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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.

The editors will 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.

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Gaps in existing knowledge of the relationships between population trends and economic and social conditions

This is the report of a Committee of Experts appointed by the Secretary-General of the United Nations. It was presented in preliminary form to the World Population Conference (Rome, September 1954) and will be considered by the United Nations Population Commission at its eighth session (March 1955).

I. INTRODUCTION

The United Nations Population Commission, at its seventh session (1953), recommended the preparation of a statement of major gaps in existing knowledge of the relationships between population trends and economic and social conditions, with reference to topics of prime importance, on which existing knowledge is seriously deficient and on which there are practical possibilities of obtaining valuable results from further studies at this time. The Commission requested that such a statement be presented to the World Population Conference, and that in due time it be published and communicated to governmental and non-governmental agencies and private research institutions interested in population studies, as well as to experts in the field of demography, for comments on the feasibility of carrying out studies on the topics indicated.¹

In carrying out this recommendation, the Secretary-General of the United Nations, with the cooperation of the United Nations Educational, Scientific and Cultural Organization, the International Council of Social Sciences, and the Social Science Research Council, assembled a committee of experts to identify the most important gaps in knowledge in the field concerned. The Committee was composed of two groups, one of which met in New York from 20 to 22 December 1953, and the other in Paris from 22 to 24 February 1954. The membership of the two groups was as follows :

New York group :

Mr. Edward A. Ackerman, Tennessee Valley Authority
Dr. John Gordon, Harvard University
Mr. Simon Kuznets, University of Pennsylvania
Mr. Wilbert Moore, Princeton University
Mr. Frank W. Notestein, Princeton University (Chairman and Rapporteur)

Mr. Paul Webbink, Social Science Research Council

Paris group :

M. Jacques Doublet, Directeur général de la Sécurité sociale
Mr. David V. Glass, London School of Economics (Chairman)
Mr. S. Groenman, University of Utrecht
M. C. Lévy-Strauss, International Council of Social Sciences
M. J. Mertens de Wilmars, University of Louvain
Mr. Frank W. Notestein, Princeton University (Rapporteur)
M. A. Sauvy, Institut national d'études démographiques
Mr. Brinley Thomas, University College, Cardiff

Mr. John D. Durand and Mrs. Margaret Rowan of the United Nations Secretariat participated in the meetings of the New York group. Mme. Alva Myrdal, Mr. Otto Klineberg, Mr. H. M. Phillips, and M. L. Diaz-Gonzales of the UNESCO Secretariat participated in the meetings of the Paris group.

The Committee took as a basis for its work the publication prepared by the United Nations Secretariat, *The Determinants and Consequences of Population Trends*,² which presents a summary of the findings of existing studies on the relationships between population trends and economic and social conditions. It was not the task of the Committee to evaluate this publication ; its assignment was to identify the principal gaps in our knowledge of these relationships as revealed by the report, and to suggest ways in which such knowledge could be increased. The Committee recognizes, nevertheless, the excellence of the work done by the Secretariat on an extremely difficult subject, and expresses the opinion that the book

¹ United Nations. *Report of the Population Commission (Seventh Session)*. Document E/2359. New York, 1953, pp. 4-5.

² United Nations. *The determinants and consequences of population trends*. Document ST/SOA/Ser.A. Population Studies, No. 17, New York, 1953.

provides an invaluable guide both to experienced research workers throughout the world and to persons who for the first time have to give serious consideration to demographic questions. Without professing to evaluate the work in detail, the Committee expresses its unanimous view that the Secretariat's book represents much the best work on the subject and believes that it will be used extensively for years to come.

One of the virtues of the Secretariat's book is that it makes painfully clear the paucity of our knowledge of the interrelationships of population, economic and social change. This inadequacy stems less from the fact that important segments of these relationships have been completely overlooked than from the superficiality of our knowledge. The basic data are wholly inadequate for most of the world's population, our theoretical structures are over-simplified and in many cases obsolete, and our ability to disentangle the complex network of causal relationships is inadequate to permit the precise evaluation of the consequences of specific changes. Yet such evaluations of the consequences of particular changes are needed if knowledge is to serve efficiently the needs of those dealing with practical problems.

Within each of the fields of interest, such as demography, economics, sociology and public health, the situation is somewhat more satisfactory than it is concerning the impact of demographic, social, economic and medical variables on each other. One result is that we are in a better position to state problems than we are to give practical guidance in their solution. Knowledge, if it is to be useful, must become much more precise over practically the whole range of topics bearing on the economic and social determinants and consequences of population change. The Committee's suggestions are intended to direct attention to the major areas in which such work is required.

Two decisions as to the scope of the Committee's work were quickly taken. One was that recommendations on matters of population policy *per se* lay outside the terms of reference. It was felt by several members that recommendations for studies designed explicitly to meet the needs of persons charged with the formulation of practical policy would differ little from recommendations for studies formulated with the purely scientific problem of advancing knowledge in mind. It was, therefore, with the scientific questions that the Committee concerned itself.

The other immediate decision was that the Committee should deliberately concentrate first on demographic questions and move from this focus to questions of interrelationships. The alternative procedure of considering as on an equal footing the needs of demography, economics, sociology, public health, geography, etc., would have led to impossibly diffuse recommendations ranging over the whole of the social and much of the natural sciences.

Some of the Committee members thought that the recommendations should be limited to a very small number of topics that together could be thought of as providing a definite research programme to be carried out in something like five years. A large majority, however, felt that such an assignment, although desirable, could not be carried out by a committee meeting in two widely separated sections for a relatively few hours. The majority held that the Committee's task was to make a variety of suggestions for studies on important topics, with the hope that the suggestions would stimulate international agencies, Governments and private scholars to undertake those projects that seemed most appropriate to their own needs and opportunities. The Committee has therefore made some fifty recommendations which are incorporated in the following report. They are numbered *seriatim*, and those deemed to be particularly important are marked with an asterisk (*).

A practical difficulty arises in summarizing the work of the two groups constituting the Committee. They organized their discussions on entirely different lines. The New York group, after having dealt with problems of basic data, considered, first, studies relating to the determinants of population change and, second, studies of population in its economic and social roles. The Paris group, after considering problems of data and other aids to research, found it more convenient to discuss, first, the research needs of the developed regions, then those of the relatively under-developed regions and, finally, questions of relationships between the developed and under-developed regions. This report utilizes the major outline of the Paris group, and within each type of region a subclassification along the lines developed in New York.

Many topics could with equal justice be classified in several places. For example, the Committee lays considerable stress on the importance of studies of the history of population change and economic growth during the eighteenth and nineteenth centuries in Europe. Such studies deal with the problems of regions that are at present rather highly developed, but much of their importance lies in the insight they could give into questions of economic and population change for the regions now undergoing, or hoping to undergo, development. Similarly, studies of mortality and morbidity may be viewed as determinants of population growth, but equally they may relate to the efficiency of the labour force. Any system of classification will be arbitrary because of the complex web of causal relationships involved.

II. AIDS TO THE ADVANCEMENT OF KNOWLEDGE

The state of knowledge in any field of inquiry depends on the basic resources that the research worker has at his disposal. Among such resources, the Committee wishes to call attention to three that are notably inadequate.

A. Basic data

Knowledge of population trends, and of their causes and consequences, is bound to remain inadequate so long as the most elementary information about size and structure of the population and the components of population change are almost completely lacking for most of the world's population. It is not the function of this Committee to make detailed recommendations on such matters, but in view of the importance of securing more adequate basic materials the Committee wants to call attention to a few general propositions.

There is great need for an extension of the basic series of census and vital statistics. In many countries such series are not now available, and in others where the data are reported they are so incomplete and inaccurate as to impair greatly their usefulness. In still other countries, where the data have been collected for a considerable time, the series are not comparable over time because of territorial shifts, changes in administrative practices, variation in quality, and the like. Many of the most fundamental studies of variation and of relationships between population and other changes depend on the availability of such information over long periods of years. The Committee therefore recommends :

(1*) That steps be taken to establish basic series on population and vital statistics where they do not now exist, and to improve their quality where such data are now seriously inadequate or defective.

(2*) The preparation of an international reference volume of basic statistics on population size and structure and on the components of population change—birth, death and migration—for as long an historical period as possible. Much of the worth of such a volume would depend on the care taken to achieve all possible comparability over time and as between countries. (Several members of the Committee pointed out that this is a type of research in which the international agency has a conspicuous advantage over private or governmental agencies.)

(3) The extension of current efforts by private scholars, governments and international organizations to evaluate the quality of basic data now being collected, some of which are so inaccurate as to be seriously misleading.

The major problems of basic data are of course different in the countries having well-developed statistical systems from those in relatively new or undeveloped systems. With reference to the former the Committee recommends :

(4) Fuller recognition that in the cases in which statistical systems have grown by accretion over a long period of years, there is need for periodical systematic stock-taking to assure that available resources are being utilized in the most efficient manner possible.

(5) That more attention be given to discovering the nature of the information required for sound research on pressing problems, and on the ways in which such data can be obtained. Evidence on many important matters such as questions of family size, costs of child-rearing, consumption patterns, etc., will remain inadequate so long as the information to be brought to bear is limited to that available from the conventional record systems. More thought given to organizing data around specific problems would doubtless result both in the modification of conventional record systems and in heavier reliance on *ad hoc* field studies utilizing sampling techniques.

(6) That attention be given to the possibility of utilizing data provided by the various social security systems for studies of internal migration and questions relating to the labour force, mortality and fertility.

With respect to the under-developed countries, the Committee calls attention to the fact that the social security systems now being organized are an invaluable potential source of basic data. It particularly urges upon the social security administrators the importance of organizing their record systems in ways that permit the collection of relevant demographic materials. For such countries it also recommends :

(7) Recognition of the fact that the methods by which such basic data are to be obtained should not be automatically assumed to be the same as those used in countries with fully developed statistical systems and an abundance of both funds and technically trained personnel to maintain them. It is probable that considerable economies could be achieved by the use of modern sampling methods in the production of regular census and vital statistics.

(8) That in the under-developed countries for which historical series are not available, *ad hoc* field studies should be undertaken on a sampling basis to supplement current census and vital statistics.

(9) That it would be desirable if a common core of quantitative demographic data could be routinely gathered by many anthropological investigations being conducted in the under-developed areas and reported to some central clearinghouse for compilation. Conversely, it would be desirable if there could be collaboration between anthropologists and demographers with a view to developing demographic procedures appropriate for use in the study of the small groups with which the anthropologists so often deal.

B. Bibliography

The Committee calls attention to the fact that, although the Secretariat's book on *The Determinants and Consequences of Population Trends* provides an excellent guide to the literature on its

explicit topic, the research worker needs to have access to a range of materials that could not possibly be covered in such a book. Many pertinent studies have been made, but their results appear in such a widely scattered literature that they are effectively lost so far as most students are concerned. The Committee therefore recommends :

(10) That attention be given by the international agencies to the possibility of producing an annotated bibliography of materials pertinent to the problems of under-developed areas, having special reference to the demographic, economic, social and public health fields.

C. *Theory and analysis*

There is much dissatisfaction with the level of economic analysis generally found in studies of population change. In part this weakness arises from the inadequacy of the theoretical framework, which is too often static, over-simplified, or even obsolete. There have been rather few attempts to incorporate in demographic studies the modern developments in economic analysis. Although the Committee laid much less emphasis on the converse proposition, it is also evident that rather low levels of sophistication concerning social and demographic theory are also too often found in economic studies. The Committee recommends :

(11) That scholars give more attention to deepening the level of economic analysis associated with demographic studies. Substantial progress might be made, for example, by the utilization of dynamic models which incorporate changes both in the economy and in the size and structure of populations. The most urgent need in the field of theory is for the development of generalizations at the relatively restricted level concerning the relationship of social, economic and population change.

III. RESEARCH ON RELATIVELY DEVELOPED AREAS

A. *Types of approach to the study of interrelationships of population, economic and social change*

Research on the large number of specific topics requiring investigation can be approached in a variety of ways. Among these the Committee calls attention to three that need further emphasis both because of their intrinsic worth and for the insight they would give to the problems of regions now undergoing, or hoping to undergo, development. The Committee recommends :

(12) The careful re-study of the historical record of the developed countries, concerning which existing generalizations are rather shallow and stereotyped. Such studies should give special attention to :

(a) The interrelationships of population growth and capital formation and use. In such

studies care must be taken to examine the situation within its social and political context. In some instances population trends that were favourable to capital accumulation appear to have occurred in a social and political context that was unfavourable to the application of savings to the expansion of production.

(b) The role of internal and international migration in the spread of modern technology and economic development.

(c) The sequence of change in population growth and in industrial and social (particularly educational) development.

(d) The impact of technology on population growth.

(e) The critical sources of resistance to social change.

(13) Renewed attempts to study the record of population growth and economic development in the backward areas of relatively developed countries. (Often in the early stages of development there is paucity of basic data. By contrast, there are a good many instances in the relatively developed countries in which a wealth of information is available concerning the processes of economic and population change of backward sections that have rather recently undergone development.)

(14) A careful re-examination of the errors in recent population projections. This re-examination should be made in the light of historical trends of population and related factors for the purpose of bringing to light the reasons for past errors, improving the basis for the future projections, and increasing the understanding of the interrelationships themselves.

In suggesting a review of population projections, the Committee is not expecting a major advance in the techniques by which the components of population change are combined. Instead it intends to emphasize the importance of gaining new insight into the factors that affect the individual components of change—fertility, mortality and migration. A study of past errors in population projections would serve to give a sharper focus to the re-examination of the record of population change in association with related variables.

B. *Studies relating to the determinants of population change*

Each of the three approaches suggested in recommendations (11)-(13) above would require the close study of fertility, mortality and migration. These approaches, however, by no means fulfil all the needs and opportunities for such work. So far as the relatively developed countries are concerned, the Committee wishes to call particular attention to the need for additional study of mortality and fertility.

1. Mortality

Recent spectacular developments in the control of contagious and infectious diseases suggest the importance of renewed emphasis on two lines of inquiry. In the first place, the long-run implications of the brief experience of new medical developments can probably be best understood by the careful examination of data relating to cause of death. In this field particular emphasis is laid on the study of trends of mortality in the older age groups to which ever larger proportions of the population are surviving. In the second place, with the progressive control of contagion and infection, new importance attaches to gaining more precise knowledge of the influence of environmental factors on life and health. The Committee recommends :

(15) The careful study of trends in mortality by cause of death, both for its own sake and to provide a better basis for projecting mortality as a component of population change.

(16) Renewed studies of the social and economic factors affecting differences in mortality with a view to improving the specificity of existing knowledge, particularly under conditions in which most contagious and infectious diseases have already been controlled.

2. Fertility

Except in the event of a major war, it seems likely that death rates will decline even below their present low levels in the relatively developed regions of the world, and that year-to-year variations will be rather small. With mortality so well controlled, fertility may be expected to be the major source of variation in the future peacetime rate of population growth. Although much is already known about the determinants of fertility, one need only note the discrepancy between the projected and the actual course of birth rates since 1940 to realize the inadequacy of existing knowledge.

The general cluster of economic and social changes that accompanied the decline of birth rates in the Western world during the nineteenth and twentieth centuries is well known. It includes such factors as urban-industrial development, the extension of mass education, the rising status of women, the growing importance of individualism, increased social mobility, etc. However, in some cases birth rates have declined in the absence of many of these changes and in other cases they have failed to decline when many such changes were present. As a guide to both the projection of future population and the formulation of practical population policy, our knowledge of the causal relations needs to be made much more specific. The Committee recommends :

(17) The careful study of certain variables, such as education, occupation, occupational mobility and governmental action outside the

field of explicit population policy, as they affected historical trends of fertility in the West.

(18) The integration of existing studies and the undertaking of additional investigations of the nature and source of the postwar rise in fertility.

In many countries a major factor in the postwar rise in fertility is to be found in the sharp increases in the proportion of persons marrying, and in the declining ages at marriage, neither of which had been forecast. The Committee recommends :

(19) Intensive studies of the nature and determinants of the new trends in family formation.

C. Studies of population in its economic roles as producers and consumers

Rather little of a precise nature is known about even some of the more direct relationships between population and economic change. In the case of the relatively developed areas, the Committee stresses the importance of additional work on four general topics. It recommends :

(20) Continuing research on the problems of dependency, especially those arising from the ageing of population, and including :

(a) The relationship of morbidity and mortality.

(b) Problems of labour-force utilization incident to ageing.

(c) The participation of married women in the labour force.

(d) The costs of dependency by age.

(21) The careful evaluation of evidence on standards and levels of living and the ways in which they have been changing. (Several members expressed the view that many studies in this field place too much reliance on aggregative indices that do not adequately reflect the true situation.)

(22) Particular attention to the costs of rearing children by size of family in the various income groups and the comparison of such actual costs with those that would be required to meet "acceptable standards".

(23) The careful investigation in a variety of circumstances of the influence of changes in the size and structure of the population on technological progress, and its application to economic development.

IV. RESEARCH ON UNDER-DEVELOPED AREAS

As in the case of the developed areas, the Committee considered general approaches by which the interrelationships of population, economic and social change might be fruitfully investigated before taking up more specific topics needing further investigation.

A. *Types of approach to the study of the inter-relationships of population, economic and social change*

Examination of the sources of error in past population projections is less likely to be a fruitful mode of studying the interrelationships for the under-developed than for the developed countries. On the other hand, for the under-developed countries questions of resources and technology and problems of economic and social development are even more important than for the developed countries. The Committee therefore recommends :

(24) Regional studies of the population-resource-technology complex, including :

(a) Exploration of the limits of development in the area according to existing technology available there or elsewhere in the world.

(b) Outlining the demands of the particular population for food and materials from other parts of the world if adequate standards of consumption are to be established or preserved.

(c) Clarification of possible contributions of the nation or region in question towards the assistance of other areas.

(d) Effects of declining rate of population increase upon the economy of the densely populated under-developed countries.

(Such studies should be made with reference to certain countries which would be distinctive as representing certain areas that are naturally linked in a world economic organization.)

(25) Studies of models of demographic, economic and social development including :

(a) Examination of the models which have been prepared explicitly for, or are implicit in, existing plans and recommendations for economic and social development of particular under-developed areas.

(b) The construction of new models showing relationships between demographic, economic and social development of given under-developed areas according to alternative assumptions regarding trends of certain factors.

B. *Studies of the determinants of population change*

A major part of existing ideas about the determinants of population change in the under-developed areas is based on the earlier experiences of the Western world. Valuable as such information can be, it is an inadequate substitute for knowledge of experience in the local setting under existing conditions. The Committee therefore makes the following recommendations for studies of mortality, fertility and migration :

1. *Studies of mortality*

(26) Studies of mortality trends to provide a better basis for population projections.

(27) Studies of the social and economic factors affecting differences in mortality.

(28) Investigations of the impact of new medical technology, which appears to have outstripped the processes of economic development, and of the possibility of using data from pilot efforts at health protection to gain new insight into these matters.

2. *Studies of fertility*

(29*) Studies of human fertility that stress particularly :

(a) The status of women.

(b) The role of education.

(c) The role of knowledge in hygiene, and particularly in the care of children.

(d) The part played by religion, including :

(1) Studies not only of differences in the fertility of religious groups, but also of changes in fertility by religion.

(2) Studies that seek to isolate the influence of religion itself on fertility from the influence of the general concomitants of religion.

(3) Studies of the formal tenets of religion with respect to fertility and the modes of changing fertility.

(30) Studies of the influence of the "normative orders" and of possible changes therein upon fertility. These studies should be based on both analytical work and experimentation with the factors deemed susceptible to change.

(31*) Studies of such development of family planning as have taken place or are taking place, with particular reference to the factors affecting their rate of spread; and studies of the technology of family planning and of the motivation for its application.

(32) Ethnological studies of the elements of social structure tending to determine family size and rates of reproduction.

3. *Studies of migration*

(33) Studies of the possibility of extensive migration between and within under-developed countries with regard to the effect of similarities and differences in the cultures on the extent of migration.

(34) Studies of emigration from densely populated under-developed areas.

C. *Studies of population in its economic roles as producers and consumers*

Knowledge of the relationships of population size, structure and change to the behaviour of people as producers and consumers is wholly inadequate. The Committee recommends :

(35) Research on more meaningful categorization of the activities of the population with

respect to the needs of its own economy, particularly from the point of view of the convertibility of skills, but also of comparability with the data for other economies.

(36*) Studies of concealed unemployment in agriculture and of the extent of the labour force likely to be released for non-agricultural work by better agricultural methods. Such studies should also give attention to the ways in which redundant labour can be utilized in capital formation.

(37) Studies of the prevalence of disability among the population in relation to the productivity of the labour force.

(38) Studies of actual consumption patterns, by age if possible.

(39) Studies of consumption and of consumer needs in relation to age. Such studies should be undertaken in order to assess the economic importance of the age structure and of premature mortality.

(40) Studies of the whole problem of the relationship of dependency to age in various types of societies and economies.

D. *Studies of other aspects of the interrelationships of population with economic and social factors*

The Committee recognizes that virtually any change in the economy or society has an impact on the processes of population change, and vice versa. To avoid endeavouring to cover too wide a range, however, it limits its suggestions to a few topics that it deems especially important. The Committee recommends :

(41) Studies of the interrelationship of population growth and the formation and utilization of indigenous capital, with particular reference to problems of economic development.

(42*) Studies of social mobility and of the new ways in which it might be stimulated.

(43*) Studies of the possibility of using efforts to improve public health as a carrier for other forms of modernization.

(44) Studies of the most appropriate means of introducing technological development, with particular attention to assessing the role that limited education could play.

(45*) Studies of problems of incentive (economic and social), especially in such regions as Africa and Indonesia.

V. RESEARCH ON THE INTERRELATIONSHIPS OF RELATIVELY DEVELOPED AND UNDER-DEVELOPED AREAS

A number of questions needing further investigation concern relationships that run between the developed and the under-developed regions. Of them, those in the fields of migration and economic development are particularly important.

A. *Migration*

The Committee recommends :

(46) Studies of the economic and demographic impact on sending and receiving areas of migration between relatively developed and under-developed regions, with particular regard to :

(a) The effect of such movements on the growth and structure of the population and labour force of the areas affected, taking particular account of the relationship between migration and natural increase.

(b) Problems of capital requirements related to migration.

(c) The costs of moving migrants, of developing productive resources, and of removing health hazards, especially in certain relatively empty areas of Latin America, and perhaps of Africa and Oceania.

(47) The careful study of the migration from Europe to Latin America, concerning which there is a considerable amount of information that has been rather inadequately exploited.

B. *Problems of economic and social change*

So far as the relationships between the relatively developed and under-developed countries are concerned, the Committee recommends :

(48) Studies of the impact on the behaviour of local populations of their exposure to contacts with the lower echelons of Technical Assistance personnel.

(49) Studies of the formation and use of international capital with respect to the development of industrial capital in the under-developed areas.

(50) Studies of the effect of high utilization of energy and resources by the developed countries on the possibility for advance in the under-developed regions.

Finally, the Committee wishes to re-emphasize the fact that this report is not intended to provide the outline for an integrated research programme. It is offered only as providing suggestions concerning topics upon which further research is feasible and urgently needed to fill gaps in our knowledge of the determinants and consequences of population trends. It expresses the belief that careful investigation along the lines suggested would provide a much sounder basis of information than now exists for the guidance of persons responsible for the formulation of population policies throughout the world. In seeking such knowledge, private scholars and the research agencies of Governments and international organizations can all contribute.

Fertility according to size of family: application to Australia

By Louis HENRY

Mr. Henry, of the Institut national d'études démographiques in France, is author of numerous studies on the measurement of human fertility. In this article he applies his method of analysis to data for Australia.

This study comprises two main parts. The first is theoretical and justifies use of the factor of size already reached by families, briefly showing how to calculate legitimate fertility indices by size of families. The second part is an application of the method to the country whose records of births by order go back farthest—namely, Australia.

* * *

Demographers have always devoted a considerable amount of attention to research into the factors governing the behaviour of individuals or groups in the various acts of life which are of demographic interest.

With regard to fertility, two factors are of primary importance :

(1) Marriage, because the great majority of births are legitimate in populations of European culture ;

(2) The mother's age, since the proportion of sterile women increases with age to reach practically 100 per cent at the age of fifty.

If only these factors were considered, however, one of the fundamental aspects of reproduction would be ignored : its partly voluntary character in many populations. Man's intervention in a matter which he had long left to nature chiefly tends to reduce the number of births : as soon as a couple has the number of children it desires, or is prepared to accept, it will endeavour to avoid further conception and to be sterile thereafter.

This means that behaviour varies according to size of the family, since a couple unwilling to have more than two children may behave " naturally " until the two children are born, but will become voluntarily sterile after the birth of the second child.¹ In such a family, neither age nor length of marriage, but only the number of children born is considered.

¹ Any aspects of behaviour intended to space out births are here disregarded. Demographically, this is a secondary aspect of birth control.

If we pass from such a family to the aggregate of families wanting only two children, the second births will be spaced out according to a certain law, and the number of families becoming voluntarily sterile afterwards will increase regularly, depending on the length of marriage. This relation between length of marriage and proportion of completed families means that length of marriage may replace family size as a factor of behaviour.

Moreover, since the ageing of women—a physiological factor of sterility—proceeds simultaneously with the length of marriage, it would seem advisable to make use of this latter factor when studying legitimate fertility, because it accounts for the effects of two important factors : family size and ageing.

This is an advantage, however, only as long as the usual relation between length of marriage and family size holds good. After an important disturbance, particularly after a war, the relation is destroyed. Couples who were young when the war broke out and who have been separated for five years will, after reunion, adapt their voluntary behaviour not to length of marriage, but to the number of births still necessary to complete the desired size of family. They may be prevented from fulfilling their wishes by sterility due to ageing, which was obviously not interrupted by the separation. In practice, the limiting effect of ageing is secondary, and size of family becomes the most important factor. Given the same duration of marriage, the fertility of couples reunited after separation caused by war will be greater than that of couples similar in other respects, but not parted by war.

The populations of European culture, whose behaviour is determined by size of family have, in the last fifty years, suffered two wars and an unprecedented economic depression. The importance of the disturbances arising from those events need not be stressed. It is therefore advisable to take explicitly into account the size already reached by families and to study the fertility of families by size—a study which, in any case, is in itself highly interesting.

When legitimate fertility is examined, irrespective of birth order, it can be described by an index such as the average number of births per family or per marriage, i.e. the average number of births (B events) per marriage (A events).

Likewise, the fertility of families of n children will be characterized by the average number of births of the $n + 1$ order per n th birth (or per marriage where $n + 1 = 1$). This average number is, by definition, less than 1 and shows what proportion of families of n children increase by the $n + 1$ birth. We call these indices the *probabilities of increase* of families of n children and refer to them as $a_0, a_1, a_2, \dots, a_n$. As is customary in demography, such indices may be determined by considering a group of couples, and are thus cohort indices, or by observations in a given year or in a given period, and are thus period indices—in this case period probabilities of increase.

To determine the latter, statistics by birth order must first be available. Once that condition is fulfilled, the traditional method would be to calculate the probabilities of increase by means of the fertility rates of the n -child families according to the time elapsed since the n th birth, more or less as life expectancy is calculated from death ratios.

In practice, such fertility rates are not available and some other procedure must be adopted. One already widely used method is to replace the index calculated from the fertility rate by an index calculated from the ratio of B events in the year studied to a weighted mean of the relevant A events observed during the year studied and in previous years.²

This method was used by C. Gini,³ J. M. Moriyama and T. Greville⁴ for infant mortality, and by C. Gini⁵ for legitimate fertility (average number of children per marriage). It has been applied to determine the average number of divorces per marriage, the most logical index for measuring the frequency of divorces.⁶

² A detailed study of the figures thus obtained shows that, in spite of certain disadvantages, they have some advantages over the traditional rates calculated from fertility rates. Hence, indices calculated by the weighted mean method, originally intended to be mere alternatives to the traditional indices, are now competing with them.

³ Gini, C. "Sulla mortalità infantile durante la guerra". *Atti della società italiana di ostetricia e ginecologia*, Vol. XIX. Gennaio 1919, pp. 293-314.

⁴ Moriyama, J. M. and Greville, T. "Effect of changing birth rates upon infant mortality rates". *Vital Statistics Special Reports*, Vol. 19, No. 21. 10 November 1944, pp. 401-412.

⁵ Gini, C. "Di un procedimento per la determinazione del numero medio dei figli legittimi per matrimonio", *Metron*, Vol. X, No. 2. Settembre 1932, pp. 3-31.

⁶ Henry, L. "Mesure de la fréquence des divorces". *Population*, 7^e année, No. 2. Avril-Juin 1952, pp. 267-282.

Its use assumes that, during an undisturbed period, the distribution of the intervals between events A and B from which the series of weights is derived is constant. But when the distribution varies, the fact may, if the variation is known, be taken into account and the number of B events in a given year may be related to a linear form of the number of earlier A events instead of to their weighted mean.⁷ However, this is a rather uncommon refinement, owing to lack of data.

In practice, the weights to be used in calculating the first probability of increase from marriage to the first birth can frequently be determined from existing statistics, whereas there are very few data for determining the other series of weights. Table 1 shows all the series of which the author is aware. In spite of the differences of time and place, they present certain similarities. Since computing the probabilities of increase by the weighted mean method does not call for any great accuracy of weights, the similarity of these series makes it possible to use those of another country or period. The probability of error may even be lessened by selecting from the series in table 1 those which seem better suited to the case in point; thus, in the case of populations practising birth control, the French or Bohemian series will be preferable to those from Slovakia or Subcarpathian Russia, where the practice is rare.

⁷ Let o be the year studied, l the previous year, and so on retrogressively. Let B_o be the B events of the year studied, A_i the A events of the year i and α_{ij} the proportion of B events following an A event in year i occurring j calendar years after A. If B events occur constantly a times per A event, we have:

$$B_o = a \sum \alpha_{ij} A_i$$

Whence:

$$a = \frac{B_o}{\sum \alpha_{ij} A_i}$$

Should the distribution of the interval between A and B be invariable, α_{ij} no longer varies as i , and we may write:

$$a = \frac{B_o}{\sum \alpha_i A_i}$$

where $\sum \alpha_i = 1$.

If a , instead of being a constant, varies mathematically, the expression $\frac{B_o}{\sum \alpha_i A_i}$ will represent the average number

of B events occurring in a year which begins at a constant interval, approximating the average interval between A and B events, before the beginning of year o .

For more details see Henry, L. *Fécondité des mariages—nouvelle méthode de mesure*. Travaux et documents de l'Institut national d'études démographiques, cahier n° 16. Paris, 1953.

TABLE 1. WEIGHTS TO BE USED IN CALCULATING PROBABILITIES OF INCREASE

Year	a_1					a_2				
	Fr.	Bo.	Mo.	Sl.	Ru.	Fr.	Bo.	Mo.	Sl.	Ru.
0	2	2	2	2	2	2	2	3	2	2
1	22	24	28	26	25	16	21	23	20	19
2	33	26	29	33	37	33	28	30	33	38
3	16	15	15	17	19	19	17	17	20	24
4	9	11	9	8	8	11	11	9	9	8
5	6	7	6	5	4	7	7	7	6	4
6	4	5	4	4	2	4	4	4	4	2
7	3	4	3	2	1	3	4	3	2	1
8	2	2	2	1	1	2	2	2	2	1
9	2	2	1	1	1	2	2	1	1	1
10	1	1	1	1	—	1	1	1	1	—
11	—	1	—	—	—	—	1	—	—	—
TOTAL	100	100	100	100	100	100	100	100	100	100

Year	a_3					a_4				
	Fr.	Bo.	Mo.	Sl.	Ru.	Fr.	Bo.	Mo.	Sl.	Ru.
0	2	3	3	2	2	3	4	3	2	2
1	16	21	23	19	18	16	22	23	20	18
2	33	28	32	35	37	33	29	33	36	37
3	20	17	17	21	27	20	17	17	22	27
4	11	11	9	9	8	11	10	9	8	8
5	6	7	6	5	4	6	6	6	4	4
6	4	4	4	4	2	4	4	4	3	2
7	3	4	2	2	1	3	3	2	2	1
8	2	2	2	1	1	2	2	1	1	1
9	2	1	1	1	—	1	1	1	1	—
10	1	1	1	1	—	1	1	1	1	—
11	—	1	—	—	—	—	1	—	—	—
TOTAL	100	100	100	100	100	100	100	100	100	100

Year	a_5					a_6					a_7				
	Fr.	Bo.	Mo.	Sl.	Ru.	Fr.	Bo.	Mo.	Sl.	Ru.	Fr.	Bo.	Mo.	Sl.	Ru.
0	3	4	3	3	3	3	4	3	3	3	4	4	4	4	4
1	17	24	24	20	18	17	24	24	20	16	18	26	24	20	19
2	36	20	33	36	36	37	31	35	36	38	37	34	35	36	38
3	20	18	19	22	27	21	18	19	23	27	20	18	20	23	24
4	10	8	9	8	9	10	8	8	8	9	10	8	8	8	9
5	6	6	5	4	3	5	6	4	4	3	5	5	4	4	3
6	3	3	3	3	2	3	3	3	3	2	2	2	2	3	1
7	2	2	2	1	1	2	2	2	1	1	1	1	1	1	1
8	1	2	1	1	1	1	2	1	1	1	1	1	1	1	1
9	1	1	1	1	—	1	1	1	1	—	1	1	1	—	—
10	1	1	—	1	—	—	1	—	—	—	—	—	—	—	—
11	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
TOTAL	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Fr. : France; Bo. : Bohemia; Mo. : Moravia; Sl. : Slovakia; Ru. : Subcarpathian Russia.

Sources : The figures for France are taken from the civil service salaried employees and wage earners survey compiled in 1907; those for Czechoslovakia were computed from vital statistics; they relate to the cohorts of women bearing their *n*th child in 1925-1926.

APPLICATION TO AUSTRALIA

The recording of birth statistics by order has generally been somewhat belated. Very few countries obtained these data before the First World War.

Among the countries with such records is Australia, having introduced the system in 1908, one year after France. But while such statistics

were interrupted in France in 1920 and 1922-1924, there is no break in the Australian figures. The study of that country therefore provides a long chronological series of probabilities of increase covering a period that includes two wars and an unprecedented economic depression.

Against that inestimable asset, Australia has the disadvantage of being a country of immigration whereas, in theory, the weighted mean method

presupposes a closed population. For the period considered, however, the difficulties resulting from this fact are not insuperable.

In Australia, statistics by order of birth refer to legitimate live births; ⁸ order of birth is determined by the number of live-born children of the present marriage.

A preliminary survey has indicated that a change has occurred in the proportion of first births by length of marriage.⁹ This change has

⁸ Actually, the tables show confinements resulting in at least one liveborn child. A table of confinements resulting in multiple births by number of children already born makes it possible to revert to live births by order.

⁹ This phenomenon is pointed out by Borrie. See Borrie, W. D., *Population Trends and Policies*. Sydney, 1948, pp. 94-95.

therefore been taken into account in calculating a_0 ; thus for marriages celebrated in 1910, 1930 and 1950, the following figures have been adopted for the distribution of first births, and figures for the intervening years may be obtained by graphical interpolation.

Year of marriage	Percentage of first births in the following years									
	0	1	2	3	4	5	6	7	8	9
1910	30	50	11	4	2	1	1	1		
1930	24	44	15	6	4	2	2	1	1	
1950	18	38	19	8	6	4	3	2	1	1

Note: 0 stands for the calendar year of marriage, 1 for following year (here 1911, 1931, 1951), and so on.

For calculating the other probabilities of increase, it has been assumed that the spacing of the intervals between births did not vary and

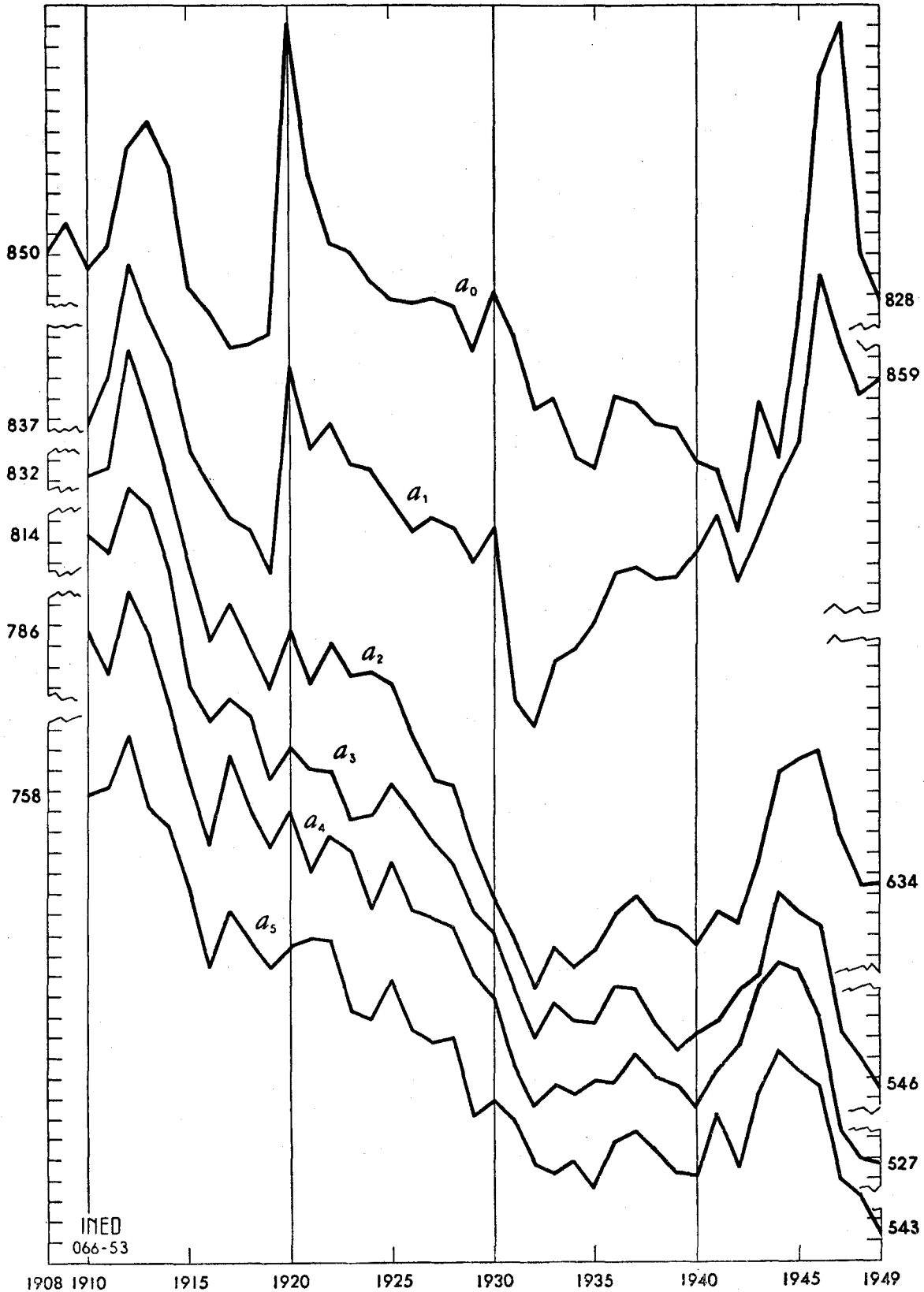
TABLE 2. AUSTRALIA: PERIOD PROBABILITIES OF INCREASE
(Multiplied by 1,000)

Year	a_0	a_1	a_2	a_3	a_4	a_5	a_6
1908	850						
1909	865						
1910	843	837	832	814	786	758	757
1911	854	860	836	806	765	761	743
1912	902	915	894	837	806	787	788
1913	915	888	866	827	783	751	730
1914	893	868	829	797	753	741	723
1915	834	824	789	742	715	712	672
1916	821	808	752	724	683	674	647
1917	804	791	769	735	727	701	674
1918	806	786	749	727	700	687	684
1919	811	764	729	696	682	674	681
1920	959	865	757	711	700	684	658
1921	888	825	732	701	670	688	671
1922	855	838	752	700	687	687	678
1923	851	817	735	676	680	653	632
1924	836	815	737	678	651	649	656
1925	828	799	732	694	675	668	684
1926	826	784	706	680	651	644	636
1927	828	791	685	665	648	638	644
1928	825	786	682	655	646	640	655
1929	803	770	651	634	619	602	607
1930	832	786	628	623	609	609	615
1931	810	705	609	595	575	599	591
1932	774	691	583	569	555	577	567
1933	780	722	603	587	566	573	563
1934	752	728	594	578	562	579	582
1935	747	741	601	577	568	565	600
1936	781	764	619	595	567	588	567
1937	778	767	628	594	581	593	590
1938	768	761	617	576	570	584	552
1939	766	762	614	564	566	574	568
1940	749	775	605	572	555	572	570
1941	745	792	621	578	573	602	588
1942	716	760	615	594	584	575	587
1943	779	784	645	600	614	612	587
1944	751	810	687	640	626	633	651
1945	818	828	694	631	622	623	611
1946	936	909	698	624	599	615	611
1947	961	876	659	572	543	569	598
1948	850	851	633	561	529	561	577
1949	828	859	634	546	527	543	572
Average 1915-1923	848	813	752	712	694	684	666
Average 1924-1930	825	790	689	661	642	636	642
Average 1931-1949	794	784	630	587	573	586	586

Figure 1

AUSTRALIA: PERIOD PROBABILITIES OF INCREASE

The dates are shown on the horizontal axis; the probabilities of increase per 1,000 are shown on the vertical axis. The figures in the margin give the value of the probabilities of increase, in 1908 or 1910 on the left, in 1949 on the right. 850 signifies, for example, that in 1908 a_0 is equal to 0.850.



the weights given for France (1906 family statistics) have been used.^{10,11}

It is possible to compute a_0 from 1908 on. Unless births are estimated by order for the period prior to 1908, the other probabilities of increase would be computable only from 1918. No appreciable error is made, however, by introducing estimated figures for births by order prior to 1908, provided that the weights by which they are multiplied are small. It is thus possible to go back as far as 1913 without undue risk. The calculation has been extended to 1910 because of the peculiarities of a_0 in the period 1910 to 1913, in order to ascertain whether they recurred in the other probabilities of increase.

The values for $a_0, a_1, a_2, a_3, a_4, a_5$ and a_6 so calculated are shown in table 2. Full calculations have been made only for the first seven probabilities of increase since, beyond that, the smallness of the relevant figures produces unduly large contingent fluctuations; even a_6 is rather seriously affected by the latter and has therefore not been carried over to figure 1.

The most striking feature of these graphs is the extent of the fluctuations, particularly in the case of childless or small families, where the 1912-1913 and 1920 peaks enclose a very marked trough. Another fall appears in the 1930's, and a peak is finally reached in 1946-1947.

Most of these irregularities are connected with events, namely, the First and Second World Wars and the economic depression of the 1930's. The disturbances caused by each of those events were spread over about ten years, so that, over a forty-year period, the series here studied include some thirty troubled years. Let us, however, attempt to determine, if only approximately, the underlying trend. In the early years of the century, no important disturbance took place, nor was there much migration. Hence the earliest probabilities of increase, 1908 to 1910 for a_0 , 1910-1911 for a_1, a_2, a_3, a_4, a_5 , and a_6 , are unlikely to deviate much from the general trend.

In 1911-1913, there was an influx of immigrants, reflected in the peak in the 1912 (a_1 to a_6) or 1913 (a_0) probabilities of increase. This peak is as pronounced as certain postwar peaks, but does not correspond to any recovery and is therefore not compensated for; consequently the 1912-1914 period must be disregarded as far as trends are concerned.

From 1915 the effect of the 1911-1913 spate of immigration became so slight as to be discounted. In that year the period of postponement caused by the First World War began. It was followed by a period of recovery which may be considered

¹⁰ This lack of variation only applies to the trend. The actual spacing of intervals between births has changed temporarily as a result of events such as wars and economic depressions.

¹¹ According to Borrie (*op. cit.*, p. 96), the changes in the spacing of children are less marked than that in the period between marriage and the birth of the first child.

completed in 1923. In so far as there was compensation, the 1915-1923 average provides a point in the trend. Another point will be given by the 1924-1930 average, as the depression was hardly able to affect fertility before 1931.¹² In 1931 a disturbance began which lasted until the end of our chronological series. According to the experience of other countries (France and the United States, for example), it may be considered as practically over by 1948-1949.¹³

The 1931-1949 period may not, in spite of the influence of the depression and then of the Second World War, be split up into two sub-periods, because the making up of births postponed during the depression began before the war and seems to have continued during the war and to have overlapped the resultant further delay. Hence, compensation for the depression and for war-time periods of postponements by subsequent periods of recovery is possible only within the period 1931-1949.¹⁴ In depicting the trends for that period, we have given the trend values the same average in 1931-1949 as the values of the time referred to.

Figure 2 shows the trends thus obtained. At the beginning a_0 is level; it falls gradually from the end of the First World War to a relatively precise date in the late 1930's. It then rises again, but does not reach the pre-1914 level by 1949. a_1 falls at the start and reaches its lowest point at approximately the same time as a_0 ; it then rises very rapidly above the 1910 level. a_2 also shows a fall until the end of the 1930's, but its subsequent recovery is very slight.

There is some uncertainty about the present trend of these three probabilities of increase. We have assumed that the upward trend has been slowing down and has completely disappeared in recent years.

After a_2 , there is no further rise in the curve. The drop continues during the whole of the period under review, but at a progressively slower rate. Moreover, whereas the relative drop between two dates is the same for a_3 as for a_4 , this drop decreases from a_4 to a_5 and again from a_5 to a_6 .

If only the principal features are considered, a reversal of the trend for a_0 and a_1 , stabilization for a_2 and a continued decline from a_3 on will be noted.

¹² During that period, from 1924 to 1927, the net annual immigration rate was between 7 and 8 per thousand. The 1926-1930 average probability of increase is therefore rather high.

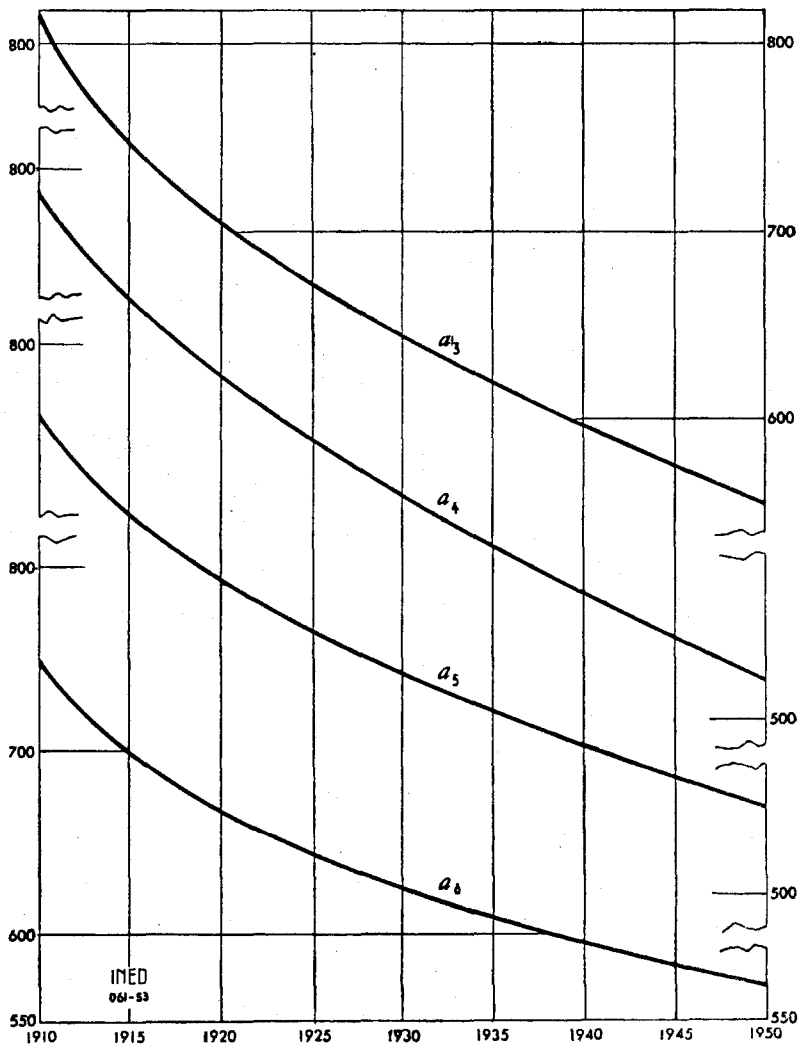
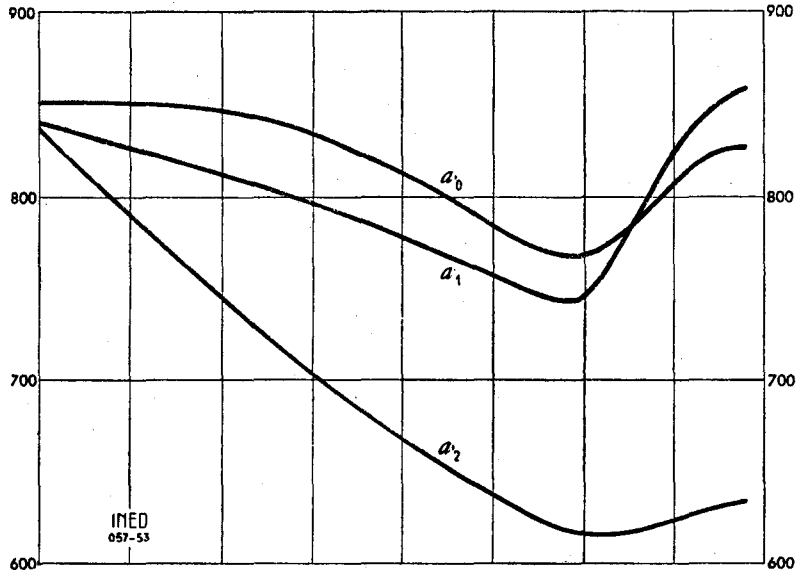
¹³ For Australia, the slight variation in probabilities of increase between 1948 and 1949 is not a decisive argument, in view of the great rise in immigration between those years. It may, however, be admitted that the full effect of that rise on probabilities of increase was not yet fully felt in 1949.

¹⁴ Actually, the 1931-1949 average must be rather low because recovery is never complete; a war increases the number of households broken up by the husband's death.

Figure 2

AUSTRALIA : TRENDS OF PERIOD PROBABILITIES OF INCREASE OF
FIGURE 1

The dates are shown on the horizontal axis ; the probabilities of
increase per 1,000 are shown on the vertical axis.



Detailed study of chronological series

This section is concerned primarily with the disturbances connected with the wars and the depression.

The decline due to the First World War is seen clearly only in a_0 and a_1 , probably owing to the fact that mobilization had less effect on fathers of two children or more. In the case of the other probabilities of increase it will be seen that there is a trough in 1916 due to the departure of troops in 1915 and 1916.

There is a marked recovery point in 1920 for a_0 and a_1 , for the same reasons as before, but it is very slight in the case of the other probabilities of increase. Except in the case of a_0 , this peak is preceded in 1919 by a trough caused by the great influenza epidemic which followed the First World War.

The more or less extensive depression of the curves which persisted almost throughout the 1930's appears to be connected with the major economic crisis. On closer inspection, however, it is seen that from a_2 onwards, the somewhat moderate fall following the First World War becomes sharper before that crisis, at a date which is somewhat difficult to set with accuracy, but which is after 1925 and before 1929. The effects of this accelerated fall are seen in the birth rate which declines more rapidly after 1927 than before. Thus, 1927 appears to be the pivot.

There is no marked change in the economic situation to which this change in trend can be attributed, yet it cannot be considered as fortuitous. 1927 is also a pivotal year for immigration, which shows a decline after having been stable from 1922 to 1927; the same is true of the marriage rate, which is steady up to 1927, but drops later.

The trend of events appears to indicate that, even before the crisis occurred, the Australian population experienced a period of uncertainty which, as a reaction, led to postponement of births.

However, childless families, or those with only one child, do not appear to have been affected by this reaction. Until 1930 there appears to be no acceleration in the decline, and it was essentially due to the crisis that the fall, which was very appreciable in the case of a_1 , occurred between 1930 and 1932. The 1932 low, which is common to all the probabilities of increase, corresponds to the most unfavourable point in the economic position of Australia, which took place slightly earlier than in other countries, probably owing to the sensitivity of the Australian economy to prices of raw materials such as wool and wheat. World prices for these commodities collapsed after the 1929 slump.

After 1932, a_0 recovers slightly in 1933 and then continues to fall, whereas all the other probabilities of increase become stabilized or show a rise.

In spite of these differences, almost all the graphs show a weakening, or a tendency to

weakness, in 1934-1935 and 1939-1940. In 1939-1940 this trend follows a slight drop in the 1939 economic indices for employment, transport, and trade.

In contrast to the First World War, the Second World War produced no very pronounced decline. At most, there is a low point for a_0 , a_1 , a_2 , and a_4 in 1942, due probably, at least in the case of the first of these probabilities of increase, to the war with Japan. It is noteworthy that from a_3 onwards, the post-1942 rise culminates before the end of the war, i.e. before the postwar recovery, which, just as after the first war and probably for the same reasons, is most perceptible in the case of a_0 and a_1 .

This wartime peak is not peculiar to Australia. It is found also in France and the United States in the case of relatively large families, the fathers of which were little affected by the war; in Switzerland it applies to all families. Moreover, changes in the birth rate during the war in Europe support the assumption that it was the same in other countries.

These wartime peaks may be ascribed to the occurrence of births delayed by the depression or the war. Stated more exactly, the recovery which must have begun in certain families at the first signs of economic recovery did not decisively outweigh postponements due to the economic or political situation until shortly before the end of the war, but it then continued beyond the wartime period.

The phenomenon of such a recovery among couples with five or six children is most remarkable. It would have been a justifiable assumption that such couples, who on the average practise birth control to a lesser extent than those with only a few children, would have been less sensitive to the economic situation and would have postponed births only to a slight extent; it would also have been logical to assume that once they were obliged by economic pressure to limit births artificially, that policy would have been adopted permanently. In that case, there would have been no recovery point for couples with many children.

The existence of such peaks therefore indicates a concordant reaction; large families and small families alike postpone and then resume procreation.

In the study of short-term variations, particular attention has been called to similar patterns observed among various categories of families in Australia, especially during the 1930's. On the whole, however, concordant reactions are less marked in that country than in some other countries, such as France, in particular.

Average number of children per marriage

In dealing with the probabilities of increase, we divided the building up of the family into stages and temporarily dispensed with the advantages of

a single index. The similarity of the variations in the probabilities of increase now prompts us to combine the latter so as to summarize in a single index the conditions of any one year.

This new summary-index must retain the advantages and, in particular, the concrete nature of those already used, with which it would, incidentally, be interesting to compare it. It also appears advisable to confine the index in the first place to an average number of children per marriage. This may be called \bar{e} and is given by the equation:

$$\bar{e} = a_0 + a_0 a_1 + a_0 a_1 a_2 + \dots + a_0 a_1 a_2 \dots a_n + \dots$$

This method of calculating \bar{e} tends to magnify fluctuations, which, as we have seen, are often concordant. For the sake of simplicity we may take, for example, the case where all the probabilities of increase fall by, say, 10 per cent. The new value, \bar{e}_1 of \bar{e} , would then be:

$$0.9a_0 + 0.81 a_0 a_1 + 0.73 a_0 a_1 a_2 + \dots,$$

or over 10 per cent below the previous value. If, for example, it is assumed that $a_0 = a_1 = 0.8$, $a_2 = 0.7$, and a_3 and the following are equal to 0.6, the value of \bar{e} is found to be 2.56 and of \bar{e}_1 , 1.95, or 24 per cent less.

Generally, the calculation of \bar{e} assumes that all probabilities of increase are known. In practice it will suffice to know the probabilities a_0 to a_6 for populations in which birth control is already widespread and a_0 to a_9 for populations in which it is still little practised.

In the former case, for example, births will be calculated up to the seventh parity inclusive and

births for the eighth and subsequent parities extrapolated. A convenient and yet adequate method is to assume that the probabilities of increase $a_7, a_8 \dots$ are equal to a_6 .

In the case of Australia, it was not enough to stop at a_6 . A simplified calculation of a_7 was made for recent periods and a_7, a_8 and a_9 for earlier periods.

The trend of probabilities of increase which have been examined indicated a recovery in a_0 and a_1 from the end of the 1930's, whereas the decline continued from a_3 onwards. It is now proposed to consider what average number of children per marriage would correspond to the values of the trend of the probabilities of increase for a number of key dates—1910, the beginning of the period under review; 1939, the year of minimum value of a_0 and a_1 ; and 1949, the last year covered by records.

The following figures are obtained:

1910	1939	1949
3.97	2.18	2.52

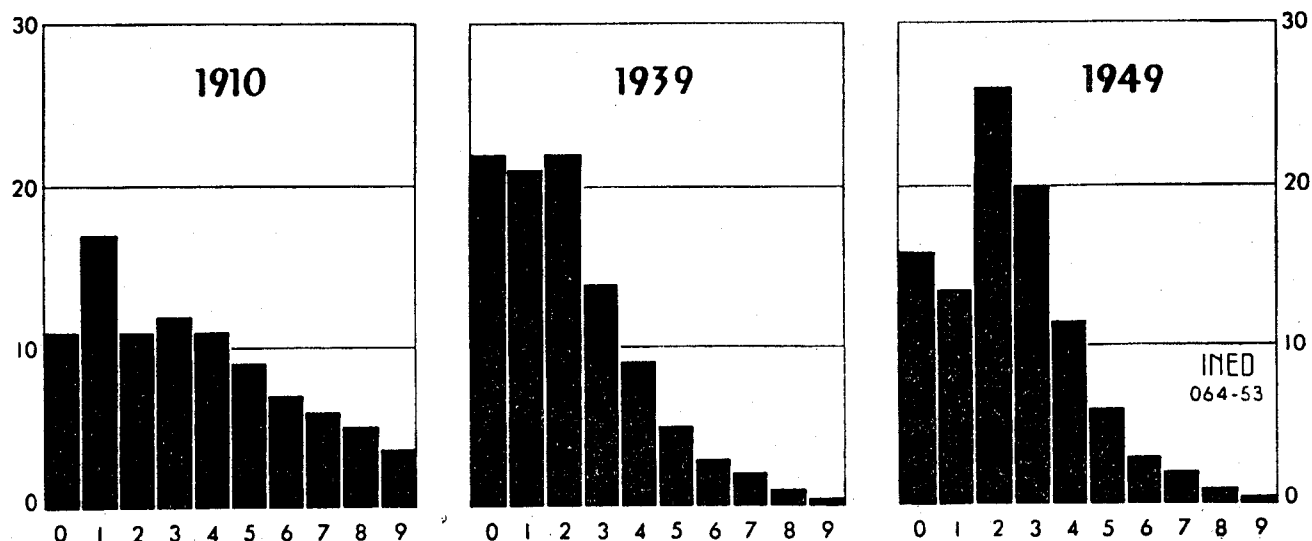
The over-all recovery appears relatively slight; in 1949, a_0 and a_1 certainly regain substantially their 1910 levels, but the other probabilities of increase, which have almost all been continually declining, are much lower.

As a further step, we may consider what distribution of families according to size would correspond to the probabilities of increase for the years 1910, 1939 and 1949. For that purpose, account must be taken of the number of children born to the parents before marriage, and subsequently

Figure 3

AUSTRALIA: DISTRIBUTION BY NUMBER OF CHILDREN BORN PER 100 COUPLES HAVING THE PROBABILITIES OF INCREASE OF 1910, 1939 AND 1949

The number of children is shown on the horizontal axis; the number of couples is shown on the vertical axis.



legitimized. These have been estimated to account for 14 per cent of illegitimate births.¹⁵

This process gives the following distribution of families according to the number of children born to the couple before or after marriage:¹⁶

	1910	1939	1949
No children	11	22	16
1 child	17	21	13.5
2 children	11	22	26
3 children	12	14	20
4 children	11	9	11.5
5 and over	38	12	13
TOTAL	100	100	100

Figure 3, which illustrates this table, shows that between 1939 and 1949, the main change was in the distribution of families with fewer than four children. Childless and one-child families decline in number, as families with two and three children increase. The number of families with four or more children varies little, whereas from 1910 to 1939 there was a marked drop in the number of families in this class.

Stated in its most elementary form, the pattern of development may be said to be as follows: an initial very strong trend brought about a change from a wide distribution of family sizes to a narrowly concentrated distribution, with a consequent gain by childless or small families. A readjustment has offset the extreme features of this movement towards very small families. This reversal of the trend did not affect the proportion of large families, but accentuated the concentration by reducing the proportion of families with no children or one child and increasing that of other small families.

Reproduction rate

A gross reproduction rate can be calculated from the average number of children per marriage. The legitimate component of this is equal to the number of daughters per marriage (female mortality must be disregarded if comparability with the standard gross reproduction rate is desired)¹⁷ multiplied by the number of marriages per woman. The illegitimate component may be regarded as equivalent to the product of the

foregoing and the ratio of illegitimate to legitimate births. The only difficulty is in the assessment of the average number of marriages per woman. It is equivalent to the product of the average number of first marriages per woman and the ratio of total marriages to the number of first marriages.

The average number of first marriages per woman which would be observed in one generation with no female mortality differs little from the proportion of ever-married women in that generation at the ages after which marriages of single women are rare, i.e. in practice from 50 years of age. This proportion is given by censuses. The ratio of total marriages to the number of first marriages may be ascertained from vital statistics.

Since the average age of mothers is about thirty years, the number of first marriages per woman has been computed as the proportion of non-celibate women over 50 years as shown by censuses in the generation of those who were 30 years old in the year under review.¹⁸ This has the effect of introducing as a main factor the marriage rate for several years preceding the year in question. For remarriages, this period has been fixed at five years, which will give an approximate value, neither too large nor too small, and the trend of that value five years prior to the period under review has been taken to represent the ratio of total marriages to the number of first marriages. To sum up, the number of marriages per woman used in calculating the reproduction rate for the year t was obtained by evaluating the product of the proportion of ever-married women over 50 years of age in the generation $(t - 30)$ and the figure for the trend of the ratio of the total number of marriages to the number of first marriages in the year $t - 5$.

This method, which is admittedly very approximate, was used to find the average number of marriages per woman, \bar{m} , in table 3. Column R_a of this table shows the gross reproduction rates obtained by combining \bar{e} and \bar{m} , while the penultimate column gives the gross reproduction rates R'_a corresponding to a number of marriages per woman which is constant and equivalent to the first value of \bar{m} , i.e. the 1910 figure of 0.907.

Figure 4 illustrates this table. It shows that, in view of the substantial fluctuations in the gross reproduction rate, the differences between R_a and R'_a due to a difference in the marriage rate are of secondary importance. Hence, R_a and R'_a will almost certainly be comparable in spite of the rough methods used to ensure comparability. It may be added that this conclusion is valid only so long as the prevailing marriage rate does not deviate too far from the trend, since R'_a is affected

¹⁵ Charles, E. "The changing structure of the family in Australia". In *Political arithmetic—a symposium of population studies* (Hogben, L., ed.) London, 1938. Chapter V, p. 220.

¹⁶ Let b be the average number of legitimate children per family, assumed to be all of parity 1. The proportion of childless families is $1 - a_0 - b$, that of families with 1 child $a_0 + b - a_0 a_1 = b + a_0(1 - a_1)$, that of families with two children $a_0 a_1 - a_0 a_1 a_2 = a_0 a_1(1 - a_2)$, and so on.

¹⁷ Let \bar{x} be the average age of women at the time of marriage or of mothers at the birth of their n th child, and i the average interval between marriage and the birth of the first child (about two years), or between the n th and $n + 1$ birth (about three years). The effect of female mortality may be eliminated by dividing a_n by the survival probability of the woman from age \bar{x} to age $\bar{x} + i$.

¹⁸ Owing to the obvious drop in the proportion of single women in the younger generations, the proportion of ever-married women over 50 years old has been assumed to be 0.90 for women born after 1910.

TABLE 3. AUSTRALIA: GROSS REPRODUCTION RATES

Year	Reproduction rate				100 R _a Total	100 R' _a	100 R _o
	100 \bar{e}	1,000 \bar{m}	Legitimate	Illegitimate			
1910	409	907	181	8	189	189	167
1911	419	909	186	9	195	194	170
1912	517	910	230	9	239	238	179
1913	470	912	209	8	217	216	176
1914	424	913	189	8	197	196	174
1915	346	914	154	8	162	161	166
1916	314	916	140	7	147	146	159
1917	320	918	143	7	150	149	155
1918	309	920	139	7	146	144	149
1919	291	921	131	7	138	136	142
1920	390	922	175	7	182	180	155
1921	337	923	152	7	159	156	151
1922	336	926	152	7	159	156	151
1923	314	929	142	7	149	146	147
1924	306	932	139	6	145	141	146
1925	305	936	139	6	145	141	144
1926	287	940	132	6	138	133	138
1927	281	943	129	6	135	130	136
1928	278	945	128	6	134	129	134
1929	253	945	117	6	123	118	128
1930	260	945	120	5	125	120	125
1931	227	944	105	5	110	105	114
1932	206	943	95	5	100	96	106
1933	218	943	100	5	105	101	105
1934	209	942	96	5	101	97	103
1935	212	942	97	5	102	98	103
1936	230	943	106	5	111	107	106
1937	232	944	107	4	111	107	108
1938	223	945	103	4	107	103	107
1939	221	946	102	4	106	102	108
1940	217	947	100	4	104	100	110
1941	224	948	103	4	107	103	115
1942	211	950	97	4	101	97	116
1943	242	953	112	5	117	112	126
1944	252	956	118	5	123	117	129
1945	278	960	130	6	136	129	134
1946	337	965	158	7	165	156	146
1947	313	970	148	6	154	144	149
1948	262	976	125	5	130	121	145
1949	255	982	122	5	127	118	146

\bar{e} : average number of children per marriage with no female mortality.

\bar{m} : average number of marriages per woman.

by sudden fluctuations in the marriage rate, whereas R_a as calculated here is not.

It would be interesting to compare the general movement of R_o and R_a , particularly in a period such as 1910-1930, when the trend of probabilities of increase is declining. In theory, R_a should fall more rapidly than R_o and remain below it unless there is a prior rise in the fertility rate.

Unfortunately, this period was affected by the war, and moreover, the initial values for the probabilities of increase other than a_o are somewhat doubtful, in view of the assumptions which must be made in calculating them and owing also to the effects of immigration.

The present study is therefore confined to a comparison of short-term fluctuations. The magnifying effect of the calculation of \bar{e} is clearly apparent, and is particularly perceptible in 1912-1914. Following large-scale immigration, the pro-

babilities of increase are all artificially inflated in this period. This concordance produces the very marked peak of R_a .

A similarly magnified fluctuation is found wherever fluctuations in the probabilities of increase are concordant in effect, as, for example, in 1916, 1919, 1920, 1932, 1936, 1937 and 1946.

The disturbing effect of the First World War, which is little felt in the case of R_o , is more perceptible in R_a , but the difference soon disappears, and from 1923 to 1930 there is little difference between R_a and R_o .

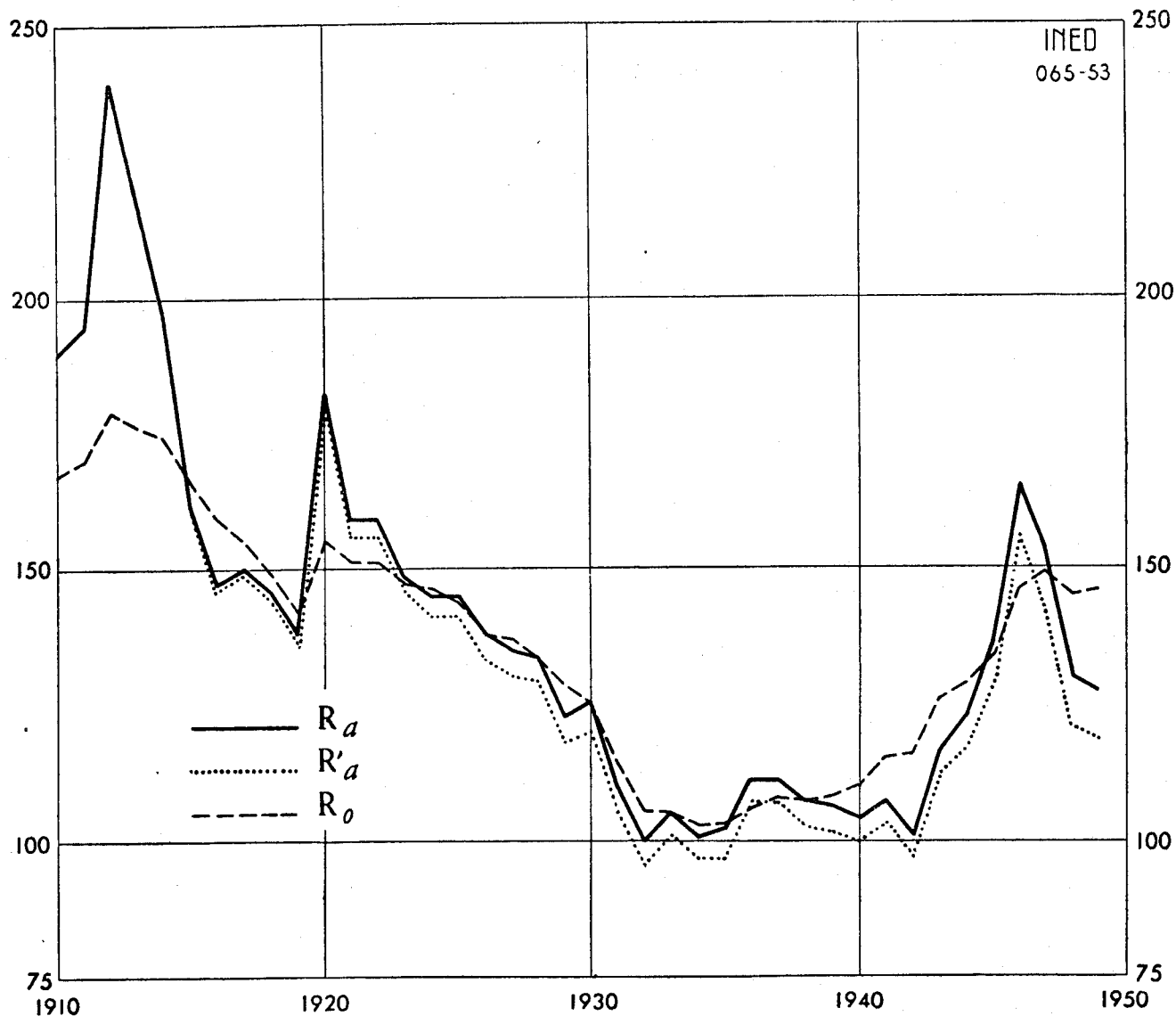
After 1930, on the other hand, R_a and R_o act rather differently. First of all, R_a reflects to a much greater extent the economic situation; the 1932 trough is more marked and the intermediate maximum of 1936-1937, connected with the economic recovery, is very clear, whereas it is practically imperceptible in the case of R_o .

Figure 4

CRUDE REPRODUCTION RATES

R_0 : crude classic rate, R_a and R'_a : crude rates calculated from the probabilities of increase.

The dates are shown on the horizontal axis; the crude reproduction rates in per cent are shown on the vertical axis.



After 1938, the discrepancy between R_a and R_0 becomes greater. R_0 rises, owing to the rapid increase in the marriage rate at the beginning of the war. R_a , on the other hand, continues to decline and shows a clearly marked low point in 1942. Only later does it rise rapidly to overtake R_0 and reach its peak in 1946. Its fall is as rapid as its previous rise, and in 1949, R_a is very much below R_0 . The difference is so marked that, even if the number of marriages per woman were greater, it would still persist.

In this respect, the position is very different from that prevailing after the First World War. The disturbance occasioned by that war was slight and did not supervene on an economic crisis. It is thus not surprising that the predictable diffe-

rence between R_0 and R_a , clearly apparent in 1948 and 1949, is entirely absent after the 1920 peak.

As already stated, this difference results from the fact that, after a major upheaval, fertility rates are abnormally high for women in the generations affected by the war. The normal reproduction rates are temporarily inflated by an abnormal pattern carried over from the recent past. In certain cases, in the United States for example, the disturbance is such that the sum of the fertility rates by age relative to first births alone exceeds unity; yet this sum is intended to represent the probability that a woman will become a mother, in the absence of female mortality.

The reproduction rates calculated on the basis of the probabilities of increase is not affected by

the consequences of the war for so long a period. By 1949, the effect of the war on R_a may be regarded as negligible.

Consequently, the use of R_a appears to be preferable to that of R_0 . Demographers have always tried to eliminate the parasitic effect of structures inherited from the past. These structures change automatically, so that any indices which are not independent of them represent a situation

which is essentially temporary and which cannot conceivably be maintained. Hence, R_0 must fall if none of the conditions which prevailed in 1949 change. The 1949 value for R_a , 1.27, therefore reflects more accurately than the figure 1.46 for R_0 the effect of factors other than population structure. For this value of 1.27 the corresponding standard net reproduction rate is 1.16, as against 1.33.

Differential fertility in Ceylon

By Earl HUYCK

This article presents evidence of existing urban-rural fertility differentials in Ceylon, but also stresses the probable relation to variations in cultural, religious, and ethnic composition of the population. Mr. Huyck read a paper on this subject at the 1952 annual meeting of the Population Association of America and currently is completing a doctoral dissertation on the broader subject of Population growth in Ceylon for American University, Washington, D.C.,

While the Western urbanized family considers it economic to limit its members by preventing conceptions, the Asian peasant family tends to continue to reproduce at high levels of fertility in the belief that numerous children will ensure daily sustenance and old age security. Owing to the increased use and efficacy of Western methods in the control of morbidity and mortality, however, Asians are likely to live longer and their children less likely to die in infancy in the future. Herein lies the crux of the demographic, economic and social problem in Asia: rapid population increase caused by widening differentials in vital rates threaten to negate contemplated economic development. The existence of fertility differentials, which may portend the widespread usage of contraception and the establishment of a small family pattern, has been demonstrated in Japan,¹ India,² and Malaya.³

Writing in the October 1949 issue of *Population Index*, Irene Taeuber presented a preliminary analysis of Ceylon as a "demographic laboratory"

¹ Irene Taeuber has written numerous articles on fertility differentials with particular reference to Japan. These appear in the *American Sociological Review*, the *Journal of Economic History*, and in *Pacific Affairs*, as well as in the following specific sources. Taeuber and Beal, Edwin G. "The demographic heritage of the Japanese Empire." *Annals of the American Academy of Political and Social Science*, Vol. 237, January 1945, pp. 64-71. Taeuber and Beal. "Guide to the official demographic statistics of Japan, Part 1, Japan Proper 1868-1945". *Population Index Supplement*, Vol. 12, No. 4, October 1946, pp. 31-32 (this section lists sources concerned with fertility); Taeuber and Notestein, Frank W. "The changing fertility of the Japanese". *Population Studies*, Vol. 1, No. 1, June 1947, pp. 2-28; Taeuber, "The reproductive mores of the Asian peasant". In *Studies in population* (Mair, G. F. ed.), Princeton, 1949, pp. 95-102.

² Davis, Kingsley. *The population of India and Pakistan*. Princeton, 1951. See especially Part III pertaining to "Human fertility".

³ Smith, T. E. *Population growth in Malaya: an analysis of recent trends*. London, 1952. Smith discusses fertility differentials both in terms of urban-rural categories and ethnic groups (Chinese, Malaysians and Indians.)

in which she noted the apparent absence of any great differences in the fertility of various categories of the population.⁴ Others, notably H. Cullumbine, have also sought to analyse the problem of the island's rapid population growth, but without attempting a detailed consideration of fertility differentials.⁵

The primary purpose of this paper is to analyse the differences between the fertility rates in urban and rural areas of Ceylon.

BACKGROUND FACTORS AFFECTING FERTILITY

According to the census of March 1953, Ceylon had a population of 8.1 million people in an area of 25,330 square miles. With one-half of its male labour force engaged in agriculture, one-fifth in trade and transportation combined, and only one-tenth in industry,⁶ the country must still be considered as under-developed. The per capita national income of \$120 in 1951, a year of peak economic activity, none the less ranks Ceylon second only to Malaya in South and South East Asia. Ceylon is dependent upon other countries for the importation of foodstuffs and even more dependent upon the export of her primary agricultural commodities. In fact, opportunities for gainful employment outside of agriculture are related primarily to the processing, trade, and transport of export crops. Modern industry of the type familiar to the West is virtually unknown. Improvement in educational facilities, however, is reflected in the decrease of illiteracy since the

⁴ Taeuber, Irene B. "Ceylon as a demographic laboratory: preface to analysis". *Population Index*, Vol. 15, No. 4, October 1949, pp. 293-304.

⁵ Cullumbine, H. "An analysis of the vital statistics of Ceylon". In *The Ceylon Journal of Medical Science*, Section D., Vol. III, parts 3 and 4, December 1950; Sarkar, N. K. "A note on abridged life tables for Ceylon, 1900-1947". *Population Studies*, Vol. 4, No. 4, March 1951, pp. 439-443.

⁶ Ceylon, Department of Census and Statistics. *Census of Ceylon 1946: statistical digest*. Vol. 1, Part 2, Colombo, 1951, table 48.

1921 Census—from 44 to 30 per cent for males, and 79 to 56 per cent for females above the age of 5 years.

Ceylon is located just off the southeastern tip of the Indian sub-continent, whence came the Sinhalese centuries ago to establish an elaborate system of irrigation-based agriculture on the northern plains. Subsequent internecine warfare and Tamil incursions from India's Coromandel coast both pushed the Sinhalese southward and westward and reduced, through deterioration and destruction, the "Great Tanks" or reservoirs to malaria-infested pools. However, the Buddhist Sinhalese remain the predominant ethnic group in Ceylon today, constituting nearly 70 per cent of the total population.

In addition to Buddhism and Hinduism there exist in Ceylon two other religions representative of the great value systems of the world: Islam and Christianity. The Moors and Malays are Muslims. The Christians—84 per cent of whom are Roman Catholics—include the Europeans, Burghers, and a number of Ceylon Tamils, and are predominantly urban. So too are the Indian Moors who perform interstitial trading functions, but in Eastern and North-Central provinces the Ceylon Moors form an important element of the rural populations.

The English, who came into possession of the whole island of Ceylon as the result of the Napoleonic War, were successful in developing the system of estate agriculture for the production of coffee and later of tea, rubber, and coconuts. To man these estates they imported Tamil labourers from India rather than rely upon the Sinhalese as a labour force. These Tamils, with their families and descendants in 1946 numbered approximately 700,000, only half of whom were born abroad. Now both the Ceylonese and Indian Governments restrict this migration with the result that those already in the island tend to remain. This restriction of Tamil immigration emphasizes the diminishing importance of immigration as compared with natural growth. In the decade 1891-1901 the natural increase was only two-thirds the migration balance of 333,000, whereas in the single year of 1953 the excess of births over deaths added 232,000 persons to the population as compared with a net loss of some 13,000 through the outbound movement of passengers.

During the period of British colonial administration lasting until Ceylon achieved the status of an independent Dominion in February 1948, health and sanitation facilities improved immeasurably, but efficient island-wide methods of controlling malarial epidemics, which had occurred at roughly five-year intervals, awaited the availability of DDT at the end of the Second World War. Primarily through its use, the death rate dropped nearly a third in one year's time—from 20.3 in 1946 to 14.3 in 1947; it levelled off at 12-13 from 1949 to 1952, but dropped to 10.9 in 1953. With the crude birth rate remaining fairly stable at

about 40, the natural increase catapulted from 18 to 28 per 1,000. Projecting the population at the latter rate to 1960, Ceylon will then have 9.8 million persons to feed—3.2 million more than at the Census of 1946. A second index of fertility, the gross reproduction rate, is computed to be about 2.6 for 1949 and the net reproduction rate, 2.0. This means a doubling of the population within a generation.

From 1946 through 1953 both the crude death rate and the infant mortality rate were cut in half, but maternal mortality fell even more spectacularly from 15.5 to 4.9 deaths per thousand live births. The secular trend of the sensitive infant mortality rate has been downward, but the course has been interrupted by malarial epidemics, which have shot the rate to over 200 on several occasions since 1900 and as high as 263 in 1935.

The dramatic effect that lowered mortality has had on lengthening the expectation of life at birth is shown by recently published official life tables.⁷ Life expectancy for males rose from 43.9 years in 1946 to 57.6 years in 1952—or more than in the previous 25 years. In 1920-1922 it was only 32.7 years. Contrary to western experience, life expectancy for females has consistently lagged two years behind that for males. However, similar increases are indicated for females. At present Ceylonese expectations of life are closer to those for the "more developed" than for the "less developed" regions of the world.

GENERAL FERTILITY RATIOS

The dynamic aspect of general fertility ratios as depicted in table 1 suggests, in the words of the *General Report* of the Census of 1946, "a

TABLE 1. GENERAL FERTILITY RATIOS, AND CRUDE BIRTH RATES FOR CEYLON: 1881-1946

Year	Children 0-4 years per 1,000 women 15-44 years		Birth rate ^b
	Reported	Adjusted for age tabulation change ^a	
1881	858	733	26.7
1891	834	717	39.9
1901	816	702	38.4
1911	686	686	36.7
1921	647	647	38.9
1946	594	594	38.2

^a The age group "0-4" shown in the censuses from 1881 to 1901 actually includes age 5. And adjustment to exclude age 5 has been made on the basis of official 1920-1922 and 1945-1947 life tables. For additional age adjustments, see the author's forthcoming dissertation, *Population growth in Ceylon*.

^b The birth rates are three-year averages centred on the census year.

Source: Reported fertility ratios are from: Ceylon, Department of Census and Statistics. *Census of Ceylon 1946: general report*. Vol. I, Part 1. Colombo, 1950, p. 204. Birth rates are from Ceylon, Department of Census and Statistics. *Statistical abstract of Ceylon 1950*. Colombo, 1951, p. 49.

⁷ Ceylon, Department of Census and Statistics. *Life, births and deaths in Ceylon 1920-1952*. Colombo, 1954, p. 38.

continuous decline in fertility within the period of 65 years from 1881 to 1946. *The decline was rapid in the first decade of this century* [italics mine] and has been steadily maintained since".⁸

A very different impression is obtained, however, when these ratios are placed alongside the birth rates for the same period. Indeed, the latter index implies sharply increasing fertility in the 1880's with subsequent stability rather than rapid decline. Actually, the early "increase" simply reflects improvement in registration, which was made compulsory in 1895 and soon appeared to be relatively complete.⁹

As to the practice of contraception, the Registrar of Vital Statistics commented in his 1939 Report¹⁰ that "in the absence of any evidence of an appreciable use of contraceptive methods, it is perhaps safe to assume that the vast majority of the population are ignorant of such methods. With the reading public and, in particular, the town dwellers, the case may be somewhat different, . . . but it is unsafe to be dogmatic where

data are wanting". Concerning folk practice, Robert Knox as early as the seventeenth century observed that among the Sinhalese: "for the matter of being with child, which many of them do not desire, they very exquisitely can prevent the same".¹¹ He did not discuss the methods used, however.

According to Bryce Ryan, who recently surveyed a Sinhalese peasant village located in the "Low Country" six miles from a market town, "abortion is well known but violently discredited. It is undoubtedly attempted, however, in instances of unmarried pregnancies. . . . *Coitus interruptus* is probably uncommon among married couples" particularly in view of the attitude of the husband: "'Why should I do that when I am legally married and entitled to have children?'" The "safe period" method is widely known, is not morally censored and is considered to be consistent with the Buddhist Way. "Probably some couples with a number of children practice it more or less."¹²

URBAN-RURAL FERTILITY DIFFERENTIALS

As indicated in table 2, the population of all Ceylon at the time of the 1946 Census was only 15 per cent urban; in 45 years the proportion urban increased only 3 per cent. As administratively defined, the term included the municipalities of Colombo (362,000) Galle and Kandy (about

¹¹ Ceylon, Department of Census and Statistics. *Census of Ceylon 1946: general report, op. cit.*, p. 69.

¹² The "Low Country" extends roughly from Puttalam in North-Western province southeastward to include Western province and Southern province as far as Hambantota. See Ryan, Bryce. "Institutional factors in Sinhalese fertility". *The Milbank Memorial Fund Quarterly*, Vol. XXX, No. 4, October 1952, pp. 360-381.

⁸ Ceylon, Department of Census and Statistics. *Census of Ceylon, 1946: general report, op. cit.*, p. 204.

⁹ However, a sample check conducted after the 1953 census enumeration and published in that year indicated that for all Ceylon births and deaths were each under-reported by about 12 per cent. This would raise the probable island birth rate for 1953 from 39.4 to 44.7. Since birth registration was more complete in urban areas (91 per cent) than in rural areas (87 per cent), the "true" birth rate would correspondingly be lower in the city, given the same registered rate for both areas. See Ceylon, Department of Census and Statistics. *Post enumeration survey 1953: Monograph No. 1*. Colombo, 1953.

¹⁰ Ceylon, Registrar-General. *Report on vital statistics for the year 1939*. Part I—Civil (Q), Colombo, p. 13; *Reports . . . covering the years 1941 through 1953* were used for other aspects of this paper.

TABLE 2. URBANIZATION, MARITAL STATUS AND LITERACY CHARACTERISTICS OF THE POPULATION BY PROVINCES, FOR CEYLON: 1946 *

Province	Population (in thousands)	Per cent urban ^b	Per cent of women 15-44 years of age ever married ^c		Per cent illiteracy in the female popula- tion 5 years of age and over ^d	
			Urban	Rural	Urban	Rural
CEYLON	6,657	15	67	74	37	59
Western	1,877	34	66	65	36	40
Central	1,135	9	65	80	43	74
Southern	961	11	57	65	38	59
Northern	480	13	76	79	23	42
Eastern	279	16	81	88	39	79
North-Western	668	5	75	78	45	55
North-Central	140	9	82	89	44	76
Uva	372	4	65	83	51	84
Sabaragamuwa	745	3	60	77	38	68

* Statistics in this and succeeding tables may not add to totals owing to rounding.

^b Urban areas administratively defined. In the 45-year intercensal period from 1901 to 1946 the proportion urban of Western province increased from one-tenth to one-third. Eastern (Trincomalee naval base) and North central provinces increased only 4 per cent in urbanization, and all other provinces increased negligibly.

^c Computed from age and marital status composition compiled from statistics by revenue districts, municipalities and urban council areas. In the municipalities the per cent ever married in the reproductive age group 15-44 were: Colombo (69), Kandy (61) and Galle (60). Of the two urban areas in Eastern province, Trincomalee had virtually as high a percentage of females of reproductive age ever married (87) as did the rural sector, but in Batticaloa only 73 per cent had ever been married. The last city of note, Jaffna, is the only urban area in Northern province.

^d Computed from the number of female illiterates for the same areas as in (c).

Sources: Ceylon, Department of Census and Statistics. *Census of Ceylon 1946: general report, op. cit.*, pp. 72, 74; Vol. III. Colombo, 1952, tables 5-7; *statistical digest*, tables 30 and 30a.

50,000 each), and 40 urban and local council areas. The only other cities of over 25,000 inhabitants, with the exceptions of Jaffna (63,000) and Trincomalee (33,000) were satellites of Colombo, Ceylon's capital, the only large commercial seaport and only city that can be considered a modern metropolis. Most urban areas appear to include rural territory.

Irene Taeuber's preliminary analysis of fertility found that "urban-rural differentials exist, but they appear minimal".¹³ The results of the present study, epitomized in tables 3 and 5, go a step further in indicating that such urban-rural differentials may be partly explained in terms of related demographic phenomena: the per cent ever married of women of reproductive age (as shown in table 2), age at marriage (table 4), and the racial-religious composition of the population (tables 6 and 7).

For the present analysis, the rural areas were determined by subtracting from the total populations for each province those areas defined as urban in the Census of 1946. Finding that earlier censuses had tended to include parties to unregistered marriages as "unmarried",¹⁴ officials of the 1946 Census attempted to include all socially approved unions regardless of whether these were registered under the General, Kandyan, or Muslim Ordinances, or were sanctioned merely by customary or religious rituals. The Indian Tamils on the estates and the Ceylon Moors traditionally have observed the latter types of unofficial ceremonies. For the island as a whole illegitimacy is a negligible factor.

Crude birth rates, general and marital fertility rates for the urban and rural areas are shown in the text table below for all Ceylon. They indicate a rural excess in fertility for all three indices, but particularly with respect to the crude birth rate. The statistics for Western province, which contains five-eighths of the total urban population, parallel closely the differentials shown in the general crude birth rate (29.3-38.2), less closely that in relation to the general fertility rate (141-167) for urban and rural areas respectively, still less for marital fertility (231-274).¹⁵

CRUDE BIRTH RATES, GENERAL AND MARITAL FERTILITY RATES FOR URBAN AND RURAL AREAS IN CEYLON: 1946

	Crude birth rate	Births per 1,000 women 15-44 years of age	Births per 1,000 married women 15-44 years of age
Urban	31.2	149	243
Rural	39.7	181	263
Rural excess ..	8.5	31	20
Rural excess (Per cent)	27	21	8

¹³ Taeuber. "Ceylon as a demographic laboratory", *op. cit.*

¹⁴ Ceylon, *Department of Census and Statistics. Census of Ceylon 1946: general report, op. cit.*, p. 192.

¹⁵ Although births for urban areas were compiled for residents only according to table XII of the Registrar-General's *Report of vital statistics for the year (1945-1947)*, there is evidence that births were not always allocated

When these three rates are adjusted for age, the same general urban-rural pattern exists for Ceylon as a whole with the respective "rural excesses" expressed as percentages being 22, 21 and 7. In the case of the adjusted rates, urban areas in Western province play an even more significant role in establishing lower urban marital fertility rates (234-286).

When 1946 Census data are used, on the other hand, a clear pattern of urban-rural fertility differentials becomes evident for all provinces, as shown in table 3. These are based on the number of children ever born per woman and per ever-married woman for the youngest cohort of women with completed fertility (age 45-49 years). This ratio reflects fertility over an extended span of years centring on the early 1930's. It is a useful index, since the apparent stability of the birth rate indicates that there has been no major change in fertility. Although the element of forgetfulness, particularly of children who died in infancy, is likely to lower the apparent total fertility, there is no reason to believe that it would depress urban more than rural fertility. The per cent of women ever married in the age group 45-49 years was high throughout Ceylon, but higher in the rural (97 per cent) than in the urban areas (93 per cent). In Northern, Eastern, and North-Western provinces, however, urban percentages were as high as those for rural areas.

In terms of children ever born per woman 45-49 years of age and per ever-married woman in the same age group, more than one additional child was born in rural than in urban areas. Only urban areas in Southern and Uva provinces had somewhat higher numbers of children than the lowest rural area (Northern province). Southern province generally had the highest fertility in both urban and rural areas, while North-Central had the lowest fertility in the urban sector and Northern province, in the rural sector.

Within the urban sector fertility was generally lower in the largest urban areas. This was true for Colombo and Galle municipalities and for Trincomalee, but not for Kandy.

The text table below shows the number of children ever born per ever-married woman for the 45-49 and older age groups in the urban and rural areas of Ceylon as a whole.

NUMBER OF CHILDREN EVER BORN PER EVER-MARRIED WOMAN FOR CEYLON: 1946

	Age of women in years				
	45-49	50-54	55-59	60-64	65 and over
Urban	3.79	3.70	3.80	3.72	3.77
Rural	4.98	4.97	5.09	4.98	4.90

properly to the place of residence and, primarily for this reason, urban-rural rates and differentials are not shown for each province. It is anticipated that better trained personnel using improved techniques of registration and machine tabulating equipment will substantially improve the situation in the near future.

TABLE 3. URBAN-RURAL FERTILITY DIFFERENTIALS FOR FIRST COHORT OF WOMEN WITH COMPLETED FERTILITY (AGED 45-49 YEARS) BY AREAS FOR CEYLON: 1946

Provinces and selected urban areas	Number of children ever born					
	Per woman 45-49 years		Per ever-married woman 45-49 years		Per cent of women 45-49 years of age ever married	
	Urban	Rural	Urban	Rural	Urban	Rural
CEYLON	3.54	4.86	3.79	4.98	93	97
Western	3.40	4.53	3.68	4.75	92	95
Colombo municipality	3.26	...	3.52	...	92	...
Other	3.56	...	3.84	...	92	...
Central	4.05	4.87	4.31	4.94	94	98
Kandy municipality	4.21	...	4.49	...	93	...
Other	3.87	...	4.11	...	94	...
Southern	4.20	5.38	4.50	5.56	93	96
Galle municipality	3.86	...	4.14	...	93	...
Other	4.48	...	4.82	...	93	...
Northern	3.08	4.04	3.13	4.10	98	98
Eastern	3.26	4.58	3.35	4.61	97	98
Trincomalee	2.80	...	2.84	...	99	...
Batticaloa	3.76	...	3.94	...	95	...
North-Western	3.69	4.86	3.83	4.94	96	98
North-Central	2.75	4.97	2.95	5.01	93	99
Uva	4.08	4.61	4.29	4.65	95	99
Sabaragamuwa	3.82	5.69	4.22	5.77	90	98

Source: Ceylon, Department of Census and Statistics. *Census of Ceylon 1946*. Vol. III. *op. cit.*, tables 5, 6, and 7.

These statistics indicate that sizeable urban-rural fertility differences have existed since at least the beginning of the twentieth century. However, the apparent long-term stability of these ratios does not necessarily mean that there has been no decrease in fertility for both sectors of the community through time, since in the earlier years one child out of five died in infancy and it is believed that mothers tend to forget deceased children.

Part of the urban-rural differential in fertility may be attributable to a later age at marriage in urban areas. Certainly in Japan, this factor, combined with increased urbanization, played an important role in the reduction of fertility.

In Ceylon the mean age at first marriage for women, estimated on the basis of the age and marital status distribution in the 1946 Census (table 4)¹⁶ tends to be higher in the city (21.8 years) than in the country (20.6). Even the latter age at marriage is not particularly low, however. If the same method of determining the mean age at first marriage is applied to females in the United States, the result shows that American women tend to marry even younger (19.7 years) than their Ceylonese sisters in either town or country.¹⁷

¹⁶ This, in general, is the method developed by R. Bachi and K. R. Gabriel for determining the mean age at marriage from quinquennial age distributions. See Gabriel. "The fertility of the Jews in Palestine: a review of research". *Population Studies*, Vol. VI, No. 3. March 1953, pp. 273-306.

¹⁷ U.S. Bureau of the Census. "Marital status and household characteristic: April 1951". *Current population reports: population characteristics*, Series P-20, No. 38, 29 April 1952, p. 10.

TABLE 4. ESTIMATED MEAN AGE OF WOMEN AT MARRIAGE, URBAN AND RURAL AREAS BY PROVINCE FOR CEYLON: 1946

Province	Mean age at marriage (in years) *	
	Urban	Rural
CEYLON	21.8	20.6
Western	22.0	22.9
Central	21.6	19.3
Southern	23.9	22.7
Northern	20.0	19.6
Eastern	18.9	17.2
North-Western	19.8	19.7
North-Central	17.8	17.2
Uva	21.4	18.5
Sabaragamuwa	22.3	20.0

* Computed from the age distribution for persons ever married in the urban and rural sectors of each province.

Source: Based on data from the 1946 Census of population.

This delay in marriage in the city could mean a decrease of 6 per cent in the effective period of fertility and thereby in the number of children. The marriage age was highest in the more highly urbanized western littoral than elsewhere. Village opinion believes 21 or 22 years to be the ideal age for a bride, according to Ryan, who feels that this relatively high figure revealed in his survey may be influenced by difficulties encountered in raising a dowry for the daughters or sisters of the family.¹⁸ A similar geographic pattern of later urban marriage is also suggested by the statistics of current marriages, under the General Marriage Ordinance. There is no evidence

¹⁸ Ryan, *op. cit.* pp. 365-366.

that this pattern would be seriously disturbed by the inclusion of Kandyan and Muslim marriages.

Illiteracy, which is lower in urban areas (table 2), correlates moderately with the number of children ever born. This is in line with findings elsewhere, notably in agricultural Bulgaria, where literacy appears to have been associated with the spread of family limitation.

It might be assumed that religion would have an important bearing upon differential fertility. Unfortunately, detailed sex and age categories are cross-tabulated with neither religion nor race within the urban and rural components to permit an analysis of the contributions ethnic groups make to the urban-rural differentials. For the country as a whole, however, fertility differentials by "race" are shown in table 5 in terms of child-woman ratios. The predominant Low Country Sinhalese, who inhabit primarily the western littoral, have a ratio of 554 children under 5 years of age per 1,000 women in the reproductive age group. This is roughly 7 per cent lower than the fertility ratio for all races—594.

TABLE 5. FERTILITY BY "RACE", FOR CEYLON: 1946

"Race"	Female population 15-44 years (in thousands)	Children 0-4 years per 1,000 women 16-44 years	Index
All "races"	1,451	594	100
Low Country Sinhalese	651	554	93
Kandyan Sinhalese	363	671	113
Ceylon Tamils	165	510	86
Indian Tamils	168	647	109
Ceylon Moors	81	623	105
Indian Moors	2	760	128
Burghers and Eurasians including Euro-Ceylonese	10	468	79
Malays	5	649	109
Veddahs	1	548	92
Europeans	1	266	45
Others	3	954	161

Source: Ceylon, Department of Census and Statistics. *Census of Ceylon 1946*. Vol. II. Colombo, 1952, p. 146 ff.

The lowest ratio is shown among the small European population, but too much confidence should not be placed in the widely varying fertility ratios for the Indian Moors and the remaining ethnic groups (Burghers and Eurasians, Malays, Veddahs, and others), since the number of females of reproductive age for none of these groups is over 10,000. The very high ratio for "others" is probably a statistical artefact resulting from the allocation of children to the racial group of the father. The low ratio for the Veddahs suggests an under-enumeration of children or very high mortality among this aboriginal group.

The urban-rural differentials appear to account in part for the statistically significant differences between the fertility ratios of the two major "racial" groups, the Low Country and the Kandyan Sinhalese, inasmuch as the former were far more urban than the latter (table 6). Similarly the Ceylon Tamils are more urban than the Indian Tamils and have lower child-woman ratios. Varying degrees of urbanization between these ethnic groups doubtless account for some of the observed differences.

As pointed out previously, the Sinhalese in general are Buddhists; the Tamils, Hindus; the Moors and Malays, Muslims. Christians, who might be expected to be influenced more than other groups by Westernization, are more numerous in the cities than in the countryside. They constitute at least one-fourth of the urban population in Western, Northern, Eastern and North-Western provinces, where urban fertility tends to be lower than in the other provinces. Muslims form important segments of rural areas in Eastern and Northern provinces, but the rural fertility of these provinces is not excessively high. Table 7 shows the per cent distribution of the urban and rural populations of each province by religion.

In summary, the evidence based on the analysis of the 1946 Census suggests that: (1) Ceylonese fertility is high but not excessively

TABLE 6. PER CENT DISTRIBUTION OF THE URBAN AND RURAL POPULATIONS OF THE PROVINCES OF CEYLON BY "RACE": 1946

Province	Low Country Sinhalese		Kandyan Sinhalese		Ceylon Tamils		Indian Tamils		Ceylon and Indian Moors		Others*	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
CEYLON	52	42	6	29	14	11	7	13	13	5	8	1
Western	60	91	2	1	7	1	8	3	12	2	10	1
Central	31	7	25	47	10	3	10	37	17	5	6	1
Southern	80	96	1	— ^b	1	1	1	2	14	1	2	— ^b
Northern	2	1	1	1	84	93	3	2	8	3	1	— ^b
Eastern	18	2	5	5	54	46	7	1	9	45	8	1
North-Western	45	31	13	59	8	3	4	2	24	5	5	— ^b
North-Central	40	10	22	71	21	5	6	2	8	11	4	— ^b
Uva	24	7	39	50	10	4	9	5	12	3	6	1
Sabaragamuwa	36	12	43	67	5	1	5	17	8	3	3	1

* Includes 113,000 (1.7 per cent of total population) Burghers, Eurasians, Malays, Veddahs, Europeans, and miscellaneous.

^b Less than one per cent.

Source: Ceylon, Department of Census and Statistics. *Census of Ceylon 1946: statistical digest, op. cit.*, tables 26 and 26a. The percentage computations were made from the numerical distributions of the population classified by "race" for revenue districts, municipal and urban council areas.

TABLE 7. PER CENT DISTRIBUTION OF THE URBAN AND RURAL POPULATIONS OF THE PROVINCES OF CEYLON BY MAJOR RELIGIONS : 1946

Province	Buddhists		Hindus		Muslims		Christians	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
CEYLON	48	68	16	21	15	5	21	7
Western	48	82	12	3	15	2	25	13
Central	53	54	15	37	19	5	13	4
Southern	79	96	2	2	16	1	4	1
Northern	3	2	61	83	8	3	28	12
Eastern	20	7	45	45	10	45	25	4
North-Western	35	77	8	3	27	5	30	15
North-Central	60	82	22	6	10	11	8	1
Uva	59	57	16	37	14	3	10	3
Sabaragamuwa	71	79	8	16	9	3	13	2

Source: Ceylon, Department of Census and Statistics. *Census of Ceylon 1946: statistical digest, op. cit.*, tables 37 and 37a. Calculations for religion were undertaken in the same manner as those for "race" (table 6).

so, and (2) a significant urban-rural fertility differential exists in each province and, for the island as a whole, amounts to more than one child ever born per woman or ever-married woman. Age at marriage, literacy, racial and religious composition have been shown to be contributing or associated factors. The degree to which each of these factors and additional elements, including caste and economic structure, plays a role, however, is masked by a plethora of complex relationships not adequately explained in the available statistics.¹⁹

On 20 March 1953, Ceylon took its second postwar census. Although detailed data for the analysis of fertility differentials will not become available for some time to come, certain relevant information has been released already. The increase in total population from 6,657,000 to 8,099,000 in the seven-year inter-censal period since 1946 amounts to 21.61 per cent, or an average annual increase of 2.8 per cent, as compared with 1.5 per cent for the previous inter-censal period from 1931 to 1946. The increase of 1,441,000 persons between 1946 and 1953 is supported by statistics on births, deaths and migration for the corresponding period.²⁰

Regarding fertility, the 1953 Census schedule included questions as to date of marriage age of mother at birth of first child, number of children born (alive or dead) and number still living. It is hoped that tabulations from these data will throw further light on the relationships between urban-rural fertility differentials and such economic

and social variables as occupation, literacy, race and religion.

IMPACT OF ECONOMIC DEVELOPMENT UPON FERTILITY

With respect to the relationship between economic development and fertility, the development anticipated by the Ceylon Government will not necessarily lead to family limitation. Until recently four-fifths of the Ceylonese occupied only a third of the area; the remainder were scattered thinly over the Dry Zone. The pressure of population on the land in the Wet Zone has resulted in the fragmentation and multiplication of peasant farms with each succeeding generation, until today the greater part of farm employment is in the cultivation of small holdings.

Of the total area of about 16.25 million acres, 6.75 million are considered suitable for agriculture in some form, and of these roughly 3.50 million acres have been cultivated. Most of the unused lands—while nearly as great in extent as those already developed—are in the Dry Zone. Since the preliminary calculations of the International Bank for Reconstruction and Development indicate that not more than 600,000 acres can be irrigated, the bulk must therefore be brought into cultivation through dry-farming techniques that cannot produce as high yields per acre.²¹

For centuries following the destruction of the ancient tank reservoirs, malaria and the lack of adequate water supplies deterred resettlement of the northern plains. Although the Irrigation Department began to maintain and repair the old tanks as early as 1900, it did not initiate new projects until 1931. The Government also undertook an anti-malaria campaign that ultimately

¹⁹ See Ryan. *Caste in modern Ceylon: the Sinhalese system in transition*. Rutgers University Press, 1953, particularly chapters 13 and 14, "Caste in urban and national life", and "A social structure in transition", pp. 307-347.

²⁰ Ceylon's first *Post enumeration survey* (*op. cit.*) is reassuring in that it indicates that census missed only 55,000 persons, or 7 for every thousand enumerated. Urban enumeration (with 9 persons missed per thousand) was somewhat less complete than rural (6 persons missed per thousand).

²¹ International Bank for Reconstruction and Development. *The Economic development of Ceylon: report of a mission organized by the International Bank for Reconstruction and Development at the request of the Government of Ceylon*. The Johns Hopkins Press, Baltimore, 1952.

reduced the number of reported malaria cases by nine-tenths from an average of 2,660,000 during 1937-1946 to 269,000 in 1952.²²

Census statistics testify to the success of these ventures. For two successive inter-censal periods the population of North-Central province has increased more rapidly than that of any province on the island—43 per cent, from 97,000 in 1931 to 140,000 in 1946 and 64 per cent thenceforth to 229,000 in 1953. Eastern, North-Western, and Uva provinces also increased one-fourth or more, due in large measure to the Gal Oya multi-purpose and other colonization schemes undertaken in areas cleared of malaria. By contrast, Western and Southern provinces increased only 19 and 18 per cent respectively. Kurunegala, a new municipality in North-Western, and Anuradhapura in North-Central province both grew far more rapidly in population than did Colombo itself, but four satellites swelled Colombo's 425,000 to a conurbation of 637,000, accounting for 7.9 per cent of the island's population.

Immediately after the end of the Second World War Ceylon embarked upon a programme of accelerated capital investment and development that was given more precise form in the first six-year plan initiated in October 1947, just prior to the attainment of political independence and scheduled to last through September 1953. The goals set for advancements through the plan have been achieved in the main. It was recast somewhat for inclusion in the Commonwealth Colombo Plan for Co-operative Economic Development in South and Southeast Asia to extend from 1951 to 1957. The revised Colombo Plan, finalized at Karachi in March 1952, anticipated the expenditure of 40 per cent of the total of nearly 6.7 million dollars on agriculture, including multi-purpose projects and rural development.²³

As distinct from the Colombo Plan, the inception of a second six-year plan to begin in 1953 and continue until 1959, was recommended by the IBRD Mission which conducted field studies in Ceylon in the latter months of 1951. The objective of all three of these plans has been to attain a greater degree of stability in the economy by featuring agricultural rather than industrial development, a *sine qua non* for a country that must import two-thirds of its foodstuffs and is generally lacking in mineral resources. To date efforts have been concentrated on the development of Gal Oya (Rock Creek), a multi-purpose project located in Eastern province between Batticaloa and Badulla. Planning started as early as

1937; construction began in earnest in 1949. Between the completion of main elements in late 1951 and the end of 1954, some 40,000 colonists moved in.²⁴

"Elsewhere smaller projects are in progress", according to the IBRD, "and others are being studied. If the irrigation works contemplated by the Mission are carried out, the period 1953-1959 should see the colonization—through a number of individual schemes—of about 125,000 acres of irrigated land plus perhaps 75,000-100,000 acres of dry land; these projects will involve resettlement of more than 250,000 people, including the non-agricultural populations of the new villages and towns which will be created. About two-thirds of these will be in Gal Oya."²⁵

This major effort, nonetheless, constitutes only a holding action in the battle between population and the extension of cultivable land, since it offsets only some fifteen months of population growth. If water supplies should be sufficient for 600,000 acres—double the present irrigated acreage—as contemplated, and associated dry-farming areas are brought into cultivation, the IBRD has estimated that a total of 1.5 million people can be resettled eventually.²⁶ However, the opening up of new lands cannot continue indefinitely, and even this number is not a great deal more than the inter-censal growth in population between 1946 and 1953.

Furthermore, the removing of the jungle cover with the resultant leaching of the soil by action of tropic sun and water and the anticipated division of land into small holdings—despite the fact that an extensive type of agriculture must be practised—will make conservation difficult. Soil productivity, in turn, will probably decrease rapidly as has happened since 1938 in the restoration of the ancient Sinhalese tanks and subsequent colonization at Minneriya in North-Central province.²⁷ The population-carrying capacity of the land will diminish accordingly.

In short, agricultural development may actually continue a high fertility-oriented culture by merely extending spatially a traditional pattern of agriculture. In this process the *mores* of the individual family, continuing in a *Gemeinschaft* environment, are likely to remain basically unaffected. Rapid industrialization, on the other hand, while not feasible in the immediate future for Ceylon, would wrest the individual family from an agricultural setting and subject it to the economically com-

²² De Silva, David M. "Public health and sanitation measures as factors affecting mortality trends in Ceylon." Paper presented at World Population Conference (Rome, September 1954). United Nations: Document E/CONF./13/272.

²³ Consultative Committee on Economic Development in South and Southeast Asia. Fourth meeting at Karachi, Pakistan, March 1952. Report . . . U.S. Department of State publication 4650, July 1952, pp. 11-17.

²⁴ MacFadden, Clifford H. "The Gal Oya Valley: Ceylon's little TVA". *The Geographical Review*, Vol. XLIV, No. 2, April 1954, p. 281; and subsequent correspondence.

²⁵ International Bank for Reconstruction and Development, *op. cit.*, p. 32.

²⁶ *Ibid.*, p. 35.

²⁷ Senewiratne, S. T. "A study of the Gal Oya project". *The Ceylon Economist*, Vol. 2, No. 1, September 1951, p. 76.

petitive *Gesellschaft* environment of the city that elsewhere has motivated family control.

CONCLUSION AND PROSPECTS FOR THE FUTURE

In conclusion, urban-rural fertility differentials exist, but are comparatively small and can be explained only in part by related demographic and social variables. Because of this and the

emphasis necessarily placed upon agricultural development in both official Ceylonese programmes and the recommendations advanced by the IBRD, the rapid spread of family limitation to the island as a whole appears unlikely in the immediate future. Without a considerable reduction in fertility from its present high level to counterbalance the drastic reduction in mortality, a rapid spurt in Ceylon's population is almost inevitable.

The cause of the ageing of populations : declining mortality or declining fertility ?

This article, prepared by the Population Division of the United Nations, shows that changes in fertility, more than changes in mortality, determine the age structure of a population.

INTRODUCTION

The present article is solely concerned with changes in the age structure of a population. Age is to be understood purely in its chronological sense, namely, as the number of years an individual has lived since his birth. The age structure of a population is conditioned by past trends in fertility, mortality and migration. The effects of migration, however, may be regarded as a separate problem requiring separate treatment. They are not considered in the present discussion.

It is a common misconception that the ageing of populations is, or has been, chiefly, if not entirely, the result of declines in mortality. As the article will demonstrate, this view is false. Declining mortality or—which is the equivalent—increasing expectation of life, accelerates population growth with respect to all age groups and not merely with respect to the segment at advanced ages. A relative slowing down of population growth in the younger age groups can, however, result from a decline in the birth rate. Birth rates, and not death rates, are the major determining factor of population structure.

Before entering into the more detailed argument, let us first expose two simple fallacies which may have tended to support the misconceived view that declines in mortality have resulted in ageing.

It is held, quite correctly, that if the expectation of life at birth—or at any other age—is increased, more persons will eventually attain certain relatively advanced ages. As a result, there will be more old people. Nevertheless, it is an error to forget that, with increased expectation of life, there will also be more young people. In fact, there are likely to be more people altogether, young, old and middle-aged. The concept of "expectation of life" does not focus attention on this fact, but it should not be disregarded.

Another fallacy stems from a misinterpretation of the experience of certain Western countries where mortality has been declining for a long period and the proportion of aged persons has shown a marked rise. It does not follow that the fall in mortality has "aged" their populations. The same countries have also experienced a marked

decrease in birth rates, and it is this which has been primarily responsible for the observed shifts in age composition.

THE FALSE ARGUMENT : "STATIONARY" POPULATIONS

The concept of the "stationary" population can find many valid applications in demographic reasoning, provided its limitations are borne in mind. A "stationary" population is one which would result from a constant annual number of births under constant mortality conditions (i.e. mortality rates for each age). It is given by the L_x -values of life tables, usually on the assumption that there are 100,000 births each year. The number of births being the same every year, obviously the number of survivors¹ to each age is determined by mortality rates up to that age. Hence, such a population will at all times have the same number of persons in each age category.

In a comparison of two "stationary" populations, one derived from a life table where mortality is high, the other from one where mortality is low, we shall find that 100,000 annual births will result in larger numbers of survivors to any age where mortality is low. This can be seen from table 1, where the "stationary" populations according to the 1920 Chilean life table for females (Mortality A) and according to the 1939-1941 United States life table for females (Mortality B) are compared. Already in the first age group (ages 0-4) fewer children will survive under Mortality A than under Mortality B—this great difference being due to the high incidence of infant mortality in Chile at that period of time.² Not only are there, under Mortality A, smaller numbers of survivors at all subsequent ages, but survival ratios are lower so that, in relative terms, the number of survivors also declines more rapidly

¹ In a life table, the l_x -values indicate survivors to an exact age; there is a direct relation between these and the L_x -values indicating numbers of persons living within an age group.

² If no child ever died before attaining age 5, 100,000 annual births would, of course, result in 500,000 children living at ages 0-4.

from one age to the next. Therefore, under Mortality A, 100,000 annual births will support a population of 3,221,094 at a stationary level, whereas, under Mortality B, 100,000 annual births can maintain a population of 6,588,801 in a stationary condition. Because of more rapidly dwindling numbers of survivors, as age advances, only 6.29 per cent of the stationary population will be aged 65 years and over under Mortality A; under Mortality B, 13.50 per cent of the population will be 65 years old or older.

TABLE 1. STATIONARY POPULATIONS RESULTING FROM 100,000 BIRTHS EACH YEAR ACCORDING TO LIFE TABLE FOR FEMALES IN CHILE, 1920, AND IN THE UNITED STATES, 1939-1941

Age in years	Chilean females, life table of 1920 (Mortality A)	United States females, life table of 1939-1941 (Mortality B)
0-4	349,596	477,349
5-9	309,762	473,021
10-14	300,688	471,075
15-19	289,947	468,368
20-24	274,229	464,119
25-29	256,401	458,832
30-34	237,723	452,593
35-39	217,830	444,922
40-44	197,528	435,129
45-49	177,096	422,084
50-54	157,361	404,351
55-59	136,725	380,191
60-64	113,444	347,417
65-69	87,307	303,569
70-74	59,204	245,827
75-79	33,172	175,827
80-84	15,469	102,436
85 and over	7,612	62,429
Total population.	3,221,094	6,588,801
Population aged 65 years and over ..	202,764	889,353
Population aged 65 years and over as percentage of total population	6.29%	13.50%

Sources: "Tablas de vida para Chile: 1920, 1930 y 1940", *Revista Chilena de Higiene y Medicina Preventiva*, Vol. VIII, No. 3, Septiembre 1946; and Greville, T. N. E. *United States Life Tables and Actuarial Tables 1939-1941*. United States, Bureau of the Census. Washington, 1946.

Forgetting for a moment that "stationary" populations are being dealt with, we might be tempted to conclude that the proportion of aged persons is higher where mortality is lower, and vice versa. Whether this conclusion is valid depends on whether the only factor which has been changed in the experiment is that of mortality. It should be remembered that valid comparisons can be made only under the condition of *ceteris paribus*.

It might indeed appear, at first sight, that fertility is the same for both populations, there being 100,000 births each year in either case. But—and this is the crucial question—where do these 100,000 annual births come from?

Under Mortality A, the population is "stationary" because 100,000 annual births are matched by 100,000 annual deaths in a population of 3,221,094 persons; this is possible if both the crude birth rate and the crude death rate (i.e. births and deaths per 1,000 total population) are equal to 31.05. Under Mortality B, 100,000 annual births and deaths would occur in a stationary population of 6,588,801; the crude birth rate and death rate would then both equal 15.18 per 1,000. Obviously, the two populations could not both be "stationary" and yet of different mortality unless they also differed with respect to fertility. We may then regard the first of the two populations as one with Mortality A and Fertility A, and the second as one with Mortality B and Fertility B.

Since, in this comparison, mortality as well as fertility has been changed, it cannot be concluded whether the change in age structure is attributable to the change in one of these factors; possibly, it is due to the change in both factors. To draw valid conclusions, we need a comparison where one factor only is changed at a time. Thus, if we can construct a fictitious population with Fertility A and Mortality B, it can be compared with either of the two stationary populations, as it will differ from the one with respect to mortality only, and from the other with respect to fertility only.

THE CORRECT ARGUMENT: "STABLE" POPULATIONS

A "stable" population is one with constant mortality and constant fertility, though mortality and fertility are not necessarily equal. If both happen to be equal, the population will be "stationary". If they are unequal, then the population will grow (or diminish) at a constant rate. Though, in the latter event, the total population as well as the numbers of persons in each age group will increase (or decrease) constantly, the proportion of the total population contained in each age group will remain unchanged.

Table 2 contains a comparison of the two "stationary" populations already discussed with a "stable" population whose mortality equals Mortality B, but whose fertility equals Fertility A.³ This is a rapidly increasing population

³ It has not been specified how frequently births occur to women of particular ages under Fertility A. Hence, an additional assumption is required. It has here been assumed that the average age of mothers at the birth of any one child approximates 27 1/2 years. Fertility A can then be defined in such a manner that 100,000 births occur in a "stable" population in one year if exactly 256,401 women are at ages 25-29. Under Mortality B, however, an annual average of 100,000 births results, 27 1/2 years later, in the survival of 458,832 women to ages 25-29. The increase from 256,401 to 458,832 in 27 1/2 years would occur at the rate of 2.14 per cent per annum. The "stable" population of table 2 has been constructed by decreasing successive age groups of the "stationary" population with Mortality B in accordance with this rate, compounded for successive five-year periods.

of high fertility and low mortality, not unlike current conditions in several countries of Latin America.

TABLE 2. COMPARISON OF STATIONARY POPULATION WITH HIGH FERTILITY AND HIGH MORTALITY, STABLE POPULATION WITH HIGH FERTILITY AND LOW MORTALITY, AND STATIONARY POPULATION WITH LOW FERTILITY AND LOW MORTALITY

Age in years	Stationary population (Mortality A, Fertility A)	Stable population (Mortality B, Fertility A)	Stationary population (Mortality B, Fertility B)
0-4	349,596	452,752	477,349
5-9	309,762	403,602	473,021
10-14	300,688	361,585	471,075
15-19	289,947	323,411	468,368
20-24	274,229	288,302	464,119
25-29	256,401	256,401	458,832
30-34	237,723	227,522	452,593
35-39	217,830	201,209	444,922
40-44	197,528	177,023	435,129
45-49	177,096	154,475	422,084
50-54	157,361	133,127	404,351
55-59	136,725	112,605	380,191
60-64	113,444	92,567	347,417
65-69	87,307	72,763	303,569
70-74	59,204	53,007	245,827
75-79	33,172	33,964	175,827
80-84	15,469	17,879	102,436
85 and over	7,612	9,480	62,429
Total population ..	3,221,094	3,371,674	6,588,801
Population aged 65 years and over	202,764	187,093	889,353
Population aged 65 years and over as percentage of total population	6.29%	5.55%	13.50%

Sources : same as for Table 1.

The influence of a change in mortality upon age structure will appear from a comparison of the stationary population with Mortality A and the stable population with equal fertility but Mortality B. The comparison indicates that, with lowered mortality, the proportion of persons aged 65 years and over might be slightly lowered as, in the present example, where the percentage falls from 6.29 per cent to 5.55 per cent. At any rate, the change in the proportion of aged persons is not very marked, nor is it necessarily in the direction of "ageing" the population.

The influence of a change in fertility upon age structure is illustrated in the comparison of the stable population with high fertility and low mortality with the stationary population with low fertility and equally low mortality. There is a very marked increase in the proportion of aged

persons. In the present example, the proportion of persons aged 65 years and over rises from 5.55 per cent to 13.50 per cent. Obviously, a change in fertility has a much greater impact upon age structure than a change in mortality of comparable magnitude.

The present experiments have been based solely upon an old life table for Chile and a somewhat more recent life table for the United States. Similar computations can be made with a great variety of life tables, either for different countries, or for the same countries at different periods of time. In general, the same conclusions will be reached, except where the two life tables compared show changes in mortality which are actually incongruous with experience (e.g., an increase in mortality rates at certain ages simultaneous with a decrease in mortality rates at other ages).

Nevertheless, the evidence is not yet conclusive. Neither "stable" nor "stationary" populations are found in reality. They are mere abstractions, showing what would become of a population in the long run if the same conditions continue to prevail indefinitely. In actuality, as the vital rates undergo various changes, populations are always "transitional", showing the effects of trends which prevailed at some time in the past, as well as the changed trends prevailing more recently. Let us, therefore, examine what the transitional effects will be if either the mortality rates or the fertility rates undergo a change.

TRANSITIONAL EFFECTS UPON AGE STRUCTURE OF CHANGES IN DEMOGRAPHIC TRENDS

Actual observations throw some light on this problem, even though the effects of diverse factors cannot be clearly separated. Table 3 illustrates the experience of Chile and the United States. In Chile, birth rates were high at the beginning of the present century and have remained fairly high until 1940 while, during the same time, death rates showed a significant decline. Nevertheless, the Chilean censuses reflect very little change in population age structure and the proportion of the population aged 60 years and over has been practically the same in 1920, 1930 and 1940. In the United States the birth rate at the beginning of this century had been estimated as 30.1⁴ and has fallen consistently until the 1935-1939 period, when it averaged 17.2. During the same period, the death rate declined also by one-third. The census figures reflect a rapid rise in the proportion of persons aged 60 years and over.

While mortality has been declining both in Chile and in the United States, the experience of the two countries differed essentially with respect to the trend of fertility, which was fairly constant in Chile, but declining in the United States. This

⁴ See Thompson, W. S., and Whelpton, P. K. *Population trends in the United States*. New York, 1933, Appendix, table 14.

TABLE 3. VITAL RATES AND PERCENTAGE OF POPULATION AGED 60 YEARS AND OVER FOR CHILE AND THE UNITED STATES, 1900-1940

Period	United States ^a		Chile ^b	
	Birth rate	Death rate	Birth rate	Death rate
1900-1904	°	16.2	36.5	30.5
1905-1909	°	15.3	37.7	31.6
1910-1914	°	13.9	38.6	30.0
1915-1919	24.3	14.4	37.4	28.4
1920-1924	22.8	12.0	39.3	31.0
1925-1929	20.1	11.8	41.7	26.4
1930-1934	17.6	11.0	34.9	24.5
1935-1939	17.2	11.0	32.9	23.7

Census year	Per cent of population aged 60 years and over	
	United States	Chile
1910	6.8	°
1920	7.5	5.9
1930	8.5	5.7
1940	10.4	5.9

^a Data up to 1919 from United States, National Office of Vital Statistics, *Vital Statistics of the United States, 1900-1940*, Washington, 1947. Data from 1920 onward from United Nations, *Demographic Yearbook, 1953*, New York 1953. Up to 1933, vital registration was not extended to all states and data refer to those states from which official registration data were obtained.

^b Data up to 1919 from United States, Bureau of the Census, *Chile, Demographic Data*, Washington (no date). Data from 1920 onward from United Nations, *Demographic Yearbook, 1953, op. cit.*

^c No data available. It is, however, known that the birth rate in the United States declined greatly since the beginning of this century. For the year 1900, it was estimated at 30.1.

^d Data not available.

is the chief reason for the "ageing" of United States population while the Chilean age structure remained as youthful as before. However, as already pointed out, the actual experience of various countries is often partly obscured by other factors, such as migration, or inaccuracies of the statistical data.

An experiment based partly on actual observation and partly on fiction has been carried out by Bourgeois-Pichat.⁵ While taking note of observed changes in French mortality since 1776, he computed the size and structure of the population of France which would have resulted if fertility had remained as high as it was in 1776. He arrived, for 1951, at the rather improbable figure of 437 million—more than ten times the actual population of France for that year. This huge fictitious French population, however, would have preserved its youthfulness, having only 3.8 per cent of all persons aged 65 years and over as against 4.3 per cent in 1776. The actual population of France, in 1951, had 11.5 per cent of all persons at ages 65 and over.

This fictitious picture of a French population differs from the true one mainly because fertility

⁵ Bourgeois-Pichat, J. *La mortalité en Europe—chances et conséquences*. Centre européen universitaire, Département des sciences sociales. Fascicule 1, Nancy, France, 1952.

(as well as mortality) has been declining. Because of falling fertility, the population of France has grown slowly and aged. Had mortality alone declined, while fertility remained constant, population would have grown rapidly and would not have aged. Actually, in the fictitious population computed by Bourgeois-Pichat, there would have been a small amount of ageing in the period from 1776 to 1806, the percentage of persons aged 65 and over rising from 4.3 to 5.0. After 1806, however, this percentage would have fallen gradually and almost continuously, to reach 3.8 in 1951.

Results of purely fictitious computations, designed to throw light on the effects of changing mortality and fertility trends upon population age structure, have also been published in an earlier issue of this *Bulletin*.⁶ The starting point of the computations was a "stationary" population with mortality equal to that of France around 1850 (and fertility as required for replacement at that level of mortality). It was then assumed that mortality would decline, within 30 years, to the level observed in France in 1933-1938, and subsequently remain at that level. Several assumptions were made with regard to fertility. On one assumption fertility would remain unchanged; on another assumption fertility would decline simultaneously with mortality and to the same extent; on a third assumption the fertility decline would occur after the mortality decline, i.e. in the second 30-year period.

Some of the results of these computations are shown in table 4. The first part of the table shows changes in the proportion of persons aged 65 and over to total population. The effect of decline in mortality is isolated under the first assumption (constant fertility); there is a very slight rise in the proportion of aged persons for 20 years, but an appreciable decline in this proportion in the following 50 years, after which the proportion tends to stabilize. By contrast with this assumption, the effect of declining fertility becomes apparent under the other two assumptions. The early decline in fertility (simultaneously with mortality) of the second assumption results in gradual ageing of the population which continues over a period of about 80 years. If the decline in fertility follows the decline in mortality—as in the third assumption—the percentage aged 65 years and over only begins to rise in a much later phase, but the rise is far more rapid.

The second part of the table shows trends in ageing as measured by the ratio of "aged persons"

⁶ "Some quantitative aspects of the aging of western populations", paper read at the Second International Gerontological Congress, St. Louis, Mo., U.S.A., reproduced in United Nations *Population Bulletin*, No. 1, document ST/SOA/Ser.N/1, New York, December 1951, pp. 42-57. Reference is here made particularly to the results of assumptions II, III and IV discussed on pp. 47-49.

TABLE 4. INDICES OF "AGEING" OF THEORETICAL POPULATIONS ON THE ASSUMPTION OF A 30-YEAR DECLINE IN MORTALITY AND THREE DIFFERENT ASSUMPTIONS REGARDING FERTILITY

Time period	Fertility assumption		
	1. Constant fertility	2. Fertility declining simultaneously with mortality	3. Fertility decline following the decline in mortality
A. Persons aged 65 years and over per 100 persons of all ages:			
0	8.6	8.6	8.6
10	8.7	8.8	8.7
20	8.8	9.2	8.8
30	8.7	9.5	8.7
40	8.2	9.8	8.3
50	7.8	10.0	8.1
60	7.3	10.4	8.0
70	6.9	10.9	8.2
80	6.8	11.2	8.8
90	6.8	11.3	9.8
100	6.9	11.1	10.9
B. Persons aged 65 years and over per 100 persons aged 20 to 64 years:			
0	15.3	15.3	15.3
10	15.7	15.7	15.7
20	16.2	16.2	16.2
30	16.3	16.5	16.3
40	15.7	16.8	15.7
50	14.8	17.1	14.8
60	13.8	17.7	14.0
70	13.1	18.7	13.9
80	12.9	19.3	14.9
90	12.9	19.5	16.6
100	13.0	19.1	18.6

Source: For data and methods, see "Some quantitative aspects of the aging of western populations", *Population Bulletin*, No. 1, *op. cit.*

(arbitrarily defined as persons aged 65 and over) to "persons in working ages" (arbitrarily defined as ages 20 to 64). These trends parallel roughly, but not exactly, the trends in the proportion of total population aged 65 and over shown in the first part of the table.

The results of these and similar computations furnish definite proof that declines in mortality have only slight effects on age structure, even if the "transitional" situation is taken into account. Whatever effect declines in mortality may have is not necessarily in the direction of "ageing", and possibly even in the direction of "rejuvenation". The effect of a decline in fertility on age structure, on the other hand, is most important.

In the following, we shall endeavour to establish the precise mortality changes which tend to "age" or "rejuvenate" a population. We shall also qualify further the effect which fluctuating fertility trends may have upon age structure. This detailed investigation, however, must be preceded by some consideration of the definition of "ageing" or "agedness" of a population.

DEFINITIONS OF AGEING — "PARTIAL" AND "TOTAL" AGEING

Whether or not one population is more aged than another cannot be clearly determined if it

is not decided what measurement of "agedness" should be employed. Different measures may lead to different conclusions. The most usual measure of "agedness" is the percentage of total population at ages 65 and over (or 60 and over). Other measures which have been proposed are the ratio of "aged" persons (e.g., aged 65 and over) to persons at "working ages" (e.g., ages 20 to 64), and the ratio of "aged dependants" (e.g., aged 65 and over) to "child dependants" (e.g., aged less than 20). The precise age-limits can, of course, be varied to suit the social circumstances of the countries concerned.

TABLE 5. PER CENT DISTRIBUTIONS BY AGE OF THE POPULATIONS OF BELGIUM AND NORWAY AND MEASURES OF "AGEDNESS" DERIVED THEREFROM: 1930

Age in years	Belgium	Norway
0-4	8.2	8.5
5-9	8.5	9.9
10-14	6.2	10.1
15-19	8.0	9.6
20-24	8.7	8.7
25-29	8.9	8.1
30-34	8.3	7.6
35-39	7.3	6.7
40-44	6.6	5.7
45-49	6.4	4.9
50-54	5.9	4.7
55-59	5.2	3.9
60-64	4.2	3.3
65-69	3.2	2.9
70-74	2.3	2.3
75-79	1.3	1.7
80-84	0.6	0.9
85 and over	0.2	0.5
TOTAL	100.0	100.0
Measures of "agedness"		
Per cent of total population aged		
50 and over	22.9	20.2
55 and over	17.0	15.5
60 and over	11.8	11.6
65 and over	7.6	8.3
70 and over	4.4	5.4
75 and over	2.1	3.1
Persons aged 60 and over per 100 persons at ages		
20-59	20.6	23.1
0-19	38.2	30.4
Persons aged 65 and over per 100 persons at ages		
15-64	10.9	13.1
0-14	33.2	29.1

Source: United Nations. *Demographic Yearbook, 1949-1950*. New York, 1950.

In table 5 the percentage age distributions of Belgium and Norway, according to censuses taken in 1930, are compared. If we consider the percentages of the two populations aged 60 and over, the population of Belgium will seem more aged than

that of Norway. If we compare percentages aged 65 and over, the Norwegian population will appear to be the more aged one. If we relate the numbers of aged persons to persons at working ages, Norway appears more aged than Belgium. If we relate the aged segment of the population to the number of children, Belgium will appear to be in a more advanced stage of ageing than Norway. Evidently, it is impossible to say which of the two populations is the more aged one.

Likewise, it is possible that the changes which occur to the same population in the course of time are such that the population appears to have aged, if one measure is taken, while it appears to have been rejuvenated, if a different measure is applied. That a population can both grow older and younger at the same time will appear from the experience of the United States. In 1940, 25.0 per cent of the population were aged less than 15 years, while 6.9 per cent were aged 65 and over; in 1950, 27.2 per cent were under 15, while 8.2 per cent were 65 and more. Both the percentage of the young and that of the old had risen.

Any measure of a population's "agedness" relates the numbers contained in some terminal age group (such as "65 and over", "60 and over", etc.) to numbers in younger age groups (or to some total consisting of younger groups and the terminal group itself). Since, however, the numbers in all age groups are affected in various ways by changing demographic trends any such measure reflects changes in numbers of old persons as well as in numbers of persons of some younger ages. Though a great variety of such measures of "agedness" can be devised, none of them has any absolute significance.

Despite this lack of any absolute measure of "agedness", we can conceive two populations which differ from each other in respect of age structure in such a manner that, no matter what measure of "agedness" is applied, the one will invariably appear more "aged" than the other. Likewise, we can conceive that one population, in the course of time, so changes its age structure that—no matter which of all the possible measures is applied—it is indubitably ageing. This is the case of a population which is ageing "totally", according to a concept developed by Feraud.⁷ On the other hand, the age structure of a population may become modified in such a manner that the population appears to be ageing according to some measurements, but growing less aged according to some other measurements. This is the case of "partial" ageing, in accordance with Feraud's concept.

The two concepts, "total ageing" and "partial ageing", were intended by Feraud to apply only

⁷ Feraud, Lucien. "A propos du vieillissement d'une population". Paper presented to the World Population Conference in Rome, Italy, 31 August-10 September 1954, United Nations document E/CONF.13/161.

to theoretical populations, i.e. to populations whose age structure is entirely determined by previous hypothetical trends, but will undergo further changes as a result of the continuance of these trends. It must be admitted that, in reality, hardly any population will be found that is capable of "total" ageing. This is so because the age structures of all existing populations contain many more or less important irregularities as a result of past fluctuations in birth rates. Thus, owing to an unusually low birth rate in 1885, an otherwise ageing population may show a decrease in the proportion aged 65 years and over from 1950 to 1951 because of the unusually small number of new entrants into this category during that one year. Likewise, other measures of ageing may be affected by irregularities in trends of numbers at some other age.

Nevertheless, if we employ Feraud's concepts somewhat more flexibly, we can conceive of real populations ageing "totally", at least so far as some broad age groups (e.g., five-year or ten-year groups) are concerned. If measurements are restricted to the population above some minimum age, such as age 15, a population may be found to be ageing consistently, according to all measures, even though the proportion of children has risen, as it has recently in the United States. We might, therefore, say that there are degrees to which the ageing of a population is "partial" rather than "total". In the discussion which follows, it should be recalled that every part of a population's age structure can change in various ways and that consequently no measurement of ageing has any absolute significance, particularly if ageing proceeds in a highly "partial" fashion.

WHAT CHANGES IN MORTALITY CAN CONTRIBUTE TO AGEING ?

Our important conclusion (see the preceding sections of this article) has been that declines in mortality have only a slight effect on age structure. In the few examples cited so far, this effect has actually been in the direction of rejuvenation. Other cases, however, can be cited where a decline in mortality may have a slightly "ageing" effect.

The United Nations projections of the population of Mexico and Central America⁸ made on the assumption of future declines in mortality, show that, with fertility remaining constant, the proportion of persons aged 60 years and over will rise very slightly, from 4.67 per cent in 1950 to 4.94 per cent in 1980. Lorimer's theoretical projection⁹ of an initially stable population, with

⁸ United Nations, *The population of Central America (including Mexico), 1950-1980*, document No. ST/SOA/Ser.A. Population Studies No. 16, New York, 1953, p. 20.

⁹ Lorimer, F. "Dynamics of age structure in a population with initially high fertility and mortality". United Nations *Population Bulletin*, No. 1, document ST/SOA/Ser.N/1. New York, December 1951, pp. 31-41.

Indian mortality rates according to the Indian life table of 1921-1931, shows that if mortality declines to the levels of the 1926-1931 life table of Japan while fertility remains as high as before, the percentage of persons aged 60 years and over will rise slightly: from an original 3.6 it will become 4.2 after 30 years and will eventually attain 4.5. Mortality declines can thus either rejuvenate or age a population, though only to a rather slight extent.

It is a somewhat complex problem to determine which type of mortality decline increases, and which type decreases a population's "agedness".¹⁰ Mortality usually declines at all ages simultaneously, though by unequal amounts for various ages. The problem can be clarified to some extent by arbitrarily assuming some much simpler mortality changes, however unrealistic these assumptions may be. Three such cases are considered below. In a strict sense, they would hold true only with respect to initially "stable" populations.

Let us imagine the effects of a decline in the age-specific death rate at one age (or one age-group) only, while death rates at other ages remain unchanged. The immediate result is the survival of increased numbers of persons at this particular age. In the course of time, the effect will be propagated further along the age pyramid as increased numbers of survivors at a given age are subjected to unchanged specific death rates at subsequent ages. Eventually, more persons will attain old age than would have if this particular change had not occurred. If we now suppose that the particular age at which the death rate has declined is past the ages of child-bearing, the effect will obviously be to age the population.

Let us assume, however, that the particular age at which the death rate has been lowered precedes the ages of potential parenthood. Though

¹⁰ A short-cut method of estimating some elements in the age structure of "stable" populations has been developed by Bourgeois-Pichat ("Charges de la population active", *Journal de la Société de statistique de Paris*, Nos. 3-4, mars-avril 1950, pp. 94-114). His formula yields an approximate estimate of the ratio of persons aged 60 years and over to persons aged 20 to 59 years and can be expressed as follows:

$$\frac{e_{60} \cdot l_{60}}{e_{20} \cdot l_{20} - e_{60} \cdot l_{60}} \cdot \frac{1}{l_{(t)28}} \cdot \frac{1}{R}$$

where e_{20} and e_{60} are expectations of life at ages 20 and 60,
 l_{20} and l_{60} are life-table survivors to ages 20 and 60,
 $l_{(t)28}$ are female life-table survivors to age 28, and
 R is the gross reproduction rate.

This formula may be used to estimate degrees of "agedness" of two "stable" populations having different rates of mortality. An indication is then obtained as to whether a given decline in mortality has an "ageing" or a "rejuvenating" effect. If fertility is assumed constant and relative values only are sought, then there is no need to substitute a numerical value for R in the formula.

after a somewhat longer period of time, increased numbers of persons will also eventually attain advanced ages. Before this happens, however, a different effect will appear. There will be more potential parents, hence more births and, consequently, more children. While, with the passage of time, more persons will enter the older ages, the increased generation of children themselves will attain parenthood and, in their turn, bear children; moreover, a large proportion of them will become parents, the chance of survival to reproductive ages having been increased. The increase in the child population, thus reinforced, will more than offset the eventual increase among the aged and the entire population will be rejuvenated.

These examples, while instructive, are unrealistic because mortality decreases generally at all ages simultaneously. One special case, however, is still worth considering. If death rates at every age decline by the same absolute amount, chances of survival at every age are improved to the same extent. The result of such a mortality decline—if it could occur—would be no change whatever in age structure; the population would increase more rapidly, but the same proportion of persons will be found in every age group as before.

In reality, mortality rates are most unlikely to decline by equal amounts at all ages. Whether mortality is high or low, the mortality rates at adolescent and early adult ages are usually only a small fraction of the mortality rates at infancy and old age. Even if adolescent mortality were to disappear almost entirely, the amount by which adolescent death rates can decline will appear quite negligible in comparison with the death rates of infants and old persons. Obviously, declines in mortality by large amounts are to be expected at those ages where risks of death are high, but can be reduced substantially; namely, at infancy and at advanced ages.

Western countries have generally been far more successful in reducing their infant death rates than in cutting the death rates of aged persons. The manner in which Western age-specific mortality rates have declined during the past two generations or so can be illustrated with a comparison of the Netherlands life tables for 1900-1909 and 1947-1949 presented in table 6.

The immediate effect of such a mortality decline—were it to occur rather suddenly—would be greatly to augment the numbers of surviving small children, and also to add appreciably to numbers of surviving aged persons, while effecting only very little change in numbers of adolescents and persons of middle ages. In the course of time, however, as the surviving children themselves progress in age, more persons will attain the ages of parenthood and eventually also old age. Whether ageing or rejuvenating, the effects of such mortality changes upon age structure as

TABLE 6. AGE-SPECIFIC MORTALITY RATES, BY SEX, AND DECLINES THEREIN, ACCORDING TO THE NETHERLANDS LIFE TABLES: 1900-1909 AND 1947-1949

Age in years	Males			Females		
	1900/1909	1947/1949	Decline	1900/1909	1947/1949	Decline
0	140.5	33.5	107.0	117.7	26.7	91.0
1	35.6	3.4	32.2	34.2	3.0	31.2
2	16.7	2.4	14.3	15.7	1.7	14.0
3	9.2	1.8	7.4	8.2	1.5	6.7
4	6.5	1.4	5.1	6.0	1.1	4.9
5	5.0	1.2	3.8	4.6	0.9	3.7
10	2.3	0.6	1.7	2.3	0.4	1.9
15	2.6	0.9	1.7	3.2	0.5	2.7
20	5.1	1.2	3.9	3.8	0.8	3.0
25	4.9	1.4	3.5	4.5	1.1	3.4
30	4.8	1.5	3.3	5.2	1.2	4.0
35	5.4	1.8	3.6	6.0	1.6	4.4
40	6.8	2.4	4.4	7.1	2.3	4.8
45	9.0	3.8	5.2	7.6	3.1	4.5
50	11.8	6.1	5.7	10.1	4.9	5.2
55	16.9	9.3	7.6	13.4	7.5	5.9
60	24.3	14.4	9.9	20.8	12.4	8.4
65	37.2	23.5	13.7	32.4	21.0	11.4
70	57.4	39.0	18.4	51.7	37.0	14.7
75	89.2	66.0	23.2	81.6	60.9	20.7
80	137.0	107.2	29.8	127.8	98.7	29.1
85	204.0	164.9	39.1	188.3	154.5	33.8
Expectation of life at birth (years)	51.0	69.4		53.4	71.5	

Source: United Nations. *Demographic Yearbook, 1953*, New York, 1953.

can occur in reality will be of a "partial" nature. The proportions of the population most likely to be increased are those at advanced ages and those in childhood while the proportion at middle ages is likely to shrink.

In Western countries where the reduction of infant mortality rates has been spectacular while the reduction of death rates among older persons has been only moderate, the net effect of mortality declines has been, in the past, mainly in the direction of rejuvenation. The mortality decline assumed in Lorimer's experiment,¹¹ on the other hand, implies a less outstanding reduction of infant mortality, coupled with a very substantial decrease of mortality rates between the ages of 30 and 70; hence, the increase in the proportion at ages 60 and over. Lorimer's calculations, however, show a highly "partial" ageing effect because the proportion at ages under 15 is also augmented.

At the present time, infant and childhood mortality rates in most Western countries are already so low that—though they may be reduced further—reductions by large amounts are no longer possible. Future progress in medicine and sanitation will achieve an additional saving of lives, but most of this gain will have to occur among aged persons. As the chances of survival to the ages of parenthood can no longer be greatly augmented, future mortality declines—assuming fertility to remain constant—will cause little increase in the

number of births. It is to be expected that in countries where mortality is already quite low further declines in mortality will tend to have an ageing effect, however, slight. In countries where current mortality is still rather high, reductions in mortality may, in the future, have slightly rejuvenating effects.

BIRTH TRENDS AND AGEING

As has been shown, changes in fertility have the most decisive influence upon a population's age structure. It would be of much interest if a precise relation between fertility trends and shifts in age composition could be established. Unfortunately, the relation is rather complex and cannot be reduced to any simple formula.

The current age structure of a population is determined—apart from rates of mortality and chances of survival to each age—by the actual absolute number of births which have occurred in each year during the past 100 years or so. The trend in the absolute annual number of births, therefore, provides the most direct clue to the changes in age structure which are likely to occur, so far as births are concerned.¹² It should, however, be recalled that this type of inference is highly theoretical since it is the birth rates, or the

¹² Reference may be made to Feraud's paper "A propos du vieillissement . . .", *op. cit.*, where it is demonstrated that in an initially "stable" population, there will be "total" ageing if the second derivative of the function of the logarithm of the annual number of births is constantly negative.

¹¹ See Lorimer, F. "Dynamics of age structure . . .", *op. cit.*

rates of fertility of women at reproductive ages, which reflect human reproductive behaviour. There is no such straightforward relationship between age structure and past trends in birth rates, or fertility rates. Moreover, just as there is no absolute measure of "agedness", so there is no absolute measure of human fertility, though a variety of measures can be used for different purposes.

Very approximately and without precise validity under all conditions, Feraud's theorem¹³ can be interpreted somewhat as follows:

1. If fertility, or the birth rate, remains constant, the population will tend to become a "stable population" and age structure will tend to stabilize.

2. If fertility, or the birth rate, decreases temporarily, the result will be "partial" ageing. At first the ratio of aged (and of middle-aged) persons to young persons is increased. Subsequently, the ratio of aged to middle-aged persons is increased while that of middle-aged to young persons is diminished. Still later—about 65 years after the event—the ratio of aged persons to middle-aged and young persons is diminished (there is "partial rejuvenation" as the contingents born under temporarily low fertility themselves reach advanced ages). Finally, about 100 years after the event, the original conditions are restored.

3. If fertility decreases to a lower level and then remains at that lower level, the result will be "total" ageing. At first, the ratio of aged (and middle-aged) persons to young persons is increased. Subsequently, the ratio of aged to middle-aged persons is increased and that of aged to young persons is further increased (without any decrease in the ratio of middle-aged to young persons). This condition tends to become permanent as the population tends to stabilize with a more "aged" age structure. The process is completed about 100 years after the event.

4. The ageing process can continue indefinitely only if there is a continuous and indefinite decline in fertility (or birth rates). This is most unlikely to occur. Though fertility may decline over a long period, a low level is eventually reached beyond which no further declines are probable. There is, therefore, a point beyond which the ageing process of a population is unlikely to continue unless the population were to become extinct by lack of replacement.

¹³ As stated in footnote 12.

SUMMARY AND CONCLUSION

From the discussion in this article, the following points emerge:

1. Populations "age" chiefly as a result of declines in fertility;

2. Declines in mortality may have either a slightly "ageing" or a slightly "rejuvenating" effect;

3. Fluctuations in fertility result in "partial" ageing which, with the passage of time, may give way to "partial" rejuvenation;

4. A permanent decline in fertility from a high to a low level results in "total" ageing; since fertility cannot continue to decline indefinitely, the ageing process eventually comes to a halt.

There is only one sense in which it can be said that the decline in mortality has caused populations to age substantially. At least in the very long run, the level of fertility cannot be entirely dissociated from that of mortality. High fertility, combined with low mortality, results in a rate of population growth which cannot be sustained indefinitely, particularly if the country's resources are limited. Hence, unless mortality were to rise again, fertility must eventually also decrease—though possibly at a very much later time.

The present rise in the agedness of Western populations is the result of a new adjustment between the frequency of births and that of deaths. While preventing populations from increasing unduly rapidly, however, the lowered birth rates bring about an increase in the proportion of the chronologically aged. This does not necessarily entail an increased incidence of the disabilities of old age since, where death rates are low, persons of advanced ages presumably are in better health than where death rates are high. Since birth rates have ceased to decline the ageing process will eventually be halted except for those additional gains in survival at old ages which new advances in medicine may be able to achieve. In countries where the birth rate has recently risen, ageing will at some future time give way to temporary, or "partial", rejuvenation.

In those parts of the world where birth rates have hitherto remained at a high level, no appreciable ageing is to be expected, irrespective of the extent and rapidity of the decline in death rates. Marked ageing can occur only after the onset of a decline in fertility. For most parts of the world, the emergence of such a trend cannot yet be foreseen.

CURRENT ITEMS

WORLD POPULATION CONFERENCE

This Conference was held in Rome from 31 August to 10 September 1954 under the auspices of the United Nations, pursuant to a resolution of the Economic and Social Council adopted in 1952. Some information on the organization of the Conference was given in *Population Bulletin* No. 2 (October 1952), and *Population Bulletin* No. 3 (October 1953) contained a provisional list of the topics to be discussed.

The details of the programme and arrangements were worked out with the advice of the Preparatory Committee for the Conference, consisting of the representatives of the interested specialized agencies, the International Union for the Scientific Study of Population, and individual experts appointed by the Secretary-General. The Preparatory Committee held meetings in 1952, 1953 and 1954, and its Sub-Committee on Organization gave constant advice to the Secretariat by mail.

At the opening meeting the following officers were elected:

Chairman: Professor L. Hersch, President of the International Union for the Scientific Study of Population.

Vice-Chairmen: Professor P. K. Whelpton, Chairman of the Preparatory Committee; Professor D. Vogel'nik, Chairman of the United Nations Population Commission; Professor Livio Livi (Italy), Member of the Preparatory Committee; Dr. K. C. K. E. Raja (India), Member of the Preparatory Committee.

Thirty meetings were held in addition to the opening and closing sessions of the Conference. Nine meetings were devoted to the growth of population, dealing with mortality and fertility trends, international migration, the prospects for future population changes, the changes in age composition and their economic and social consequences. Four meetings were held for discussions on the relations between population and resources, including agricultural resources, fuel and minerals; on capital formation, investment, and employment problems related to population trends; and on the general interrelationships of population, economic development and social change. Two meetings were devoted to population distribution and internal migration, both in industrial countries and countries in process of industrialization; one to the social aspects of population changes, with special reference to the family and its chang-

ing functions; one to legislation, administrative programmes and services relevant to population; and one to population changes in relation to genetic factors. A series of methodological sessions was also held dealing with the quality of demographic statistics, techniques of demographic measurement and analysis, methods of making population projections, design and control of demographic field studies, problems and methods in demographic studies of preliterate peoples, methods of research on relations between intelligence and fertility, and concepts and definitions in demographic statistics. On the last day of the Conference two plenary meetings were held in which the rapporteurs of certain substantive meetings made their contribution to a general review of the outlook for population growth and of the economic and social implications of population trends.

More than 450 participants from about seventy countries and territories attended the Conference and more than 400 written communications were submitted. The participants included demographers, economists, experts on agricultural development and other natural resources, statisticians, sociologists, experts on public health, labour and social welfare, and administrators responsible for planning and execution of development programmes. The diversity of fields of knowledge represented made for a many-sided discussion on subjects which had never before been broached before a world forum.

The proceedings of the Conference are being prepared for publication by the United Nations Secretariat. It is planned to include in the publication the programme, names of participants, and summary reports of the various meetings in addition to the texts of the papers presented to the Conference. The date of issue of these proceedings will be announced as soon as possible.

POPULATION COMMISSION TO MEET IN MARCH 1955

The eighth session of the United Nations Population Commission will be held at United Nations Headquarters in New York from 14 to 25 March 1955. States to be represented on the 15-member body include: Argentina, Belgium, Brazil, Canada, China, Costa Rica, France, India, Iran, Sweden, Syria, Ukrainian Soviet Socialist Republic, Union of Soviet Socialist Republics, United Kingdom and United States. A first item

of business will be the election of a chairman to replace Dr. Dolfe Vogelnik (Yugoslavia), whose country has recently completed its term of membership in the Commission.

Among the topics to be discussed at this session are : technical assistance activities in the field of population, results of the World Population Conference, gaps in existing knowledge of relationships between population trends and economic and social factors, studies of internal migration, plans for the preparation of standards for population censuses to be taken in and around 1960, and the programme of population studies for 1955-1956. Consideration will be given to proposals for re-orienting the programme of population studies in line with the Secretary-General's new plans for publications and studies in the economic and social fields.

THIRD INTERNATIONAL GERONTOLOGICAL CONGRESS : LONDON 1954

The Third International Gerontological Congress was held in London from 19 to 23 July 1954 under the auspices of the International Association of Gerontology. More than 500 experts from 40 countries attended, and about 250 papers were presented on medical, psychological, economic and social aspects of the problems of aged and ageing persons.

Although only two papers dealt with population trends as such, there was considerable discussion of their importance in relation to certain issues of public policy. Particular attention was paid to the question, to what extent policies relating to employment and retirement of elderly persons should be influenced by the increasing numerical importance of this age-group in the population

rather than by the needs and desires of the individuals concerned.

The proceedings of the Congress, including the papers presented, are scheduled for publication by E. and S. Livingstone, Ltd., of Edinburgh and London, near the end of 1954 or early in 1955.

INTERNATIONAL CATHOLIC MIGRATION CONGRESS : BREDA 1954

Problems of Catholic migration were the subject of study at the International Catholic Migration congress held at Breda, the Netherlands, from 11 to 17 September 1954. More than 300 population and migration experts were present, including numerous members of the clergy and religious orders and representing every continent. The Congress was convened under the patronage of Cardinal de Jong, Archbishop of Utrecht.

Special working groups of the Congress dealt with the following problems: the relations of Catholic migration organizations with Church and State, problems of preparation and selection of migrants in emigration countries, problems of placement and integration of migrants in immigration countries, refugees, intra-European migration, financing of international migration, documentation and research, and Christian principles in migration. Resolutions adopted included general statements of policy, proposals regarding the administrative structure and future work of the International Catholic Migration Commission, and appeals to Catholic organizations and international bodies to provide various types of assistance to migrants. The proceedings of the Congress will be published by the Catholic Social Research Institute, Paul Gabrielstraat 28, The Hague.