

apparently show an alarming increase. I remarked, when discussing phthisis, as to the effect of better diagnosis, and the same applies with added force in the case of cancer, for there is no doubt that this disease has not always been duly noted in the certificate of death.

It is stated in the supplement to the sixty-fifth annual report that "the practice of writing to medical attendants for further information concerning indefinitely stated causes of death, has resulted in the addition of a large number of deaths under the heading of cancer."

One satisfactory feature is evident—the less rapid rate of increase of the disease during recent years among females. This, I think, is probably due to better diagnosis in the earlier stages of the disease, when it is more susceptible to treatment.

The records of recent years indicate the wonderful progress which the army of workers for the improvement in sanitation and the general health of the population has accomplished, and cannot but act as an incentive to all to press forward with unabated vigour.

CHAPTER V

THE PREPARATION OF MORTALITY TABLES : (a) NATIONAL, (b) MUNICIPAL, (c) OCCUPATIONAL

THE subject of life tables, or mortality tables, as they are usually termed, is of enormous importance, for it is by the aid of such tables alone that improvements in the death rates can be accurately measured. This is true whether the comparison relates to the death rates of the whole population or to particular sections of the population. It is also equally true of the death rates of particular diseases or occupations.

It is well known that the mortality rates prevailing amongst persons engaged in different occupations vary very considerably, and it would be of great value if tables representing the general mortality rates relating to the more usual occupations in various districts could be readily obtained. Speaking from my own personal experience, I am bound to confess that such tables are almost impossible to calculate. The difficulty is that persons engaged in any given occupations subject to rates of mortality differing from those of the general population, remain in such occupations whilst well, but on becoming in any way impaired take up some other occupation, either from choice or necessity, and when death occurs are classified in accordance with their more recent occupation. Generally, it is found that men actually engaged in any specialised occupation are subject to abnormally

low rates of mortality, whilst amongst those who retire, especially at the middle ages, the rates of mortality are considerably above the average.

Voluminous statistics are given in Part II. of the supplement to the sixty-fifth annual report of the Registrar-General as to occupational mortality. Particulars are given of the deaths in 105 occupational groups, both while actually employed and after retirement. These figures in some measure meet the difficulty mentioned above, but the deaths are necessarily classified according to the occupation given on the certificate, and, as already pointed out, this may or may not be the occupation in which the disease was contracted. Such statistics, therefore, have only a limited value. I would refer students of this most interesting branch of my subject to a paper by Dr. James Crawford Dunlop, published in the *Transactions of the Faculty of Actuaries*, in Vol. 5, p. 1, in which the Registrar-General's figures are exhaustively dealt with.

Before discussing national and municipal tables, it will be desirable to state clearly the meaning of the term "mortality table." The best definition I can find is that given in the Institute of Actuaries Text-Book, viz., "A mortality table is the instrument by means of which are measured the probabilities of life and the probabilities of death." That is to say, a mortality table is a mathematical instrument by means of which we are able to extract the true facts that are buried in the rough material or crude data.

The mortality table has been described by Dr. Farr, to whose genius the first population mortality tables for England and Wales are due, as representing a generation passing through time. It records the births of a certain number of children, say 100,000, and tabulates the

number surviving on each successive birthday, until in extreme old age there are no survivors remaining.

By taking the difference between the numbers tabulated as surviving at successive ages, the numbers dying between those ages are obtained. The probability of dying within a year at a particular age is the ratio between the number living at that age, and the number dying before the next birthday. Similarly, the probability of living for a year at a particular age is the ratio of the number surviving to a given age ($x + 1$), compared with the number living at the previous age x . Thus, the probability of dying in a year at age 20 is found by dividing the number of deaths between 20 and 21, by the number living at age 20; and the probability of living a year at age 20 is found by dividing the number surviving to the exact age 21 by the number living at the exact age 20.

In constructing a mortality table, it is not possible to trace a particular body of persons from birth to extreme old age. In the first place the observations would embrace a period of about 100 years, and this alone would vitiate the results brought out by the table, quite apart from the impossibility of tracing the lives through so long a period. As we know that the rates of mortality vary from time to time, it is advisable that the period over which the observations extend should be limited.

If a body of lives is traced in the manner suggested above, the rate of mortality shown by such a table at age 0 would be the rate that was experienced 100 years ago, whilst the rate of mortality at age 50 would be the rate experienced 50 years ago, and it would only be at the extreme old ages that the rates could be said to represent present-day mortality. What is required is a table which will give for each age the rates of mortality which are being experienced at the *present time*. In constructing this we

facitly assume that the survivors of those just born will be experiencing the same rates of mortality 50 years hence as those persons who are now aged 50. What the rate of mortality will be 50 years hence it is impossible to forecast, nor for the purposes of the present inquiry is it necessary that we should attempt to do so.

There are many ways of constructing mortality tables, all of which will more or less accurately fulfil the required conditions, and it would be a simple matter to give examples of the methods which have been adopted in the construction of many well-known tables. I think, however, that it will be of greater practical value if I confine myself to a description of a method which can be readily and easily applied by those who do not profess to be expert mathematicians. I do this with great confidence in view of the fact that it will enable those interested to obtain, with the expenditure of comparatively little labour, a series of tables which will exhibit the rates of mortality experienced in successive years, and from which the progress that is being made may be accurately measured. I shall, however, content myself with a brief outline of the method here, leaving the details which are necessary for its application to the appendix.

As explained above, in order to ascertain the rates of mortality, we require to know the numbers living and the numbers dying at each age, and if we are in possession of these facts, we can obtain rates of mortality. So long as both the numerator and the denominator of each fraction refer to the same persons, it is not necessary that all the numerators and denominators should refer to the same body of persons, and, indeed, if we are to obtain for each age the rates of mortality which are being experienced during the same period, it is essential that they should not refer to the same body of persons. The numbers living at each

age can be obtained from the census returns, and the numbers dying from the Registrar-General's annual returns. We are, therefore, in possession of the data which enables us to obtain the rates of mortality experienced in this country to within a few months of the present time.

I have already pointed out that the mortality table represents the life history of a large population all of whom are assumed to have been born at the same moment. If we endeavour to form a mortality table by means of the census returns and the register of deaths, we are at once met with the evident difficulty of the varying population. If we took the population according to a given census and compared it with the deaths which occurred in several succeeding years, the results would be incorrect for several reasons, one of which is that the population will probably have increased during the period for which the deaths were recorded.

In order to involve the least possible error, the census figures are compared with the deaths recorded during a period for which the census figures used are the central point. As the census is taken on April 3rd, and the deaths are recorded in calendar years, the census figures are adjusted so as to bring them up to the centre of the year, viz., June 30th. The result of taking the deaths for a period before and after the census date is that we do not obtain the rates of mortality and survival which I have above described, but what are known as "central rates of mortality," and further adjustments are necessary in order to obtain the rates in the form most suitable for practical use.

Another difficulty to which I must refer is the impossibility of getting correct ages recorded. For instance, if a man dies at any age approximating to 50, it is quite usual

for that round figure to be stated. To overcome this serious difficulty, we are obliged to deal only with groups of ages, obtaining the records for intermediate ages by means of graduation. I have thought it advisable to mention these few points in order to prevent anyone coming to the conclusion that the methods I have used are unduly complicated. Far from this being the case, I have purposely discarded every refinement and have, as I have already explained, set out a method which, whilst giving sufficiently correct results, has been made as simple as possible, so that it may be readily used by anybody of average knowledge and ability.

My object in delivering the Chadwick lectures was to assist all those who are striving for sanitary reform and the improvement of the public health. I believe that the Registrar-General, by means of his greatly improved form of statistical returns, has placed in our hands a very powerful instrument which we cannot afford to neglect. I have endeavoured to show how this instrument can be most readily used.

I hope and believe that in the future mortality tables will be formed at comparatively short intervals, both for the whole of the country and for many separate districts, so that the rates may be compared and the progress towards improved mortality rates indicated clearly and indisputably. I think that, to make such tables as useful as possible, they should show, not only the mortality rates for each year of age, but also for each age the rates of mortality due to various diseases. I have taken particular care with regard to infantile ages, because, as I have previously said, it is by saving our infantile population that we can best safeguard the future of our nation.

I call for volunteers to help in what I verily believe to

be a work of paramount importance. I am trying to break down the old superstition that statistics in general and census returns in particular are of no practical value, if not worse than useless. I hope that I may succeed, and I believe that I shall.

I shall give some examples of mortality tables such as I hope will in future become general, and it will be seen from these that in many cases excessive rates of mortality are still prevalent from certain diseases. Whilst thankfully acknowledging the great progress which has already been achieved, I am asking that in each district an up-to-date analysis of mortality may be made, and instant steps taken to remedy any preventable excess.

The Registrar-General in his annual reports will, in the future, publish the estimated population as at June 30th in each year, and, although the figures will necessarily be approximate, the methods of adjustment will be such that they can be used without hesitation. The data used in the illustrative tables which I have constructed, have been taken from the seventy-fourth annual report of the Registrar-General, and refer to the year 1911. From these I have constructed rates of mortality for England and Wales and for Liverpool, and thence I have passed back to the mortality tables, which have thus been constructed by an inverse process. It will be seen that by this method the mortality table represents the future progression of the present generation, if the existing rates of mortality continue to be experienced.

The figures given by the Registrar-General are tabulated in five-yearly age-groups up to age 25, in ten-yearly groups from 25 to 85, with a final group for ages 85 and upwards. We require to know the number at each individual age, and in the detailed account I have shown

how a very close approximation to these numbers may be obtained.

Briefly, the method employed is that known as osculatory interpolation, the terms on each side of the interpolated value being involved in proportions varying with their proximity to such value. The interpolation could have been effected by means of a freehand curve, but this would have been open to the objection that no two operators would have arrived at identical results. Where the table is constructed by a mathematical formula, a definite rule can be adopted, and every operator, whatever his degree of skill, must, if he follows the rules set out, derive the same results. Where the tables are required for comparison, this is an essential condition. The method is not applicable to infantile ages, and for these the system adopted has been based on the births and deaths of recent years.

CHAPTER VI

PRACTICAL USES OF MORTALITY TABLES BY MEDICAL OFFICERS AND OTHERS—CAUSES OF DEATH AND THEIR PREVENTION

I NOW want to illustrate by means of the mortality tables for England and Wales, London and Liverpool, the lesson which may be learnt from this branch of Vital Statistics.

In Diagrams 16 and 17 on pp. 78 and 82, are shown the rates of mortality according to :—

(1) The sixth English life table based on the two censuses 1891 and 1901, and the deaths for the intervening ten years.

(2) The table constructed for the purpose of the National Insurance Act based on the estimated population at June 30th, 1909, and the deaths for the years 1908-9-10.

(3) The life table for London based on the two censuses 1901 and 1911, and the deaths for the intervening period.

(4) A Liverpool life table based on the population and deaths in Liverpool for the year 1911. (See Appendix, Schedules G and H.)

(5) A life table on the basis of the population and deaths in 1911 in England and Wales. (See Appendix, Schedules E and F.)

The last-mentioned table and the Liverpool table I constructed for the purposes of the Chadwick lectures by the method to which I have already referred.