On some statistical indications of a relationship between scarlatina, puerperal fever, and certain other diseases / by G.B. Longstaff.

With the Author's

Compliments

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ON SOME STATISTICAL INDICATIONS OF A RELATIONSHIP BETWEEN SCARLATINA, PUERPERAL FEVER, AND CERTAIN OTHER DISEASES.

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About a year and a half ago the idea occurred to me that by plotting out by the graphic method the annually varying death-rates from various causes in England and Wales, as given by Dr. Farr, in the Registrar-General's Annual Reports, interesting results might be obtained, more especially as the resulting curves would allow of easy comparison. It must be well known to all present that results which can only be arrived at with much labour, and some uncertainty, by the study of long columns of figures, become at once obvious when the same figures are reduced to diagrams. The object of my investigations has been, not so much to ascertain the fluctuations in the fatality of the several diseases, interesting as these may be in themselves, but rather, by the careful comparison of the curves, to see whether any, and if so what, relations subsist between diseases believed to be distinct, with a view to correcting, if needs be, the methods of classification now in use, but chiefly to search for ætiological clues.

I have accordingly traced eighty-nine curves, representing the death-rates per million in England and Wales from as many "alleged causes"; the figures being obtained from a table in the "letter of Dr. Farr to the Register-General" at the end of the annual report. In my smaller diagrams, of which I have a specimen here, the facts are represented for the twenty-nine years 1850–78 inclusive. By a simple application of the law of combinations, it will be found that to compare all these eighty-nine curves, two and two together, would involve 3,916 operations. Of these I have as yet only actually made 1,425, leaving still no fewer than 2,491 to be performed. However, as the zymotic diseases have been compared with nearly all the others, there is

reason to believe that the most important results have been obtained already, and that the remainder of the work will be less fruitful.

I should remark, that several of the causes of death have not been examined at all, since the numbers are so very small, that they could not, by any possibility, yield trustworthy results.

It is my intention this evening to put before you, very shortly, certain of the indications of the above 1,425 comparisons. A variety of circumstances have interfered with my work, more especially the great time required for the construction of these enlarged diagrams; so that I must ask you to consider this as a preliminary paper, which may, or may not, be followed by others, according, on the one hand, as you may be disposed to hear more from me on the subject; and on the other, according as further work may lead to results of importance, or the reverse.

At a very early stage, the close relationships of the curves of diphtheria and croup caught my attention, and soon after the practical identity of the curves of puerperal fever and erysipelas. More recently, I observed that the disease curves may be divided into four groups at least, viz.,—I. The diarrhœal group, characterised by having the greatest mortality during the summer quarter, and by being most fatal in years with hot and dry summers. II. The bronchitic group, characterised by having the greatest mortality during the winter months, and being most fatal in years with very cold winters. III. The scarlatinal group, under consideration to-night. IV. A provisional group, comprising all the other diseases which do not appear, so far as we know at present, to be greatly influenced, or at all events mainly regulated, by any meteorological conditions. Among these may be mentioned small-pox, measles, whooping-cough, phthisis, and (probably) enteric fever.

Remember, that this classification is provisional, and is only drawn up to facilitate the examination of the death-returns of the United Kingdom. Thus, for instance, I know full well that whooping-cough is most fatal in the early months of the year, and that if whooping-cough breaks out during cold weather, it is more likely to be fatal than under the reverse conditions; but what I do assert is, that taking a long term of years, and the whole kingdom into account, the mortality from whooping-cough does not vary directly with the coldness of the winters, as that of bronchitis or pneumonia does.

Since 1855, the Registrar-General has given, in the form of a supplementary table, the deaths in England and Wales in each year, classified under very many more heads than are shown in the other tables. To insure the greatest accuracy attainable, I have abandoned my first charts, and am now working from the "supplementary tables", the labour of calculating the rates being reduced to a minimum by the aid of M. Thomas's Arithmometer—a most useful machine. I soon found it impracticable to draw all the curves to one vertical scale, and finally decided on the method employed by Messrs. Buchan and Mitchell,* viz., of finding the mean for each disease, and plotting out the annual death-rate at so much per cent. in excess or defect of this mean. This entails, of course, additional calculations; but the results obtained are strictly comparable, and enable us to note with ease such facts as that two diseases are affected in the same manner by hot summers, but the one threefold as much as the other: so that it is, perhaps, allowable to infer that, in the former, summer heat is a main cause of the disease; while, in the latter, it is but one of many contributory causes. By employing in all cases death-rates per thousand living in each year (or per million, as is more convenient when the death-rate from a single disease is under consideration), all fallacies due to increase of population are avoided.

The larger diagram accompanying this paper shows certain curves constructed in the manner above described, and grouped together in order to bring out as clearly as may be the points to which I wish to draw your attention. The vertical columns divide the curves into twenty-four portions, corresponding to the twenty-four years, 1855-78. The horizontal portions of the coloured lines mark the height above or below the mean of the death-rate in question in each year—on one scale throughout, each small division corresponding to 10 per cent. The horizontal lines are connected by sloping lines, to give continuity to the curve, and to facilitate comparisons.

The mean of each disease is indicated by a dotted line of corresponding colour; the figure at the right hand showing what is the mean death-rate per million living in England and Wales; while the names of the diseases are given on the left hand in corresponding colours, viz., pyæmia, puerperal fever, erysipelas, "rheumatism, with disease of heart or pericardium", scarlatina, laryngitis, quinsy, croup, diphtheria, and cynanche maligna.

* Journal of the Scottish Meteorological Society, 1874, p. 187.

It will be seen that the curve of scarlatina presents four marked elevations, or periods of epidemic fatality, separated by three equally well marked depressions, or periods of minimum fatality. In the most fatal year (1863), the deaths from scarlatina exceeded the mean by 73 per cent.; whereas, in the least fatal year (1861), they fell to 47 per cent. below the mean.

These four periods of epidemic fatality are, to some greater or less extent, apparent in all the ten curves, the fluctuations varying more in degree than in direction.

In the curves of puerperal fever, erysipelas, pyæmia, and "rheumatism accompanied with heart affection", the fourth or last epidemic period, 1874-5, is the most marked; whereas, in the curves of cynanche maligna, diphtheria, and quinsy, the first epidemic period is far the most prominent.

The second epidemic period is most distinct in scarlatina, croup, and diphtheria; the third in scarlatina and "rheumatism with heart affection", being but faintly indicated in most of the other curves.

Cynanche maligna and quinsy would not be sufficiently important causes of death (only averaging 17 and 14 per 1,000,000 respectively), were it not for their very interesting relations to diphtheria.

Previously to 1855, but few deaths from diphtheria were registered in England and Wales, and they were not kept separate in Dr. Farr's analysis of the Registrar's returns.

In 1856, the total number of deaths registered in England and Wales, as due to diphtheria, increased from 186 to 229—not by any means a striking rise—but in the same year the deaths attributed to quinsy rose from 371 to 413; whereas those assigned to cynanche maligna rose from 199 to 374, a very notable increase. In 1857, the diphtheria deaths rose further, from 229 to 310; those attributed to quinsy from 413 to 485; but those attributed to cynanche maligna increased suddenly from 374 to 1,273, such a leap up as must have alarmed the few persons who were cognisant of the fact. This may be taken as probably the first indication of the coming outburst of what was long spoken of as "the new disease, diphtheria", though, probably, in reality, but an old foe under a new name.

In 1858, practitioners began to be more alive to the real facts of the case; and although the deaths attributed to quinsy and cynanche maligna showed still further increments, viz., from 485 to 623 in one case, and from 1,273 to 1,770 in the other, the deaths more correctly assigned to

diphtheria rose with alarming suddenness from 310 to 4,836. In 1859, the great stir created by the letters in the public and medical Press, drew the attention of all observers to "the new disease", and, accordingly, we see that in that year the curves of quinsy and cynanche maligna began to fall more rapidly even than they rose; and, with the exception of the period of the recrudescence of the diphtheria epidemic in 1863, have continued to fall, till those diseases now have a very insignificant place in the list, and only account for 216 and 179 deaths respectively, on the average of the last five years.

But, meanwhile, diphtheria rose, in 1859, from 4,836 to 9,587. The epidemic may be said to have lasted with diminished, but varying fatality, till 1865. During the last five years, the deaths have averaged 3,092, or about one-sixth of the number that have been slain by scarlatina. It must be borne in mind, however, that the disease is far more prevalent in the United States, in Germany, and more especially just now, in Russia, than it is with us.

The croup curve seems to have been affected in like manner, but in the earlier years to a less extent, by the epidemic of diphtheria. Since 1861, the curves of croup and of diphtheria have been so very similar, as to suggest that at the very least there is great confusion in the diagnosis of the two diseases, and even to be a weighty argument in favour of those pathologists who maintain their identity.

Pyæmia has no place in the Registrar-General's reports prior to 1862, and there can be little doubt but that the steady rise from that year must be attributed to changes of nomenclature; for if not, what is to be said for our boasted improvements in operative surgery and hospital hygiene? In spite of this steady rise, its resemblance to the curves of erysipelas and puerperal fever is strikingly suggestive.

You have, probably, already observed that the curves of erysipelas and puerperal fever are, practically, identical, with the exception that the increased fatality of puerperal fever in 1874-5, was about twice as great as that of erysipelas. I confess that I find it difficult to avoid the conclusion that they are both due to one poison.

Though the puerperal fever curve has great points of resemblance to the scarlatina curve, it is far more like that of erysipelas; it is also extremely like that of "rheumatism with disease of heart or pericardium". So that we may infer some close relationship to rheumatic fever—a point that I must reserve for further investigation, but may merely remark that the erysipelas curve is still more like the rheumatism curve.

I have here a small diagram*, which attempts to represent the mutual relationships of the various diseases in the large diagram—the distances between the circles being supposed proportional to the closeness of relationship.

Dr. Thos. C. Minor, of Cincinnati, U.S.A., writing, in 1874, on "Erysipelas and Child-Bed Fever",† says, in reference to the deaths from these two diseases in the United States in 1870:—

"1. Erysipelas and child-bed fever seemed to prevail together throughout all the States. 2. Any marked increase, in any one locality, of one disease, was apparently accompanied by a corresponding increase of the other. 3. Where histories of past epidemics, of either disease, were obtainable from any of the States, the apparent connection of the two diseases was noticed by physicians at the time of such epidemics, and remarked on. 4. This relationship indicates that there is an intimate connection existing between child-bed fever and erysipelas, and justifies the inference that in any place where erysipelas is found, there will be found child-bed fever."

Again, referring to an epidemic of child-bed fever in Cincinnati, Dr. Minor says:—

"1. The two diseases, child-bed fever and erysipelas, prevailed at the same time, in the same localities. 2. Where an isolated death from child-bed fever was noted outside of the infected districts, a corresponding death from erysipelas was noted in the same locality. This was almost invariably the case. 3. Infants die of erysipelas shortly after or before their parents die of child-bed fever. 4. A few physicians attending child-bed fever cases and erysipelas cases at the same time, as exhibited by the death-register, were the most unfortunate in their practice. 5. Physicians having large obstetric practices, but who were known to be believers in the close connection of child-bed fever and erysipelas, returned few death certificates from either causes."

Again, on examining the alleged connection of typhus fever and scarlatina with child-bed fever, Dr. Minor found that:—

"1. Epidemic typhus is not always associated with an outbreak of epidemic child-bed fever, or *vice versâ*. 2. Epidemic scarlet fever is very seldom associated with an outbreak of epidemic child-bed fever, or *vice versâ*. 3. Epidemic erysipelas is invariably associated with an outbreak of child-bed fever, or *vice versâ*."

* The diagram referred to has not been engraved for the Transactions.

† *Practitioner*, August 1875.

I am at present engaged in examining the relations between the death-rates from puerperal fever and erysipelas, in the eleven registration divisions of England and Wales. This small unfinished chart* shows the curves of six of the registration divisions—which shows that in all cases the two curves are very similar. A relationship which holds true in the several parts of the country, as well as in the entire area, can scarcely be fortuitous. Not only do the fluctuations of the curves agree, but it will be noticed that in the district in which one disease is very fatal, the other is also unusually fatal, and *vice versâ*.

I will now examine the subject from a different point of view. The smaller diagram is reproduced with modifications of detail from an admirable paper by Messrs. Buchan and Mitchell, in the journal of the Scottish Meteorological Society, by the kind permission of the authors. These gentlemen analysed the weekly mortality returns for London for the thirty years 1845-74, and constructed curves showing the average number of deaths from a number of causes in each successive week of the year. The curves are on such a scale that in every case the same percentage deviation from the mean is represented by the same distance above or below the dotted line indicating the mean average weekly number of deaths. A little reflection will show that the increase of population does not greatly affect the result, except that great epidemics in recent years must disturb the curve more than epidemics of like relative extent in the earlier years. Diphtheria was not separated from scarlatina in the London returns until 1861, so that the great epidemic 1859-60 is merged in the scarlatina line.

The coloured lines in this diagram correspond to one year—that is one *average* year, which is divided by the vertical black lines into 52 weeks. The months are indicated by figures at the top and bottom. For the sake of distinctness the areas representing the excess of mortality above the mean are coloured in. The coloured figures to the right hand indicate the mean average number of deaths from each cause in every week in London, and the distance of the continuous coloured line above or below the mean indicates the percentage deviation from that number, one small division of the vertical scale corresponding to ten per cent.

It must be premised that "laryngitis" in this diagram comprises laryngismus stridulus and œdema glottidis (the latter of small account), which have been excluded in the

* The diagram referred to has not been engraved for the Transactions.

construction of the larger chart; also, "rheumatism" includes all cases returned under that heading—presumably many of them chronic joint affections, whereas these cases, along with many others, are excluded in the larger diagram. "Rheumatism, with disease of heart or pericardium", may be fairly regarded as comprising few cases other than acute rheumatism, though of course not including by any means all the deaths due to rheumatic fever.

The colours on the two charts otherwise correspond. Now, in certain respects, all the eight curves resemble one another. All the curves are above the mean from the last week in November to the first week in January inclusive, and they are all below the mean from the first week in June to the second week in August inclusive.

There are grounds for believing that if the deaths from laryngismus stridulus could be separated from laryngitis deaths the curve would be somewhat modified, so as to approach more nearly that of croup. As it is, this curve resembles more closely that of bronchitis than my examination of the annually fluctuating death-rates from these two causes would have led me to expect. Messrs. Buchan and Mitchell state that the sudden depression of the curve in January is almost constant from year to year. May not this be caused by the deaths from laryngismus stridulus commencing to rise to their maximum at this point, as the curves of epilepsy and convulsions do?

Omitting for a moment scarlatina from consideration, and dismissing laryngitis as unsatisfactory, we have remaining six curves having a very striking resemblance one to another, which is more especially remarked in the case of erysipelas and puerperal fever. The scarlatina curve, if shifted about five weeks further on, would be not unlike the other curves. It is conceivable that similar causes may tend to the production of scarlatina first, and later on to the other affections—somewhat as a change of type is frequently observed during the course of an epidemic, notably in cholera.

It should be added, that all of these curves have been modified from those published in the memoir referred to by the use of what is known as "Bloxam's method", whereby, instead of taking the average number of deaths in each particular week, the mean of the average of that week, the week preceeding, and the week following is taken. The method is very useful when the number of deaths, or the number of years is too small to give a smooth curve; inequalities produced in accordance with the law of proba-

bilities are removed, and a close approximation is obtained of the curve that would result from the plotting out of a large number of deaths for a longer term of years.

You will naturally ask, "Is there any peculiarity of season or otherwise which determines or has a share in determining the fatality of this group of diseases in certain years?" As the curves as a rule rise in the autumn and remain high throughout the winter, one is naturally led to suspect that a very hot summer, or a very hard winter, is the determining cause. So far as I have been able to investigate the point, it does not appear that the heat of summer or the cold of winter varies either in a direct or inverse relation to the fatality of these diseases. But when the amount of rain is examined from this point of view, it appears that there is some kind of inverse relationship between the two. The same result is obtained whether the amount of the fall or the number of days on which it falls is considered, the connection being somewhat closer in the latter case.

I have calculated the percentage variation from the mean of both the rainfall and the number of rainy days, and added the two together.

The result is shown at the top of the larger diagram, by the blue area, the ordinates being measured from the top downwards, so that the curve formed by the line limiting the blue area is placed upside down, and the inverse relation appears as a direct relation, and is thus much more easily realised. (Dr. Buchanan's method.)

This relationship is nearly as close as that which subsists between diarrhœa and hot summers on the one hand, or bronchitis and cold winters on the other; and it is strikingly suggestive. How the rainfall influences the fatality of these diseases (we do not know how far it may be related to their prevalence) is another question. Assuming the connection to be real, it seems most natural to suppose that the frequent fall of rain purifies the air, and removes from it the particles of contagious matter; that it acts, to some extent, as the process of inunction in scarlatina is supposed to act, by making the poison less diffusible. Anyhow, the seasonal prevalence of these diseases is not at all obviously related to the rainfall.

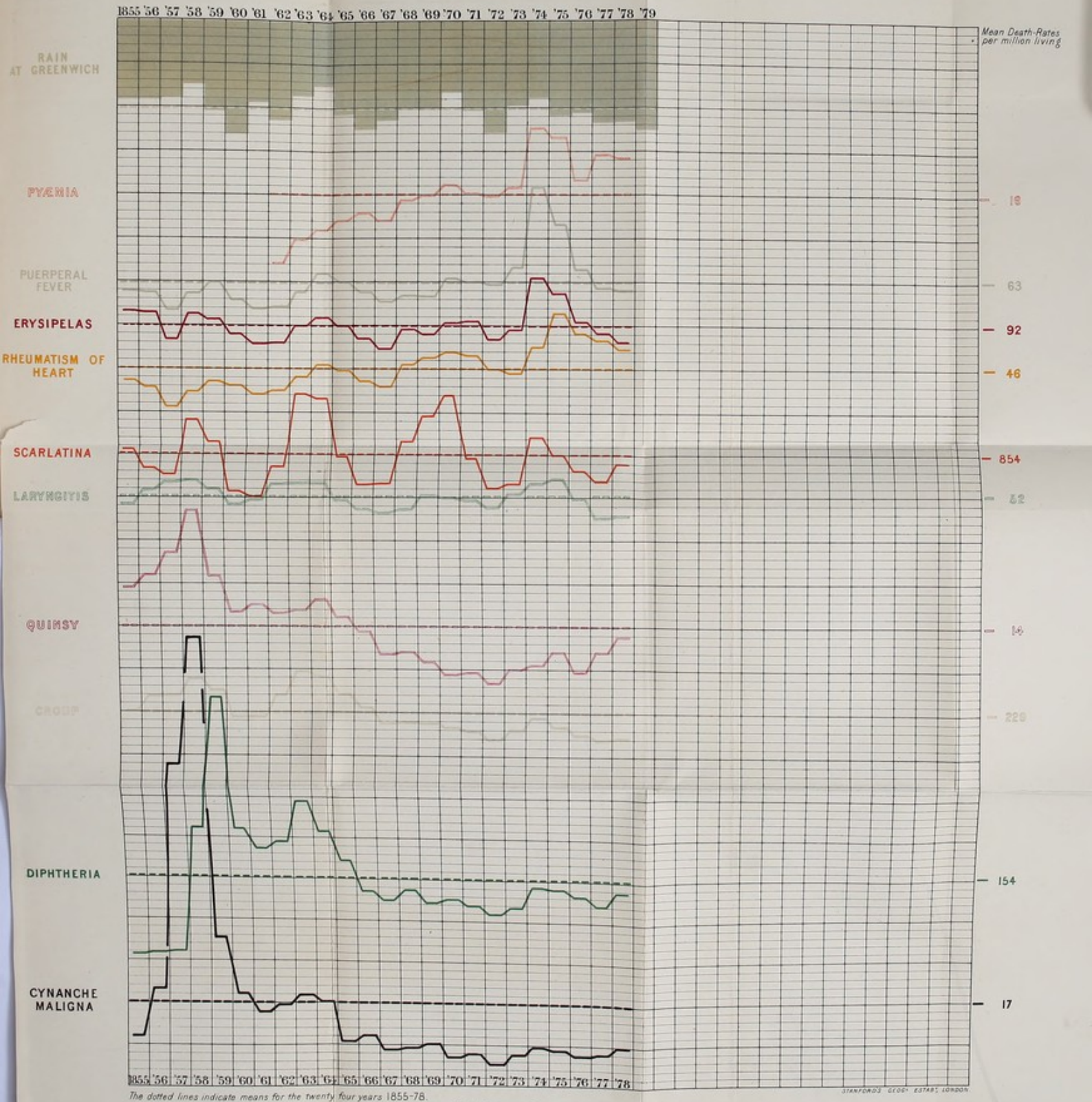
There are many indications, in recent medical writings, of a growing opinion that the process of analysis has been carried too far in our classification of disease; and there can be no doubt that, more especially considered from an ætiological standpoint, such a result is to be deprecated. If great care be not taken, such confusion may be created

as "species making" has caused in zoology and botany. It is important not to lose sight of the possible influence of the individual on the disease that attacks him; further observations on which point are greatly wanted. We may hope for much, too, from increased accuracy in diagnosis, and greater care in filling up death certificates.

ENGLAND AND WALES.

DEATH - RATES FROM ERYSIPELAS, SCARLATINA AND CERTAIN OTHER DISEASES WITH RAIN AT GREENWICH.

ALL AGES AND BOTH SEXES.



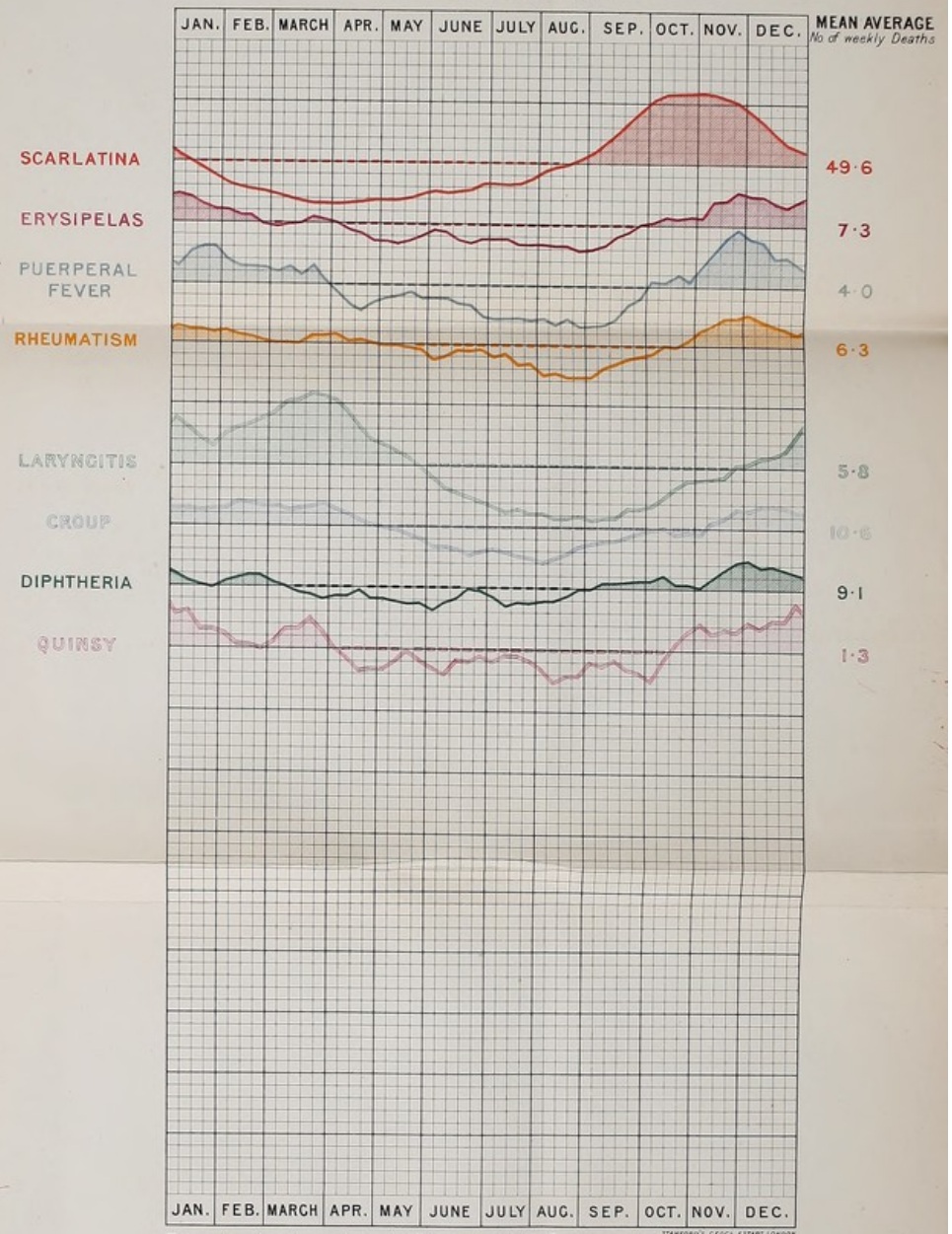
The dotted lines indicate means for the twenty four years 1855-78.
The curves express the fluctuation per cent above or below the Mean. Each division of the vertical scale corresponding to ten per cent.
The figures at the side give the actual values of the Means of the Death-Rates per million persons estimated to be living.

LONDON

WEEKLY DEATHS FROM SCARLATINA & CERTAIN OTHER DISEASES

Excess or Defect per cent. compared with the Mean.

AVERAGE OF 30 YEARS.



The numbers have been adjusted by "Bloxham's Method" previous to the construction of the curves.

Scale. Each small division of the vertical scale corresponds to ten per cent. of excess or defect from the Mean.

STANFORD'S GEOG. ESTAB. LONDON