

SECTION OF STATE MEDICINE.

EARTH TEMPERATURE AND DIARRHOEAL DISEASES IN DUBLIN DURING 1904.

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IN an elaborate report to the Local Government Board for England upon the causation of the annual mortality from "diarrhoea," which is observed principally in the summer season of the year, the late Dr. Edward Ballard in 1887 advanced the proposition that the temperature of the soil is a far more effective element in raising the death-rate from diarrhoeal diseases than any other meteorological factor.¹ He constructed for London and many other towns in the kingdom a large number of charts showing week by week for many years the earth-temperature at a depth of 1 foot from the surface and at a depth of 4 feet also, each chart showing in addition the diarrhoeal mortality of the corresponding weeks. The general result shown by these charts is as follows:—

(a.) The summer rise of diarrhoeal mortality does not commence until the mean temperature recorded by the 4-foot earth thermometer has attained somewhere about 56° F., no matter what may have been the temperature previously attained by the atmosphere or recorded by the 1-foot earth thermometer.

(b.) The maximal diarrhoeal mortality of the year is usually observed in the week in which the temperature

recorded by the 4-foot earth thermometer attains its mean weekly maximum.

(c.) The decline of the diarrhœal mortality coincides with the decline of the temperature recorded by the 4-foot earth thermometer, which temperature *declines* very much more slowly than the atmospheric temperature, or than that recorded by the 1-foot earth thermometer. The epidemic mortality may in consequence continue (although declining) long after the last-mentioned temperatures have fallen greatly, and may extend some way into the fourth quarter of the year.

(d.) The atmospheric temperature and that of the more superficial layers of the soil exert little, if any, influence on the prevalence of diarrhœa until the temperature recorded by the 4-foot earth thermometer has risen to 56° F. Then their influence is apparent, but it is a subsidiary one, notwithstanding the statement made by Dr. August Hirsch that the summer diarrhœa of children makes its appearance as an epidemic only in those districts whose average temperature for the day in the warm season is rather more than 15° C. (59° F.).

Dr. Ballard believed that a working hypothesis, or provisional explanation, that would best accord with the whole evidence then in his possession bearing on the production of epidemic diarrhœa, may be stated as follows:—

1. The essential cause of diarrhœa resides ordinarily in the superficial layers of the earth, where it is intimately associated with the life processes of some micro-organism not yet detected, captured, or isolated.

2. The vital manifestations of such organism are dependent, among other things, perhaps principally, upon conditions of season and on the presence of dead organic matter which is its pabulum.

3. On occasion, such micro-organism is capable of getting abroad from its primary habitat, the earth, and having become air-borne obtains opportunity for fastening on non-living organic material, and of using such organic material both as nidus and as pabulum in undergoing various phases of its life-history.

4. In food, inside of as well as outside of the human body, such micro-organism finds, especially at certain seasons, nidus and pabulum convenient for its development, multiplication, or evolution.

5. From food, as also from the contained organic matter of particular soils, such micro-organism can manufacture, by the chemical changes wrought therein through certain of its life processes, a substance which is a *virulent chemical poison*.

6. This chemical substance is, in the human body, the material cause of epidemic diarrhœa.

To the foregoing we have only to add Dr. Meinert's words: "The poison, or a combination of poisons, appears to work upon the medulla oblongata, for there lies the centre for intestinal secretion, vomitings, convulsions, respiratory and vaso-motor phenomena." This is a quotation from an article on "Cholera Infantum" by Dr. E. Meinert, of Dresden, which appeared in the *Medical Annual* for 1893. In that article Meinert fully accepts Ballard's views, especially his statement that *density of buildings*, whether dwellinghouses or otherwise, upon area—quite apart from *density of population* upon area—promotes diarrhœal mortality to a remarkable degree, particularly because crowding together of buildings of whatever sort restricts and offers an impediment to the free circulation of air.

On January 1, 1904, through the liberality of the Provost and Senior Fellows of Trinity College, a Normal

Climatological Station was established within the precincts of the University of Dublin. The station, which is under the supervision of Professor W. E. Thrift, M.A., F.T.C.D., occupies an open space in the Fellows' Garden, Trinity College, and is fully equipped. At the suggestion of Dr. William Napier Shaw, F.R.S., Secretary of the Meteorological Office, London, the equipment included two earth thermometers. One of these has its bulb at a depth of 12 inches (1 ft. earth thermometer) below the surface of the ground. The bulb of the other is sunk in a metal tube to a depth of 4 feet.

So far, of course, the observations for only one year—1904—are available for discussion. Nevertheless, I thought that the State Medicine Section of the Royal Academy of Medicine in Ireland would be interested in the attempt to test the accuracy of Ballard's theory by a comparison of the death-curve of diarrhœal diseases in the Dublin Registration Area during the summer and autumn of 1904 with the earth temperature records in Trinity College—the site of the Observatory being in the very centre of the Metropolitan District.

The observer, my son, Arthur Robert Moore, B.A., has thrown the figures into two diagrams. The first of these (Diagram I.) gives three temperature curves for each day of the three months, July to September, 1904. The continuous black line is that of the air temperature at 4 feet *above* the ground recorded in a Stevenson's screen at 9 a.m. daily. The upper green line shows the earth-temperature at 9 a.m. each day at a depth of one foot *below* the surface of the ground; the lower blue line similarly gives the earth-temperature four feet below the surface. At the base of the diagram will be seen in red the number of deaths from "diarrhœal diseases" registered week by week in the Dublin Registration District.

Diagram II. contains two weekly curves for the whole year 1904. The upper of these represents the weekly march of underground temperature at a depth of four feet. The lower red curve gives the number of deaths from diarrhoeal diseases registered in each week of 1904 in the Dublin Registration Area.

In both diagrams especially heavy rainfalls have been entered, and in the epidemic season weekly measurements of an inch or upwards on two occasions seem to have been closely followed by a decline in the number of deaths from diarrhoeal diseases. Thus in the week ended September 3, the rainfall amounted to one inch (.999 inch); a fortnight later the weekly diarrhoeal deaths fell from 26 to 14. Again, in the week ended September 17, the rainfall exceeded an inch and a quarter (1.285 inches); a fortnight later the weekly diarrhoeal deaths fell from 28 to 16.

Reference to the curves in Diagram II. shows that diarrhoeal mortality in the Dublin District in 1904 was trifling till the week ended August 6—that is, the third week after the subsoil temperature at 4 feet had passed above 56° F. The mortality rapidly increased till the week ended August 27, in which 35 deaths from diarrhoeal diseases were registered, or about 10 per cent. of all the deaths from those diseases in the whole year 1904. This maximum of mortality followed the maximum of warmth of the soil at 4 feet (58.5°) by an interval of just a fortnight. Such a coincidence is remarkable. Diarrhoea kills very young children quickly—usually within a week. Then, allowing a few days for delay in registration, we come to the close of the second week.

Diagram II. also shows that the 4-foot thermometer stood at 56° or upwards from the 10th of July to the 24th of September—a period of eleven weeks. Starting a

similar period of eleven weeks a fortnight later (to allow time for the malady to attack and kill and for registration of the resulting deaths), we find that in the eleven weeks beginning July 24 and ending October 8, the diarrhœal deaths were 249, or 71.7 per cent. of the total deaths from diarrhœal diseases registered in 1904, 339 in number. Of these, only 18 were registered in the first quarter of the year, only 10 in the second, 243 in the third, and 68 in the fourth quarter. In his Quarterly Summary of the weekly returns of births and deaths in the Dublin Registration Area, under date October 1, 1904, the Registrar General observes:—"The deaths from diarrhœal diseases form a feature of the mortality statistics, this being a usual coincidence at the period of the year included in this report (July 3 to October 1, 1904, inclusive). The total number of deaths assigned to above causes was 243—namely, 104 deaths from epidemic diarrhœa, epidemic enteritis, and 139 deaths from '*diarrhœa dysentery*.' The total equals a rate of 2.6 per 1,000 of the population (estimated) of the Dublin Registration Area, and exceeds the average for the corresponding quarter of the past 10 years by 33 deaths. Of the total deaths, 204, equal to an annual rate of 2.8 per 1,000, appertained to City Districts, and 38, equal to an annual rate of 1.8 per 1,000, appertained to the Urban Districts which, with the City, constitute the Dublin Registration Area." The mean of the readings of the 4-foot earth thermometer in these thirteen weeks ending October 1, 1904, was 57.0°—a remarkable coincidence, to say the least, this figure being one degree above the "critical" temperature at 56° F. In my opinion, "Diarrhœal Diseases" should be "notifiable" from July 1 to September 30 in each year, so as to give even more timely warning of an epidemic tendency.

Dr. Edward W. Hope, Medical Officer of Health for Liverpool, some years ago investigated the influence of the mode of feeding of young infants on the prevalence and fatality of diarrhœa, and came to the conclusion that infants fed solely from the breast are notably exempt from fatal diarrhœa, whereas infants fed with artificial food to the exclusion of breast milk suffer most severely from his dread disease. In relation to this Dr. Ballard's observations go to show that the direct or indirect exposure of food to telluric emanations tends to render it liable to produce diarrhœa, particularly when the storing place is dark and ill-ventilated.

According to Flexner the bacillus of dysentery can be isolated from the intestinal discharges and the intestinal mucosa of a large percentage of children suffering from the diarrhœal diseases prevalent along the Atlantic seaboard of the United States of America in summer. The type of bacillus most commonly found is that known as the Flexner-Harris. The Shiga type is exceptionally met with, and both types may occur in association.² There is some reason to believe that the dysentery bacillus may be found among the saprophytic intestinal bacteria. So long ago as 1890, Weichselbaum (Wien. klin. Wochenschrift, 1890, Vol. III., page 187) isolated the *Diplococcus pneumoniæ* in a case of membranous enteritis. It will be well in future for this organism to be sought for in the stools of "summer diarrhœa."

¹ *Supplement in continuation of the Report of the Medical Officer for 1887. Annual Report of the Local Government Board, 1887-88. London: Eyre & Spottiswoode. 1889. Quarto. P. 1, et seq.*

² Recent Investigations concerning the Pathology of the Infectious Diseases. By Aldred Scott Warthin, Ph.D., M.D., Professor of Pathology, University of Michigan. International Clinics. Vol. IV. Fourteenth Series. 1905. Page 238.

DR. KIRKPATRICK said that the chief interest and value of the observations was to give an indication of the onset of these attacks of summer diarrhoea in children to the authorities, who could then take precautionary measures, and give timely warning of its approach. This was possible, owing to the interval which elapsed between the rise of the earth-temperature to the critical line of 56° and the incidence of the diarrhoea. He did not think there was sufficient evidence to show that the rise of the temperature to the critical line and the summer diarrhoea were connected casually. It was more probable that the earth-temperature reached a certain height only during conditions when epidemic diarrhoea was liable to arise also, and there was probably an organism which could develop when the earth-temperature had been a sufficient height for a certain length of time. This was borne out by the fact that the mortality from summer diarrhoea was much less amongst breast-fed than bottle-fed children, and everyone knew the difficulty of giving bottle-fed children even moderately sterile food. There could be no doubt that this epidemic diarrhoea was started by the introduction of poisonous food into children, and it was probably caused by organisms capable of producing decomposition in food stuffs, and not by any specific bacillus. He hoped that active measures would be taken next year to prevent the onset of summer diarrhoea and warning given in time to take due precautions.

DR. CRAIG was sure that Sir John Moore did not mean to convey that the earth-temperature alone caused this epidemic diarrhoea. It was well recognised that this very fatal affection was due to micro-organisms. He thought that the heightened temperature tended to increase putrefaction, and that flies had a great deal to do with carrying the infection. People who were careful with regard to their food were rarely affected with summer diarrhoea. He thought that children used often to be affected through the state of the bottles themselves.

DR. M'VITTIE said he would like to have an explanation of the statement that diarrhoeal diseases were more markedly on the increase in those districts where the houses were closely built than where there was an excess of population. This would indicate that the earth-temperature could not be the main factor, because a large portion of earth covered by closely-built houses could not rise to the same temperature as places where there

was a lot of open space between the houses. Closely-built houses maintained a more equable earth-temperature in summer and winter. Therefore there must be a number of other factors in the causation of these diseases, such as increase of fruit supply, &c. Another factor was that young people in cities became exhausted at that time of year, and their capacities for mastering those diseases were lowered. Small children played much in the sun, got into heats, and then got chilled.

DR. LANGFORD SYMES thought that those who suggested that there was a multiple series of factors producing those diseases held the correct view. These diseases seemed to destroy more children than adults, and, perhaps, a milk diet accounted for that. We seemed to be more exempt from them in Ireland than in other places, such as New York, where the infant death-rate was much higher. The climate here seemed to minimise them, there being no great difference between the summer and winter temperatures in Dublin. The earth-temperature certainly seemed to have a great deal to do with the development of the organisms which caused the diseases and predicts their onset. As to food, it was found by Holt that this factor greatly influenced their onset amongst infants. The ground had recently been gone over again in America by bacteriologists, and they had come to the conclusion that not only the earth-temperature, but also food, had a good deal to say to their causation. Again, Holt had noticed in his series seven cases of breast-fed infants who had also got water from the tap without boiling, and the seven had died; therefore the diseases might be water borne. Another factor was sanitation, and indeed these diseases used to be taken as a sanitary index. With regard to infection, light had been recently thrown on this question by Shiga in Japan, who had found a bacillus which gave the Widal and Pfeiffer reactions with blood serum, and which he considered to be the specific bacillus of the diseases. It was called the *Bacillus dysenteriae* of Shiga. Besides this bacillus there was also the Flexner-Harris type, which was found principally in the mucous portions of the stools, and in scrapings from the mucosa after death. An acid medium was necessary for their growth, and we know that many children's foods developed acidity, which might account for their ready growth. A serum had been made from horses, and injected in these cases, but it

had not proved to have much value. He thought that Dr. Craig had struck a good note in referring to flies, insects, &c., as a means of conveying serious infection.

DR. MATSON asked Sir John Moore if he thought that the nature of the ground had anything to do with those diseases. He himself, whilst in a London hospital, had seen a severe epidemic, and had gone from that to Hampshire, where a similar epidemic occurred. The soils in the two places were very different. The following year, whilst in Las Palmas, where the temperature was 80° to 85°, he asked a doctor there what his experience of those diseases was. He told him that he had never seen them in children nursed by their mothers, whilst there was a considerable amount of fatal diarrhoea amongst older children who were liable to infection from fruit, garbage, &c.

DR. WINTER said that Sir John spoke of a heavy rainfall seeming to have been followed by a decline in the death-rate. While in England, twelve years ago, he himself had had occasion to examine the reports on the Tees Valley epidemic of enteric fever, and a heavy rainfall there was followed by a great increase in the number of cases. If these two facts were correct, he would say that enteric was water borne, and these diarrhoeal diseases were not water borne, but were carried through the air, contaminating the food.

DR. NINIAN FALKINER said he would like to call attention to the nomenclature of these so-called diarrhoeal diseases. Some years ago statisticians found a number of cases returned as gastro-enteritis, enteritis, and muco-enteritis, and it soon became evident that these terms were loosely used. A special committee was appointed, the net result of whose labours was that these three divisions were all placed amongst the local diseases of the digestive system.

SIR JOHN MOORE, in replying to Dr. Kirkpatrick, said that last year the observations had actually been used to give warning of the onset of diarrhoeal diseases. He had been careful in his paper not to commit himself to the view that the earth-temperature was the absolute cause of these diseases, but he said there was a remarkable coincidence. He agreed that various organisms might cause the diarrhoea. A very interesting point was that the symptoms were referable to poisoning of the centres in the medulla oblongata. He also agreed with Dr. Craig as to the mischief

caused by flies, and thought that this was very far-reaching. He believed that small-pox infection had often been carried by them. He could not quite agree with Dr. M'Vittie that the mere placing of houses over the soil would very materially interfere with the rise of the subsoil temperature. With regard to Dr. Symes' observations, he said that everyone agreed that food was of extreme importance. As to the nature of the soil it was certain that clayey soil always warmed up more slowly than gravel or sand, so that diarrhoeal diseases might be expected earlier in the latter case. With regard to what Dr. Winter had said, he thought that the mortality had been checked last year by heavy rains, this fact telling in favour of contamination by dust or flies.