as that to which they have been applied, it is natural that the results by the factor methods differ little from those given by the more detailed methods of numerator separation and denominator adjustment. It should be noted, however, how little the rates given by the two factor methods differ from each other.

A better demonstration of the accuracy of the factor method can be obtained by applying the 1950 factors to the experience of another year, as would actually be done in practice. Crude and adjusted quarterly rates in England and Wales in 1947 are compared below :

	Crude rates per 1,000 births occurring in the same quarters	Adjusted rates by denominator adjustment	Adjusted rates by 1950 f factors
1st quarter	52.42	55.19	54.54
2nd quarter	39.32	39.70	39.62
3rd quarter	33.32	32.08	32.41
4th quarter	41.15	38.37	39.21

The rates given by the factor method are intermediate between the crude rates and the accurately adjusted rates, and closer to the latter.

The factor methods of adjustment can be used in the calculation of monthly rates in the same way as for quarterly rates, but a set of 13 instead of five factors is required.

III. ADDITIONAL ASPECTS

A. Comparative risk of dying at different ages during infancy

The conventional manner of stating infant mortality rates at various ages is illustrated in the following table showing the rates for England and Wales, 1950 (per 1,000 births occurring in the same year):

Days				Months			
0–	*1–*	*7–*	*28–*	*3–*	*6–*	*9–*	*Total*
7.2	8.0	3.3	4.3	3.8	2.0	1.3	29.9

The numerator is the number of children dying at the ages stated, and the denominator, the number of births, remains the same at each age. This method of presentation has the virtue of simplicity and the advantage of traditional usage, but it fails to provide an immediate comparison between the mortality risks at different ages, partly because the number at risk of death at each age is not constant but is diminishing owing to death losses, and partly—and more important—because the durations of risk at each age vary widely, between one day and three months. Thus the risk of dying at one to six days, as indicated above, seems at first glance to be greater than the risk of dying on the first day and the risk at 28 days–three months seems greater than at 7–27 days.

Varying the denominator at each age by subtracting all the deaths at earlier ages, and multiplying each numerator by a factor equal to 365/number of days in each age group, yields the following comparative indices:

Days				Months		
0–	*1–*	*7–*	*28–*	*3–*	*6–*	*9–12*
2 632	490	59	25	15	8	5

From this presentation, it becomes at once evident that the risk of dying on the first day is enormously greater than at later ages, e.g., 175 times greater than at three to six months instead of two times greater as suggested by the conventional method of presentation.

It is not proposed that this comparative method of presentation should be substituted for the conventional method; it should be looked upon as an ancillary method to be reserved for those occasions when interest is being taken in the relative risk of death at different ages rather than the contribution to the total infant mortality made by each age group.

B. Standardized infant mortality rates

The type of adjusted infant mortality rate adopted by the Registrar-General in 1920 (approximate matching part year numerator separation, page 39) was described by him as a "standardized" rate to distinguish it from the "crude", i.e., conventional, unadjusted rate. It is confusing and inadvisable to use "standardized" for this purpose and the term is more appropriately used in other circumstances.

The infant mortality rate varies with sex, race, legitimacy, socio-economic circumstances, age and parity of mother, family size, and numerous other factors, and a standardized rate for a given place and time should be one which has been adjusted to make allowance for the particular distribution of one or more of these associated factors in the given experience compared with that of a standard experience.

Consider the following hypothetical situation:

	Legitimate		*Illegitimate*		
	Male	*Female*	*Male*	*Female*	*Total*
Standard (e.g., national) births...	340 000	320 000	20 000	19 000	659 000
Distribution per 1,000 total births	486	458	29	27	1 000
Area A					
Births	40 000	35 000	800	700	76 500
Deaths	1 600	1 050	48	35	2 733
	Crude infant mortality rate =				*35.7*
Area B					
Births	20 000	17 000	1 600	1 380	39 980
Deaths	780	493	94	68	1 435
	Crude infant mortality rate =				*35.9*
Deaths in a Standard thousand births					
Area A	19.44	13.74	1.74	1.35	*36.3*
Area B.....	18.95	13.28	1.70	1.33	*35.3*

As judged by the crude rates, Area A had a slightly more favourable infant mortality experience than Area B. Making allowance, by standardization, for the slightly different sex ratios of births in the two areas and, more important,

the higher level of illegitimacy in Area B, the standardized rates indicate that in fact Area B had a better infant mortality experience than Area A.

C. Measurement of infant mortality by the method suggested by Bourgeois-Pichat

In a series of papers, Bourgeois-Pichat, of l'Institut national d'études démographique, Paris, has put forward a technique for the measurement of infant mortality designed to distinguish between two components, deaths due to endogenic causes (causes operating upon the infant before and during birth) and exogenic causes (causes operating upon the infant after birth). Bourgeois-Pichat points out that this is an important distinction from the medical viewpoint in that the preventive measures designed to reduce the endogenic causes of mortality (e.g., prematurity, congenital conditions) are different from those that are effective against exogenic causes (e.g., infectious diseases). Moreover, in the majority of Western countries much greater improvement took place in the first four decades of this century in infant mortality attributable to exogenic rather than to endogenic causes, suggesting that it is against the former that preventive measures have proved the more effective.

This is exemplified by the following infant mortality rates in England and Wales :

Causes	*1901–05*	*1939*	*1939 as per cent of 1901–05*
Developmental and wasting diseases (prematurity, congenital malformations and congenital debility)	45	25	*56*
Other causes	93	26	*28*

It must be noted, however, that mortality from the developmental and wasting diseases did not by any means remain resistant to improvement, and it is a misnomer to label them " unavoidable causes " as is sometimes done. Indeed, between 1939 and 1949, mortality from these causes declined almost as rapidly as from other causes :

	1939	*1949*	*1949 as per cent of 1939*
Developmental and wasting diseases	25	16	*64*
Other causes	26	16	*62*

Although it is important to be able to distinguish endogenic from exogenic mortality, medically certified statements of cause of death of infants are sometimes lacking, or even when available, are generally less accurate diagnostically than for deaths at older, except very old, ages. As mentioned in part I, it is often a difficult matter to diagnose with confidence the cause of death of a young infant.

One way of attempting to distinguish between the two groups of causes of death is to classify the infant deaths according to age. Infants who die during the first few weeks of life are the victims mainly of endogenic causes, but at later stages of the first year an increasing proportion of the deaths can be ascribed to exogenic causes. Accordingly, a breakdown of infant mortality into deaths during the first few weeks and deaths during the remainder of the first year should provide at least an approximate, and possibly a sufficient, indication of the relative contributions of the two groups of cases to the total rate.

The purpose of Bourgeois-Pichat's method is to provide a more accurate distinction between the two groups than can be achieved by dividing the infant deaths arbitrarily at a selected age, e.g., four weeks, or by depending upon the stated medical causes of death, if and when available ; and in addition it is to emphasize the importance of the exogenic component as being the more significant from the public health aspect, a view with which paediatricians and health officers in advanced countries, having regard to recent trends and developments, will not necessarily agree.

Distinguishing the exogenic component and treating it as the principal component of the infant mortality rate gets rid of the difficulty inherent in the total infant mortality rate as to whether any of the early deaths have been omitted and classified as stillbirths ; moreover, Bourgeois-Pichat proposes that the endogenic component and stillbirths should be combined as " perinatal mortality ".

Several methods of calculation have been described by Bourgeois-Pichat in his papers, and the methods can yield annual or monthly rates based either on births during the same period or incorporating adjustments so as to relate the births and deaths. Each of the methods is designed to determine mathematically the proportion of the infant deaths that behave as though due to endogenic causes (increasing rapidly during the first few days of life, then tailing off) and the proportion due to exogenic causes (with the risk of dying cumulating linearly with age).

A worked example of the calculation, applied to the infant deaths in England and Wales in 1950, is given in table 20, no adjustment being made for " related births ". It will be noted that the method requires tabulation of the infant

TABLE 20. CALCULATION OF "EXOGENIC" INFANT MORTALITY RATE, ENGLAND AND WALES, 1950

Age (months)	No. of deaths	Cumulated deaths (up)	Rate per 1,000 live births occurring in 1950 (697,097)	Coefficient*	Rate ÷ coefficient
1	1 614	7 900	11.33	.801	14.14
2	1 398	6 286	9.02	.654	13.79
3	1 067	4 888	7.01	.550	12.75
4	862	3 821	5.48	.459	11.94
5	702	2 959	4.24	.381	11.13
6	551	2 257	3.24	.312	10.38
7	458	1 706	2.45	.249	9.78
8	374	1 248	1.79	.189	9.47
9	328	874	1.25	.139	8.99
10	296	546	0.78	.089	8.76
11	250	250	0.36	.044	8.18
	Exogenic rate = Average =				10.85

Total infant mortality rate = 29.86 per 1,000 live births occurring

Exogenic infant mortality rate = 10.85 per 1,000 live births occurring

Endogenic infant mortality rate = 19.01 per 1,000 live births occurring

* Same coefficients for various countries and all times.

deaths at various ages within the first year (single months in the example) and that for each computation a series of coefficients are used, previously calculated and constant in place and time. Alternatively, a graphic method of calculation may be used.

The endogenic and exogenic rates were 10.85 and 19.01 respectively. For comparison, the conventional neonatal rate was 11.33 and the postnatal rate 18.53.

Accepting that it is useful to be able to split the infant mortality rate into its two components of fundamentally different causation independently of reported medical causes, it has to be decided whether the method of Bourgeois-Pichat offers any *practical* advantage over a simple split of the total rate into say neonatal and postnatal mortality as previously defined (deaths under 28 days, and deaths between 28 days and one year), a split which requires a minimum of special tabulation and calculation.

Table 21 compares, for 20 countries in 1948, the total infant mortality rate, the postnatal mortality rate and the exogenic mortality rate (Bourgeois-Pichat). The resemblance between the series is striking. The coefficient of rank correlation between total and exogenic rates was 0.968, and between the postnatal and exogenic rates, 0.996. So far as determining the relative position of total infant mortality in one country compared with others, the exogenic is no better (and no worse) than the conventional total rate; and so far as the exogenic rate measures exogenic causes, the relative position of the various countries as indicated by the exogenic rates is practically identical with that indicated by the postnatal rates. Clearly, for this purpose the postnatal rate is as good as the exogenic rate, and much easier to obtain, a division of infant mortality at four weeks or one month being tabulated in the majority of countries.

It may be argued that if the age distribution of the deaths from endogenic and from exogenic causes alters, as in fact it is tending to do, due to infants dying from endogenic causes later in infancy, the neonatal/postnatal division would serve less well to distinguish the two groups. This is so, but in practice the difficulty may be overcome by transferring the age at which the division is made. The same objection, however, applies to the Bourgeois-Pichat method, which, it should be noted, does not distinguish and measure mortality from endogenic and exogenic causes directly as such, but the mortality that it seems reasonable to ascribe to these causes by virtue of the age distribution of the deaths. If deaths actually due to endogenic causes behave chronologically like deaths due to exogenic causes, they will be treated as due to exogenic causes by Bourgeois-Pichat's method.

On the whole, it seems fair to say that Bourgeois-Pichat has offered a novel and ingenious method

TABLE 21. TOTAL INFANT MORTALITY RATES, POSTNATAL MORTALITY RATES, ABD EXOGENIC MORTALITY RATES (BOURGEOIS-PICHAT), PER 1,000 LIVE BIRTHS, AND THEIR RANK ORDER, VARIOUS COUNTRIES, 1948

	Total infant mortality rate	Rank	Postnatal mortality rate	Rank	Exogenic mortality rate (Bourgeois-Pichat)	Rank
New Zealand (excluding Maoris) ...	22	*1*	6	*1 ½*	5	*1*
Sweden	23	*2*	6	*1 ½*	6	*2*
Australia ...	28	*3*	8	*3*	9	*3*
United States (white population)	30	*5*	9	*4*	10	*4*
England and Wales	33	*6*	14	*7*	14	*5 ½*
Switzerland .	36	*9*	10	*5*	14	*5 ½*
Netherlands .	29	*4*	12	*6*	15	*7*
Denmark ...	35	*8*	16	*8*	17	*8*
Norway	34	*7*	18	*9 ½*	21	*9*
Scotland	43	*10 ½*	18	*9 ½*	25	*10*
Northern Ireland ...	43	*10 ½*	19	*11*	27	*11*
Irish Republic	49	*12*	26	*12*	34	*12 ½*
Finland	52	*15*	28	*13*	34	*12 ½*
Belgium	50	*13*	30	*14 ½*	37	*14 ½*
France	51	*14*	30	*14 ½*	37	*14 ½*
Western Germany	68	*16*	32	*16*	40	*16*
Austria	75	*19*	36	*17*	45	*17 ½*
Italy	70	*18*	38	*18*	45	*17 ½*
Spain	69	*17*	45	*19*	58	*19*
Portugal	100	*20*	66	*20*	83	*20*

for measuring certain aspects of infant mortality but that from the viewpoint of medical statistics the method offers no practical advantages over existing methods and is unlikely ever to be adopted widely for purposes of medical administration and research.

Conclusions

From the medical viewpoint, the infant mortality rate is an index of supreme importance and must be measured accurately; but in practice, reasonable, not meticulous, accuracy is all that is required.

The main sources of error in measuring infant mortality are incomplete registration of births and deaths, non-uniform definitions and registration procedures, and failure to relate deaths to the births from which they come.

Various methods of calculation designed to compensate for the last source of error are available.

The method proposed by Bourgeois-Pichat to measure separately mortality from endogenic and exogenic causes is unlikely to be used widely for purposes of medical statistics.

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Comment of Mortimer Spiegelman

(New York City, United States)

To serve as a basis for policy and action, any index of mortality in infancy should be clearly defined, simple to compute, as accurate as the circumstances warrant, and easy to explain to the physician, health worker, or interested administrator. The comprehensive account of the measurement of infant mortality by Dr. Logan sets forth, in detailed terms, the techniques suited to communities where registration of births and of infant deaths is virtually complete. These techniques are also applicable in instances where there is reason to believe that both births and infant deaths at all periods within the first year are underregistered to the same, but limited, degree. Since the technique selected is a matter of judgment, the method of choice for the moment should be under steady examination for its suitability in the light of the changing circumstances. When a new method of measuring infant mortality is adopted, the report bearing the new results should give a clear account of it and also state the reason for the change; at the same time, the past series should be recomputed for a period long enough to show the effect of the change.

To supplement the account by Dr. Logan :

(I) a description will be given of some recent methods of computing infant mortality for life tables;

(II) the problem of computing infant mortality for specific causes of death will be examined;

(III) the new directions for the control of infant mortality will be surveyed, since they bear upon the method of measuring infant mortality proposed by Bourgeois-Pichat;

(IV) a critique of the Bourgeois-Pichat proposal will be presented;

(V) the essentials for improvement of infant mortality data will be summarized.

I. *Some recent methods of computing infant mortality for life tables*

Since the life table based upon a census enumeration is an important document in the history of a nation, great care is usually taken in its construction so that it may reflect accurately the

TABLE 1. SCHEMATIC OUTLINE FOR COMPUTING INFANT MORTALITY IN ENGLISH LIFE TABLE NO. 10

Quarter period	*Quarter year of age*	*Deaths, D (numerator)*	*Related births, B (denominator)*
1	0–2 months	${}_1d_0 + {}_1d_1 + {}_1d_2$	$\frac{1}{2} \times {}_4b_{-1} + b_0 + b_1 + b_2 - \frac{1}{2} \times {}_4b_2$
2	3–5 months	${}_2d_0 + {}_2d_1 + {}_2d_2$	$\frac{1}{2} \times {}_3b_{-1} + {}_4b_{-1} + b_0 + b_1 + {}_1b_2 + {}_2b_2 + \frac{1}{2} \times {}_3b_2$
3	6–8 months	${}_3d_0 + {}_3d_1 + {}_3d_2$	$\frac{1}{2} \times {}_2b_{-1} + {}_3b_{-1} + {}_4b_{-1} + b_0 + b_1 + {}_1b_2 + \frac{1}{2} \times {}_2b_2$
4	9–11 months	${}_4d_0 + {}_4d_1 + {}_4d_2$	$\frac{1}{2} \times {}_1b_{-1} + {}_2b_{-1} + {}_3b_{-1} + {}_4b_{-1} + b_0 + b_1 + \frac{1}{2} \times {}_1b_2$

$$q_0 = \frac{D_1}{B_1} + \frac{D_2}{B_2} + \frac{D_3}{B_3} + \frac{D_4}{B_4}$$

${}_sd_t$ = deaths in the s^{th} quarter year of life in calendar year t
${}_nb_t$ = births in the n^{th} quarter of calendar year t
b_t = births in the entire calendar year t

prevailing situation in mortality and longevity. An essential element in the computation is the mortality rate in the first year of life, commonly denoted by q_0.

A. *The English Life Tables*

In each of the official English life tables where the infant mortality rate was computed from births and deaths under one year of age, it was tacitly assumed that both were fully recorded. Thus, in computing English Life Table No. 1, based upon the census of 1841 and recorded deaths for that year, Farr used the denominator adjustment method described by Dr. Logan on page 43 taking $r = 0.5$. This approach was departed from in several of the later English Life Tables, but use was again made, in modified form, of recorded births and infant deaths beginning with Life Table No. 8, based upon the census of 1911 and deaths for 1910–1912. For the latest of the series, No. 10,[1] which was computed from the census of 1931 and deaths of 1930–1932, the infant mortality rate was derived from infant deaths within each quarter-year of life and births in each quarter of successive calendar years. The method used is essentially the denominator adjustment approach outlined on page 41 by Dr. Logan. From the available data, there was computed the probability that a newborn child: (1) will die within the first quarter year of life; (2) will survive the first quarter year of life, but will die within the second quarter; (3) will survive the first two quarters, but will die within the third quarter; and (4) will survive the first three quarters, but will die within the fourth quarter. The sum of these four probabilities yielded the infant mortality rate. The numerator and denominator for the computation of the separate probabilities, based on deaths for a three-year period, is shown in table 1.

The method just described has been used recently in the life tables of several English-speaking countries.

B. *The United States Life Tables*

Because birth data were lacking for the United States life tables built around the censuses of 1900, 1910, and 1920 [2] some improvising was necessary for computing mortality in the first year of life in these cases; deaths in infancy were assumed to be completely recorded.

For the life tables derived by Greville [3] from the census of 1940 and deaths for 1939–1941, not only were the birth data more adequate but there was also available a measure of the extent to which births failed to be recorded. This measure was obtained, in connexion with the census of 1 April 1940, by matching a card for each child under four months of age in the enumeration with the birth and infant death records within the preceding four-month period. In order to examine completeness of registration of infant deaths, a detailed survey was made, for each state, of deaths under one year of age per 1,000 births adjusted for under-registration. This investigation led Greville to believe that infant deaths may

[1] Watson, A. W., "Life tables". *The Registrar-General's Decennial Supplement, England and Wales, 1931.* London, 1936.

[2] Glover, J. W., *United States life tables, 1890, 1901, 1910, and 1901-1910.* United States, Bureau of the Census, Washington, 1921, p. 338 *et seq.* Foudray, E., *United States abridged life tables, 1919-1920.* United States, Bureau of the Census, Washington, 1923, p. 31 *et seq.*

[3] Greville, T. N. E., *United States life tables and actuarial tables, 1939-1941.* United States, Bureau of the Census, Washington, 1946, p. 101 *et seq.*

be incompletely reported in the same degree as births, and that there would be small error in computing infant mortality directly from recorded births and deaths. Infant mortality was computed by first using a separation factor to allocate infant deaths to year of birth and then applying the multiplicative technique described by Dr. Logan on page 35.

Greville had reason to believe, on the basis of various estimates, that under-registration of deaths was relatively greater in the first week of life than in the rest of the first year. Arbitrarily chosen adjustments, varying by age within the first year of life, were made to increase recorded deaths. The results were used in computing the life table functions for subdivisions of the first year. The method of arriving at the mortality rates is that described by Dr. Logan on page 52, but without allowance for the varying length of the subdivisions.

C. *Life tables based upon a comparison of successive censuses*

This method has been used for the life tables of India.[4] An approach somewhat different from that of the Indian life tables has been used by Mortara for the Brazilian life tables.[5] In this, the computation of infant mortality is necessarily crude. Recorded births in each year of the intercensal period are compared with the surviving numbers enumerated in the second census. The survival ratios are computed and compared with those in existing life tables. If a table is found which has closely comparable survival ratios, proportional factors are formed from the ratio of deaths in infancy to total deaths from birth to successive ages in this life table. These factors, when multiplied by the corresponding differences between recorded births and census enumeration, yield estimates of infant deaths in the intercensal years. With the annual births available, infant mortality rates may be computed in the conventional manner. The method is obviously such that the result may be regarded only as a rough approximation.

II. *Infant mortality for specific causes of death*

It is not usual to adjust infant mortality rates for specific causes of death to take account of changes in births in two successive years, possibly because these rates are too small to warrant the refinement. However, if such adjusted rates are required at any time, it is desirable that they be computed by a method with the additive property, so that the sum of the results for the individual causes will agree with the result computed for all causes combined. Of the methods described by Dr. Logan, the additive property is found only in the case of (I) exact matching of births and deaths where computation is by the relatively accurate, but theoretically unsound, additive substitute and (II) approximate matching of births and deaths in the instances cited. The factor methods (III) do not have the additive property since the single numerator separation factor f and the single denominator separation factor r are not applicable to specific causes of death. The numerator separation approach would be applicable if the factors f were on hand for each cause of infantile death.

To illustrate the extent to which the numerator separation factor f varies with cause of death, these have been approximated with data for the United States in 1948. These data were available by age for the total year only and by each calendar month without regard to age. The deaths within each calendar month were distributed according to age on the basis of the annual totals and the results then allocated to year of birth, very much as in table 16 by Dr. Logan. The results are shown in table 2 below.

The size of the separation factor f for the several causes of death has a close inverse relation to their concentration within the early part of the first year of life. Thus, the factors were only 0.010 for premature birth, 0.012 for injury at birth, and 0.026 for the category consisting of other diseases peculiar to the first year of life. On the other hand, the factor for diarrhoea and enteritis was 0.287, and for pneumonia and influenza it was as high as 0.398. For the last, the proportion of infant deaths allocated to births of the previous calendar year was high for two reasons. First, a sizable fraction of deaths from pneumonia and influenza falls in the later months of infancy; second, there is a high fraction of deaths from these

TABLE 2. ESTIMATED PROPORTION (f) OF DEATHS UNDER ONE YEAR OF AGE IN 1948 ARISING AMONG BIRTHS IN 1947, BY SPECIFIED CAUSES OF DEATH, UNITED STATES

Cause of death	*Separation factor (f)*
All causes	.133
Congenital malformations	.144
Congenital debility	.156
Premature birth	.010
Injury at birth	.012
Other diseases peculiar to first year of life	.026
Pneumonia and influenza	.398
Diarrhoea and enteritis	.287
All other causes	.287

[4] Vaidyanathan, L. S., *Actuarial report on the age tables and rates of mortality with life tables for India and Provinces, Census of India, 1931.* Bombay, 1933.

[5] Mortara, G., *Methods of using census statistics for the calculation of life tables and other demographic measures.* United Nations, Document ST/SOA/Ser.A/7. New York, 1949.

TABLE 3. PER CENT DISTRIBUTION OF BIRTHS ACCORDING TO QUARTERS OF THE CALENDAR YEAR, UNITED STATES, 1943 TO 1948

Year	Number of births	Calendar quarter (Total year = 100%)			
		Jan.–Mar.	Apr.–June	July–Sept.	Oct.–Dec.
1943 ...	2 934 860	25.7	24.3	26.2	23.8
1944 ...	2 794 800	24.6	23.8	26.6	25.0
1945 ...	2 735.456	24.9	24.2	26.4	24.5
1946 ...	3 288 672	20.0	21.2	28.1	30.7
1947 ...	3 699 940	26.2	24.3	25.6	23.9
1948 ...	3 535 068	25.0	23.1	26.6	25.3

conditions in the early winter months of the calendar year, so that many belong to births of the year before. For congenital malformations and congenital debility, the ratios were 0.144 and 0.156 respectively, somewhat above the average for all causes, namely 0.133.

The utility of adjusted infant mortality rates for specific causes of death was examined on the basis of birth records for the United States from 1943 to 1948 and of infant deaths for each year but the first. Table 3 shows the numbers of births during this period and their distribution by quarterly periods within each year. This period is characterized by two years of noticable decrease in births—1944 and 1948, by one year of relative stability—1945, and by two years of rapid rise—1946 and 1947. In the first three years of this period, the peak for births fell in the quarter from July through September. With the subsequent upswing in births, the peak shifted to the last quarter in 1946 and to the first quarter of 1947, but the third quarter peak was resumed in 1948.

Because of the marked shift in the seasonal incidence of births during the period of survey, the adjusted infant mortality rates for the specific causes of death were computed by the part matching method of English Life Table No. 10, modified to produce single year results. Although data were available for computing by the method described by Dr. Logan on page 41, the extra detail could hardly affect the final figures. The results are shown in table 4.

For the years in which the change in number of births from the year before was not very appreciable—1944, 1945 and 1948, the adjusted infant mortality rates for the specified causes of death differ from the conventional rates by 0.1 at most. However, in the first year of rapid rise in births —1946—the adjusted rates are higher than the conventional rates in each instance, by as much as 0.7 for premature birth. On the other hand, in 1947, the second year of rapid rise in births, the adjusted and the conventional rates are again in close agreement, differing by 0.2 at most.

From the foregoing account, it is apparent that adjustment of the infant mortality rate for specific causes of death affected the year-to-year changes only in 1946 and 1947, when births rose rapidly. Thus, the conventional rate for congenital malformations fell by ten per cent from 1945 to 1946, but the adjusted rate was unchanged, the decrease coming the next year. For premature birth, the conventional rate rose by only 4.3 per cent from 1945 to 1946, while the adjusted rate had an 11.3 per cent rise ; also, the adjusted rate had the faster decrease from 1946 to 1947. The only other disease category for which the conventional and adjusted rates showed appreciable differences in year-to-year

TABLE 4. INFANT MORTALITY RATES PER 1,000 LIVE BIRTHS FOR SPECIFIC CAUSES OF DEATH, CONVENTIONAL AND ADJUSTED, UNITED STATES, 1944 to 1948

Cause of death	Calendar year				
	1944	1945	1946	1947	1948
All causes					
Conventional	39.8	38.3	33.8	32.2	32.0
Adjusted, A [a]	39.6	38.0	36.4	31.8	32.0
Adjusted, B [b]	39.4	38.1	34.6	32.8	31.8
Congenital malformations					
Conventional	5.1	5.0	4.5	4.6	4.5
Adjusted, A [a]	5.1	4.9	4.9	4.6	4.5
Congenital debility					
Conventional	.9	.8	.5	.5	.5
Adjusted, A [a]	.9	.8	.6	.5	.5
Premature birth					
Conventional	11.9	11.6	12.1	11.1	11.1
Adjusted, A [a]	11.9	11.5	12.8	10.9	11.1
Injury at birth					
Conventional	3.6	3.6	3.6	3.5	3.4
Adjusted, A [a]	3.7	3.6	3.8	3.5	3.5
Other diseases peculiar to first year of life					
Conventional	2.5	2.6	2.5	2.6	2.4
Adjusted, A [a]	2.5	2.6	2.7	2.5	2.5
Pneumonia and influenza					
Conventional	5.6	5.3	3.8	3.6	3.7
Adjusted, A [a]	5.6	5.3	4.3	3.5	3.6
Diarrhoea and enteritis					
Conventional	3.3	3.0	1.7	1.5	1.8
Adjusted, A [a]	3.3	3.0	1.9	1.5	1.8
All other causes					
Conventional	6.9	6.4	5.1	4.8	4.6
Adjusted, A [a]	6.6	6.3	5.4	4.8	4.3

[a] Adjustment A : Computed from deaths in quarter-year age periods and related births in quarter-year calendar periods.

[b] Adjustment B : Computed by using separation factor to allocate total infant deaths to year of birth ; results as published by National Office of Vital Statistics, United States Public Health Service.

changes from 1945 to 1947 is pneumonia and influenza. In view of the circumstances just described, it appears that for an accurate picture of year-to-year variations in infant mortality for specific causes of death, adjustment is necessary only when there are rapid changes in the annual numbers of births or in their seasonal distribution. However, such adjustment need be made only for a few leading causes of death in infancy.

Incidentally, the data in table 4 for all causes of infant death permit a comparison of two methods of adjustment : (A) by relating deaths in quarter-year age periods to births in quarter-year calendar periods ; (B) by the use of numerator separation factors to allocate infant deaths to year of birth. The two methods are seen to produce appreciable differences in 1946 and 1947, both years of rapidly increasing numbers of births and with atypical seasonal distributions. Since the part matching method takes account of the changes in both seasonal distribution and annual totals, the results it produces seem the more reliable, as indicated by Dr. Logan.

III. *The new directions for the control of infant mortality*

The reduction of mortality in infancy, very largely through control of the infections, has hitherto benefited principally the post-neonatal period, that is, the months of infancy following the first. As a result, increasing attention is being focused upon mortality within the first month of life and its typical causes of death. An example is furnished in a recent annual report of the Royal New Zealand Society for the Health of Women and Children,[6] accounting for current experience in a country whose infant mortality record is often cited as a goal for others. In this report, a table summarizing the principal causes of infantile deaths presents data separately for age under one month and for the age group one to 11 months. For each group, the causes of death are shown in two categories : the first, under a heading " Prenatal and Natal Causes," and the second under " Other Causes ". The first category includes prematurity, congenital malformations, injury at birth, and a group of diseases of early infancy (atelectasis, congenital debility, blood conditions, syphilis, maternal toxaemia, pyloric stenosis, other diseases of early infancy). Very much the same grouping by age and cause of death categories, with data for the United States, is found in the manual on premature infants prepared for physicians by Dunham.[7]

[6] Royal New Zealand Society for the Health of Women and Children, Inc., *Thirty-fourth report of the Dominion Council for the year ended 31st March, 1951.* Dunedin, 1951, p. 12.

[7] Dunham, E. C., *Premature infants ; a manual for physicians.* Children's Bureau Publication No. 325. Washington, 1948, p. 34.

To give further emphasis to the relatively increasing importance of mortality in the very early periods of infancy, the World Health Organization recommended adoption of the age classification noted by Dr. Logan on page 31. This, in conjunction with the more detailed classification of causes of death specified in the sixth revision of the *International Lists of Diseases and Causes of Death*, is designed to provide a better insight into neonatal mortality. A particular feature of the Sixth International List of 1948 is the cross-classification of immaturity (or prematurity) with the conditions included within the category " Certain diseases of early infancy ".

Perhaps the most intensive large-scale and long-range investigation of neonatal mortality is that undertaken in Chicago with beginnings in 1935.[8] This survey, which covered all facets of the problem, led to a definite programme for the control of neonatal mortality involving the co-operation of the public health officer, obstetrician, paediatrician, nurse, hospital administrator, nutritionist, and social service agencies. In view of the benefits that such a programme may bring, not only locally but also by example, there might be some interest in a proposal by Dickinson and Welker.[9] With the very low level now reached by infant mortality in a number of countries, they ask whether the infant mortality rate might not be abandoned in favour of either a joint foetal-neonatal rate (often referred to as a perinatal rate) or the foetal and neonatal rates separately. In fact, they even foresee a time when it might be advantageous to make common use of a rate including only foetal deaths and deaths of the live-born within the first week of age.

The situation just outlined raises doubts as to the need of a new measure of infant mortality, such as that proposed by Bourgeois-Pichat, in order to stimulate further interest in the changing nature of the problem. However, it is worth considering this proposal further in the light of the criteria set forth at the opening of these comments, namely, clarity of definition, accuracy, ease in explanation, and simplicity of computation.

IV. *The Bourgeois-Pichat measure of infant mortality*

Bourgeois-Pichat argues for a dichotomy of the infant mortality rate into an endogenous rate and an exogenous rate. This division, it is

[8] Bundesen, H. N., Potter, E. L., Fishbein, W. I., Bauer, F. C., and Plotzka, G. V., " Progress in the prevention of needless neonatal deaths ". In *Report of the Chicago Health Department for the year 1951.* Chicago, 1953, pp. 1-272. For a summary see *Journal of the American Medical Association,* Vol. 148, No. 11, 15 March 1952, pp. 907-917.

[9] Dickinson, F. G. and Welker, E. L., *Infant deaths and stillbirths in leading nations.* Bulletin 73, American Medical Association, Chicago, 1950.

claimed, is more informative and accurate for distinguishing mortality due to influences originating before or during birth (endogenous) from that arising out of the environment after birth (exogenous) than either data regarding causes of death or deaths by age.[10] The basis for this contention is that, in places where a large proportion of infant deaths are reported by physicians, there will be an overstatement in the reporting of the causes endogenous in nature. On the other hand, where the proportion reported by other than physicians is high, the causes exogenous in nature will be overstated since many are terminal conditions whose symptoms draw attention.[11] This framework defines what the endogenous and the exogenous rates are intended to convey.

The approach by Bourgeois-Pichat raises several questions. Thus, one would want to know what objective tests have been used to ascertain how accurately the exogenous and the endogenous rates, computed by his method, actually measure the concepts they define. It the computed results are to be used for medical guidance, one must ask how they compare with the best that medical opinion has to offer, namely, findings produced by expert clinical and pathological examination. This criterion is the same as that used in testing the accuracy of statements of causes of death on death certificates.[12] Failing such objective tests, the question of the accuracy of the method proposed remains open.

Furthermore, it appears that the terms " endogenous " and " exogenous " may mislead unless they are carefully defined wherever used. Otherwise, there is a danger that the " endogenous " element in infant mortality will come to be regarded as an unavoidable element by common, though mistaken, usage. Any genetic factors causing congenital malformations are truly endogenous, but there are many environmental factors affecting the child through its mother that some might regard as exogenous, in the absence of the definition by Bourgeois-Pichat. Moreover, many of these prenatal environmental factors are amenable to some degree of control by public health practices.[13]

[10] Bourgeois-Pichat, J., " La mesure de la mortalité infantile. I. Principes et méthodes. " *Population*, 6e année, No. 2, avril-juin 1951, pp. 233-248.

[11] Bourgeois-Pichat, J., " La mesure de la mortalité infantile. II. Les causes de décès. " *Population*, 6e année, No. 3, juillet-sept. 1951, pp. 459-480.

[12] Swartout, H. O. and Webster, R. G., " To what extent are mortality statistics dependable ? " *American Journal of Public Health*, Vol. 30, July 1940, pp. 811-815; and Pohlen, K. and Emerson, H. " Errors in clinical statements of causes of death. " *American Journal of Public Health*, Vol. 32, March 1942, pp. 251-260.

[13] Dunham, E. C., *op. cit.*, p. 182. For a review of recent studies on humans indicating the importance of nutrition in pregnancy, see Burke, B. S. and Stuart, H. C., " Nutritional requirements during pregnancy and lactation. " *Journal of the American Medical Association*, Vol. 137, No. 2, 8 May 1948, pp. 119-128.

Thus, Bourgeois-Pichat, in a later paper, seemingly modifies his definitions when he cites congenital malformations arising out of german measles during pregnancy, a rather recent addition to medical knowledge, as an exogenous condition, rather than endogenous.[14] The precise definitions, accordingly, become rather uncertain.

Even as originally defined, the endogenous and exogenous rates, as computed by the proposed formula, may present some ambiguity to the physician or health officer responsible for policy and action. It would be difficult to describe quantitatively to these specialists, trained to a rather conventional medical terminology, the specific morbid conditions that make up the endogenic and exogenic totals. To know either of these totals by itself is not necessarily helpful, since a health programme must be designed according to the incidence and prevalence of specific conditions ; this information comes only from a classification on the basis of the contributory, underlying and immediate causes of morbidity and mortality.

The method of computing the exogenous and endogenous rates is simple. The exogenous rate is, essentially, a weighted average of the mortality rates for each month in infancy after the first; the endogenous rate is then the difference between the mortality rate for the first year of life and the exogenous rate. The weights are invariant in time and among countries or communities.

However, the facility of the computation should not obscure the empirical nature of the process. Although universality is claimed for the weight factors, this still remains to be demonstrated by objective test, a matter already referred to. If any invariant property should be found in this instance, it would be most interesting in view of the many mathematical expressions proposed to represent variation in mortality for all ages.[15]

V. *The essentials for improvement of infant mortality data*

There is no present apparent need for new measures, of the kind proposed by Bourgeois-Pichat, which seek to circumvent by arithmetic means the inadequacies of the basic cause-of-death data. Improvements in such data are to be sought, rather, by a more fundamental approach. In this direction, the World Health Organization and the

[14] Bourgeois-Pichat, J., " Essai sur la mortalité biologique de l'homme. " *Population*, 7e année, No. 3, juillet-sept. 1952, pp. 381-394.

[15] Frechet, M., " Sur les expressions analytiques de la mortalité valables pour la vie entière. " Journal de la Société de Statistique de Paris, Vol. 88, No. 7-8, juillet-août 1947, pp. 261-285; and Elston, J. S., " Survey of mathematical formulas that have been used to express a law of mortality. " *Record of the American Institute of Actuaries*, Vol. 12, June 1923, pp. 66-95. Also, Ogborn, M. E., " On the nature of the function expressive of the law of human mortality. " *Journal of the Institute of Actuaries*, Vol. 79, Part II, No. 352, 1953, pp. 170–212.

Statistical Office of the United Nations are taking active steps along three lines.

The first essential for the improvement of cause-of-death statistics is completeness in reporting the fact of death; for computing infant mortality, there is a corresponding need for completeness in reporting of births. This is recognized by the United Nations in its recommendation that " In establishing or developing a vital statistics system, first priority should be given to setting up procedures for the registration and reporting of live births and deaths ".[16] Moreover, the WHO Expert Committee on Health Statistics, at its first session in 1949, recommended that " countries be asked to give an estimate of the completeness of their mortality figures and the proportion of deaths which were adequately certified by physicians as to their causes;... ".[17]

The efforts to improve the accuracy of the statement of cause of death, the second essential, are evident in WHO Regulations No. 1, in the recommendations of its Expert Committee on Health Statistics, in the United Nations *Principles for a Vital Statistics System*, and in training centres on vital and health statistics conducted jointly by WHO and the UN. Particularly pertinent, in this connexion, is the suggestion made by the Expert Committee to the national committees on vital and health statistics or their equivalents, that they study the problems of infant and foetal death statistics and also seek " better utilization of records of maternity and children's hospitals for medical-statistical research into the causes of foetal and infant death... ".[18]

[16] United Nations, *Principles for a vital statistics system.* Document E/CN.3/143. New York, 1952, p. 15.

[17] World Health Organization, Expert Committee on Health Statistics, *Report on the first session.* WHO Technical Report Series, No. 5, Geneva, 1950, p. 7.

[18] World Health Organization, Expert Committee on Health Statistics, *Report on the second session.* WHO Technical Report Series, No. 25, Geneva, 1950, p. 4-5.

Of the latter, a model is set by the Chicago report on the *Progress in the Prevention of Needless Neonatal Death.*

The principal advance in coding, the third essential for the improvement of cause-of-death statistics, came with the sixth revision of the *International Statistical Classification of Diseases, Injuries, and Causes of Death.* Among its features is a more-informative classification of the causes of infant deaths than was previously the case. In addition, WHO Regulations No. 1 specify a standard classification by age within the first year of life. There are, further, a number of other activities sponsored by the WHO and the UN for improvement of coding procedures generally which benefit the infant records.

Summary

A method for measuring infant mortality suited to the circumstances of existing situations may be found among those described by Dr. Logan.

In most circumstances, the conventional method will suffice for computing infant mortality rates for specific causes of death. Where refined methods are indicated, the choice should be among those having the additive property.

The proposal by Bourgeois-Pichat to compute an " exogenous " rate and an " endogenous " rate, in order to meet shortcomings in cause-of-death reports, is interesting and the method of computation is simple. However, the concept does not appear to be well-defined, nor is it easy to explain to the physician and health administrator who need specific information for policy and action.

Fundamentally, improvement in cause-of-death statistics requires continued efforts for completeness in registration, for accuracy in certification, and for precision in coding.

Comment of Jesus Villar Salinas, M.D.

(The Menendez Pelayo International University of Santander)

On studying Dr. Logan's careful and detailed work on the measurement of infant mortality, three aspects of the subject which are of particular importance will be commented upon. These are :

I. The need for precise definitions, of an international character, of the concepts employed in the measurement of infant mortality.

II. The application of simple methods of calculation of the infant mortality rate in countries where sources of statistical information are not well developed.

III. The convenience of establishing a simple method of ascertaining infant mortality (1) from genetic causes and in connexion with birth, and (2) from other causes.

I. *Looseness of the terms employed in the measurement of infant mortality*

The most precise mortality rates, obtained by the most refined techniques of computation, are of no use unless they are based on accurate data supplied by adequate registration of births and deaths. As Dr. Logan has pointed out, there is no doubt of the need for adequate registration systems and the publication of complete and reliable data in all countries.

The definitions of live birth and foetal death proposed by the Third World Health Assembly were greatly needed. It is not enough, however, that these definitions be accepted by all countries. The obstetricians themselves must make their reports in keeping with the relevant provisions.

It is true that in certain countries, such as Belgium, Bolivia, France and Spain, children born alive but dying before birth registration are classified as stillborn, but in the official statistical publications of nearly all these countries it is possible to find the number of such cases, tabulated separately from actual stillbirths. It should, however, be pointed out that at least in Spain, and possibly in other countries, too, many of the live births dying within 24 hours after birth are the more readily registered as foetal deaths owing to the fact that such an inaccuracy is of no legal consequence.

The figure for neonatal mortality in Spain is strikingly low, even when it includes the live births that die within 24 hours after birth. In a recent study of the figures for Madrid, Arbelo Curbelo [1] found that the mortality rate for deaths under one day, for the years 1943-45, was 2.7 per 1,000 live births. The rate for deaths under one day over the same period of years in London was 8.5 per 1,000. For the last few years the rate for deaths under one day in Spain has averaged five or six per 1,000 live births, in contrast with a much higher figure for the first 24 hours in other countries in which the total infant mortality rate is, nevertheless, lower than in Spain. However, the comparatively small number of deaths under one day registered in Spain is offset by a correspondingly larger proportion of stillbirths. Certain circumstances, such as the greater ease of civil registration and burial of a foetus, foster the doctors' or midwives' complaisance in certifying as foetal deaths those which occur within 24 hours after birth. In countries where this is apt to happen, doctors and midwives should be impressed with the absolute necessity for accurate statements about the time when death occurred, as being of the utmost importance to the health officer in the interpretation of neonatal mortality rates.

One method of overcoming the difficulties imposed by faulty registration is to make a comparative study of the *perinatal* mortality rate, a rate which is in itself of prime interest since it covers intermediate plus late foetal deaths as well as deaths in the first week or month of life.

By the combination of neonatal and foetal deaths, the lower figure for neonatal mortality in countries such as Spain is compensated for by the greater number of foetal deaths registered. The joint total yields a mortality rate around the period of birth in which the essential biological factors do not vary to any great extent. From an etiological point of view, death from congenital debility and malformation is much the same in the case of a foetus dying within its mother's womb a short time before birth, as in an infant dying in the first few days or weeks of life after birth. Before proceeding to the comparative studies suggested, however, it is necessary to define the term " perinatal mortality rate " and what exactly it implies in the various concepts outlined by Dr. Logan.

As indicated in the report of the Expert Committee on Health Statistics, the terms stillbirth, abortion, miscarriage and foetal death should be more precisely interpreted and uniformly applied in all countries than they are at present.[2] An example of the present confusion is the variation in the reporting of stillbirths. The minimum period of gestation after which a stillbirth must be reported is 28 weeks in England and Wales, 24 weeks in Belgium and Switzerland, 26 weeks in Czechoslovakia, 32 weeks in Norway, 29 weeks in Denmark, and 16 weeks in Japan, and is not specified in Spain, France and Italy.[3] Attention has been drawn to this unsatisfactory state of affairs by L. Baumgartner, H. M. Wallace, E. Landsberg and V. Pessin, who, by quoting the statistics of New York City, show that 44 per cent of foetal deaths were not registered in the years 1943–45.[4] If this can happen in a country of such outstanding public health services, how much greater is the likelihood of its happening in countries or districts where such services are less highly organized.

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[1] Arbelo Curbelo, A., *Necesidad demográfico-sanitaria de rectificar el concepto legal de nacido vivo.* Publicaciones " Al Servicio de España y del Niño español ", No. 171, Madrid, Mayo 1952, p. 7.

[2] World Health Organization, Expert Committee on Health Statistics, *Report on the second session.* Technical Report Series, No. 25, Geneva, 1950, p. 11.

[3] Pascua, M., " Diversity of stillbirth definitions and some statistical repercussions. " World Health Organization. *Epidemiological and Vital Statistics Report,* Vol. I, No. 10, March 1948, pp. 210-222.

[4] Baumgartner, L., Wallace, H. M., Landsberg, E. and Pessin, V., " The inadequacy of routine reporting of fetal deaths ". *American Journal of Public Health,* Vol. 39, No. 12, December 1949, pp. 1549-1552.

II. *Adjusted infant mortality rates*

The calculation of infant mortality rates differs from that of the specific mortality rates for other age groups, in which the mortality rate is the proportion dying out of the number of persons in the specific age group living in the period of time under consideration. In the case of children under one year, the number of deaths is measured against the number of live births registered within the period of time under consideration.

Aware of the difficulties involved, statisticians have sought to adjust the crude conventional or unadjusted rates, and Dr. Logan offers a detailed and comprehensive study of the different methods which might be applied in the adjustment of the conventional rates to take into account fluctuations in the births for the current year and births for the preceding year. He has also sought to reduce the error in the age distribution of infant mortality and in the seasonal variations of birth and mortality. Dr. Logan points out the advantages and disadvantages of the different techniques.

It would be of advantage to adopt some of these techniques on an international scale, so as to achieve, by a more uniform presentation of statistics, a sound basis for comparison of the birth and infant mortality rates of different countries.

Of the methods described, many are applicable only in countries where there is detailed classification in the published statistics of births and mortality. Some of the more exact methods might be employed if the recommendations of WHO Nomenclature Regulations No. 1 (1948) were more widely accepted and observed in all countries. The methods suggested, however, do not allow for retrospective study and comparison between older statistics and those calculated with the new techniques.

Where birth and mortality rates are compiled from incomplete records it appears that methods based on age group infant mortality classifications are most suitable.

One of the most elementary and practical methods of achieving a highly simplified adjustment, described by Dr. Logan, is the whole year matching by numerator separation from the two component groups of neonatal and post-neonatal deaths.

Although the infant mortality rates for England and Wales show modification only in their decimal figures when calculated by this method, because of the high proportion of neonatal deaths, the same method of calculation applied to other countries reveals sufficient differences between the adjusted and conventional rates to warrant its use. Thus, in Spain, the adjusted infant mortality rate for 1950 calculated by this method is 66.62 per 1,000, which is lower by 1.40 per thousand than the conventional rate of 68.02 per 1,000. The difference amounts to 2.05 per cent in Spain as against 0.87 per cent in England and Wales for the same year.

The sizable difference between the conventional and the adjusted rate in Spain points to the need for adjustment in countries of high infant mortality in which the proportion of post-noenatal deaths is very high, especially if they show a marked decline in births. A simple method is sufficient to adjust the crude rates.

With these same data, the simplified whole year numerator separation method can be used, based on neonatal and post-neonatal deaths. For infant mortality in Spain in 1950, $1 - f = 0.66$. This approaches the result obtained by the numerator separation method employed in the Spanish Life Tables which yields $1 - f = 0.70$, for the proportion of deaths under one year occurring in the calendar year of birth.[5]

For the computation of quarterly and monthly rates, which is of great importance because of the seasonal variations in the mortality rate, the methods proposed by Dr. Logan cannot be applied in the many countries in which monthly infant mortality is not classified by age. The number given for each month in the calendar year is only the total of deaths at all ages under one year. Consequently, the only applicable method of calculation is to use as denominator the average quarterly or monthly births in the 12-month period ending with the current quarter or month. This is the accepted method in Spain, which has been applied by Pascua [6] and by the present author [7] as follows :

$$\text{Monthly rate} = \frac{\frac{d_m}{D_m} \times 365 \times 1{,}000}{b_m + b_{m-1} + b_{m-2} + \ldots . b_{m-11}},$$

where d_m is the infant deaths in the current month, D_m is the number of days in the month, and b_m, b_{m-1}, b_{m-2}... etc., the live births in the previous months up to b_{m-11}. This method yields the infant mortality of the current month which is expressed as a yearly rate based on the number of live births for the year ending with the month in question, without any adjustment or separation factor. A similar process is followed for the calculation of the quarterly rates.

Infant mortality is one of the demographic phenomena most affected by seasonal changes.

[5] Instituto Nacional de Estadística, *Tablas de mortalidad de la población española. Años 1900 a 1940.* Madrid, 1952, p. 101.

[6] Pascua, M., *La mortalidad infantil en España.* Spain, Departamento de Estadísticas sanitarias de la Dirección General de Sanidad, Madrid, 1934, p. 46.

[7] Villar Salinas, J., *Tendencia contemporánea de la mortalidad infantil española.* Publicaciones " Al Servicio de España y del Niño español ", No. 155, Madrid, Enero 1951, p. 12.

It is well-known that hot weather has a direct bearing on infantile enteritis and diarrhoea, and that low temperatures favour diseases of the respiratory organs, so that climatic conditions cannot be overlooked in accounting for the monthly fluctuations of infant mortality. The seasonal rise in summer is especially important in countries where infant mortality is at a high level. It would be advantageous to have a uniform system whereby the index of typical seasonal variation in the infant mortality of each country might be calculated. Once the index had been calculated, it could be used for several successive years in the adjustment of the conventional monthly rate to the seasonal variation.

Although it would entail a certain amount of mathematical calculation, the adjustment could be done by a comparatively simple process, based on a consideration of the time series as the product of four forces, operating with rather distinct and separate emphasis : seasonal, secular, cyclical and irregular. If O = original data, T = secular trend, S = seasonal variation, C = cyclical variation, and I = the irregular component, the relationship which often prevails among them may be stated in general terms as follows :

$$O = T \times S \times C \times I$$

The secular trend of infant mortality in many countries is in the form of a rapid reduction. Where this is the case, it must be borne in mind in calculating the seasonal index, for the December rate will be lowered by 11/12 of the annual decline, independently of the seasonal fluctuations.

To the general tendency may be added many demographic phenomena which result in cyclical movements or fluctuations lasting over a year, but of irregular duration, which cause little appreciable difference in infant mortality.

Irregular variations, which are represented by " I " are those not included under any classification. In infant mortality they are evidenced by unusual increase in deaths caused by epidemics.

Finally, it is necessary to consider the seasonal variations, which are of particular concern at the moment.

To obtain these variations over a series of years we must eliminate trend and cycles, i.e., T × C. The first step is to calculate a centred 12-month moving average, which is dominated by the trend and cycle movements. By dividing the original data by the averages, we get

$$\frac{T \times C \times S \times I}{T \times C} = S \times I$$

We then proceed to eliminate the irregular influences by calculating the mean of the rates for each month over a period of years.

This method has been applied to the calculation of the index of seasonal variation of mortality in Spain for the period 1926–1930 and 1942–1948. The results are shown in table 1 and figure 1. Also shown in the table is the index for the Département de la Seine (France) for the period 1934–38, taken from *Population*.

Comparison of the indices of these two countries suggests the need for a more extended study of infant mortality, to include the assessment of the extraordinary variations in the seasonal patterns for different countries. It should, however, be

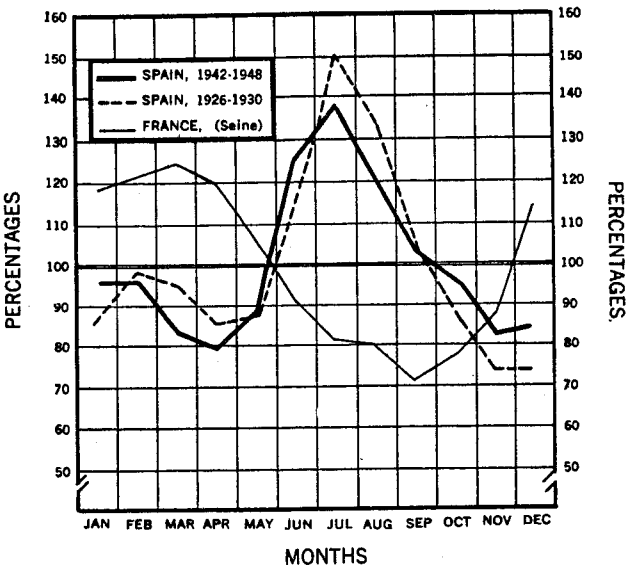
TABLE 1. INDEXES OF TYPICAL SEASONAL VARIATIONS OF THE INFANT MORTALITY RATE

Month	Spain [a] 1926–30	Spain [a] 1942–48	Département de la Seine [b] 1934–38
January	89	96	119
February	98	96	122
March	95	84	125
April	85	79	120
May	87	88	107
June	117	126	92
July	150	138	82
August	134	121	80
September	105	103	72
October	88	96	78
November	74	82	88
December	74	84	115

[a] From : Villar Salinas, J., *Tendencia contemporánea de la mortalidad española*. Publicaciones " Al Servicio de España y del Niño español ", No. 155, Madrid, Enero 1951, p. 15.

[b] From : Henry, L., " La situation démographique ". *Population*, 3e année, No. 3, juillet-sept. 1948, p. 532.

FIGURE 1. INDEXES OF TYPICAL SEASONAL VARIATIONS OF THE INFANT MORTALITY RATE



pointed out that there are insufficient data available to obtain seasonal indices of infant mortality with the adjusted rates.

III. *Age specific infant mortality rates by specified causes*

Although F. T. Berg studied mortality in the first month of life as far back as 1869,[8] and Swedish statistics from 1861 onwards have given infant mortality rates classified by age in days, world-wide interest in the mortality of the newborn was first aroused only about 25 years ago. When infant mortality rates started showing a marked decline, attention was concentrated on the specific causes of death in the first days of life, for, as Dr. A. Wallgren (Stockholm) [9] points out, declining infant mortality reaches the point where it is reduced almost to the neonatal rate. This leads to the conclusion that measures for reducing infant mortality have been much less effective in the first week than in later weeks of infant life, as shown in the high neonatal mortality rates.

The concept of the special character of neonatal (*nouveau-né, neugeborenen, recien nacido*) mortality has gradually come to be generally accepted. There exists, however, no definite demarcation between the neonatal and post-neonatal ages. According to the older and stricter school (Pfaundler, Wallgren, Finkelstein, MacIntosh, etc.) neonatal mortality is confined to the first two weeks of life; the modern school admits a margin of up to four weeks or the first month of life (Marfan, Banu, Peason, Wolf, Arce, etc.). General acceptanee of the WHO Nomenclature Regulation No. 1 would of course remove the confusion on this score. As it is, the published infant mortality records of many countries refer to the total number of deaths within the first month of life, out of the total number of live births in the period under consideration, generally a calendar year.

However, in infant mortality, as in other demographic phenomena, records in different countries show interesting differences. In countries with a low infant mortality rate, the proportion of neonatal deaths is comparatively high, as much as 80 per cent of the total infant mortality. Study of the post-neonatal rates is, however, of great importance in countries which have not yet reached a low level in spite of a steady downward trend in their infant mortality.

Furthermore, in countries with a low infant mortality, the neonatal rate is composed almost entirely of deaths from premature birth, congenital malformation and injury at birth, i.e., obstetrical and congenital causes.

When Dr. Logan states that a breakdown of infant mortality into deaths before and after the first few weeks of life is possibly a sufficient indication of the relative incidence of the different types of causes of death, without further need for investigation of specific causes, he probably has in mind the countries of low infant mortality, where such a separation into neonatal and post-neonatal mortality rates would be a sufficient guide to the physician, health worker or administrator.

The case is quite different for countries with medium or high infant mortality. In these countries, a high proportion of neonatal mortality cannot be ascribed to premature birth, congenital malformation and injury at birth, but rather derives from the same causes as does post-neonatal mortality.

Table 2 shows the different structure of infant mortality in the United States and in Spain in 1946. In the United States, 88 per cent of all the deaths under one month result from congenital malformations and diseases peculiar to the first year of life (congenital debility, premature birth, injury at birth, asphyxia, etc.), and the balance of 12 per cent are deaths from external causes. In Spain, on the other hand, the total of obstetrical and congenital deaths amounts to 63 per cent of the deaths under one month, leaving 37 per cent of deaths from all other causes.

It is a matter of prime importance that in the published infant mortality rates of every country such a distinction be made, in clear and generally accepted terms, between the two sources of infant mortality. The two sources must be studied by health officers from different angles, as the preventive measures will be different. To overcome the neonatal causes which offer such resistance to improvement even in countries with low infant

TABLE 2. PERCENTAGE DISTRIBUTION OF DEATHS UNDER ONE MONTH, UNITED STATES AND SPAIN, 1946

Causes of death	*United States* [a]	*Spain* [b]
All causes	100.00	100.00
Infectious diseases	0.8	4.4
Diarrhoea, enteritis, etc.	1.7	9.5
Diseases of the respiratory system	7.6	12.4
Congenital malformations and diseases peculiar to first year of life	88.0	63.4
All other causes	1.9	10.3

[a] From: United States. Bureau of the Census, *Infant mortality from selected causes by age, race, and sex: United States, 1946.* Vital Statistics-Special Reports, Vol. 29, Number 14. Washington, March 1949, p. 209.

[b] From: Spain. Instituto Nacional de Estadística, *Movimiento natural de la población de España 1946.* Madrid, 1948, p. 101.

[8] Arbelo Curbelo, A., *La mortalidad neonatal en España.* Publicaciones "Al Servicio de España y del Niño español", No. 157, Madrid, Marzo 1951, p. 3.

[9] Wallgren, A., "Estudios sobre los prematuros". *Revista Española de Pediatria,* Tomo VIII, No. 5, Septiembre-Octubre 1952, pp. 557-570.

mortality, requires research in eugenics, obstetrics, prenatal care and premature birth, while defence measures in the post-neonatal age must be of the nature of a widespread knowledge of the basic requirements of hygiene, nutrition, and precautions in infectious diseases, in their special relationship to infant mortality.

If declarations as to the causes of infant deaths were always accurate, the mortality rates for specific causes would undoubtedly be the best way of assessing the constitution of infant mortality. Unfortunately, this is not the case. Furthermore, many countries do not even give the monthly age distribution in the specified causes of death of infants. The countries best organized in this respect reveal the inevitable shortcomings of defective declarations on the causes of death. Thus, in the published results of one of the most intensive investigations of neonatal mortality, it is stated that, out of 8,905 neonatal deaths in Chicago, for the period 1936–1949, for which adequate post-mortem and clinical data were available, 32.4 per cent of the specified causes were malformations and injury at birth. The highest proportion of deaths is attributed to abnormal pulmonary ventilation (43.7 per cent).[10] A comparison of these percentages with those shown in table 2 indicates an overstatement in the specified causes of a congenital nature in the registered results of the post-mortem examinations. By a different process, Bourgeois-Pichat finds that French and English doctors overstate congenital mortality.[11]

The afore-mentioned considerations have led to the adoption of the Bourgeois-Pichat method in assessing the geographical distribution of the two types of infant mortality throughout Spain.[12] The precision of such a theoretical representation of endogenic and exogenic mortality incidence may be open to question on the grounds of over-simplicity. As a record, it is also liable to prove inaccurate in the light of subsequent scientific investigation of classified causes, such as the endogenous nature of German measles during pregnancy and the importance of toxoplasmosis in foetal mortality and congenital malformation. As a simple expression of the prevalence and tendencies of the two main sources of infant mortality, however, these calculations are intended to suggest the theoretical differences and practical measures required in each case for the different areas.

A lack of objective tests, based on clinical and pathological findings and supported by statistical results, might be alleged against the Bourgeois-Pichat system, but this lack is common to all the mortality rates of whatever age group.

In his table 21, Dr. Logan finds that the coefficient of rank correlation between the post-neonatal and exogenic rates is 0.996, but it is interesting to note that when the 20 countries he compares are split up into three groups, the average differences between the post-neonatal rate and exogenic mortality rate are as follows:

	Difference
Group of the first 7 countries listed ...	1
Group of the 8th to the 14th countries listed	6
Group of the last 6 countries listed	10

This shows that the post-neonatal rate does not coincide exactly with the exogenic rate of Bourgeois-Pichat. The higher the infant mortality the greater is the divergence between the two rates. This fact is significant in that it reveals the extent of exogenic causes in the neonatal rates in countries of high infant mortality and points the way to reduction of the high rates in these same countries.

The techniques of the Bourgeois-Pichat system are not any more involved than those usually employed in obtaining the standardized or adjusted mortality rates. Furthermore, the Bourgeois-Pichat methods are quite compatible with some of those suggested by Dr. Logan for the adjustment of the infant mortality rates by age, including the factor method in cases where the published statistics of the country in question provide the necessary data. Table 3 gives the computational

TABLE 3. CALCULATION OF "EXOGENIC" INFANT MORTALITY RATE—SPAIN, 1948

Age (months)	*Rate per 1,000 live births occurring in 1948*	*Coefficient* *	*Rate ÷ coefficient*
1–2	14.00	0.25130	55.70
3–5	16.17	0.23810	67.91
6–11	16.34	0.31105	52.53
Exogenic rate = Average = 58.71			
Total infant mortality rate	= 67.94 per 1,000 live births		
Exogenic infant mortality rate	= 58.71 per 1,000 live births		
Endogenic infant mortality rate	= 9.23 per 1,000 live births		

* Same coefficients for various countries and all times.

[10] Bundesen, H. N., Potter, E. L., Fishbein, W. I., and Bauer, F. C., "Progress in the prevention of needless neonatal deaths." *Journal of the American Medical Association*, Vol. 148, No. 11, 15 March 1952, pp. 907-917.

[11] Bourgeois-Pichat, J., "La mesure de la mortalité infantile. II. Les causes de décès." *Population*, 6e année, No. 3, juillet-sept. 1951, pp. 459-480.

[12] Villar Salinas, J., "La mortalidad infantil contemporánea de las provincias españolas disociadas en sus dos grandes causas." *Revista de Sanidad e Higiene Pública.* (Madrid) Año XXV, Octubre-Noviembre 1951, pp. 592-637.

method for countries such as Spain where the published statistics do not include infant mortality by all ages under one year. The year 1948 was selected because it is the year given in table 21 of Dr. Logan's report.

The endogenic mortality rate is 9.23 per 1,000 live births occurring (including those dying within 24 hours after birth). The neonatal mortality (calculated to include the deaths under one month of age) is 21.42 per 1,000, a much higher figure. The congenital and obstetrical mortality rate for under one month is 15.09 per 1,000, also higher than the endogenic rate. Bearing in mind the enormous importance of exogenous causes of death in Spain, the differences do not appear to be implausible.

In view of the risk of live births dying before registration being classified as foetal deaths, it is preferable to add the endogenic rate to the foetal rate in calculating infant mortality for Spain. The perinatal rate obtained in this way is the most suited to assess the rate of congenital and obstetrical mortality.

Summary

It is not enough for countries to accept theoretically the distinctions between a live birth and a foetal death. Doctors and midwives should also be impressed with a lively sense of responsibility for the accuracy of their statements in the recording of foetal and infant deaths.

Some of the methods of adjustment described by Dr. Logan might be adopted to advantage. The best system for countries where registration records are not very complete is that of the whole year matching numerator separation method, working from the two groups of neonatal and post-neonatal mortality. The higher the post-neonatal mortality the greater is the advantage to be derived from the adjustment method.

From the point of view of the health officer estimating trends and developments, published data on the index of typical seasonal variations of infant mortality rates which reveal the effect of climatic conditions and environment on mortality are most enlightening sources of information.

In his biometric studies, Bourgeois-Pichat divides infant mortality into two main groups, each of which requires a different line of approach in research and the practical application of measures for reducing mortality. Consequently, the fundamental importance of estimating as closely as possible the proportion of mortality in each group is apparent. Bourgeois-Pichat does this by an abbreviated method which is no more complicated than any other of the rate adjustment methods contemplated.

The method of calculation of the exogenic rate counteracts a tendency noted in the case of many doctors to overstate the endogenic causes in death certificates.

CURRENT ITEMS

Seventh session of Population Commission

The seventh session of the United Nations Population Commission was held at United Nations Headquarters in New York from 19 to 30 January 1953. The States represented were : Australia, Belgium, Brazil, China, France, Indonesia, Iran, Mexico, Peru, Sweden, Ukrainian Soviet Socialist Republic, Union of Soviet Socialist Republics, United Kingdom, United States and Yugoslavia. Dolphe Vogelnik (Yugoslavia) was elected Chairman.

In the early years of its existence, the Commission laid primary stress on activities designed to improve the quantity and quality of basic demographic data, this being a prerequisite for its other functions of studying the interrelations of demographic, economic and social factors, and formulating advice on policies affecting population. At this session, the Commission reviewed the substantial progress which has been made in improving basic demographic data, and decided to concentrate in the future on three lines of work, namely : (1) studies of the interrelationships of demographic, economic and social factors ; (2) analyses of future population trends ; and (3) studies of migration. The Economic and Social Council at its fifteenth session in April 1953 endorsed this decision.

When the Commission met, the Secretariat's report on the findings of existing studies of the interrelationships of demographic, economic and social factors, entitled *Determinants and Consequences of Population Trends*, was nearly completed. The Commission expressed the hope that various Governments might undertake concrete studies designed to provide further information on some of these relationships. The Economic and Social Council, moreover, at its XVth session, held in April 1953, called attention to the usefulness of such studies in carrying out programmes of economic and social development.

Studies of the interrelationships of demographic, economic and social factors in particular local areas of under-developed countries were recognized by the Commission as a necessary supplement to the world-wide and regional studies. The Economic and Social Council had earlier pointed to the value of studies of this type in indicating the possible effects of various types of developmental measures on population growth and the social and economic consequences of population changes. The Commission was informed of the progress being made in carrying out such a study in Mysore State, India, by the Government of India and the United Nations ; it recommended that the Secretary-General co-operate, on the widest scale possible, with Governments of other States requesting assistance in carrying out similar projects. Noting that the effects of economic and social development on fertility and mortality trends in under-developed countries could be investigated by means of intensive field studies in areas where large-scale development programmes are under way, the Commission recommended that the Secretary-General extend the fullest possible co-operation to Governments or agencies wishing to carry out such studies.

In addition to special field studies, the Commission felt that pilot studies which take account of existing data would also be desirable in certain under-developed countries and should be undertaken as resources become available. So far as mortality studies are concerned, the Commission felt that data on trends and differences in rates for different population groups or areas should be examined with two purposes : (*a*) to throw light on the effects of particular factors tending to reduce mortality or to keep it high, and on the influence of consequent mortality changes upon population trends ; (*b*) to determine what improvements in the quality of the data and extensions of their scope are needed in order to provide a better basis for analyses of this type. As regards fertility studies, the Commission suggested (*a*) a survey of the types of statistics available in a selected group of under-developed countries which could be applied in analytical studies ; and (*b*) a consideration of the types of additional information needed. The Commission also suggested a comparative analysis of differences in the fertility of various population groups (urban and rural groups, social classes or castes, religious groups, occupational and income categories, literate and illiterate persons, etc.) in a number of under-developed countries.

The Commission received at this session a report summarizing the results of international migration studies undertaken by the United Nations and the specialized agencies since 1946. At the Commission's request, this report is to be published.

The Commission adopted a series of recommendations to Governments for the improvement of

international migration statistics, which had been prepared by the Secretariat in collaboration with the International Labour Office and after consultation with interested Governments and international organizations. These recommendations were also reviewed and adopted by the Statistical Commission at its seventh session. The consultations alone had increased the volume of migration statistics available and led some Governments to make improvements which promoted international comparability of the data. The international standards which have now been adopted are believed likely to bring about further improvements in the quality and comparability of the data collected on international migrants.

The Commission noted that much of the past work of international agencies in the field of migration had related to short-term problems, for example, those of refugees and displaced persons, and suggested that more study is needed of long-term relationships between migration and population trends for use in formulating migration policies. Some members of the Commission called attention to the importance of internal as well as international migration as a factor in the economic development of many countries. A resolution, later adopted by the Economic and Social Council, was drafted, recommending that Member States continue to give special attention to the problem of internal migration and its social and economic implications, inviting Member States to take action necessary to improve the statistical information on internal migration, and requesting the Secretary-General to aid those Member States requesting technical assistance in this field.

The Commission stressed the need for analysing the large amount of valuable information on demographic, economic and social conditions obtained in the national population censuses taken in and around 1950. The Commission's recommendations in this connexion are discussed in this *Bulletin* (see Special Notices). The Economic and Social Council at its XVth session invited Governments to prepare analytical studies of their census results, taking into account the views of the Population Commission, and requested the Secretary-General to give appropriate technical assistance to Governments seeking aid in this connexion.

The next session of the Population Commission will be held in 1955.

Conference on European population studies [1]

An international conference on European population studies was held in Paris from 21 to 23 May under the auspices of the *Institut national d'études démographiques*. In addition to French specialists, the conference was attended by more than fifty statisticians, demographers, economists, and university professors from other European countries. The four largest delegations were from Germany, Belgium, Italy and the Netherlands. One or more persons from Austria, England, Greece, Norway, Portugal, Spain, Sweden and Switzerland were present. Observers were sent by the United Nations, UNESCO, ILO, the Council of Europe, the Organization for European Economic Co-operation, the *Communauté européenne du charbon et de l'acier*, the International Refugee Association, and the Inter-governmental Committee for European Migration.

The purpose of the meeting was an exchange of information on work programmes, methods, and results of research. Emphasis was placed on common problems and questions relevant to population in the region of Western Europe, including those which have arisen in connexion with the projects of unification and the supra-national coal and steel communities. Particular attention was paid to the possibilities of co-operation among specialists in different European countries, in studying questions of common interest.

There were two principal subjects of discussion : the problems of the active population and of migration. Each of these was referred to a working group which received and discussed a score of communications. The papers and discussion will be reproduced in a forthcoming publication of the *Institut national d'études démographiques.*

It became apparent during the discussion that a permanent liaison was necessary to ensure the success of efforts to assist, through research in population, the persons and organizations responsible for supra-national activities. For this purpose, the Conference established a permanent *Comité d'études européennes de population.* This committee is intended to perform a double function of liaison : on the one hand, with the Council of Europe and the European specialized institutions for the purpose of formulating problems and needs for documents or data, and, on the other hand, with correspondents and regional organizations qualified to supply these needs. It is expected that the Committee will consist of one member from each country, who will have responsibility for liaison between the committee and the qualified persons and organizations in his country. Mr. Idenburg, Director-General of the Netherlands Central Statistical Bureau, was unanimously elected as the first chairman of this committee. The secretariat will be supplied by the *Institut national d'études démographiques* in Paris.

World Congress on Fertility and Sterility

The First World Congress on Fertility and Sterility met in New York on 25 to 31 May 1953. It was sponsored by the International Fertility

[1] This notice is based on a communication from M. Alfred Sauvy, Director of the *Institut national d'études démographiques* and former Chairman of the United Nations Population Commission.

Association whose object is " to study and combat infertility " and by the American Society for the Study of Sterility, and was attended by about 1,800 persons from 48 countries. This is believed to have been the world's largest medical meeting devoted to problems of reproduction. The Congress was divided into 25 meetings of two or three hours, some of them held simultaneously, and each dealing with a different topic. Among the topics considered were clinical aspects of ovarian physiology, factors influencing sperm-egg union, treatment of anovulation, blood incompatibility and fertility, perinatal mortality, psychogenic aspects of the infertile couple, and reports from infertility clinics. Transactions of the Congress will be published in a limited edition.

The Secretary-General of the International Fertility Association is Dr. Carlos D. Guerrero, Miguel E. Schulz, No. 19, Mexico, D.F., Mexico.

Pax Romana Conference

" Population problems and their economic aspects " was the subject of a conference held in Venice, 14–18 May 1953, by Pax Romana, the international movement of Catholic intellectuals. Approximately 100 persons attended the conference, most of them from European countries. The programme included a discussion by laymen and the clergy of the following main papers, which were mimeographed and distributed before the meetings :

Chanoine Louis Janssens : Principles of natural law and their practical application to demographic problems.

Alfred Sauvy : World demographic dynamics and the dangers of imbalance (the population and resources of the world).

Prof. Dr. J. A. Veraart : Possibilities of improving balance through migratory movements.

Francis Aylward : Possibilities of improving balance through changes in diet.

Prof. Dr. Jean Valarche : Possibilities of improving balance through increasing world resources.

Prof. Dr. Pasquale Saraceno : Possibilities of improving balance through the economic development of overpopulated countries.

The Secretary-General of Pax Romana is M. Ramon Sugranyes de Franch, 14, Rue St. Michel, Fribourg, Switzerland.

1953 meeting of Population Association of America

The 1953 annual meeting of the Population Association of America was held at Cincinnati and Oxford, Ohio, on 2–3 May. The following officers were elected to serve for the coming year: President : Irene B. Taeuber, Office of Population Research, Princeton University ; First Vice-President : Margaret Jarman Hagood, United States Bureau of Agricultural Economics ; Second Vice-President : Joseph J. Spengler, Duke University ; Treasurer : Mortimer Spiegelman, Metropolitan Life Insurance Company ; and Secretary : Hugh Carter, United States National Office of Vital Statistics. The meetings included four sessions at which papers were presented and discussed by members of the Association. The major topics were : " Metropolitan Areas ", " International Population Movements ", and " Demographic Changes and Economic Development ". The number of guests from countries other than the United States and Canada was larger than at any previous annual meeting of the Association.

Population Council formed in United States

The Population Council, Inc., a non-profit corporation, has recently been established in the United States to encourage research and education in the relation of population to the world's material and cultural resources. The Council is intended to serve as a centre for the collection and exchange of information on developments in the population field ; it will support research and promote the diffusion of knowledge gained through research. Frederick H. Osborn, formerly Deputy United States Representative on the United Nations Atomic Energy Commission, is Executive Vice-President of the Council and is responsible for directing its work. Other members of the Board of Trustees are : President, John D. Rockefeller 3rd, Chairman of the Board of the Rockefeller Foundation ; Dr. Frank G. Boudreau, Executive Director of the Milbank Memorial Fund ; Dr. Detlev W. Bronk, President of Johns Hopkins University ; Dr. Karl T. Compton, Chairman of the Corporation of the Massachusetts Institute of Technology ; Dr. Frank W. Notestein, Director of the Office of Population Research, Princeton University ; Dr. Thomas Parran, Dean of the Graduate School of Public Health, University of Pittsburgh ; and Lewis L. Strauss, Chairman of the United States Atomic Energy Commission. The Council's offices are located at 230 Park Avenue, New York City.

Director of Population Division retires

P. K. Whelpton retired on 30 June 1953 from his post as Director of the Population Division of the United Nations Department of Social Affairs, and took up his duties as Director of the Scripps Foundation for Research in Population Problems at Miami University, Oxford, Ohio. Since his departure, J. D. Durand, Deputy Director, has been in direct charge of the Division.