Caustation of
Epidemic Diarrhoea.

by

W. Riach,
MB (Edin. 1894)
B.P.H (Edin. + Glasg. 1898)

12 Stileing Terrace,
Brighton.
The Causation of Epidemic Diarrhoea.

Introduction.

No one can gainsay the extreme importance of this subject as viewed by the place which diarrhoea take amongst the fatal + disabling diseases.

From the following figures it will be seen that diarrhoea mortality is greater than the mortality from any other of the symptomatic + that in deaths from any cause whatever it stands third, coupled with "other tubercular diseases." The figures are obtained by the decennial supplement of the Registrar-General, + extend over a period of 35 years, the death-rate being stated in terms of per million population.

Under the heading of "all respiratory diseases" are included all forms of pneumonia, bronchitis, pleurisy &c, +
under diarrhoea, + dysentery are included: true dysentery however is now a disease unknown in this country, + there has been little cholera since 1866.

In England + Wales, death-rate per million pop, from all causes + from several diseases from 1861-95:

<table>
<thead>
<tr>
<th>Years</th>
<th>All causes</th>
<th>All Respiratory Disease</th>
<th>Pneumonia</th>
<th>Other Respiratory Diseases</th>
<th>Diarrhoea</th>
<th>Scarlet Fever</th>
<th>Scurvy</th>
<th>Rheumatic Fever</th>
<th>Influenza</th>
<th>Congestion</th>
<th>Malaria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1861-70</td>
<td>22,416</td>
<td>3,591</td>
<td>2,475</td>
<td>765</td>
<td>1,076</td>
<td>972</td>
<td>885</td>
<td>527</td>
<td>440</td>
<td>1,378</td>
<td></td>
</tr>
<tr>
<td>1871-80</td>
<td>21,272</td>
<td>3,899</td>
<td>2,116</td>
<td>747</td>
<td>935</td>
<td>716</td>
<td>482</td>
<td>512</td>
<td>378</td>
<td>1,235</td>
<td></td>
</tr>
<tr>
<td>1881-90</td>
<td>19,080</td>
<td>3,729</td>
<td>1,724</td>
<td>696</td>
<td>674</td>
<td>334</td>
<td>235</td>
<td>450</td>
<td>440</td>
<td>1,235</td>
<td></td>
</tr>
<tr>
<td>1891-95</td>
<td>18,737</td>
<td>?</td>
<td>1,464</td>
<td>660</td>
<td>652</td>
<td>182</td>
<td>185</td>
<td>392</td>
<td>408</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The next tabular statement shows, in 1,000 deaths, what proportion of them are due to
(1) "all respiratory diseases" (2) 'diarrhoea'
(3) Scarlet fever.

<table>
<thead>
<tr>
<th>Period of Years</th>
<th>All respir. diseases</th>
<th>Diarrhoea</th>
<th>Scarlet Fever</th>
</tr>
</thead>
<tbody>
<tr>
<td>1861-70</td>
<td>160.0</td>
<td>48.0</td>
<td>43.4</td>
</tr>
<tr>
<td>1871-80</td>
<td>184.0</td>
<td>44.0</td>
<td>33.5</td>
</tr>
<tr>
<td>1881-90</td>
<td>195.0</td>
<td>35.3</td>
<td>17.5</td>
</tr>
<tr>
<td>1891-95</td>
<td>?</td>
<td>35.0</td>
<td>9.7</td>
</tr>
</tbody>
</table>

We thus see that in England + Wales
48 out of every 1000 deaths (recorded from all causes) were due to 'diarrhoea' in the decennium 1861-70; 44 in 1871-80; 35.3 in 1881-1890; and in the quinquennium from 1891-1895, 35 deaths out of every 1000 were due to 'diarrhoea'.

The comparison between the mortality from 'diarrhoea' and scarlet fever is especially interesting. In the decennium 1861-70, diarrhoea and scarlet fever were almost equally fatal; in the following decades, the mortality from scarlet fever very rapidly decreased, so that in the years from 1891-95 (inclusive) 'diarrhoea' was responsible for nearly 4 times as many deaths as scarletina.

For the same period (91-95) deaths from diarrhoea were 4 times as numerous as those from 'fever' (typhoid, typhus and continued fever), and 1/2 as many again as those from measles and whooping-cough. The deadly nature of the disease returned as 'diarrhoea' in the Registrar-General's reports is therefore very apparent.
Nomenclature. The name recommended by the Royal College of Physicians of England in their 'Nomenclature of Diseases' is 'Epidemic Diarrhoea'. The old name of Summer Diarrhoea is now discarded. Most commonly, simply 'diarrhoea' is returned as the cause of death; other terms are also used, such as 'choleraic diarrhoea', 'English cholera', 'cholera nostras', 'infantile cholera', 'dysenteric diarrhoea' etc.

It is highly probable also that many deaths, returned as 'infantile debility', 'marasmus', 'want of breast milk' and 'vomiting', especially those occurring in the epidemic season, should have registered as due to 'diarrhoea'. Dr. Longstaff ('Studies in Statistics'—article on Summer Diarrhoea) has drawn mortality curves for these diseases, and they resemble most closely the mortality curve of 'diarrhoea'.

Again, the Registrar-General under the heading of 'Diarrhoea' does not include
those from 'enteritis', 'gastro-enteritis', 'muco-enteritis', 'gastro-intestinal catarrh', etc., these are registered quite separately. It becomes a debatable question whether they should not be recorded as deaths from 'diarrhoea'. No one can deny that a death recorded as due to enteritis occurring in an infant under one year of age (especially if in the 3rd quarter of the year), and a death recorded as due to diarrhoea, should be placed for statistical purposes under the same heading.

Dr. Louis Paukés (British Medical Journal — May 28th, 1898) has shown that in London there has been a great increase in the number of deaths from enteritis + gastro-enteritis, and that of late years a much larger proportion of these enteritis deaths occur in infants under 1 year of age, as compared with former years.

The following table is taken from his article:
Percentage of Deaths at Three Age Periods to Total Deaths.

<table>
<thead>
<tr>
<th>Years</th>
<th>Diarrhoea + Cholera</th>
<th>Enteritis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>under 1</td>
<td>1 to 5</td>
</tr>
<tr>
<td>1861-65</td>
<td>62</td>
<td>20</td>
</tr>
<tr>
<td>1866-70</td>
<td>68</td>
<td>18</td>
</tr>
<tr>
<td>1871-75</td>
<td>71</td>
<td>17</td>
</tr>
<tr>
<td>1876-80</td>
<td>70</td>
<td>17</td>
</tr>
<tr>
<td>1881-85</td>
<td>76</td>
<td>16</td>
</tr>
<tr>
<td>1886-90</td>
<td>73</td>
<td>16</td>
</tr>
<tr>
<td>1891-95</td>
<td>74</td>
<td>15</td>
</tr>
<tr>
<td>1896-97</td>
<td>79</td>
<td>13</td>
</tr>
</tbody>
</table>

This table shows that whereas 30 years ago only 30 per cent of the enteritis deaths were of infants under 1 year, during the past two years the percentage has been 68, closely approaching the proportions at similar age periods which we find recorded in diarrhoea mortality.

The following figures show how the enteritis deaths have almost trebled themselves of late years:

Death-rate per million pop. in London

<table>
<thead>
<tr>
<th>Period of Years</th>
<th>Diarrhoea and Cholera</th>
<th>Enteritis</th>
<th>Diarrhoea, Cholera and Enteritis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1861 - 1870*</td>
<td>1105</td>
<td>102</td>
<td>1207</td>
</tr>
<tr>
<td>1871 - 1880</td>
<td>987</td>
<td>100</td>
<td>1087</td>
</tr>
<tr>
<td>1881 - 1890</td>
<td>772</td>
<td>115</td>
<td>887</td>
</tr>
<tr>
<td>1891 - 1897</td>
<td>711</td>
<td>291</td>
<td>1002</td>
</tr>
</tbody>
</table>

* The deaths from Asiatic Cholera in 1866 have been excluded.
The only probable explanation for this very rapid increase in enteritis deaths is, that a large proportion of them would formerly have been certified as due to diarrhoea.

The following facts tend to show that the deaths registered as due to enteritis are the result of a disease very similar in character, and perhaps identical with that causing the deaths which are registered as due to diarrhoea:

1. The symptoms and signs of each are similar in character.

2. The greatest mortality occurs in those under 1 year of age.

3. Week by week, the mortality seasonal curves are all but identical.

Assuming that the deaths from these two diseases are similar in character it is at once evident (v. column 3 of last table) that at the present time there is a grave understatement of diarrhoea mortality.

How does this affect comparative statistics for different towns, one of the main lines upon which I propose to
investigate the causation of "epidemic"
diarrhoea? Does it detract greatly from their value, or are deductions gathered from such statistics fallacious?
I think not. I may be assumed that this "fashion" of returning diarrhoea deaths as enteritis is general.
It exists to much the same extent in all the different towns in the country. We thus see that though there is an
undoubted fallacy in comparing the present mortality of a town with the previous mortality in the same
town, yet in comparing statistics of different towns, this fallacy does not hold good.
Still, it is a matter for regret that the Registrar-General in estimating the death rate of a community from diarrhoeal diseases does not take
cognizance of enteritis mortality as well as of that directly registered as due to diarrhoea + dysentery.
"Diarrhoea" — a general disease of specific character.

The fatal malady, most commonly returned in medical certificates of death simply by the term 'diarrhoea', labour under a great disadvantage in being called by what is merely a symptom. In the 'Nomenclature of Diseases' issued by the Royal College of Physicians of London, it is recommended to be called 'epidemic diarrhoea', and this learned body shows its idea of the 'causa causans' of the disease by placing it in the group of diseases, "dependent on Morbid Poisons," in the same sub-group as small-pox, scarlet fever, typhoid, Asiatic cholera &c.

The Registrar-General also shows his appreciation of the disease as a general one of specific character, by including it as one of the chief "symptoms.

Very little justification of this is needed, but I will endeavor to detail a few reasons why 'diarrhoea' should be
designated a general disease, due to a specific morbid poison.

(1) Predromata. Sometimes the illness comes on very suddenly with no premonitory symptoms, but in the great majority of cases the child is noted to be "out of sorts", " fretful", "feverish", "off its feed", "dull", "losing its natural brightness & liveliness" or for some days before actual 'diarrhoea' sets in.

This would seem to indicate that though in a few cases the specific cause of the illness sometimes operates with the suddenness and virulence of a chemical poison, there is usually a period in which the poison seems to be developing in the body, with disturbance of the nervous & vascular systems before the intestinal system is attacked.

(2) Absence, or comparative absence of the symptom (diarrhoea) from which the disease derives its name. It is a matter of frequent occurrence, at the season when epidemic diarrhoea is at
its height, especially for those in dispensary practice, to attend cases which almost certainly are cases of epidemic diarrhoea, but in which the diarrhoea is in no way remarkable, in fact almost absent. The same clinical course is run, but the diarrhoea is not great. After a few days of fretfulness and apparent distaste for the breast or 'bottle', the child begins to vomit its milk; this may become continuous and child rapidly loses flesh, convulsions may come on, child gets pale and collapsed etc., but there is little or no diarrhoea.

(3) There is frequently observed a profound degree of collapse, which is not at all commensurate with the amount of diarrhoea or the number of diarrheal stools.

(4) The occurrence of convulsions, mostly observed late in the illness of fatal cases seems to indicate that some morbid poison has been accumulating in the blood, because of the inability
of the damaged kidney (v. infra) to throw off the poison.

(5) Post-mortem changes. The changes invariably found in the liver and kidney are in my opinion the most important reason (as far as our present knowledge of the disease goes) why diarrhoea should be reckoned among the general diseases due to a specific microbial poison. Dr. Klein (v. J. Ballard's report on diarrhoea to the Local Government Board, 1884, pp. 14) found that the kidneys even when normal to the naked eye, were invariably found to be diseased when examined under the microscope, showing inflammatory and degenerative changes, intense glomerular and parenchymatous nephritis being demonstrated even in cases of very short duration. The condition of the liver varied. It was either congested, or pale and bloodless, the former condition prevailing in the cases of short, and the latter in those of longer duration; but in every case
examined there was one invariable condition, namely, fatty degeneration of the liver cells, slight in cases of short (only a few hours) duration, but pronounced and extensive, or complete in all parts of the organ, when the illness had been protracted. This condition of the liver, as Dr. Ballard truly remarks, reminds one for the moment of the operation of at least one chemical poison — phosphorus.

(6) Occasionally it would seem that ‘chankrea,’ indistinguishable from ordinary ‘epidemic diarrhoea,’ may sometimes be communicated from person to person. Dr. Bruce Low (Appendix F. Report to the L. G. B. 1887) gives details of four different outbreaks in which ‘chankrea’ was undoubtedly of an infective nature. From these accounts it would appear that all that necessary to contract the disease was to be in the same room with an affected person while a motion was being passed or to inhale the offensive odour of such a stool;
Hull. 1876-98 (in text): showing percentage deviation above and below mean.

Rainfall 3rd 2nd

Diarrhoea Death Rate 3rd 2nd

Temperature 3rd 2nd
as a rule within 24 hours a person so exposed was violently attacked with vomiting and purging.

Relation of Diarrhoea Death Rate to Temperature and Rainfall.

The relation of a high mean temperature of the air and deficient rainfall has long been recognised as productive of a high 'diarrhoea' mortality. These charts show this relationship well. They refer to the conditions which have existed in London, Brighton, Bristol and Hull. Each chart covers the period of years from 1876-1898, and the data have been obtained from the returns of the Registrar-General. Each chart shows the percentage above and below the mean of the rainfall, temperature, and diarrhoea death rate for the 3rd quarter of each year during the period stated.
BRISTOL 1876-1898 (v. Text)

Rainfall 3.22

Temperature 3° 2°

Diarrhoea Death Rate 3° 2°
The differences in temperature in different years are not great, and consequently, in order to show up these differences, a much larger scale has been adopted for temperature than for rainfall or death rate. The same scale, however, has been used for each of the four towns: for rainfall, temperature, and diarrhoea death rate, respectively.

The temperature, rainfall, and death rate for each year have been placed in the same vertical line and painted in the same colour, in order to help the eye to study the relationship between, for any one particular year. The charts show that the relation of temperature to diarrhoea mortality is much closer than the relation (inverse) of rainfall to diarrhoea mortality. There is no exception to the rule that a heavy rainfall in the 3rd quarter coupled with a low mean temperature for that quarter is productive of a very low diarrhoea mortality.
Brighton 1870-1894 v. temp

Rainfall 3rd Quarter

Temperature 3.25°

Diarrhoea Death Rate 3.25°
On the other hand, a very high temperature and a very low rainfall do not always produce the excessive mortality we should reasonably expect. E.g. Hull 1884. Here, the mean temperature of the air for the 3rd quarter was the highest recorded for the period of years under examination, and the rainfall was the smallest, yet the diarrhoea death rate was not excessive, being only 26% above the mean.

An excessive death rate is sometimes experienced when the 3rd quarter is not at all hot and the rainfall is quite up to the mean. E.g. Brighton 1887. Given a high temperature, excessive rainfall at the same time does not as a rule reduce the mortality, as might be anticipated. E.g. Hull in 1881 and 1895, Bristol 1876, Brighton 1880.

For London temperature and diarrhoea death rate correspond in quite a remarkable way, the curves of the two being almost identical; the
only marked exception being in 1893, when the temperature was very high and the rainfall was below the mean, yet the diarrhoea mortality was comparatively low.

By a study of these charts, it is seen that, with few exceptions, a high mean temperature is productive of a high diarrhoeal mortality, and vice versa.

Also, but with more exceptions, a dry season is conducive to a high death rate, and a wet season to a low death rate.

Earth Temperatures and Diarrhoea.

The late Dr. Ballard stated that there is a much more intimate relation between earth temperatures and diarrhoea mortality than between atmospheric temperatures and diarrhoea mortality, i.e., the curve of diarrhoea mortality follows more closely the curve of the temperature of the earth than of the atmosphere. He says (Report
to the Local Government Board, 1884),
"I have made, for London and other towns, 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 from the surface, each chart showing also the diarrhoeal mortality of the corresponding week. The general result shown by these charts is:—

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 maximum mortality 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 diarrhoeal mortality is in this connexion not
less instructive, perhaps more so, than its rise. It coincides with the decline of the temperature recorded by the 14-foot thermometer, which temperature declines very much more slowly than the atmospheric temperature, or than that recorded by the 1-foot earth thermometer; so that the epidemic mortality may continue (although declining) long after the last-mentioned temperatures have fallen greatly, and may extend some way into the fourth quarter of the year. This statement by Dr. Ballard is very suggestive. It indicates that the heating of the superficial layers of the earth have an importance influence in precipitating the prevalence of diarrhoea, and it is probable these superficial layers of the earth harbour something which cause the disease. The mere heating of the earth is not a sufficient explanation because of the very great difference
we find in the diarrhoeal mortality of
different towns in the United Kingdom
often situated only a few miles distant
from one another where the
climatological conditions must be
very similar; we also find that
different parts of the same town
show great differences in mortality
from diarrhoea. Probably the only
effect which the heating of the
earth has upon the causation of
diarrhoea is that it gives some
other factor favourable conditions
under which to operate.
This leads me to the main work
of my thesis viz. the investigation
into the diarrhoeal mortality, and
local conditions existing in 31 of
the large towns of the United
Kingdom.
Diarrhoea Mortality in Different Towns.

Method of Stating Results.

All the statistics in the following pages refer to diarrhoea deaths and not diarrhoea sickness, the former only being available.

As is well known, deaths from diarrhoea chiefly occur in very young children.

The following figures show the total deaths from diarrhoea in London 1891-96 and the percentage occurring under 1 year.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total at all ages</th>
<th>Under 1 year</th>
<th>% Under 1 year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1891</td>
<td>2510</td>
<td>1826</td>
<td>73%</td>
</tr>
<tr>
<td>1892</td>
<td>2633</td>
<td>1880</td>
<td>72%</td>
</tr>
<tr>
<td>1893</td>
<td>3579</td>
<td>2618</td>
<td>73%</td>
</tr>
<tr>
<td>1894</td>
<td>1812</td>
<td>1341</td>
<td>74%</td>
</tr>
<tr>
<td>1895</td>
<td>3674</td>
<td>2820</td>
<td>77%</td>
</tr>
<tr>
<td>1896</td>
<td>3318</td>
<td>2641</td>
<td>79%</td>
</tr>
<tr>
<td></td>
<td>17526</td>
<td>13328</td>
<td>76.2%</td>
</tr>
</tbody>
</table>

The Medical Officer of Health for Hull states in his report for 1896...
that there were 3433 deaths from diarrhoea in the 16 years 1881-1896 inclusive; of these 2651 occurred in infants under one year of age, i.e. 77.2% of total deaths.


Total at all ages 489; under 1 = 388
i.e. 79.3% of total deaths.

It may therefore be assumed that of the total deaths from diarrhoea, 75-80% occur in those under 1.

For the formation of reliable statistics for comparing one town with another it is advisable that the deaths from any particular disease at a given age-group should be stated per 1000 of the population living at the age group. In view of this statement, and of the fact that almost all the diarrhoea deaths occur in infants, it is obviously unfair to state diarrhoeal mortality in terms of 1000 population living at all ages (as done by the Registrar-General); we cannot expect to get a true
comparison between a town with a high birth-rate and one with a low birth-rate. Now that birth registration is complete practically complete, the number of births is a true index of the infantile population; and I believe a truer representation of diarrheal mortality for comparing one town with another is obtained by stating diarrhoea deaths at all ages per 1000 births than per 1000 population. In all the statistics which follow this has been carried out.

Method of Investigation.

The main procedure upon which I have attempted to investigate the causation of epidemic diarrhoea was suggested to me by my friend, Dr. Newsholme, medical officer of Health, Brighton; he pointed out to me the curious freedom from diarrheal mortality which characterised Halifax and Huddersfield.
and its great prevalence in neighbouring townships in the West Riding of Yorkshire e.g. Leeds, Bradford etc. He suggested that a series of charts showing the diarrhoea mortality in each quarter of the year should be made for all the great towns for a long series of years, then compare the differences between them, and inquire into the local conditions pertaining to each. This I have done.

In dealing with such a mass of statistical figures it is hardly possible that every single death-rate has been accurately calculated, but I believe very few mistakes have crept in, and that the charts give a true and accurate representation of diarrhoea mortality in the different towns.

I only give a tabular statement for one town, Leicester, in order to show the plan on which the charts have been constructed:—
<table>
<thead>
<tr>
<th>Year</th>
<th>1st Quarter</th>
<th>2nd Quarter</th>
<th>3rd Quarter</th>
<th>4th Quarter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Deaths</td>
<td>Live Born</td>
<td>Live Born</td>
<td>Live Born</td>
</tr>
<tr>
<td></td>
<td>Direct Rate</td>
<td>Rate per 1000</td>
<td>Rate per 1000</td>
<td>Rate per 1000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1876</td>
<td>1142</td>
<td>4</td>
<td>39.57</td>
<td>17.71</td>
</tr>
<tr>
<td>1877</td>
<td>1143</td>
<td>2</td>
<td>39.57</td>
<td>17.71</td>
</tr>
<tr>
<td>1878</td>
<td>1143</td>
<td>2</td>
<td>39.57</td>
<td>17.71</td>
</tr>
<tr>
<td>1879</td>
<td>1143</td>
<td>2</td>
<td>39.57</td>
<td>17.71</td>
</tr>
<tr>
<td>1880</td>
<td>1143</td>
<td>2</td>
<td>39.57</td>
<td>17.71</td>
</tr>
<tr>
<td>1881</td>
<td>1143</td>
<td>2</td>
<td>39.57</td>
<td>17.71</td>
</tr>
<tr>
<td>1882</td>
<td>1143</td>
<td>2</td>
<td>39.57</td>
<td>17.71</td>
</tr>
<tr>
<td>1883</td>
<td>1143</td>
<td>2</td>
<td>39.57</td>
<td>17.71</td>
</tr>
<tr>
<td>1884</td>
<td>1143</td>
<td>2</td>
<td>39.57</td>
<td>17.71</td>
</tr>
<tr>
<td>1885</td>
<td>1143</td>
<td>2</td>
<td>39.57</td>
<td>17.71</td>
</tr>
<tr>
<td>1886</td>
<td>1143</td>
<td>2</td>
<td>39.57</td>
<td>17.71</td>
</tr>
<tr>
<td>1887</td>
<td>1143</td>
<td>2</td>
<td>39.57</td>
<td>17.71</td>
</tr>
<tr>
<td>1888</td>
<td>1143</td>
<td>2</td>
<td>39.57</td>
<td>17.71</td>
</tr>
<tr>
<td>1889</td>
<td>1143</td>
<td>2</td>
<td>39.57</td>
<td>17.71</td>
</tr>
<tr>
<td>1890</td>
<td>1143</td>
<td>2</td>
<td>39.57</td>
<td>17.71</td>
</tr>
</tbody>
</table>

Annual death rate per 1000 births = 47.8
A similar table was constructed for each of the other 30 towns but I do not include them as the death rate for any quarter can be easily ascertained by reference to the scale at the side of each diagram. Also the relative bulk of diarrhoeal mortality in the different towns can be much more clearly seen in a diagrammatic representation than in a tabular list of death-rates.

For most of the towns the period of years covered is from 1876-1898—23 years. Some only from 1882-1898; this is because the latter group of towns were not included in the Registrar-General's quarterly reports until 1882. By adding up the total number of births and diarrhoea deaths in any given quarter for all the years (1876-98) the average death rate per 1000 births is obtained for that quarter for the whole period e.g. Leicester, 3rd quarter 166 per 1000 births, i.e. if the rate of mortality which was present in the 3rd quarter had continued throughout the
year 166 deaths would have occurred per 1000 births.

Also by adding up the total births and total deaths for the four quarters, the annual death rate per 1000 births is ascertained e.g. Leicester = 47.8 per 1000 births, the average annual death rate during the period 1876 - 1898.
The tables having been constructed, their diagrammatic representation to charts is easy. The distance between two horizontal lines (v. opposite page) represents 5 deaths per 1000 births; this scale was found to be the most suitable, and is used throughout for all the charts so that they are strictly comparable. The distance between two vertical lines represents one year. The different quarters of one particular year are placed one above the other in the same vertical line. The base line having been drawn, the line representing the death rate in the 1st quarter of the year is plotted out from the tabular statement.
of death rates for that quarter; then the
death rate of the 1st and 2nd Quarter
having been added together, the resulting
death rate is plotted out according to
scale above the line representing the
1st Quarter's death rate; then the 1st,
2nd and 3rd quarter having been added
together the death rate obtained by
their addition is next plotted out,
likewise for the 4th quarter.

By this method the death rate for
each quarter of the year is clearly
shown, and in order that the result
may be still more impressive to the
eye, the different quarters have
been painted in different colours;
the 1st quarter's death rate mortality
in brown; the 2nd quarter in yellow;
the 3rd in blue, and the fourth
in red.

Of course the top line in the diagram
does not represent the annual death
rate per 1000 births; the result of
adding the four quarters together being
to obtain the annual death per 4000
births.

This method of adding the four quarter's death rates together may be objected to on the ground that it is always fallacious to add rates together; but the births vary to such a small extent in the quarters of one year that the error occurs behind the decimal point; and as this error cannot be delineated on the scale on which the charts are drawn, the fallacy will be readily forgiven.

These diagrams demonstrate very prominently the enormous fatal incidence of diarrhoea in the 3rd quarter of the year; but they also show that there is quite a perceptible amount of fatal diarrhoea in the other quarters.

I shall now proceed to examine the great towns in the order of their mortality from diarrhoea, beginning with the town having the highest mortality viz:—
Preston.

This town occupies the most unenviable position in having the greatest mortality from diarrhoea of all the towns (31 in number) of which I have been able to obtain records. A glance at the chart below shows to what a tremendous extent diarrhoea is fatal. As is invariably the case in all the towns, the greatest incidence of deaths is in the 3rd quarter. Also notice that in the 2nd quarter in 1893 diarrhoea was very fatal; this was due to the exceptional heat and dryness of the early summer months which prevailed all over the country in that year. In the 3rd quarter of 1893, the death rate reached the frightful total of 263 per 1000 births.

The average annual death rate for the period 1882-98 was 60 per 1000 births; for 3rd quarter during that period 173 per 1000 births.

It can be seen from the chart that there is a distinct tendency towards
Improvement of late years; there has been ample room for this; the meteorological conditions from 1885-92 were favorable to a low diarrheal death, and in 1897-98 the conditions favored a high mortality, but in Preston the favourable meteorological conditions have not produced the mortality which might have been expected. It is interesting to note that in this connection the M.O.H. in his annual report for 1897 states that the middens in the town are being gradually abolished year by year, and replaced by water closets.

Preston is situated at the mouth of the Ribble, on the west coast of Lancashire. The district is flat, and about half of the town is built on the upper boulder clay, and the other half on glacial gravel; so that about 1/2 of the town is housed upon upon a pervious and the other half on an impervious subsoil. I may state here that most of my
geological data have been obtained
from the drift (surface) maps of the
Geological Survey, kindly shown
and demonstrated to me by
W. Clement Reid of the Geological
Museum, Jermyn St., London, W.
Preston is one of the oldest manufacturing
towns in Lancashire, and there is
a large amount of female labour
in the mills. According to J. G. Collet
(Journal of Royal Statistical Society,
June 1898), there is at least 59%
excess (over unmarried women) of occupied
wives and widows between the ages
of 25-45. This is important in view
of the fact that 75-80% of infantile
deaths occur under 1 year of age.
Disposal of Sewage. (My data for this
are invariably obtained from the
reports of J. Boobyer to the
Nottingham Health Committee, the
date of which is 1892.
Preston is a midden town, ¼ of
the houses having W.C.'s, the other
¾ having midden privies.
Leicester.

Leicester stands 2nd on the list of great towns, being next to Preston in maximum mortality from diarrhoea. It is characterised particularly by the epidemics of its diarrhoea mortality; there is very little in the 1st, 3rd, and 4th Quarters; practically all 2nd quarter diarrhoea (v. chart p. 28).

The death-rate for the 1st quarter 1876-98 was 3.6 per 1000 births; 2nd quarter = 16.6. i.e. the 3rd quarter mortality was 46 times as great as the diarrhoea in the 1st quarter.

Annual death rate (1876-98) was 47.8 per 1000 births. Whatever the cause, or combination of causes, of diarrhoea mortality, as soon as the meteorological factor is in evidence Leicester responds very quickly, more quickly than any other town. Of late years it has shown a tendency to improve; their great sewerage scheme was only finished a few years ago.

Leicester, a midland town, situated in a gentle hollow on the River Soar.
is built, speaking generally on clay, beneath which lies the red sandstone, and overlying all is a varying amount of mould. Following the bed of the river for a variable distance on either side, alluvial deposit is found, consisting of sand, gravel or of a varying thickness. The greater part of the population is housed on the marshy alluvium, the remainder on boulder clay and on sand and other impervious beds. The subsoil of the borough has been for a long time past, at least half a century, in a polluted state and in many localities actually sewage sodden, according to the late T. VonKris (from whose report for 1887 the greater part of the above information as to geology has been obtained.) The direction of the valley is such that the prevailing winds do not sweep along it but rather across it. The gradients in the town are not at all good.
Leicester used to be a midden, until quite recently, but is now a water-closet town. The past history of a town often throws light on its diarrheal mortality. The soil of a town, once polluted, must take many years to purify itself, even though no fresh pollution is being added to it; the nitrification, oxidisation, and other purifying processes must operate at great disadvantage in the soil of a town, the soil being undisturbed, never not exposed to the air, and paved over in great part.
Bolton.

Bolton has the 3rd highest mortality from diarrhoea, the annual death-rate per 1000 births being 41.2 per 1000 births for the period 1882-1898.

Taking the meteorological conditions into account, on looking at the chart, it would seem that the mortality is more or less stationary, neither improving nor going back.

In Bolton a large number of women are employed in the cotton industry; according to M. Collet, there is at least 15% excess (of unmarried women) of occupied wives and widows between the ages of 25-45.

"Bolton lies on the undulating planes of the coal measures, in the central portion of the Lancashire coal-field, with its southern and northern boundaries of New Red Sandstone and Millstone Grit. The district is deeply overgrown with boulder clay and sand. The valley in which it lies is surrounded by hills on
three sides, being open to the south, where it slopes gradually towards Manchester.

Mr. O. H. report 1896. Unfortunately, I have been unable to find out the proportion of population housed on the boulder clay, + the proportion on the sand, so that all I can affirm as to the subsoil is that part is porous, + part impervious. The elevations in the town vary from 230 - 500 feet above sea level, so that gradients in the town may be taken as fairly good.

Leakness is more endemic in Bolton than in most of the English towns, there appears to be a special incidence on the 4th quarter (v. chart).

Disposal of Sewage. \( \frac{2}{3} \) of the houses have middens, \( \frac{1}{3} \) have "fiales" — a few W.C.'s. (Boothby's Report 1894).

The average density of population in 1896 was 50.9 persons per acre. This density was only exceeded by two of the large towns, London + Plymouth.
Salford.

Salford, the sixth town to Manchester, has a much greater diarrhoecal mortality, Salford being 4.5% and Manchester 14.5% on my list of great towns. The town stands on a level plain, and the gradients are not good.

"The solid geology consists of the coal measures and red sandstone. The surface drift is of clay and sand. Not more than 10% is on sand, the rest on clay. The sand mainly lies over the coal measures but sometimes clay lies over them. Ninety per cent of the town is built on an imperious subsoil, and 10% on pervious."

(H. O.T. report)

Disposal of Sewage. Majority of houses have middens, but a good proportion have pails and 1/4 have W.C.'s.

Annual diarrhoecal death rate is 39.3 per 1000 births.
Hull.

Hull is a seaport town, standing on an almost absolutely level plain; the town is so low as to render embankment necessary to protect it from inundation.

The soil is entirely Humber alluvium consisting of fine sandy clay, used extensively in making bricks.

The level of the subsoil water is under these circumstances necessarily near the surface.

Meteorology. The average rainfall of the 3rd quarter of the year for the 23 years 1876-1898 was 7.79 inches, and the average temperature for the same period was 56.6°F (in the 3rd quarter).

Disposal of Refuse. Practically all the houses have middens, which are mostly small cemented receptacles.

Taking into account the meteorological conditions it would seem from the chart that Hull has remained almost stationary as regards its diarrheal mortality.
The average annual death rate for the period 1876–1898 was 38.4 per 1000 births; the 3rd quarter rate being 122 per 1000 births. Practically all the diarrhoea deaths occur in the epidemic season, very little endemic diarrhoea; compare with the next town which is

**Blackburn.**

The chart of diarrhoeal mortality for Blackburn is most remarkable; it is characterised by great endemicity. As is invariably the case, the 3rd quarter furnishes the highest mortality but there is a great deal also in the 1st, 2nd, and 4th quarters. Observe the enormous mortality figured on the chart for the 4th quarter of 1895; the actual number of diarrhoea deaths for that year are as follows:—

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>12</td>
</tr>
<tr>
<td>2nd</td>
<td>17</td>
</tr>
<tr>
<td>3rd</td>
<td>14</td>
</tr>
<tr>
<td>4th</td>
<td>102</td>
</tr>
</tbody>
</table>

The death rate for
the 1st quarter (1882-1898) averaged 16.5 per 1000 births; for the 3rd quarter for the same period it was 89; i.e. the 3rd quarter mortality was only 5½ times that of the 1st quarter; compare this with Leicester, where the 3rd quarter was forty-six times that of the 1st, and Hull, where the 3rd quarter was 23 times that of the 1st. What this portends it is difficult to say, but these enormous differences must mean something. The idea forces itself upon me that a large percentage of what is returned in Blackburn as diarrhoea may not be true epidemic diarrhoea at all but some other disease, or diseases possibly more prevalent in Blackburn than in the majority of other English towns.

The relation of Blackburn to the other towns as regards the death rate in the four different quarters is interesting. The first quarter of the year has a greater death rate than any other town being 16.5 per 1000 births
the 2nd quarter mortality is only exceeded by that of Preston; while for the 3rd quarter its death-rate receded to the 16th place, 15 other towns exceeding its mortality for this quarter; in the 4th quarter it was again the worst of all the towns, except Preston. So we see that in the 1st, 2nd, and 4th quarters, Blackburn occupies a supremely bad position while for the 3rd quarter it has a fairly good position; the average death-rate in the 3rd quarter for all the 31 towns, good & bad, is 87.7, that of Blackburn is almost the same being 89 per 1000 births.

Blackburn is 15 miles East of Preston & is situated, geologically, on the lower coal measures. There is a narrow strip of Alluvium in the valley of the Darwen. Millstone grit (rock & shale) comes to the surface over a considerable area. The coal measures are covered with drift beds of clay and sand, at least 90% of the town is built over the coal
measures. The drift beds are a gravelly clay, although there is a considerable area in the centre of the town with a good depth of fine sand. About $\frac{1}{5}$ of the population are housed on the very pervious sand, and $\frac{5}{6}$ on the marl which is only partially pervious. The gradients in the town are fairly good. The town varies from 300 to 700 feet above the sea level. Mrs Collet states that there are more women employed in industries in this town than in any other of the large English towns; there is at least 47% excess (over unmarried women) of occupied wives and widows over 25-45 years of age.

System of Sewerage. Pail or pan closets are in most use; $\frac{1}{3}$ of the houses have W.C.s and $\frac{1}{6}$ of the houses have privy midden. (1894)
Birmingham.

Birmingham has the 7th highest diarrhoea mortality.

The M.D.H. in his annual report for 1893 says:— "The highest part on the town is 679 feet above the mean sea level, and its lowest 261 feet. Thus there is much less stagnation of air than would be the case if the town occupied a lower situation and indeed Birmingham is somewhat distinguished for its sharp winds. It is built for the most part on sand or gravel. The soil is therefore porous and the site undulating." It may be inferred from the above report that the gradients in Birmingham are fairly good, and that the town is built on a previous sub-soil.

The annual diarrhoea death rate averaged for 1876-98 36-9 per 1000 births; for the 3rd quarter, it was 10-9 per 1000 births.
Last summer (V chart) Birmingham did not suffer from diarrhoea to the extent which the meteorological conditions would have led us to expect.

Disposal of Sewage. It is a mixed town. W.C.s and prepaid or paid closets are about equally common, 
\[ \frac{1}{8} \] of total houses have a middle privy attached to the dwelling.

Leeds.

The annual diarrhoal mortality in Leeds 1876-98 averaged 34.8 per 1000 births.

It is situated on the coal measures. Along the course of the river Aire, which runs through the centre of the town, there is a considerable portion of alluvium. With this exception the subsoil is either sandstone, shale, or clay. The greater part of the most populous areas in the town lies almost entirely on the shale or clay. This shale or
Clay is covered by the alluvium in a portion of the centre of the town.
The alluvium is to some extent porous, the shale and clay are impermeable, so that Leeds as a whole may be said to be built on a partially impermeable site. The above geological facts are obtained partly from the drift maps of the Geological Survey, and partly from the M.D.H. reports.

Ascending from the alluvial flats by the river side, the gradients in the town are good on both sides of the river.

Disposal of Sewage. Leeds is a mixed town; about half the houses have to the other half middens. I might here detail an interesting experiment carried out in 1893 by Dr. Spottiswoode Cameron, the M.O.H., Leeds (V. British Medical Journal 1894):

In 1893 an experiment was made by emptying the middens and ash-pits and cleaning the street gullies more frequently than was the regular custom in one particular district in the town.
(the S.E.), the other districts being scavenged as before. While the diarrhoea death rate in the 3rd quarter of 1892 increased for the whole borough in 1893 (3.42 to 5.20 per 1000 population), it increased considerably in all the districts except the S.E. in which the death rate fell from 7.00 to 6.47 per 1000 population. The chart shows that the diarrhoeal mortality in Leeds is almost entirely confined to the epidemic period, very little pre- or post-epidemic diarrhoea.

Liverpool.

Liverpool is the 9th worst town of the 31 investigated, having an annual diarrhoea death rate 1876-98 of 3.47 per 1000 births; the 3rd quarter being 10.2 per 1000 births. It has somewhat deteriorated of late years. Liverpool is built almost entirely on Sandstone, the Keuper and Bunter formations. Sandstone varies greatly in
penosity, the softer variety being quite
pervious, and the hard only partially
so; Liverpool is built for the most
part on the softer variety. In the
outer part of the town where few
houses are built, a considerable
amount of boulder clay is met with.
Disposal of Sewage. Is entirely a
water-closet town.

Sheffield.

Sheffield has an annual diarrhoea
mortality 1876-98 of 34.5 per 1000
births; 3rd quarter 31. per 1000 births.
It has distinctly deteriorated of late years.
Geology. There is a considerable
amount of alluvium along the valleys;
sandstone + shales alternate in other
parts of the town.
The town is built partly on an impervious
and partly on a pervious subsoil;
but I am unable to state what
proportion of the population is
upon each. The gradients in the
town are good. Sheffield is a mixed
Disposal of Sewage. Town: about $\frac{1}{5}$ of the houses have
water-closets, the remaining $\frac{4}{5}$
have midden privies.

Wolverhampton.

In order of maximum diarrheal mortality
Wolverhampton comes 11th on the list of
great towns, with an annual death
rate of 34.3 per 1000 births (1876-1898);
3rd quarter death rate was 10.4 per 1000 births.
Good and bad years alternate almost
invariably until 1895; from then during
1895-98 the death rate has kept up
very high. Even taking into account
the meteorological conditions, Wolverhampton has
greatly deteriorated of late years.
Disposal of Sewage. Wolverhampton is
a 'pail' town: $\frac{1}{5}$ of the houses have
water-closets, the rest have pail-closets.
Nottingham.

The annual diarrhoea death rate for this town averaged for the period 1876-98 32.4 per 1000 births; its mortality has remained about stationary during that period. The mortality for the 3rd quarter was 101 per 1000 birth births. It is 12.5% on the list of towns.

It is situated on an acclivity of a rock rising above the Trent. The gradients in the town are fairly good.

Disposal of Sewage. Nottingham is another of the 'paid' towns; 5/6 of the houses have paid closets; the remaining 1/6 have water-closets.
Norwich.

This old city is characterised by isolated years of great diarrhoea mortality; it suffered exceptionally in 1880 and 1886. (v. chart) It shows some improvement as regards its diarrhoea death rate of late years; the hot and dry summers of recent years have not caused the diarrhoea death rate to run up to the same extent as formerly.

The annual death rate (1876-1893) averaged 32.2 deaths per 1000 births; in the 3rd quarter for the same period 10.6.

Practically all the deaths occur in the 3rd quarter; the death rate of the 3rd quarter being 29 times as great as that of the 1st quarter, and 3.5 times as great many deaths occur in the 3rd quarter than in the other nine months of the year.

Geology. (M.O.H. Report 1897). The higher levels in the city are made up of glacial gravel beds, though the which the valleys have been excavated.
exposing at their margins the crag formation and chalk, while gravel and alluvial deposits occupy the lower ground. The chalk, which at Norwich is more than a 1000 feet thick and underlies the whole of the city, comes to the surface in several places in the town, and may be reached at no great depths in all parts of the Municipal area. The subsoil of the city is almost universally of a pervious character.

About \( \frac{1}{5} \) of the population are housed on the flat low lying alluvium, where the subsoil water is only about 3 feet from the surface; the inhabitants of this district are, as the M.O.H., T. Cooper Patten, expressed it to me, "Squating on a Sponge."

The remaining \( \frac{4}{5} \) of the population are on the chalk on gradients which are good.

Disposal of Sewage. Norwich is a mixed town; \( \frac{2}{5} \) of houses have middens, \( \frac{1}{5} \) have septic tanks, \( \frac{1}{5} \) water closets.
(Boothby's report 1894). The M.O.H. now
informs me (1899) that ½ only of
the houses have middens, ½ W.C.,
+ ½ privies; this fact may go some
way to explain that howwich
has improved of late years in
cholera mortality.

Manchester.

This large city occupies a fairly good
position with regards to its cholera
mortality; it is 14th on the list
with an annual death rate of
32.2 per 1000 births, and only 7% abovethe average for the great towns
(whick is 30.1). The 3rd quarter death
rate was 88 per 1000 births (1876-98).

Geology. The greater part of
Manchester is built upon a marl,
a mixture of sand, gravel, + clay,
underneath which is the New Red
Sandstone. Its site is thus only
partially pervious.
Disposal of Sewage. About $\frac{1}{2}$ of the houses have fail closets, $\frac{1}{4}$ have W.C.'s, and $\frac{1}{4}$ middens. Manchester has distinctly deteriorated of late years, even taking into account the meteorological conditions.

**Bradford.**

The chart shows that this town has very greatly deteriorated of recent years, perhaps more so than any other town. It is characterised by great ups and downs in its diarrheal mortality, indicated by the peaks and valleys on the chart; these peaks and valleys are more marked in the case of midden towns, as a rule, than in the case of towns having other methods of excreta removal (fauls or W.C.'s).

Disposal of Sewage: $\frac{3}{4}$ of houses have privy middens; $\frac{1}{4}$ have W.C.'s. Bradford stands 15th on the list of
great towns, with an annual diarrhoea death rate (1876-1898) of 31.2 per 1000 births.

Sunderland.

Sunderland had for the period 1876-98 an average annual diarrhoea mortality of 31.1 per 1000 births, being only 370 higher than the average for the 31 great towns. The 3rd quarter mortality was 46 per 1000 births for the same period. The subsoil of the town consists of an impervious layer of boulder clay, varying from a few feet to a 100 feet in thickness. This clay as a rule is simply covered by a layer of clayey marl, but in certain parts of the municipal district over limited areas beds of sand and gravel are found overlying the clay.

 Monkwearmouth (a district of Sunderland) is situated for the most part on one of these sand or gravel beds, and it
shows a greater mortality from diarrhoea and enteritis than any of the other sub-districts of Sunderland. (M.O.H. report 1894)

The gradients are not good; the town being built for the most part on a flat plain.

In all the towns previously noted (16 in number) the annual death rate was greater than the average death rate for all the 31 towns taken together; the average annual death-rate being 30.1 per 1000 births; the remaining 15 towns have an annual death rate which is smaller than this. These towns will now be taken in the order of maximum mortality.
Portsmouth.

The average annual death rate 1876-1898 for this town was 29.7 per 1000 births, only 1.7 below the average for all the towns. For the 3rd quarter the death rate was 97 per 1000 births. The deaths are almost confined to the epidemic period.

The diarrhoeal mortality has remained about stationary; the chart shows there are no signs of the town's improvement in this respect.

Geology. Portsmouth is chiefly built on gravel, a greater part is only 15 feet above mean sea level. The level of sub-soil water is always only a few feet from the surface. Here and there are stretches of loam clay, but this is too thin that the foundations of the houses are on the gravel. The town is therefore built upon a pervious sub-soil.
built is very flat.

Disposal of sewage. It is entirely a water-closet town.

Dublin.

Dublin is characterised by the endemic nature of its diarrhoeal mortality. There appears to be a special incidence of deaths in the 4th quarter of the year; the death rate for this quarter being exceeded by that in Bolton, Blackburn, & Preston, three of the very worst towns.

The annual death rate (shorter period, 1882-1898) averaged 27.1 per 1,000 births, which is 18.5% on the list of towns in the order of maximum mortality. The mortality in 1898 (v. chart) shows a remarkable drop; possibly the climatic and meteorological conditions in Dublin were quite different to those existing over England & Scotland, last summer.

I am unable to make sense of this.

Geology. Dublin and its suburbs are
built partly upon stiff clay, and partly upon gravel resting upon rock or clay; 2/3 of the population are housed upon the clay, 1/3 upon the gravel. The gravel extends for some distance upon both sides of the Liffey; the clay is upon the higher land more remote from the river. (M.O.H. annual report 1891). In this same report Sir Chas Cameron, the M.O.H. of Dublin, showed that a large percentage of cases of typhoid fever occurred upon the gravel than upon the clay (in the proportion of 150:100). He also goes on to state: "Until recently (this was in 1891) there existed in Dublin middens in large numbers, with consequent organic pollution of the soil, from the effects of which the soil has not yet had time to recover. . . . . . . . . Dublin is a low lying city; the greater part of Dublin (city) is built upon literally a water logged site, and on this part it is only when the tide is out that the subsoils are drained."

Disposal of Sewage. Dublin is now
entirely a water-closet town.

Brighton.

The annual diarrhoea death rate averaged for the 23 years 1876-98 2.71 per 1000 births. Brighton occupies the 19th position on the list of great towns. The death rate for the 3rd quarter averaged 57 per 1000 births. The town has not improved of recent years with regard to its diarrhoea mortality; it has remained much about the same.

Geology. A seaside town, built mainly on the pervious chalk, with combe rock in the lower parts of the town, i.e. a mixture of flints and chalk, even more pervious than the chalk itself. The town is built mainly on the slopes of hills, some of which are very steep. The subsoil water is very low. Brighton is thus built on a pervious subsoil, and the gradients in the town are very good.

Meteorology. For the 3rd quarter of the
year, during the 23 years 1876-98 the mean daily atmospheric temperature averaged 59.3°F and the rainfall averaged 7.26 inches for the whole quarter.

Disposal of sewage; entirely a water-closet town. House refuse is removed once a week in galvanized iron dustbins.

Cardiff.

This Welsh seaport occupies the 26th position on the list, with an annual diarrhoea death rate of 24.4 per 1000 births for 1882-1898. The 3rd quarter death rate for the same period averaged 68 per 1000 births.

The chart would seem to indicate that Cardiff has remained stationary or regards its mortality from diarrhoea but the probabilities are that it has really improved as the meteorological conditions have been very favourable during the past few years to a high diarrhoea mortality. Cardiff is entirely a W.C. town.
Newcastle.

The records for this town show that the annual diarrhoea death rate has averaged 23.5 per 1000 births for the period 1876-1898, 4 the 3rd quarter 45 per 1000 births.

Ecology. Newcastle is situated entirely on the coal measures, & the drift consists of boulder clay over the greater part of the town, with occasional glacial gravel & pebble beds. The gradients in the town are fairly good.

Newcastle is entirely a water closet town. The chart indicates that the death rate shows little tendency either to increase or decrease.

Glasgow.

The Scotch towns have to be congratulated as to their relative diarrhoea mortality as compared with the large majority of
Glasgow, 1852-1898
English towns. Along with the last town noted, Newcastle, Glasgow occupies the 21st place, having an annual death rate of 23.5 per 1000 births 1882-1898. (Newcastle had the same but the period of years was 1876-1898). The 3rd quarter death rate in Glasgow was 52 per 1000 births. The diarrhoea mortality is to a great extent endemic in type; in the 1st quarter it occupies a supremely bad position, in that its death rate is only exceeded by that of Blackburn and Preston; in the 3rd quarter on the other hand, its position is excellent, only 5 of the 31 towns have a smaller death rate. Glasgow is one of the water-closet towns. The gradients in the town are generally fairly good.
Birkenhead.

As regards its diarrheal mortality, Birkenhead offers a great contrast to its sister town, Liverpool. Liverpool being #1 on the list while Birkenhead occupies the 23rd position. Its annual diarrheal death rate was 23.2 per 1000 births for 1876-1878; 3rd quarter death rate = 69 per 1000 births.

It appears to have deteriorated of late years. The 2nd quarter of 1893 shows an enormous mortality; this excess in the 2nd quarter of 1893 is observed in most of the towns, but not to such an excessive degree as in Birkenhead; it was due to the late spring and early summer months being exceptionally hot and dry.

Geology and Drainage. The town is fairly flat, is in great part built on a gravelly, boulder clay with pebble beds underneath. It is a water closet town.
London.

Not only is London truly remarkable for its low general death rate, but its diarrhoea mortality also is wonderfully low. It occupies the 24th place in the list of 31 towns, only 7 having a smaller annual diarrhoea death rate. The death rate for 1876-1878 is 23.1 per 1000 births which is 23.2% below the mean for all the great towns. Its 3rd quarter death rate is 72 per 1000 births.

The course of the diarrhoea varies less from year to year (v. chart) than in any other of the great towns, peaks and valleys are conspicuous by their absence, the general trend of the curve being very uniform.

The mortality has remained about stationary during the period 1876-98.

Meteorology. The average daily mean atmospheric temperature for the 3rd quarter 1876-1878 was 60.1°F; the rainfall for the 3rd quarter of the
same period being 6.82 inches.

Geology. Mr. W. B. Woodward is the author of an excellent little work on the subject of the subsoils of London, published in the memoir of the Geological Survey. This subject is most complex and I found it impossible to give the properties of population living on inferior or impervious subsoils. The following extracts from his book lead me to suppose that London for the most part is built on a rather impervious subsoil, but this may be a most imperfect statement.

"A large part of the central parts of London are built upon "made ground." Possibly no other city is so little influenced by the nature of the original subsoil."

"There are but small areas of alluvium in the country of London proper."

"A large part of Old London and the villages now incorporated in modern London are built on valley terraces of gravel and loam; the loam is
sometimes overlain by the gravel, but more usually it forms a covering extending over a considerable portion of the gravel; this loam (sandy clay or brick-earth) is practically impervious."

"The 'London clay' underlies the valley gravels and it forms the surface of the ground in many places in London."

London is entirely a water-closet town.

**Plymouth.**

Plymouth occupies the 25th place with an annual diarrhoea death rate of 22.9 per 1000 births (1876 - 1898); the 3rd quarter death rate was 6.6 per 1000 births.

**Geology.** The town stands upon the slate and limestone. The limestone rocks are compact in themselves but broken by joints and fissures. The slate rocks vary considerably in character from the loose broken material known as "shillet" to the compact red and purple slates. As a rule, the slate rocks admit freely of percolation.
This geological information is obtained from the M.O. H.'s annual report for 1898. The gradients are not very great; the highest point being 200 feet above sea level, a portion of a recently added area.

Plymouth is entirely a water-closet town.

Derby.

This town occupies a surprisingly good position. Its annual diarrheic death rate being 22.3 per 1000 births; and its 3rd quarter death rate 67 per 1000 births (1882-1898).

Disposal of Sewage. Derby is a mixed town as regards sewage; middens & W.C.s are equally numerous; 3/5 of the houses have both or from closets.

Geology. There is a considerable amount of alluvium in the valley of the Donau; on either side of the Valley are the Upper Keuper sandstone rocks, but overlying this is a Red, very clayey, Marl.
By far the greater part of Derby is
housed upon the impervious marl.
The gradients in the town are on the
whole good, but they show very
variation between good and bad.

Oldham.

For one of the Lancashire 'cotton' towns
Oldham has a wonderfully small death
rate from diarrhoea; it is 27 in the
last with an annual death rate
(1876-1898) of only 20 per 1000 births,
and for the 3rd quarter 47 per 1000 births.

Disposal of Sewage. The system of
sewage is practically entirely by
means of 'sails'.

Geology. Oldham is chiefly situated
upon the boulder clay, a small portion
on sand, but generally the subsoil
may be said to be quite of an
impervious nature.

The gradients are steep; the lowest
part of the town is 354 feet above
the sea level; the highest 1225 ft. above
the sea level.

Edinburgh.

Edinburgh does not suffer much from fatal epidemic diarrhoea. In my list of 31 large towns, it stands 28th on the list with an annual death rate (1882-1898) of 20 per 1000 births; only 3 of the towns have a better record than Edinburgh, viz. Bristol, Huddersfield, and Halifax. Its 3rd quarter death rate is 12 per 1000 births; this death rate is 52% below the average 3rd quarter death rate for all the towns and only Halifax can boast of a smaller death-rate. Though taking such a good place as regards the 3rd quarter, it takes a bad position in 1st, 2nd + 4th quarters of the year, thus showing the endemic nature of the disease returned by the Registrar-General as 'diarrhoea'; in this respect it closely resembles four other towns, viz. Glasgow, Dublin,
Blackburn, and Preston.

Edinburgh is entirely a water-closet town. Geology. Generally speaking, Edinburgh is built upon an impervious sub-soil; the drift consisting of the boulder clay.

The capital of Scotland is famous for its steep streets. The gradients are exceptionally good, especially in the Old and New Town; the slopes of the more suburban parts of the city are also good, but not so steep, (e.g. Newington, Grange & Morningside.) In the older and more insanitary parts the gradients are very steep.

Bristol.

Bristol has the 3rd lowest annual death rate from diarrhoea, which is, for the 23 years 1876-1898, 14 per 1000 births, the 3rd quarter rate being 47 per 1000 births. The death rate last year (1898) was greatly in excess of what it had ever been before. (V. chart.)
Geology. The old city is situated chiefly on low ground in a broad valley lined by the alluvial deposit of the R. Avon. Parts of the city are upon higher ground on the now Red Sandstone, through which the New Cut, or artificial course of the Avon, has been cut. The high table-land of Clifton, Cotham and Redland is situated upon the denuded edges of an arch of carboniferous rocks. The steep ascents ascending from Granby Hill past Brandon Hill to Marlborough Hill are on the outcrop of the Millstone Grit. The drift over the greater part of the city consists of the New Red Marl. (The above information is obtained from the M.O.H.'s report for 1897 and the Drift Map of the Geological Survey.)

Meteorology. The average rainfall of the 3rd quarter for the 23 years 1876-1898 was 9.8 inches; the average mean daily temperature for the same period being 59.7°F.
Bristol is entirely a water-closet town. The gradients in the city are, generally speaking, very good.

Huddersfield.

Huddersfield has the lowest mortality from diarrhoea of any of the large towns, with the sole exception of Halifax. Its annual death rate for the period 1882-1895 averaged 15.7 per 1000 births, its 3rd quarter death rate being 4.8 per 1000 births. Halifax Huddersfield showed a large increase in its mortality last year (1895 vs. chart).

Disposal of Sewage. This is carried out by means of the 'pail' system.

Geology: "About 4/5 of the population are situated upon layers of coal, ranging from thin coal to fire clay, through soft bed flag, soft bed coal, middle hard bed coal and rock, to the better bed coal and fire clay strata,
which are all comprised in the lower 
cal coal measures or ganister beds of the 
carboniferous rocks; these strata are 
rendered almost impervious by the 
clay overlying the coal.
"The Remanider of Population is housed 
on sand rock, flags, shales, & 
sandstone and is pervious."
"The gradients of the town are steep. 
Lowest part of Huddersfield is 
150 above feet, at highest 1000 feet 
above sea level." M.O.H. report.
In 1894, it was calculated that 
there were 8.3 persons to an acre.

Halifax.

This town occupies the premier position 
in having the smallest diarrhoeal 
mortality of all the 31 towns. 
The annual death rate for the period 
1882-1898 averaged only 12.5 per 1000 
births; the 3rd quarter death rate 
being 40 per 1000 births.
The gradients in the town are good;
I have unfortunately been unable to acquire any reliable geological data with regard to Halifax.

Disposal of sewage is by means of the 'pail' system ('Goull').

It will have been noted that the period of observation in the towns have varied from 23 years in some (1876-1898) to 17 years in others (1882-1898); 20 of the 31 towns for the longer period and the remaining 11 for the shorter period. These towns are therefore not strictly comparable with one another and their position in the list of mortality comparatively may not be quite exact; the probabilities are that each of the towns of the shorter period should be really a place or so higher in the list because the six years previous to 1882 were, on the whole, rather favourable, as regards meteorological conditions, to diarrhoea mortality. This fact does not under-rate except
tis a very slight extent, the value of the statistics; once a town establishes a claim to be a 'diarrhoea' town or otherwise, in a period of 5 or 6 years it does not change its character; the evidence of the charts has been ample proof of this, so that I think the order in which the towns have been placed would vary very little from the order they would have taken if records of the towns with the shorter period had been accessible to me since 1896.

The following table shows the towns in the order of their annual mortality from diarrhoea; the towns which have under the longer period of observation been given a separate column to those under the shorter period, so that the longer period towns may be compared with one another, + the shorter period towns similarly; the table also gives the annual and the 3rd quarter death rate, & the percentage deviation from the mean for all the towns.
<table>
<thead>
<tr>
<th></th>
<th>1876-1898</th>
<th>1882-1898</th>
<th>Annual death rate and percentage deviation from mean</th>
<th>Average 3rd quarter death rate and % deviation from mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Preston</td>
<td>60.0</td>
<td>+99</td>
<td>+97</td>
</tr>
<tr>
<td>2</td>
<td>Leiceste</td>
<td>47.8</td>
<td>+59</td>
<td>+66</td>
</tr>
<tr>
<td>3</td>
<td>Bolton</td>
<td>41.2</td>
<td>+37</td>
<td>+12</td>
</tr>
<tr>
<td>4</td>
<td>Salford</td>
<td>39.3</td>
<td>+31</td>
<td>+13</td>
</tr>
<tr>
<td>5</td>
<td>Hull</td>
<td>38.9</td>
<td>+29</td>
<td>+12</td>
</tr>
<tr>
<td>6</td>
<td>Blackburn</td>
<td>38.5</td>
<td>+28</td>
<td>+8</td>
</tr>
<tr>
<td>7</td>
<td>Birmingham</td>
<td>36.9</td>
<td>+23</td>
<td>+10</td>
</tr>
<tr>
<td>8</td>
<td>Leeds</td>
<td>34.8</td>
<td>+16</td>
<td>+10</td>
</tr>
<tr>
<td>9</td>
<td>Liverpool</td>
<td>34.7</td>
<td>+15</td>
<td>+10</td>
</tr>
<tr>
<td>10</td>
<td>Sheffield</td>
<td>34.5</td>
<td>+15</td>
<td>+11</td>
</tr>
<tr>
<td>11</td>
<td>Wolverhampton</td>
<td>34.3</td>
<td>+14</td>
<td>+10</td>
</tr>
<tr>
<td>12</td>
<td>Nottinghamp</td>
<td>32.4</td>
<td>+8</td>
<td>+11</td>
</tr>
<tr>
<td>13</td>
<td>Norwich</td>
<td>32.2</td>
<td>+7</td>
<td>+16</td>
</tr>
<tr>
<td>14</td>
<td>Manchester</td>
<td>32.2</td>
<td>+7</td>
<td>+16</td>
</tr>
<tr>
<td>15</td>
<td>Bradford</td>
<td>31.2</td>
<td>+4</td>
<td>+9</td>
</tr>
<tr>
<td>16</td>
<td>Sunderland</td>
<td>31.1</td>
<td>+3</td>
<td>+9</td>
</tr>
<tr>
<td>17</td>
<td>Portsmouth</td>
<td>29.7</td>
<td>-1</td>
<td>+7</td>
</tr>
<tr>
<td>18</td>
<td>Dublin</td>
<td>27.4</td>
<td>-9</td>
<td>-6</td>
</tr>
<tr>
<td>19</td>
<td>Brighton</td>
<td>27.1</td>
<td>-10</td>
<td>-1</td>
</tr>
<tr>
<td>20</td>
<td>Cardiff</td>
<td>24.4</td>
<td>-19</td>
<td>-22</td>
</tr>
<tr>
<td>21</td>
<td>Glasgow</td>
<td>23.5</td>
<td>-22</td>
<td>-22</td>
</tr>
<tr>
<td>22</td>
<td>Newcastle</td>
<td>23.5</td>
<td>-22</td>
<td>-22</td>
</tr>
<tr>
<td>23</td>
<td>Birkenhead</td>
<td>23.2</td>
<td>-23</td>
<td>-23</td>
</tr>
<tr>
<td>24</td>
<td>London</td>
<td>28.1</td>
<td>-23</td>
<td>-23</td>
</tr>
<tr>
<td>25</td>
<td>Plymouth</td>
<td>22.9</td>
<td>-24</td>
<td>-24</td>
</tr>
<tr>
<td>26</td>
<td>Derby</td>
<td>22.3</td>
<td>-26</td>
<td>-26</td>
</tr>
<tr>
<td>27</td>
<td>Cardiff</td>
<td>20.0</td>
<td>-34</td>
<td>-34</td>
</tr>
<tr>
<td>28</td>
<td>Edinburgh</td>
<td>20.0</td>
<td>-34</td>
<td>-34</td>
</tr>
<tr>
<td>29</td>
<td>Bristol</td>
<td>19.0</td>
<td>-37</td>
<td>-37</td>
</tr>
<tr>
<td>30</td>
<td>Huddersfield</td>
<td>18.7</td>
<td>-48</td>
<td>-48</td>
</tr>
<tr>
<td>31</td>
<td>Halifax</td>
<td>12.5</td>
<td>-58</td>
<td>-58</td>
</tr>
</tbody>
</table>

**The Great Towns**

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Average 3rd quarter death rate and % deviation from mean:**

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Average 3rd quarter death rate and % deviation from mean:**

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Classification of towns, as to whether they have improved, deteriorated, or remained stationary. My opinions are based upon a study of the charts. In stating an opinion we must take into account meteorological conditions, the period of years under observation, and the fact that of late years it has become the fashion to record as 'intemperance' a large number of deaths which would in former years have been registered as diarrhoea.

<table>
<thead>
<tr>
<th>Stationary</th>
<th>Deteriorated</th>
<th>Improved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newcastle</td>
<td>Sunderland ++</td>
<td>Leicester</td>
</tr>
<tr>
<td>Dublin</td>
<td>Hull + Huddersfield+</td>
<td>? Cardiff</td>
</tr>
<tr>
<td>Glasgow</td>
<td>Liverpool + Sheffield++</td>
<td>Preston</td>
</tr>
<tr>
<td>Edinburgh</td>
<td>Manchester ++</td>
<td>Plymouth</td>
</tr>
<tr>
<td>London</td>
<td>Salford +</td>
<td>Norwich</td>
</tr>
<tr>
<td>Birmingham</td>
<td>B'ham Kenhead +</td>
<td></td>
</tr>
<tr>
<td>Nottingham</td>
<td>Bolton +</td>
<td></td>
</tr>
<tr>
<td>Portsmouth</td>
<td>Bradford +</td>
<td></td>
</tr>
<tr>
<td>Bristol</td>
<td>Brighton ?</td>
<td></td>
</tr>
<tr>
<td>Norwich</td>
<td>Wolverhampton ++</td>
<td></td>
</tr>
<tr>
<td>Blackburn</td>
<td>Derby + Halifax +</td>
<td></td>
</tr>
<tr>
<td>Leeds Oldham</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Classification of Towns in the order of their average diarrheal mortality per 1000 births (beginning with maximum) in each of the quarters of the year. The average mortality for all the towns for the 1st quarter being 6.06 per 1000 births: for 2nd quarter = 9.12; for 3rd quarter = 87.7; and for the 4th quarter = 13.5.

<table>
<thead>
<tr>
<th>1st quarter</th>
<th>2nd quarter</th>
<th>3rd quarter</th>
<th>4th quarter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Blackburn 16.5</td>
<td>Preston 19.6</td>
<td>Preston 17.0</td>
<td>Preston 35.0</td>
</tr>
<tr>
<td>2 Preston 13.2</td>
<td>Blackburn 15.9</td>
<td>Leicester 16.0</td>
<td>Blackburn 35.0</td>
</tr>
<tr>
<td>3 Glasgow 12.1</td>
<td>Bolton 14.2</td>
<td>Hull 12.0</td>
<td>Bolton 31.5</td>
</tr>
<tr>
<td>4 Edinburgh 10.7</td>
<td>Glasgow 14.1</td>
<td>Salford 17.0</td>
<td>Salford 28.4</td>
</tr>
<tr>
<td>5 Bolton 10.5</td>
<td>Manchester 13.7</td>
<td>Bolton 12.0</td>
<td>Bolnhurst 20.6</td>
</tr>
<tr>
<td>6 Dublin 10.4</td>
<td>Salford 12.9</td>
<td>Sheffield 11.0</td>
<td>Walsall 26.0</td>
</tr>
<tr>
<td>7 Salford 9.5</td>
<td>Liverpool 12.4</td>
<td>Liverpool 10.9</td>
<td>Manchester 23.0</td>
</tr>
<tr>
<td>8 Manchester 9.0</td>
<td>Liverpool 12.4</td>
<td>Birmingham 10.9</td>
<td>Birmingham 16.6</td>
</tr>
<tr>
<td>9 Warrington 8.3</td>
<td>Leicester 11.9</td>
<td>Leeds 10.9</td>
<td>Hull 19.4</td>
</tr>
<tr>
<td>10 Altrincham 8.0</td>
<td>Birmingham 11.1</td>
<td>Norwich 10.6</td>
<td>Manchester 18.7</td>
</tr>
<tr>
<td>11 Birkenhead 7.9</td>
<td>Bradford 10.1</td>
<td>Liverpool 10.2</td>
<td>Liverpool 21.8</td>
</tr>
<tr>
<td>12 Liverpool 7.0</td>
<td>Plymouth 9.7</td>
<td>Nottingham 10.1</td>
<td>Sunderland 18.0</td>
</tr>
<tr>
<td>13 Bradford 6.9</td>
<td>Warrington 9.8</td>
<td>Portsmouth 9.0</td>
<td>Sunderland 18.0</td>
</tr>
<tr>
<td>14 Nottingham 6.7</td>
<td>Dublin 9.6</td>
<td>Sunderland 9.4</td>
<td>Liverpool 17.7</td>
</tr>
<tr>
<td>15 Bristol 6.4</td>
<td>Leeds 9.0</td>
<td>Bradford 9.0</td>
<td>Oldham 17.3</td>
</tr>
<tr>
<td>16 Newcastle 6.1</td>
<td>Cardiff 8.8</td>
<td>Blackburn 8.7</td>
<td>Warrington 18.5</td>
</tr>
<tr>
<td>17 Cardiff 6.0</td>
<td>Warrington 8.7</td>
<td>Manchester 8.7</td>
<td>Leeds 16.5</td>
</tr>
<tr>
<td>18 Birkenhead 5.7</td>
<td>Bristol 8.5</td>
<td>Brighton 8.6</td>
<td>Warrington 18.7</td>
</tr>
<tr>
<td>19 Derby 5.4</td>
<td>Warrington 8.7</td>
<td>Newcastle 8.9</td>
<td>Sheffield 15.4</td>
</tr>
<tr>
<td>20 Sheffield 5.4</td>
<td>Hull 8.6</td>
<td>Bradford 6.6</td>
<td>Cardiff 15.4</td>
</tr>
<tr>
<td>21 Hull 5.4</td>
<td>Warrington 8.7</td>
<td>Blackburn 6.6</td>
<td>Sheffield 14.7</td>
</tr>
<tr>
<td>22 Manchester 5.0</td>
<td>Birkenhead 8.4</td>
<td>Cardiff 6.2</td>
<td>Leicestershire 13.7</td>
</tr>
<tr>
<td>23 Leeds 4.9</td>
<td>London 8.1</td>
<td>Derby 6.2</td>
<td>Leicestershire 13.2</td>
</tr>
<tr>
<td>24 Plymouth 4.8</td>
<td>Portsmouth 8.9</td>
<td>Plymouth 6.7</td>
<td>Plymouth 12.4</td>
</tr>
<tr>
<td>25 London 4.8</td>
<td>Sheffield 7.7</td>
<td>Newcastle 6.5</td>
<td>Derby 12.1</td>
</tr>
<tr>
<td>26 Sunderland 4.7</td>
<td>Sunderland 7.1</td>
<td>Newcastle 6.5</td>
<td>Sunderland 11.4</td>
</tr>
<tr>
<td>27 Halifax 4.2</td>
<td>Newcastle 7.2</td>
<td>Oldham 5.6</td>
<td>Birkenhead 10.3</td>
</tr>
<tr>
<td>28 Portsmouth 4.0</td>
<td>Newcastle 7.2</td>
<td>Blackburn 5.9</td>
<td>Birkenhead 10.2</td>
</tr>
<tr>
<td>29 Norwich 3.7</td>
<td>Brighton 5.9</td>
<td>Huddersfield 4.6</td>
<td>Birkenhead 9.9</td>
</tr>
<tr>
<td>30 Leicester 3.6</td>
<td>Huddersfield 5.4</td>
<td>Edinburgh 4.2</td>
<td>Huddersfield 9.2</td>
</tr>
<tr>
<td>31 Brighton 3.5</td>
<td>Huddersfield 5.1</td>
<td>Huddersfield 3.0</td>
<td>London 7.3</td>
</tr>
</tbody>
</table>
Ratio between 3rd quarter and 1st quarter diarrhoea mortality in the different towns. This is a sort of index of the endemicity or epidemicity of diarrhoea in a town. The chief points of interest have been already mentioned in previous pages, but I now give a complete list of the towns in this relation.

The 1st quarter invariably shows the smallest mortality, with the sole exception of Blackburn in which the death rate for the 2nd quarter is slightly smaller than for the 1st. The 3rd quarter death rate is divided by that of the 1st quarter, and the resulting figure is the number of times the death rate in the epidemic quarter is greater than the death rate of the quarter in which diarrhoea is least fatal.

1. Leicester 165.0, 3.2 = 45.9
2. Norwich 106.0, 3.7 = 28.8
3. Brighton 86.7, 3.5 = 24.9
4. Portsmouth 96.9, 4.0 = 24.2
5. Hull 122, 5.4 = 22.6
<table>
<thead>
<tr>
<th></th>
<th>City</th>
<th>104.0</th>
<th>4.9</th>
<th>= 22.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Sheffield</td>
<td>111.0</td>
<td>5.4</td>
<td>= 20.1</td>
</tr>
<tr>
<td>8</td>
<td>Sunderland</td>
<td>440.0</td>
<td>4.9</td>
<td>= 20.0</td>
</tr>
<tr>
<td>9</td>
<td>Nottingham</td>
<td>111.0</td>
<td>6.7</td>
<td>= 15.1</td>
</tr>
<tr>
<td>10</td>
<td>London</td>
<td>71.6</td>
<td>4.8</td>
<td>= 14.7</td>
</tr>
<tr>
<td>11</td>
<td>Liverpool</td>
<td>142.0</td>
<td>7.0</td>
<td>= 14.6</td>
</tr>
<tr>
<td>12</td>
<td>Birmingham</td>
<td>102.0</td>
<td>7.9</td>
<td>= 13.8</td>
</tr>
<tr>
<td>13</td>
<td>Plymouth</td>
<td>45.7</td>
<td>4.8</td>
<td>= 13.8</td>
</tr>
<tr>
<td>14</td>
<td>Blackburn, Preston</td>
<td>173.0</td>
<td>13.2</td>
<td>= 13.7</td>
</tr>
<tr>
<td>15</td>
<td>Bradford</td>
<td>92.4</td>
<td>6.9</td>
<td>= 13.1</td>
</tr>
<tr>
<td>16</td>
<td>Wolverhampton</td>
<td>104.0</td>
<td>9.5</td>
<td>= 12.6</td>
</tr>
<tr>
<td>17</td>
<td>Salford</td>
<td>119.0</td>
<td>9.5</td>
<td>= 12.6</td>
</tr>
<tr>
<td>18</td>
<td>Derby</td>
<td>67.2</td>
<td>5.4</td>
<td>= 12.5</td>
</tr>
<tr>
<td>19</td>
<td>Birkenhead</td>
<td>63.6</td>
<td>5.7</td>
<td>= 12.2</td>
</tr>
<tr>
<td>20</td>
<td>Cardiff</td>
<td>68.1</td>
<td>6.0</td>
<td>= 11.4</td>
</tr>
<tr>
<td>21</td>
<td>Newcastle</td>
<td>65.2</td>
<td>6.7</td>
<td>= 10.8</td>
</tr>
<tr>
<td>22</td>
<td>Bolton</td>
<td>112.0</td>
<td>10.5</td>
<td>= 10.7</td>
</tr>
<tr>
<td>23</td>
<td>Manchester</td>
<td>87.9</td>
<td>9.0</td>
<td>= 9.8</td>
</tr>
<tr>
<td>24</td>
<td>Huddersfield</td>
<td>42.6</td>
<td>5.0</td>
<td>= 8.5</td>
</tr>
<tr>
<td>25</td>
<td>Bristol</td>
<td>46.9</td>
<td>6.0</td>
<td>= 7.8</td>
</tr>
<tr>
<td>26</td>
<td>Halifax</td>
<td>30.3</td>
<td>4.2</td>
<td>= 7.2</td>
</tr>
<tr>
<td>27</td>
<td>Dublin</td>
<td>67.3</td>
<td>10.4</td>
<td>= 6.5</td>
</tr>
<tr>
<td>28</td>
<td>Oldham</td>
<td>50.7</td>
<td>8.0</td>
<td>= 6.3</td>
</tr>
<tr>
<td>29</td>
<td>Blackburn</td>
<td>59.3</td>
<td>10.6</td>
<td>= 5.4</td>
</tr>
<tr>
<td>30</td>
<td>Glasgow</td>
<td>51.7</td>
<td>12.1</td>
<td>= 4.3</td>
</tr>
<tr>
<td>31</td>
<td>Edinburgh</td>
<td>42.2</td>
<td>10.7</td>
<td>= 3.9</td>
</tr>
</tbody>
</table>
Reasons for the Great Differences in Diarrheal Mortality in the Different Large Towns.

The data set forth in the previous pages answer this question.
It is obvious that if it can be fully explained why towns should vary so much in diarrheal mortality, it will go very far to explain the causation of the disease; the two questions are intimately bound up in one another.

The following important table sets forth what are, in my opinion, the three main factors in causing these differences in mortality; I have placed them in three columns in what I consider the order of their importance (1) method of disposal of sewage; (2) physiographical features of the town; whether built on a flat surface or whether gradients good; (3) impervious or pervious nature of the subsoil. The towns are placed in
<table>
<thead>
<tr>
<th>Years in order of diarrheal mortality</th>
<th>System of Disposal of Sewage</th>
<th>Contour of surface whether gradients are good or bad</th>
<th>Previous or impervious fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preston</td>
<td>Middens</td>
<td>Flat</td>
<td>½ pervious; ½ impervious</td>
</tr>
<tr>
<td>Leicester</td>
<td>W.C. (lately middens)</td>
<td>Flat</td>
<td>½ pervious; ½ impervious</td>
</tr>
<tr>
<td>Bolton</td>
<td>Middens</td>
<td>Fairly good</td>
<td>partly pervious; partly impervious</td>
</tr>
<tr>
<td>Salford</td>
<td>Middens</td>
<td>Flat</td>
<td>impervious</td>
</tr>
<tr>
<td>Hull</td>
<td>Middens</td>
<td>Very Flat</td>
<td>pervious (partially)</td>
</tr>
<tr>
<td>Blackburn</td>
<td>Pails</td>
<td>Fairly good</td>
<td>do</td>
</tr>
<tr>
<td>Birmingham</td>
<td>mixed (½ W.C., ½ Pails)</td>
<td>Fairly good</td>
<td>pervious</td>
</tr>
<tr>
<td>Leeds</td>
<td>mixed (½ W.C., ½ middens)</td>
<td>Fairly good</td>
<td>mostly impervious</td>
</tr>
<tr>
<td>Liverpool</td>
<td>W.C.</td>
<td>Very Good</td>
<td>pervious (2)</td>
</tr>
<tr>
<td>Sheffield</td>
<td>middens</td>
<td>Fairly Good</td>
<td>pervious (2)</td>
</tr>
<tr>
<td>Wolvesley</td>
<td>Pails</td>
<td>Fairly Good</td>
<td>pervious (2)</td>
</tr>
<tr>
<td>Nottingham</td>
<td>middens</td>
<td>Fairly Good</td>
<td>impervious</td>
</tr>
<tr>
<td>Norwich</td>
<td>chiefly middens</td>
<td>Fairly Good</td>
<td>pervious</td>
</tr>
<tr>
<td>Manchester</td>
<td>mixed (½ W.C., ½ middens)</td>
<td>?</td>
<td>partially pervious (2)</td>
</tr>
<tr>
<td>Bradford</td>
<td>middens</td>
<td>?</td>
<td>impervious</td>
</tr>
<tr>
<td>Sunderland</td>
<td>middens</td>
<td>Flat</td>
<td>mostly impervious</td>
</tr>
<tr>
<td>Portsmouth</td>
<td>W.C.</td>
<td>Very Flat</td>
<td>pervious</td>
</tr>
<tr>
<td>Dublin</td>
<td>W.C.</td>
<td>Flat</td>
<td>½ pervious; ½ impervious</td>
</tr>
<tr>
<td>Brighton</td>
<td>W.C.</td>
<td>Very Good</td>
<td>pervious</td>
</tr>
<tr>
<td>Cardiff</td>
<td>W.C.</td>
<td>Fairly Good</td>
<td>impervious</td>
</tr>
<tr>
<td>Newcastle</td>
<td>W.C.</td>
<td>Fairly Good</td>
<td>impervious</td>
</tr>
<tr>
<td>Glasgow</td>
<td>W.C.</td>
<td>Fairly Good</td>
<td>mostly impervious</td>
</tr>
<tr>
<td>Bath</td>
<td>W.C.</td>
<td>Fairly Good</td>
<td>mostly impervious</td>
</tr>
<tr>
<td>London</td>
<td>W.C.</td>
<td>?</td>
<td>impervious</td>
</tr>
<tr>
<td>Plymouth</td>
<td>W.C.</td>
<td>Fairly Good</td>
<td>pervious</td>
</tr>
<tr>
<td>Derby</td>
<td>mixed (⅔ middens, ⅓ W.C., ⅓ Pails)</td>
<td>Fairly Good</td>
<td>impervious</td>
</tr>
<tr>
<td>Oldham</td>
<td>Pails</td>
<td>Very Good</td>
<td>impervious</td>
</tr>
<tr>
<td>Edinburgh</td>
<td>W.C.</td>
<td>Very Good</td>
<td>impervious</td>
</tr>
<tr>
<td>Bristol</td>
<td>W.C.</td>
<td>Very Good</td>
<td>impervious</td>
</tr>
<tr>
<td>Huddersfield</td>
<td>Pails</td>
<td>Very Good</td>
<td>impervious</td>
</tr>
<tr>
<td>Halifax</td>
<td>Pails</td>
<td>?</td>
<td>?</td>
</tr>
</tbody>
</table>
the exact order of their annual diarrhoea death rate being per 1000 births, beginning with Preston which has the highest death rate and ending with Halifax which has the lowest.
The horizontal line about the middle of the table indicates where the average death rate for all the towns, good and bad together, would come in; each town above the line having a death rate greater than the average for all the towns, and all the towns below the line having a death rate under the average for all the towns.

1) Disposal of Sewage.

On an examination of the table we find that no less than 11 out of the 15 towns with death rates below the average for all the towns are water-closet towns, while only 2 towns have a death rate above the average, and of them (Leicester) was until a few years ago a midden town.

Again, of the 16 towns having a
death rate above the average. I am aware of midden towns, and only 1 town (Derby) of that town only partially a midden town, has a death rate under the average. Is this absolutely clear that the midden system favours diarrheal mortality. What does the employment of the midden system imply? It means organic pollution of the soil. In an inaugural address to the Midland Medical Society, the chief Medical Officer to the Local Government Board, Sir Richard Thorne Thorne, says in reference to the prevalence of middens in the large Midland and northern towns of England: "Generally sunk below the surface of the ground, often open to rainfall, always storing up decomposing excreta and refuse, it provides almost every condition favourable to the produce of anaerobic and to the saturation of the soil with filth."

With regard to our towns, it have
an average death rate which is above that for all the towns, and 3 are below. The fact that 3 of the ‘pail’ towns should be so low on the list (Halifax, Huddersfield, Oldham) indicates the great superiority of this dry system, with movable receptacles, has over the other dry system (middens, fixed receptacles) but an efficiently carried out ‘pail’ system there is no likelihood of soil pollution; the system is simplicity itself and the whole management is directly under the eye. Recent excrement, even if kept near the house for some days does not seem to be greatly potent in producing disease; if, however, as in middens, adits, cesspools, it is left for weeks, and sometimes months, to putrefy and ferment, especially if leakage take place into the soil, we have the necessary conditions for producing disease.

(2) Physiographical Features
This is the second most important factor in causing the difference in diarrhoea mortality noticeable in
different large towns.
The fact that the 4 towns which have the smallest death rate (I have unfortunately no reliable information regarding Halifax) viz. Huddersfield, Bristol, Edinburgh, & Oldham, have excellent gradients, and that the towns with the 1st 2nd 4th & 5th highest death rate should be very flat point strongly to the importance of this factor. This factor also has an important relation to soil pollution; a town built on a flat surface cannot be efficiently drained as regards its subsoil, & so any pollution which may exist is likely to remain.

(3) Pervious or impervious subsoil.
This is another important factor in explaining the differences in diarrheic mortality observed in large towns. It must be taken in conjunction with the last factor i.e. the presence or absence of good gradients in the town. This factor, like the previous two, has an importance relation to organic pollution of the soil.
What is the state of matters existing when an unpervious subsoil exists in a town which is built on a flat surface? There is always, especially if surface of ground is flat, a greater or less depth of disturbed pervious soil or mould over the subsoil, i.e. the 'natural soil' which may be regarded as the weathered portion of the subsoil. Supposing organic pollution of this, the natural soil exists, when rain falls, the level of the ground water (held up by the unpervious subsoil, usually clay) rises, but does not rapidly drain away, but it slowly falls by very gradual drainage & by evaporation leaving the polluted 'natural soil' much as before, & not acting much or any purifying influence upon it; examples of this condition may be said to be present in Leicester, Preston, Salford, Hull etc.

Again, on the other hand, what happens when an unpervious subsoil exists where the gradients are good. The rain falls on the pervious 'natural soil'
But is soon caught by the impervious stratum and at once runs off, in the nature of an underground stream, carrying with it in solution or suspension any pollution which may exist; examples of this are seen in the 5 towns with the lowest annual diarrhoea death rate, e.g. Huddersfield, Bristol, Edinburgh, Glasgow, Oldham, + Derby.

Again, what is the natural sequence of affairs in a town where the gradients are good but the subsoil is pervious. Here, when the rain falls, it gradually soaks through, but does not acquire the character of an underground stream as happens when the impervious stratum exists so that organic pollution is lesened; the purification of the soil is not likely to be so thorough as when the impervious layer is present. A good example of this condition is Brighton and may explain why that town, with its low general death rate, should suffer comparatively severely.
from diarrhoea.

We thus see that a porous soil is a soil on which diarrhoeal mortality tends to be high; but, when a town is built on an imperious subsoil, this condition is favourable or not favourable to diarrhoeal mortality according to whether the gradients are bad or good.

The three factors above referred to are the chief reasons for the great difference observed in the diarrhoeal mortality of different towns, but there are also other factors which are important in this relation.

(a) Paving of courts and yards. 
Bad and irregular or broken paving of the courts and yards around houses necessarily leads to pollution of the soil in close proximity to the dwelling, and hence to diarrhoeal mortality.

(b) Scavenging. The frequency and method of removal of dry refuse
from houses.

(c) Parental ethical responsibility of parents of children. This is generally granted to exist in a higher degree in the lower classes of the Scotch than of the English, and may be one of the factors, but not an important one in my opinion, in explaining why there is so much less prevalence of diarrheal mortality in Scotland than in England.

(d) Employment of married women. This has been referred to on previous pages, and no doubt accentuates the diarrheal mortality in the Lancashire or 'cotton' towns.

The maternal neglect, which almost necessarily follows the employment of women with young children, may be to some extent counterbalanced by the better wages earned.
Conclusion

The conclusion, which I have arrived at, as to the ultimate 'Causes of Epidemic Diarrhoea' has been the same as that of the late Dr. Ballard in his report to the Local Government Board (1887); but as far as I have studied his published writings, makes his statement, as it were, 'ex cathedra'; he gives no sufficient data for his conclusion.

From the very strong evidence, which I have detailed, pointing to the organic pollution of the soil as the main factor in causing the great difference in diarrhoeal mortality in our large towns, and the fact, now accepted, first pointed out by Dr. Ballard, that the soil temperature bears a very close relation (much closer than atmospheric temperature) to diarrhoea prevalence and mortality, it appears to me to be a reasonable assumption that the causes of 'epidemic diarrhoea'
emanates from the soil.
The evidence previously led as to its being a 'specific' general disease, quite apart from the fact that Dr. Klein in his latest report (1898) to the Local Government Board claims to have isolated the specific organism (from the stools & from ash pits), lead me to assume that epidemic diarrhoea is due to a saprophytic, and as well as a parasitic organism; and this micro-organism has two distinct phases in its life history, one in the soil and the other in the human body.
This organism lives on the organic matter of a polluted soil, but may at certain times (during the epidemic season when the rising of the soil temperature favours its growth and activity) become air-borne, and is conveyed into the human system, either by inhalation, or, most probably, by swallowing in food, where it produces a highly poisonous 'alkaloid' or
'Toxin', which produces the symptoms of the disease.