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Causation of 'Epidemic Diarrhoea'

by

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The Causation of Epidemic Diarrhoea.

Introduction.

No one can gainsay the extreme importance of this subject as viewed by the place which 'diarrhoea' takes 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 Zymotics, & that in deaths from any cause whatever in this list it stands third, coupled with "other tubercular diseases." The figures are obtained from the decennial supplements 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, &

Cholera &
under Diarrhoea, ~~&~~ dysentery are included;
true dysentery however is now a disease
unknown having its origin in this country, & there has
been little cholera since 1866.

England & Wales. Death-rate per million pop.
from all causes & from several diseases
from 1861-95.

Years.	all Respir Causes	all Respiratory Diseases	Phthisis	Other Tubercular Diseases	Diarrhoeal diseases	Scarlet Fever	Typhus or Typhoid	Whooping Cough	Measles.
1861-70	22416	3591	2475	765	1076	972	885	527	440
1871-80	21272	3899	2116	747	935	716	482	512	378
1881-90	19080	3729	1724	696	674	334	235	450	440
1891-95	18737	?	1464	660	652	182	185	392	408

The next tabular statement shows, in 1000
deaths, what proportion of them are due to
(1) "all respiratory diseases" (2) 'diarrhoea'
(3) Scarlet fever.

Period of Years.	all respiratory Diseases	Diarrhoea	Scarlet Fever
1861-70	160.	48.	43·4
1871-80	184.	44.	33·5
1881-90	195.	35·3	17·5
1891-95	?	35.	9·7

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; & in the quinquennium from 1891-1895, 35 deaths out of every 1000 were due to 'diarrhoea'.

The comparison between the mortality from 'diarrhoea' & scarlet fever is specially interesting. In the decennium 1861-70 'diarrhoea' & 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 scarlatina.

For the same period ('91-'95) deaths from diarrhoea were 4 times as numerous as those from 'fever' (typhoid, typhus & continued fever), & ½ as many again as those from measles & 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' &c. It is highly probable also that many deaths, returned as 'infantile debility' 'marasmus' 'want of breast milk' and 'vomiting', especially those occuring in the epidemic season, should have been registered as due to 'diarrhoea'. Dr. Longstaff ('Studies in Statistics'— article on Summer Diarrhoea) has drawn mortality curves for these diseases, & they imitate 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', &c.; 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 the death occurs 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 Parkes (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, & 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 tables are taken from his article:—

Percentage of Deaths at Three Age Periods to Total Deaths.

	Diarrhoea + Cholera			Enteritis		
Years	Under 1	1 to 5	Over 5	Under 1	1 to 5	Over 5
	Per Cent	Per cent	Per cent	Per cent	Per cent	Per cent
1861-65	62	20	18	30	12	58
1866-70	68	18	14	36	12	52
1871-75	71	17	12	37	13	50
1876-80	70	17	13	44	14	42
1881-85	71	16	13	38	13	49
1886-90	73	16	11	49	12	39
1891-95	74	15	11	61	13	26
1896-97	79	13	8	68	13	19

This table shows that whereas 30 years ago only 30 per cent of the enteritis deaths were of infants under 1 years, 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 shows how the enteritis deaths have almost trebled themselves of late years:—

Death-rate per million pop. in London

Period of Years	Diarrhoea and Cholera	Enteritis	Diarrhoea, Cholera and Enteritis
1861 – 1870*	1105	102	1207
1871 – 1880	987	100	1087
1881 – 1890	772	115	887
1891 – 1897	711	291	1002

* 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 tends 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, & 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, & 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 cognisance 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', labours 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', & 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 ~~one~~ a general one of specific character; by including it as one of the chief 7 zymotics.

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) Prodromata. 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" &c 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 &c, 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 diarrhoeal 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

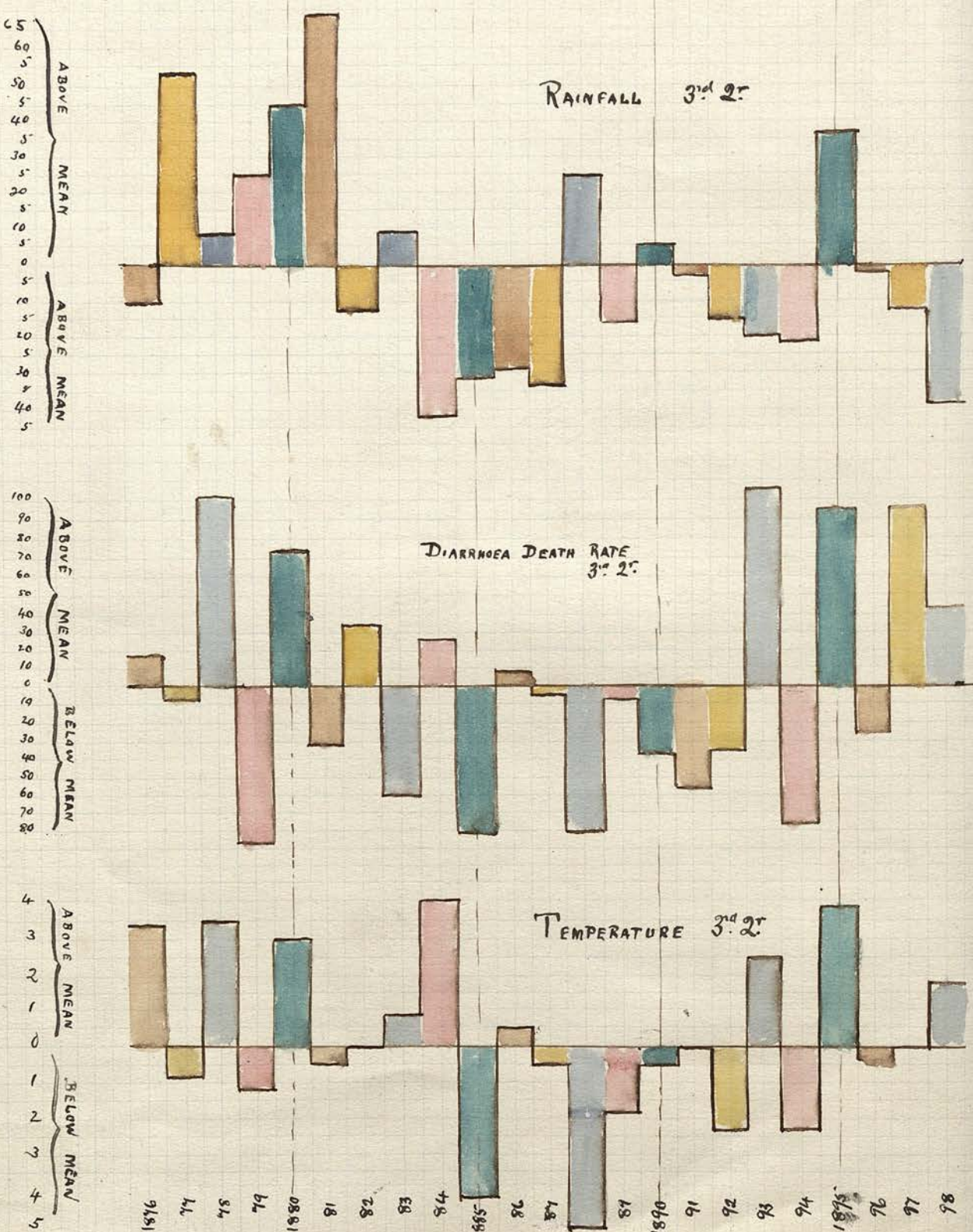
of the damaged kidney (v. infra) to throw off the poison.

(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 morbid poison. Dr. Klein (v. Dr. 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 D^r. Ballard truly remarks, reminds one for the moment of the operation of at least one chemical poison — phosphorus.

(6) Occasionally it would seem that 'diarrhoea', indistinguishable from ordinary 'epidemic diarrhoea', may sometimes be communicated from person to person. D^r. Bruce Low (Appendix H. Report to the L. G. B. 1887) gives details of four different outbreaks in which 'diarrhoea' 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 a affected person while a motion was being passed, or to inhale the offensive odour of such a stool;

Hull. 1876-98 (v text.) : showing percentage deviation above and below mean.



as a rule within 24 hours a person so exposed was violently ~~ill~~ taken with vomiting and purging.

Relation of Diarrhoea Death Rate to Temperature and Rainfall.

The relation of a high mean temperature of the air & 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, & the data have been obtained from the returns of the Registrar-General. Each chart shows the percentage above & below the mean of the rainfall, temperature, & diarrhoea death rate for the 3rd quarter of each year during the period stated.

Bristol Deviation from mean 3rd Q.

Rainfall.

Temperature

Diarrhoea death.

BRISTOL 1876–1898 (v. TEXT)

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 & diarrhoea death rate respectively.

The temperature, rainfall, & death rate for each year have been placed in the same ~~year~~ vertical line & painted in the same colour, in order to help the eye to study the relationship between them 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.

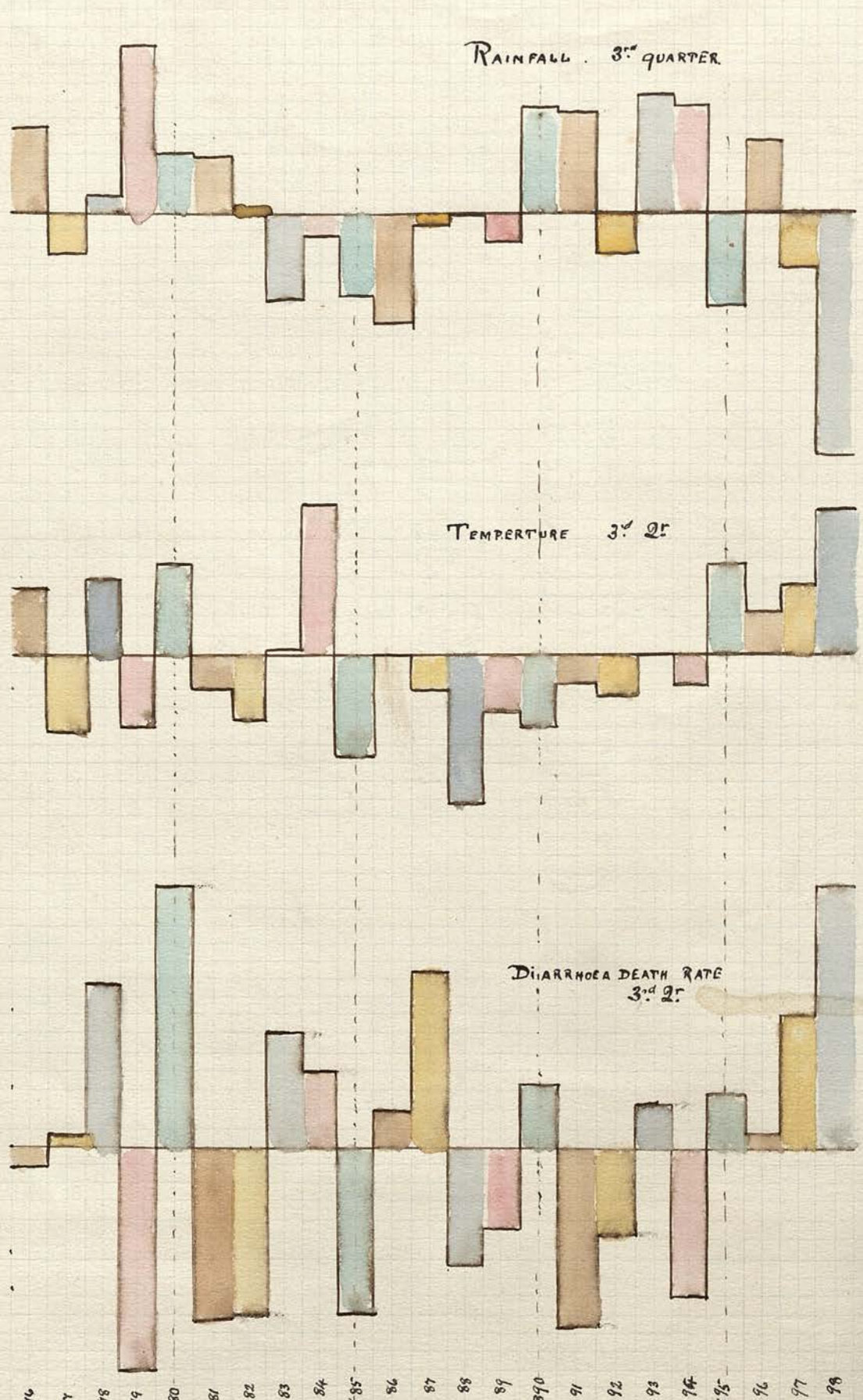
Brighton: deviation from mean
3rd Quartile

Ramsgate

Temp.

Diar.

Brighton 1876 - 1898 V. Text



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, & 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 & the rainfall is quite up to the mean. eg. Brighton 1887.

Given a high temperature, excessive rainfall at the same time does not as a rule reduce the mortality as might be anticipated. Eg. Hull in 1881 & 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

LONDON. 1876–1898. V. text.

only marked exception being in 1893, when the temperature was very high & 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, & vice versa.
Also, but with more exceptions, a dry season is conducive to a high death rate, & 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, 1887),
"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 weeks. The general
result shown by these charts is :—

a. The summer rise of diarrhoea
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 4-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, & 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 differences

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 shows the total deaths from diarrhoea in London 1891-96 and the percentage occuring under 1 year

Year	Total at all ages	Under 1 year	% under 1 year
1891	2510	1826	73%
1892	2633	1880	72%
1893	3579	2618	73%
1894	1812	1341	74%
1895	3674	2820	77%
1896	3318	2641	79%
	17526	13328	76·2%

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.

Again Leeds. M.O.H. report 1895.

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 same 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 diarrhoeal 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 diarrhoeal mortality which characterised Halifax and Huddersfield,

and its great prevalence in neighbouring townships in the West Riding of Yorkshire e.g. Leeds, Bradford &c. 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, & 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:-

Leicester 1876–1898.

Year.	1st Quarter			2nd Quarter				3rd Quarter				4th Quarter			
	Births	Diarrhoea Deaths.	Death rate per 1000 births	Births	Diarrhoea Deaths	Death Rate per 1000 births	Death rate of 1st + 2nd quarters.	Births	Diarrhoea Deaths	Death rate per 1000 births	Death Rate of 1st + 2nd + 3rd Quarters	Births	Diarrhoea deaths	Death Rate per 1000 births	Death Rate of 1st, 2nd, 3rd + 4th quarters
1876	1319	8	6.06	1142	4	3.51	9.57	1143	238	209.	218.5	1171	10	8.55	227.5
77	1283	3	2.35	1156	2	1.73	4.1	1120	165	148.	152.1	1145	12	10.6	162.7
78	1253	5	4.01	1208	14	11.6	15.6	1157	264	228.	243.6	1147	17	14.8	258.
79	1259	5	3.97	1123	7	6.25	10.2	1192	60	50.5	60.7	1214	13	10.8	71.5
1880	1234	9	7.32	1248	13	10.4	17.7	1247	343	275.	292.7	1101	30	27.2	320.
81	1282	4	3.13	1211	11	9.09	12.2	1132	166	147.	159.2	1086	8	7.34	166.5
82	1252	3	2.41	1219	18	14.8	17.2	1211	179	148.	165.2	1174	9	7.69	172.9
83	1282	6	4.69	1256	4	3.18	7.9	1129	125	111.	119.	1120	12	10.8	129.8
84	1232	5	4.07	1220	9	7.38	11.4	1190	302	254.	265.4	1279	12	9.38	274.8
85	1232	9	7.32	1191	14	11.8	19.1	1104	163	148.	167.	1125	3	2.68	169.7
86	1297	5	3.85	1194	8	6.73	10.6	1185	217	184.	194.6	1181	22	18.7	213.
87	1158	2	1.73	1172	5	4.28	6.	1222	229	188	194.	1127	7	6.19	200.2
88	1251	1	.801	1252	2	1.61	2.4	1104	121	109.	111.4	1179	23	19.5	130.9
89	1233	6	4.88	1255	22	17.5	22.4	1083	185	172.	194.4	1186	9	7.57	202.
1890	1245	3	2.42	1226	14	11.4	13.8	1186	162	136.	149.8	1132	36	31.9	181.7
91	1200	7	5.83	1277	8	6.25	12.0	1182	164	139.	151.	1130	25	22.2	173.2
92	1362	7	5.15	1569	19	12.2	17.35	1473	164	112.	129.3	1378	16	11.6	140.9
93	1530	3	1.96	1544	111	72.2	74.2	1516	272	185.	239.	1416	15	10.6	269.6
94	1510	2	1.33	1465	8	5.48	6.8	1405	156	111.	117.8	1554	10	6.46	124.3
95	1559	4	2.57	1536	23	14.9	17.5	1428	311	218.	235.5	1431	32	22.4	258.
96	1493	3	2.02	1520	31	20.4	22.4	1510	231	153.	175.4	1689	8	4.73	180.
97	1668	5	2.99	1523	4	2.63	5.6	1540	338	219.	224.6	1475	11	7.48	232.
98	1576	5	3.17	1612	8	4.97	8.1	1516	278	183.	191.	1452	37	25.5	216.5
	30710	110	3.60	30119	359	11.9	15.5	28975	4833	166.	181.5	28892	377	13.1	194.6

30710
30119
28975
28892
Total births = 118696

110
359
4833
377
5679 = deaths

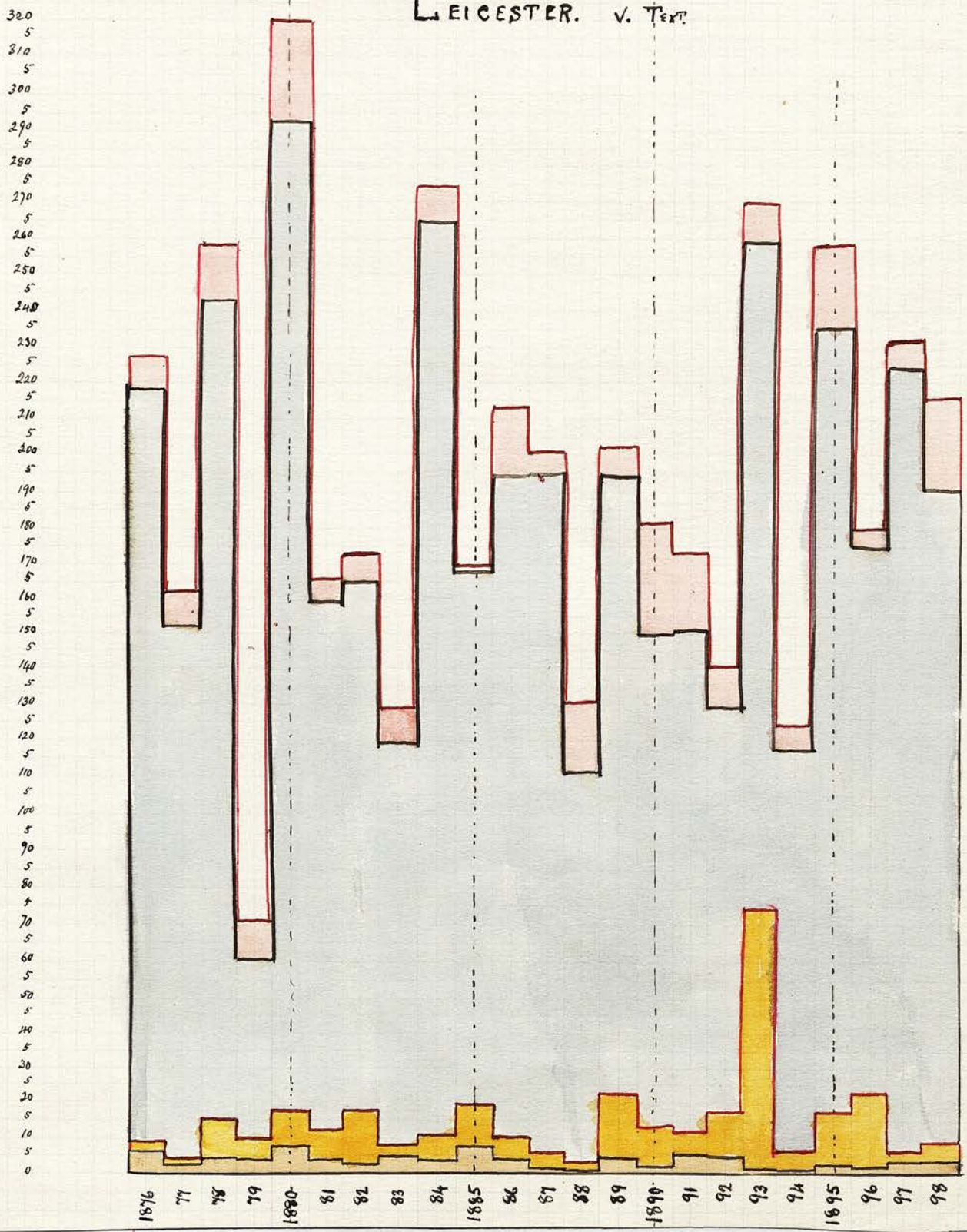
3rd Quarter death rate = 166 per 1000 births.

∴ 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

LEICESTER. V. TEXT.



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, + is used throughout for all the charts so that they are strictly comparable. The distance between two vertical ~~lines~~ spaces 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 & 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, & 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 diarrhoea 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 1882–98.
350
340
330
320
310
300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1882
83
84
1885
86
87
88
89
1890
91
92
93
94
1895
96
97
98

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 ~~tells~~ 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 & 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 = 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 diarrhoeal mortality and in 1897-98 the conditions favoured a high mortality, but in Preston the favouring meteorological conditions have not produced the mortality ~~on~~ 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, + 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 ½ 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 Mr. 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 Miss Collet (Journal of Royal Statistical Society, June 1898), there is at least 39% 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 diarrhoea deaths occur under 1 year of age.

Disposal of Sewage. (My data for this are invariably obtained from the report of Dr. Boobbyer to the Nottingham Health Committee, the date of which is 1894)

Preston is a midden town, 1/4 of the houses having W.C.'s, the other 3/4ths having midden privies.

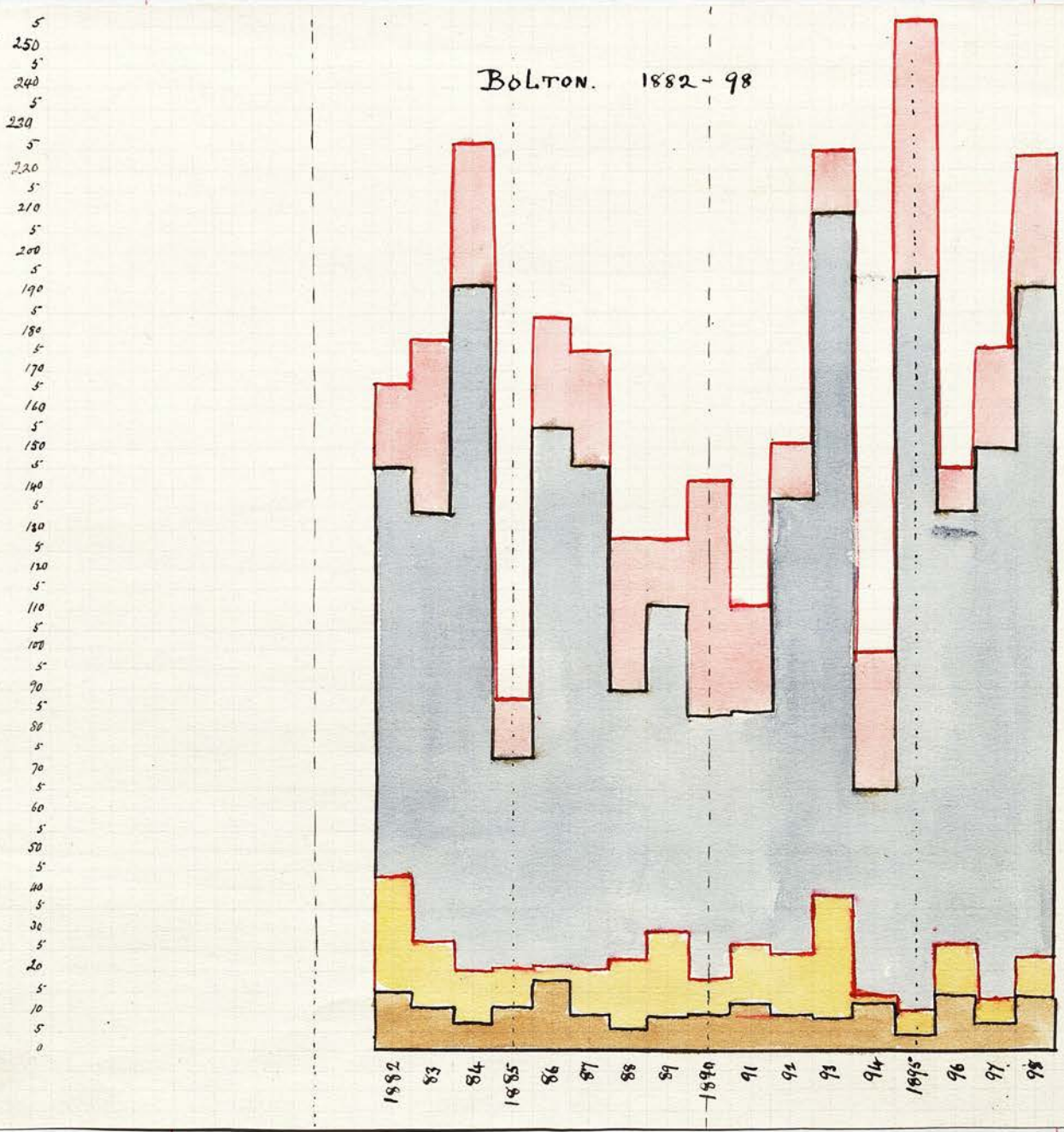
Leicester.

Leicester stands 2nd. on the list of great towns, being next to Preston in maximum mortality from diarrhoea. It is characterised particularly by the epidemicity of its diarrhoea mortality; there is very little in the 1st. 2nd + 4th Quarter; practically all 3rd. quarter diarrhoea (v. chart p 28) The deathrate for the 1st. quarter 1876-98 was 3.6 per 1000 births; 3rd. quarter = 166. 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 new 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 &c of a varying thickness. The greater part of the population is housed on the marshy alluvium, the remainder on boulder clay & on marl & other impervious beds. The subsoil of the borough has been for a long time past, at least half a century, in a polluted state & in many localities actually sewage sodden, according to the late Dr. Tomkins (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 town until quite recently, but is now a water-closet town. The past history of a town often throws light on its diarrhoeal 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, not exposed to the air, & paved over in great part.


BOLTON. 1882 - 98
250
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230
220
210
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170
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140
130
120
110
100
90
80
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50
40
30
20
10
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1882
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85 86
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1890-1
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1895
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Bolton.

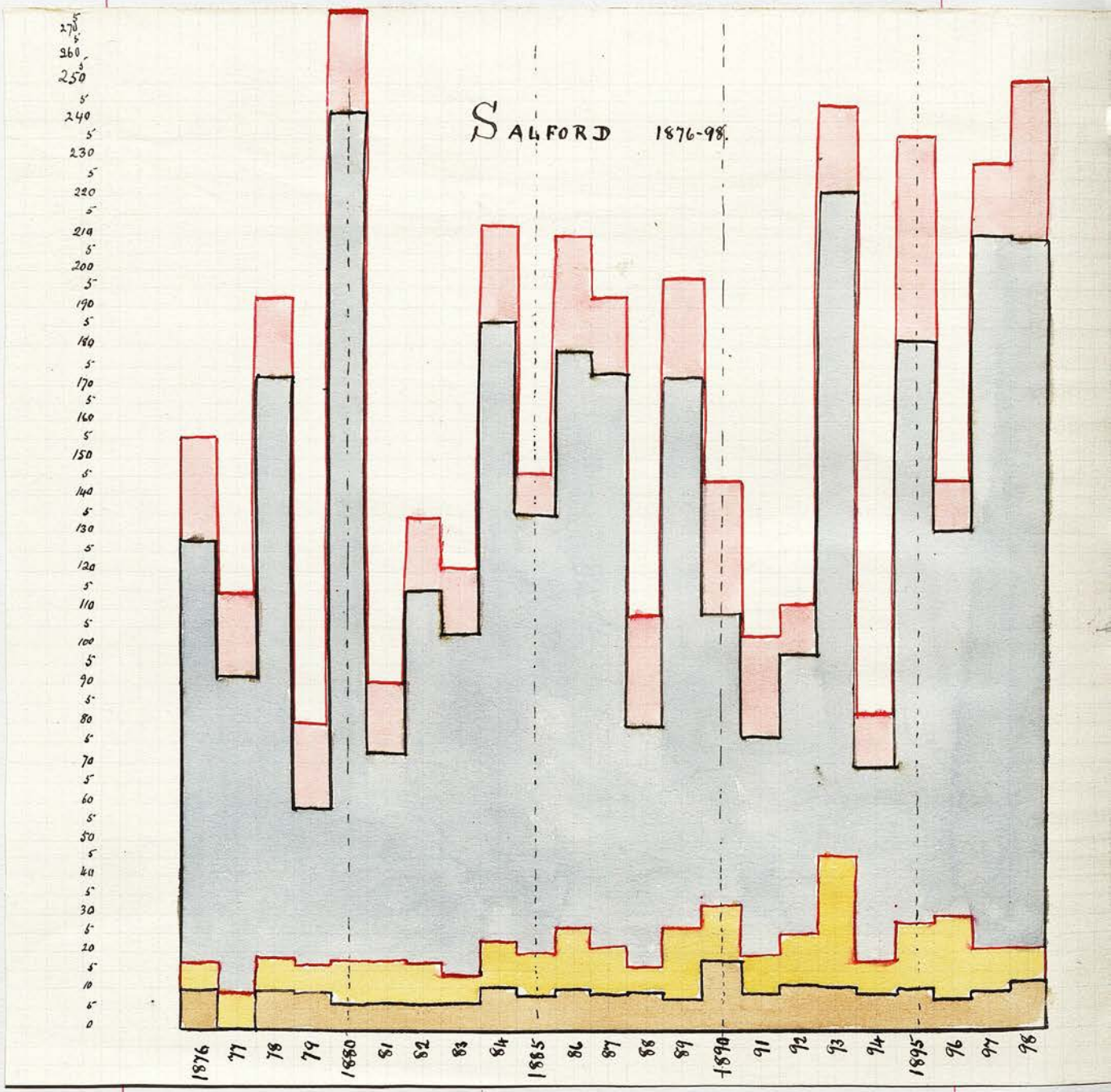
Bolton has the 3rd highest mortality from diarrhoea, the annual death-rate ~~for 1000 births~~ being 41·2 per 1000 births for the period 1882-1898.

Taking the meteorological conditions into account, on looking at the chart, it would seem that the mortality is more or less stationary, neither improving or going back.

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

"Bolton lies on the undulating plains 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 overspread with boulder clay & 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."
M. 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 pervious, & 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.
Diarrhoea is more endemic in Bolton than in ~~most~~ majority of the English towns; there appears to be a special incidence on the 4th quarter (v. chart.)
Disposal of Sewage. $\frac{2}{3}$rds of the houses have middens, $\frac{1}{3}$ have "pails" — a few W. C's. (Boobbyer'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 1876-98.
270
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10
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Salford.

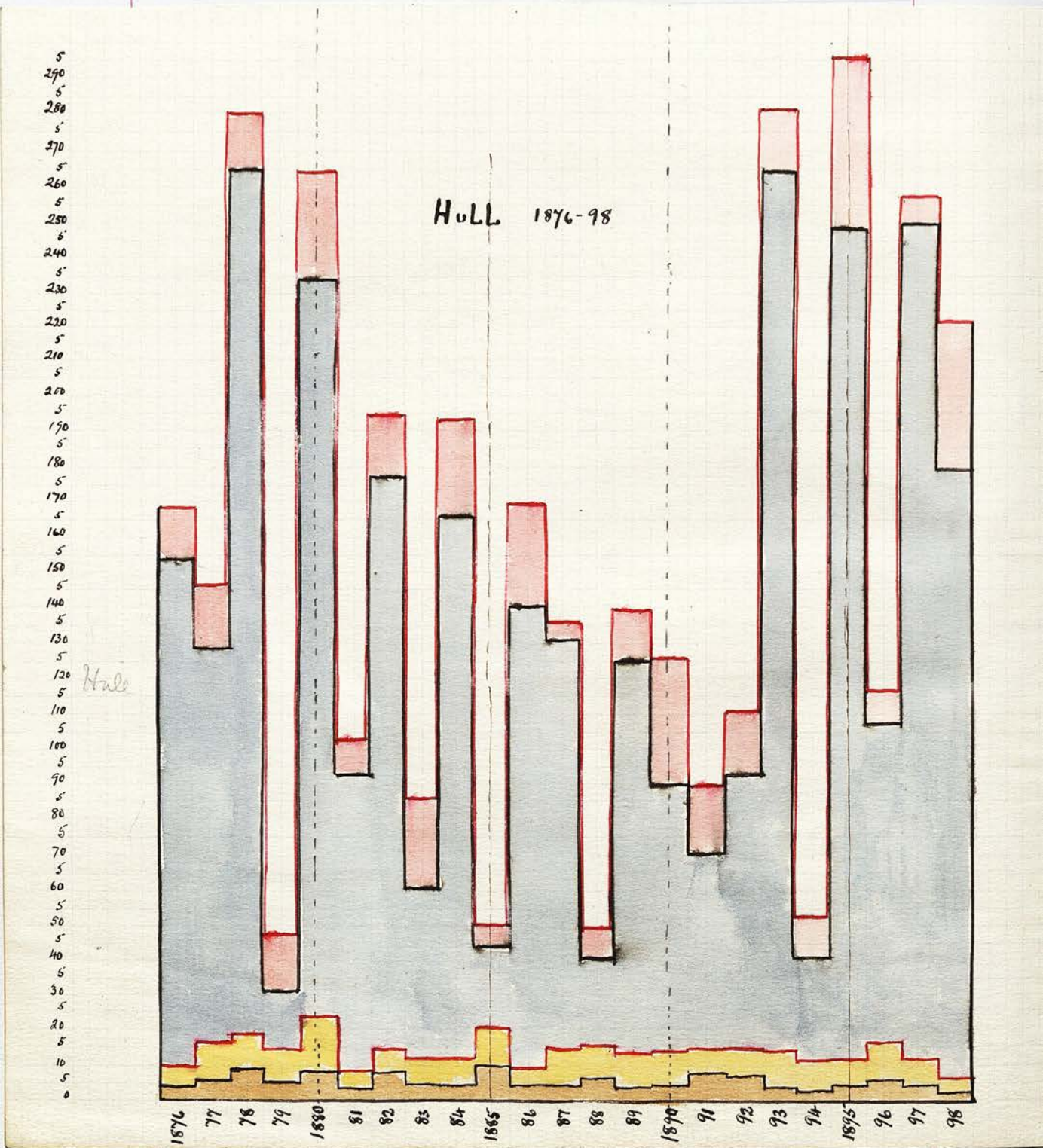
Salford, the sister town to Manchester, has a much greater diarrhoeal mortality; Salford being 4th + Manchester 14th on my list of great towns.

The town stands on a level plain, and the gradients are not good.

"The solid geology consists of the coal measures + new 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 impervious subsoil, and 10% on pervious. (No. of H. report)

Disposal of Sewage. Majority of houses have middens, but a good proportion have pails and 1/6th have W. C.'s

Annual diarrhoeal death rate is 39.3 per 1000 births.


HULL 1876-98
Hull
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200
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140
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120
110
100
90
80
70
60
50
40
30
20
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1876
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1895
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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.

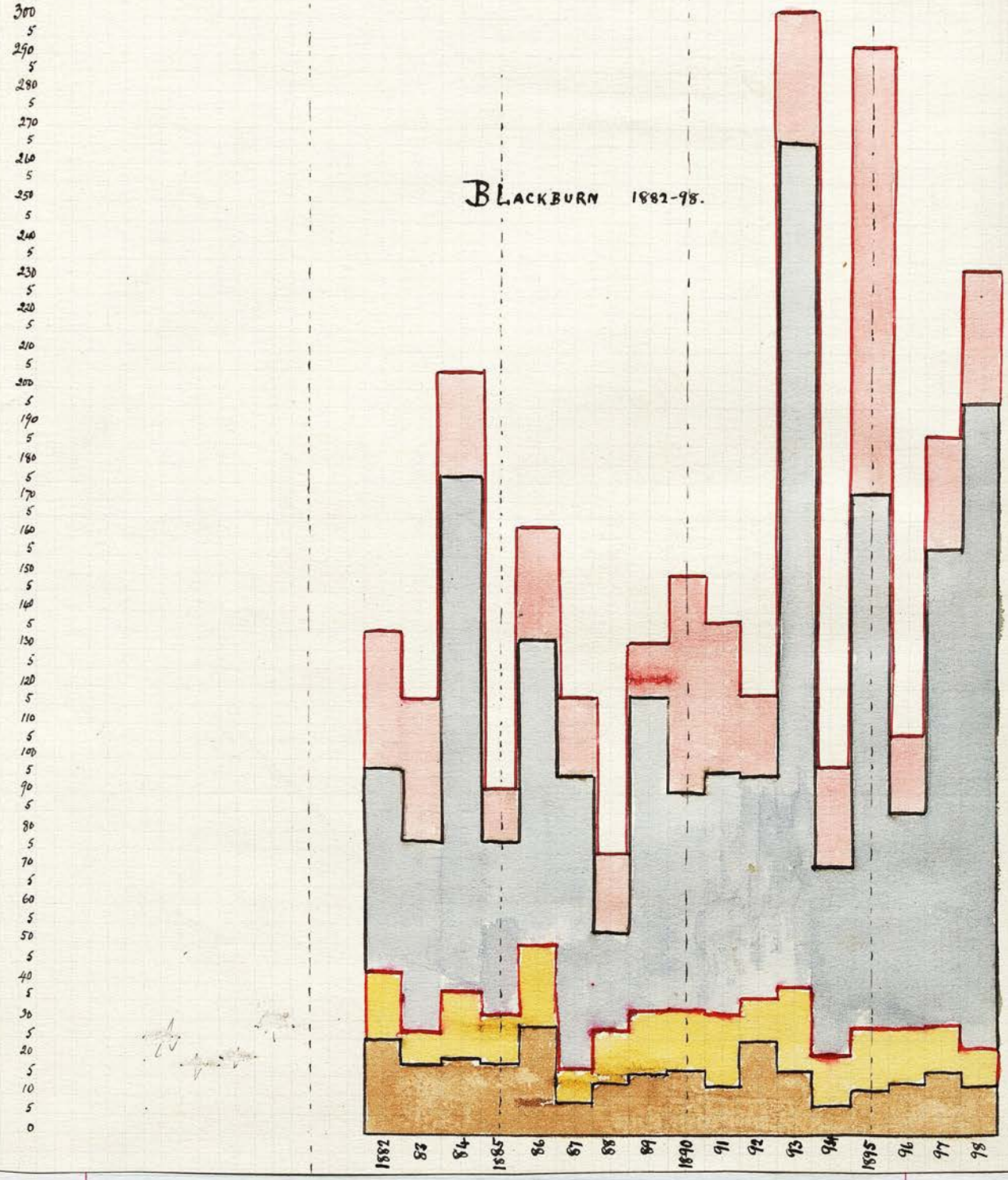
The soil is entirely Humber alluvium consisting of fine sandy clay, used extensively in making bricks.

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, & the average temperature for the same period was 56·6° F (in the 3rd quarter).

Disposal of ~~Refuse~~ sewage. 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 diarrhoeal mortality.


BLACKBURN 1882-98.
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1895
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The average annual death rate for the period 1876 – 1898 was 38·9 per 1000 births; the 3.rd 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 3.rd quarter furnishes the highest mortality but there is a great deal also in the 1.st 2.nd & 4.th quarters. Observe the enormous mortality figured on the chart for the 4.th quarter of 1895; the actual number of diarrhoea deaths for that year are as follows :— 1.st quarter = 12; 2.nd quarter = 17 3.rd quarter = 144 4.th quarter = 102; the number of deaths in the 4.th quarter nearly approached those of the 3.rd. The death rate for

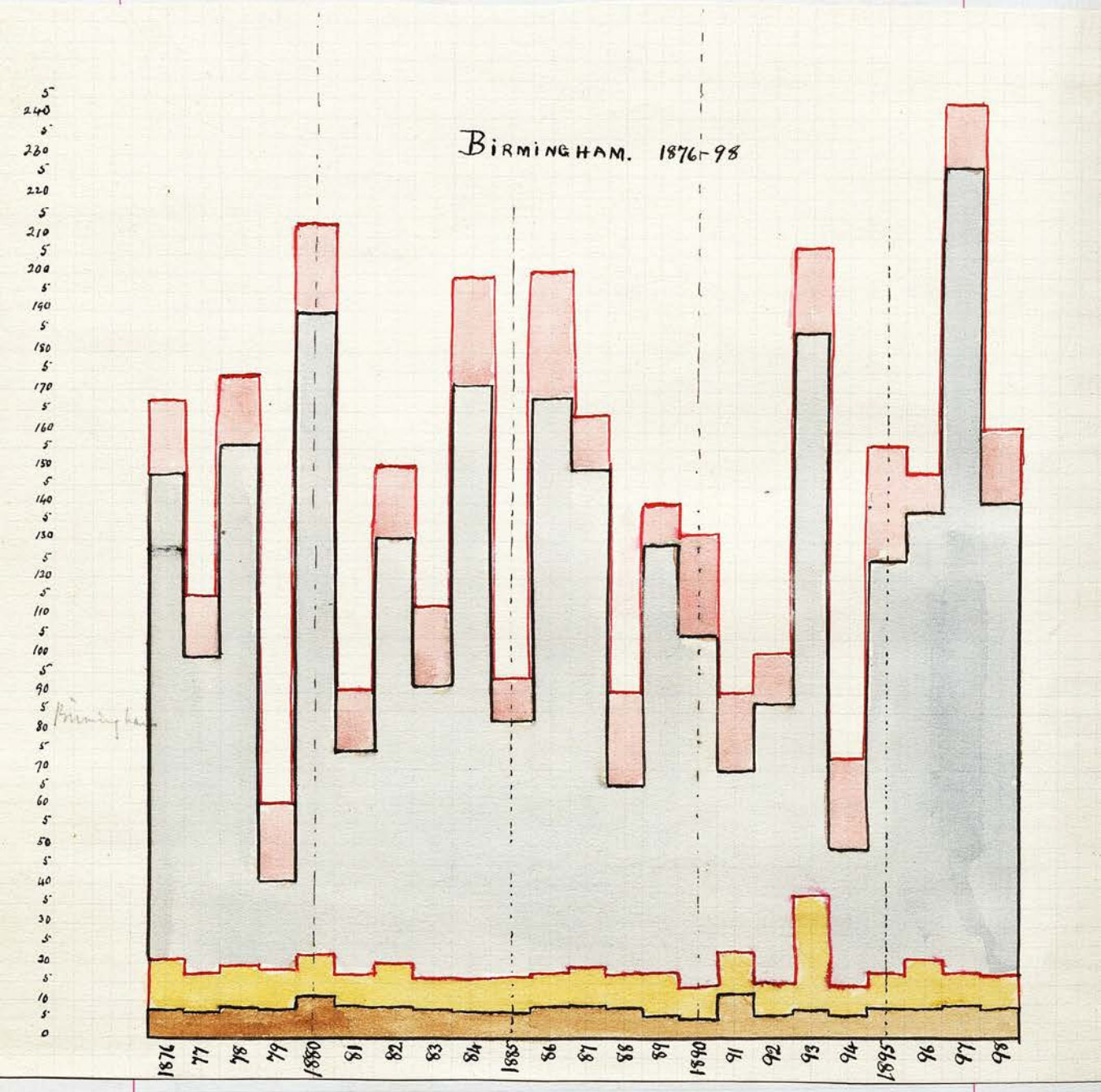
the 1st. quarter (1882-1898) averaged 16·5 per 1000 births; for the 3rd. quarter for the same period it was 89; i.e. the 3rd. quarter mortality was only 5½ times that of the 1st. quarter: compare this with Leicester, where the 3rd. quarter was forty-six times that of the 1st., and Hull, where the 3rd. quarter was 23 times that of the 1st. What this portends it is difficult to say but these enormous differences must mean something fundamental: the idea forces itself upon one 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 $\frac{1}{6}$th of the population are housed on the very pervious sand, and $\frac{5}{6}$th 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.
Mis 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 bet 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 middens. (1894)


BIRMINGHAM. 1876-98
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1880/81
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Birmingham.

Birmingham has the 7th highest diarrhoea mortality.

The M.O.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 pervious subsoil.

The annual diarrhoea death rate averaged for 1876-98 36·9 per 1000 births; for the 3rd quarter, it was 109 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 pan or pail closets are about equally common, $\frac{1}{8}^{th}$ of total houses have a midden privy attached to the dwelling.

Leeds.

The annual diarrhoeal 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

LEEDS. 1876-98
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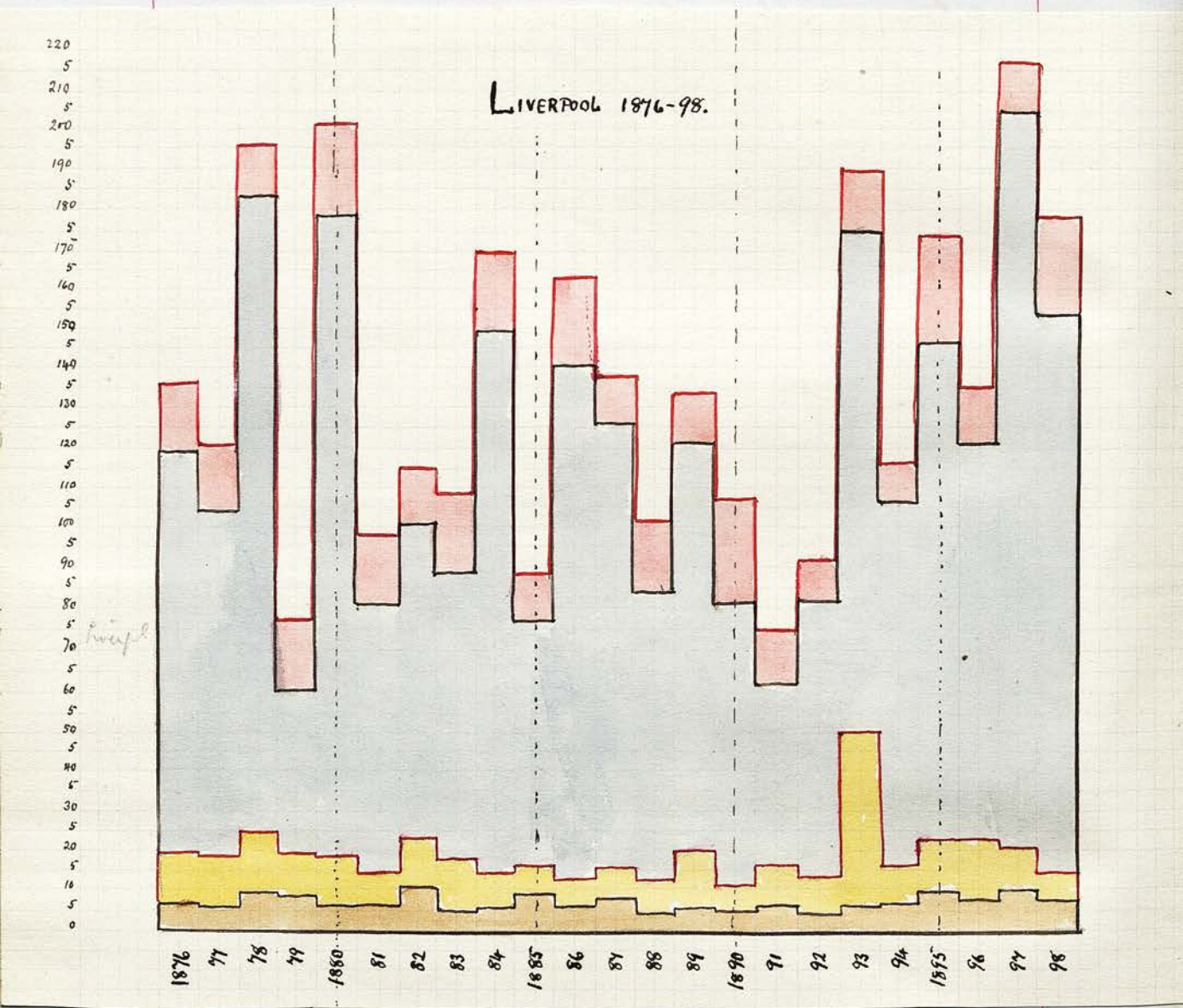
1895
96
97
98

clay is covered by the alluvium in a portion of the centre of the town.
The alluvium is to some extent porous the shale & clay are impervious, so that Leeds as a whole may be said to be built on a partially impervious site. The above geological facts are obtained partly from the drift maps of the Geological Survey, & partly from the M. O. H.'s 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 W.C.'s the other half middens. I might here detail an interesting experiment carried out in 1893 by D^r Spottiswoode Cameron, the M. O. H., Leeds & (v. British Medical Journal 1894):—
In 1893 an experiment was made by emptying the middens and ashpits and cleaning the street gullies more frequently than was the regular custom in one particular district in the town


LIVERPOOL 1876-98.
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(the S.E.), the other districts being scavenged as heretofore. 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 34·7 per 1000 births; the 3rd quarter being 102 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

SHEFFIELD
1876-98
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10
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1876
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1895
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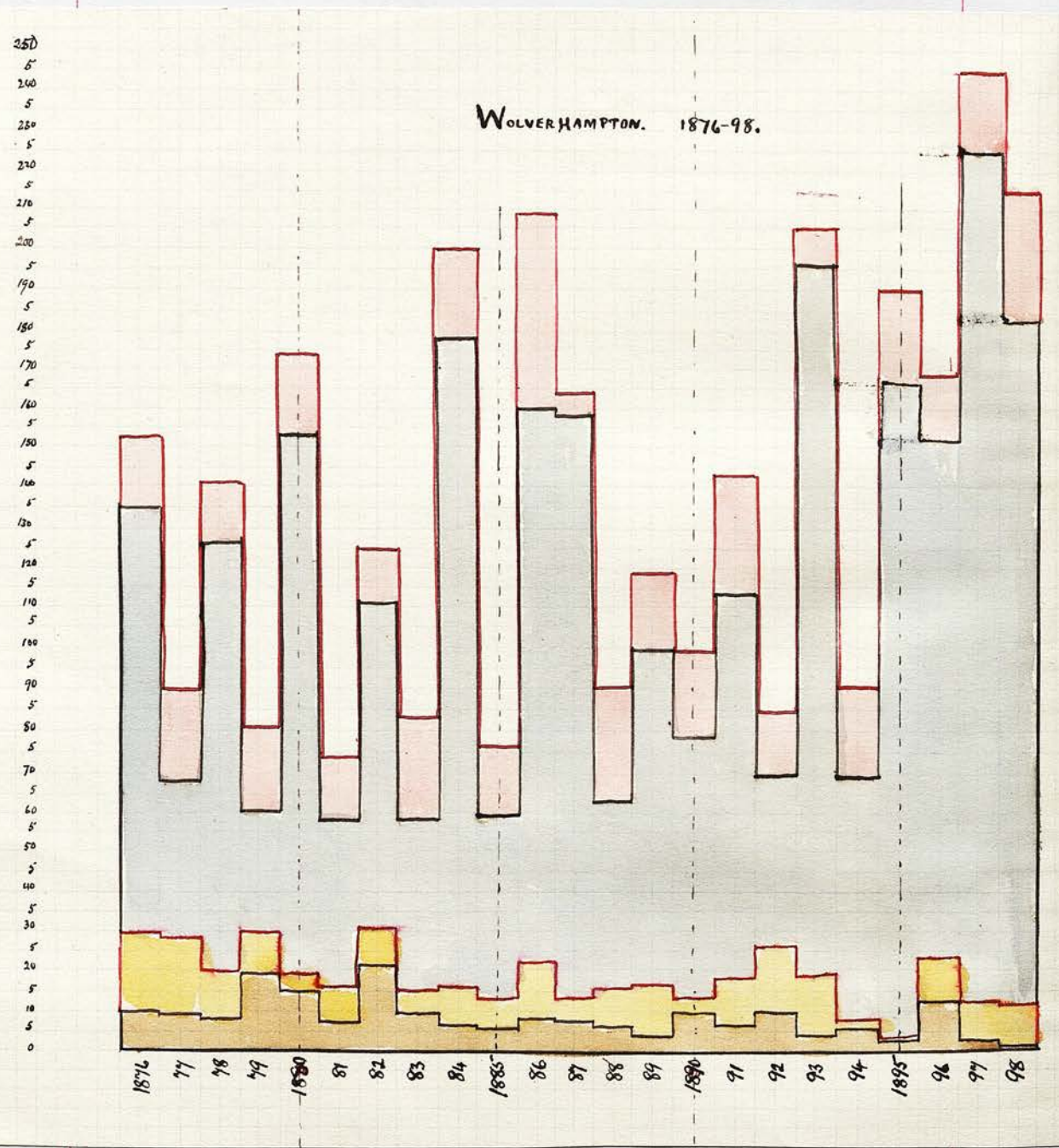
porosity, the softer variety being quite pervious, and the hard only partially so; Liverpool is built for the most part on the softer variety. In the outer part of the town where fewer houses are built, a considerable amount of boulder clay is met with.
Disposal of Sewage. Is entirely a water-closet town

Sheffield.

Sheffield has an annual diarrhoea mortality 1876-98 of 34·5 per 1000 births; 3rd quarter 111· 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


WOLVERHAMPTON. 1876-98.
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10
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1876
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1881
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1886
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1891
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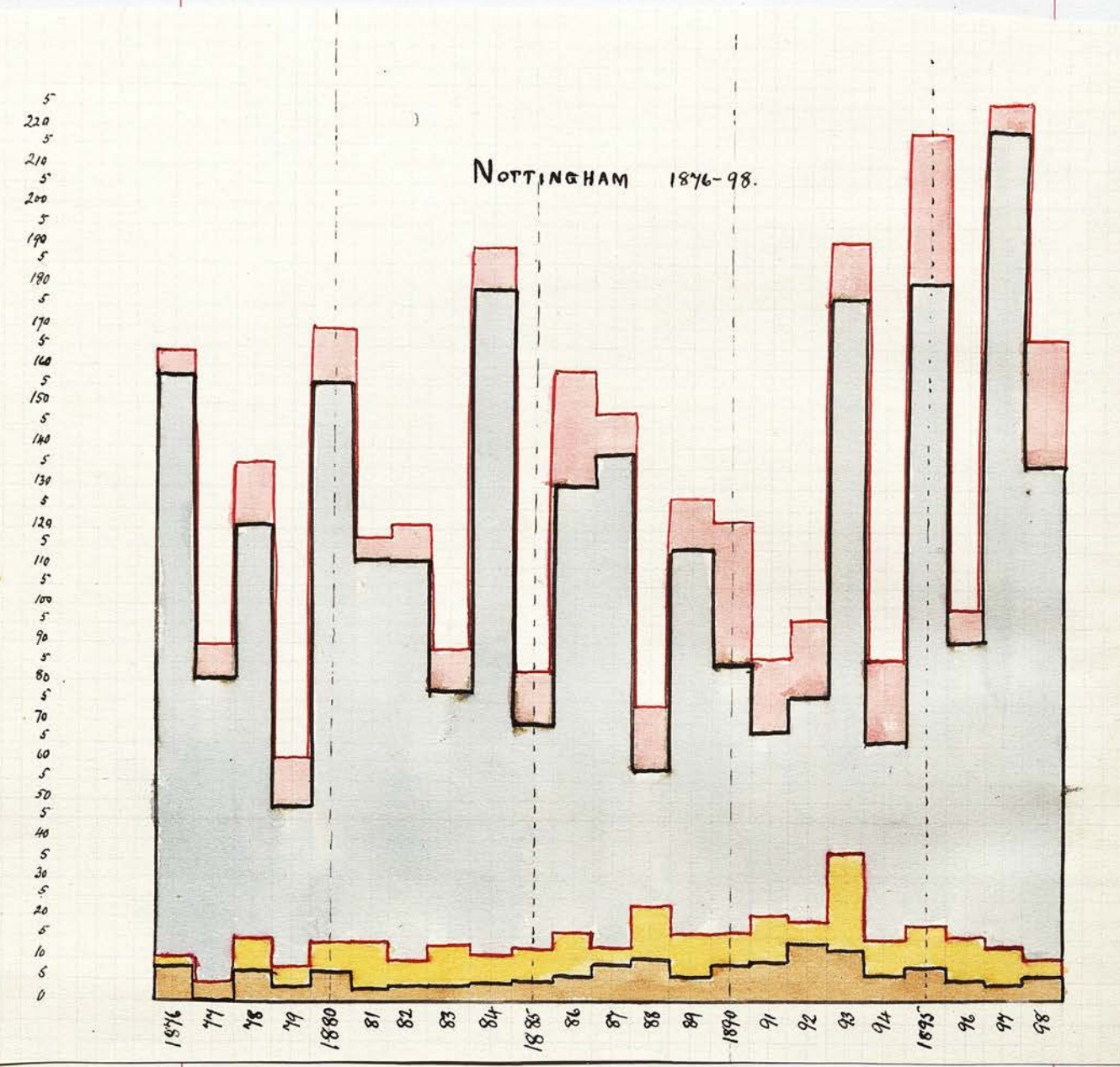
1896
97
98

town are good.
Disposal of Sewage. Sheffield ~~Leeds~~ is a midden town; about $\frac{1}{5}$ of the houses have water-closets, the remaining 4/5ths have midden privies.

Wolverhampton.

In order of maximum diarrhoeal 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; $\frac{1}{8}$th of the houses have waterclosets, the rest have pail-closets.


NOTTINGHAM 1876-98.
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1895
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98

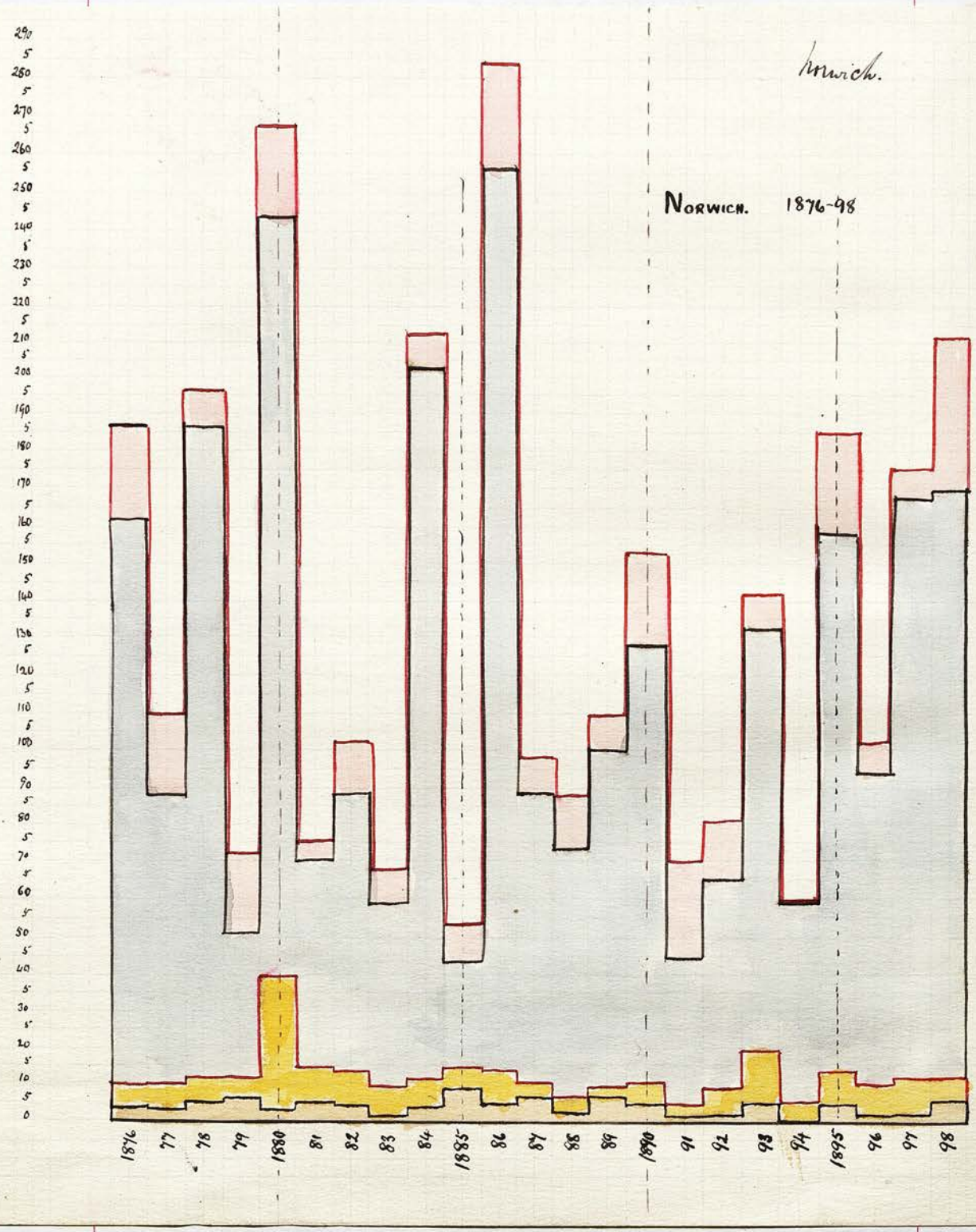
Nottingham.

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 12th on the list of towns.

It is situated on an acclivity of a rock rising above the Trent.

The gradients in the town are faidly good.

Disposal of Sewage. Nottingham is another of the 'pail' towns; $\frac{5}{6}$ths of the houses have pail closets; the remaining $\frac{1}{6}$th have water-closets.


Norwich.
Norwich. 1876-98
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Norwich.

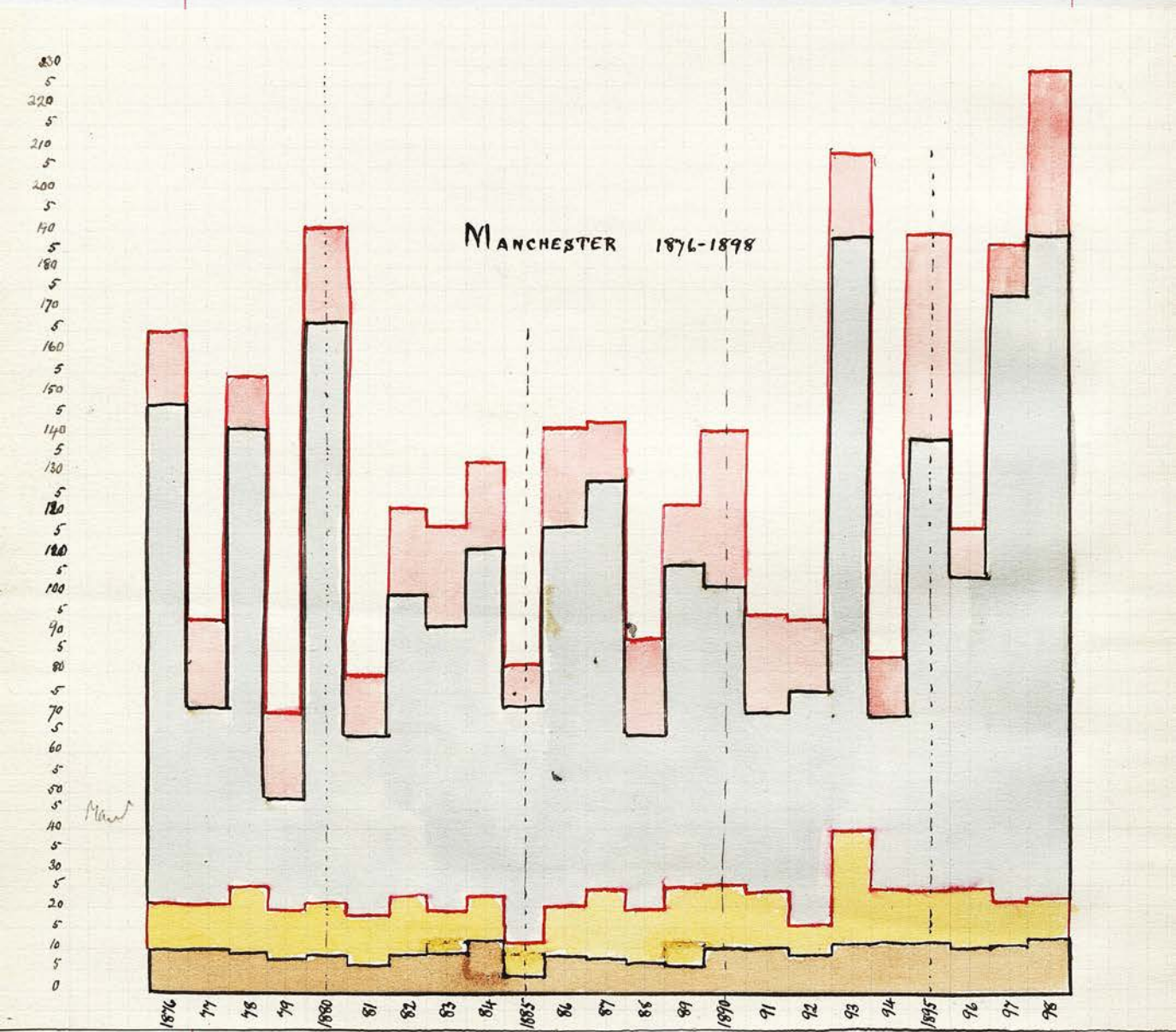
This old city is characterised by isolated years of great diarrhoea mortality; it suffered exceptionally in 1880 & 1886. (v. chart:) It shows some improvement as regards its diarrhoea death rate of late years; the hot and dry summers of recent years have not caused the diarrhoea death rate to run up to the same extent as formerly.
The annual death rate (1876-1898) averaged 32·2 deaths per 1000 births; in the 3rd quarter for the same period 106.
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, through ~~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 & underlies the whole of the city, comes to the surface in several places in the town, & may be reached at no great depth 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., Dr. Cooper Pattin, expressed it to me, "squatting on a sponge."

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

Disposal of Sewage. Norwich is a mixed town; $\frac{3}{5}$ths of houses have middens, $\frac{1}{5}$ pails, $\frac{1}{5}$ water-closets


MANCHESTER 1876-1898
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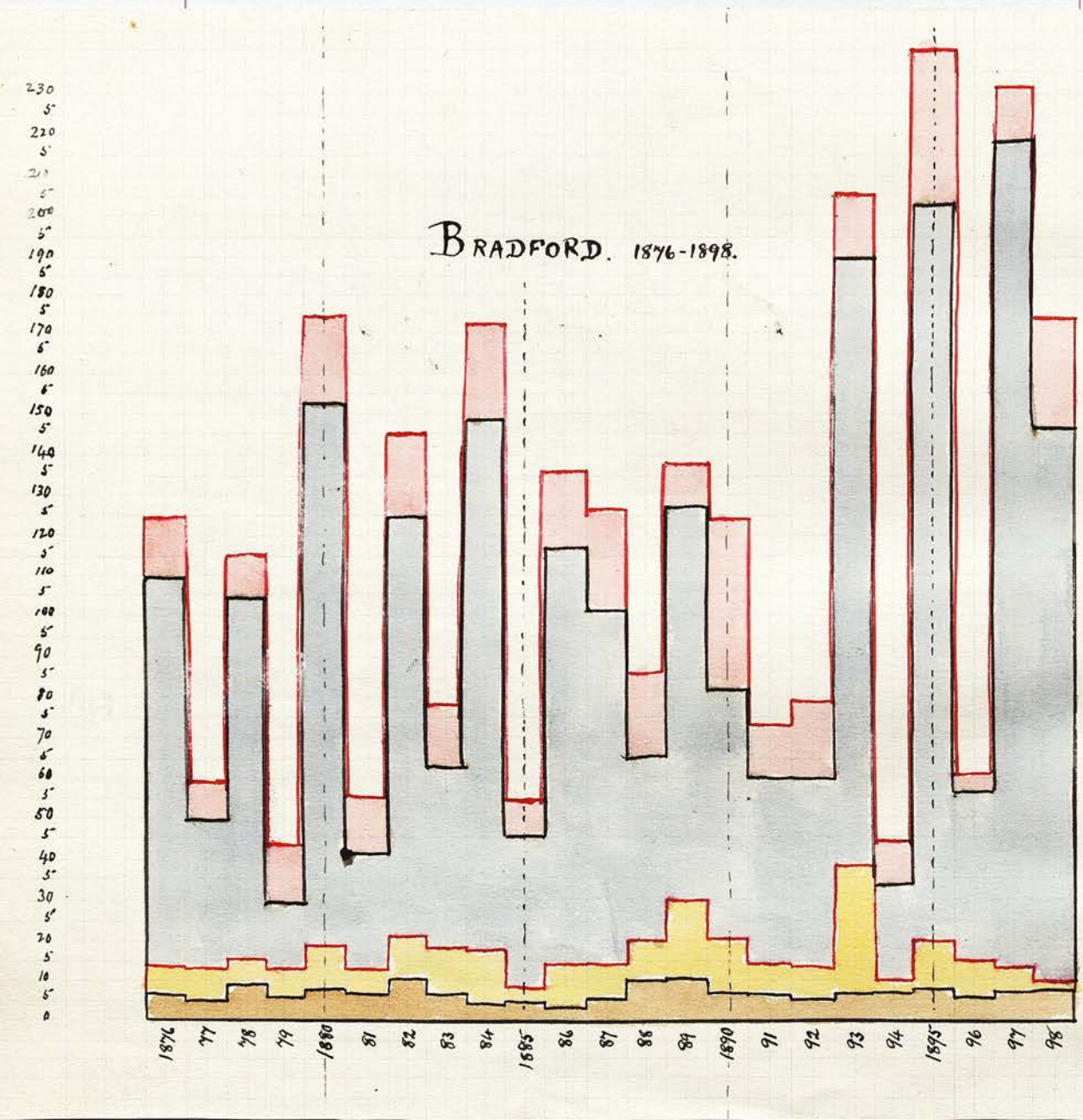
(Boobbyer's report 1894). The M.O.H. now informs me (1899) that ½ only of the houses have middens, ⅓ W.C.'s, + ⅙ pails; this fact may go some way to explain that Norwich has improved of late years in diarrhoea mortality.

Manchester.

This large city occupies a fairly good position with regards to its diarrhoea mortality; it is 14th on the list with an annual death rate of 32.2 per 1000 births, and only 7% above the average for the great towns (which 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.


BRADFORD. 1876-1898.
230
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210
200
190
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170
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130
120
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100
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40
30
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1876
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1895
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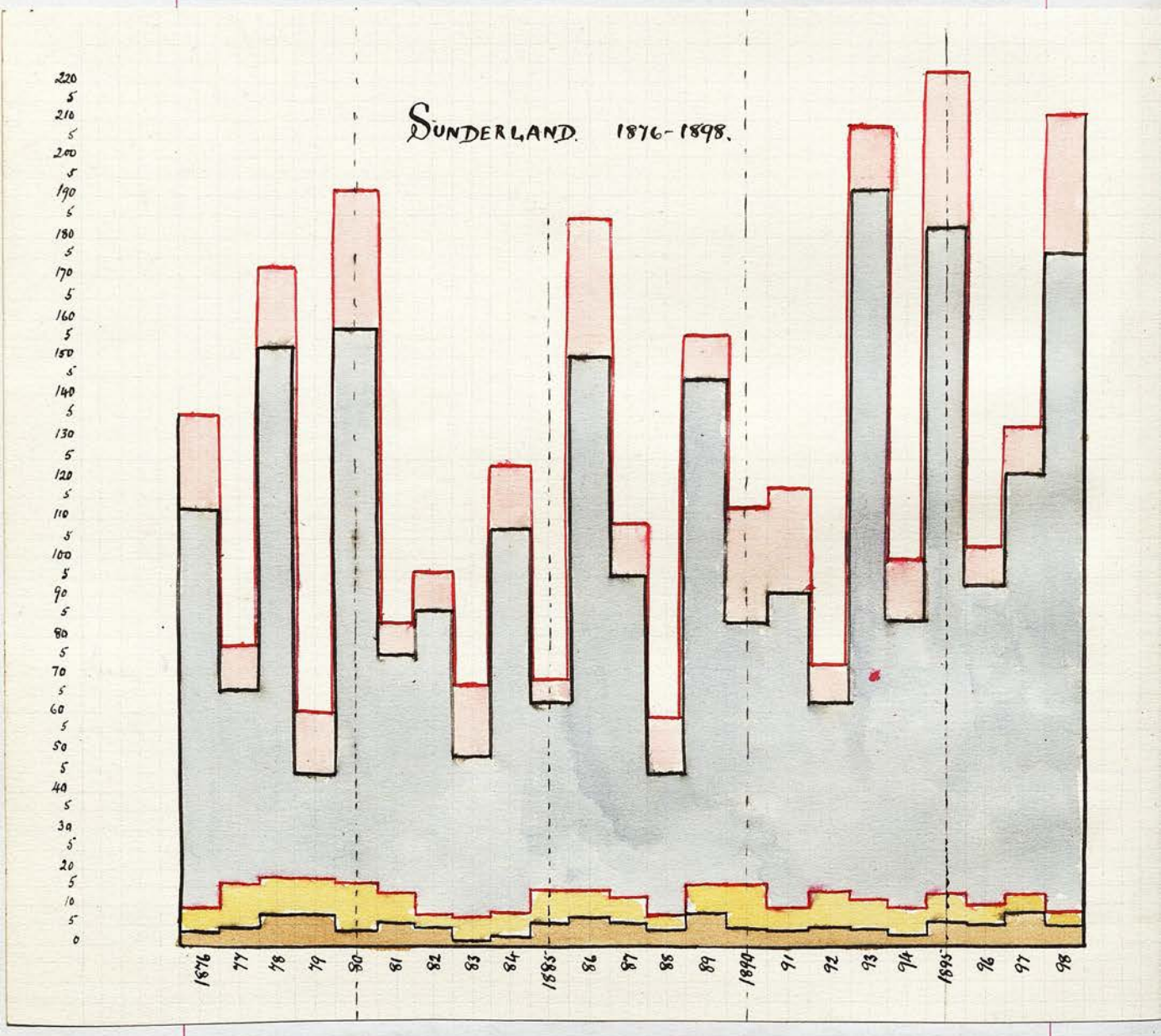
Disposal of Sewage. About ½ of the houses have pail closets, ¼ have W.C's and ¼ middens.
Manchester has distinctly deteriorated of late years, even taking into account the meteorological conditions.

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 & downs in its diarrhoeal 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 (pails or W.C's).
Disposal of Sewage: ¾ of houses have privy middens; ¼ have W.C's.
Bradford stands 15th on the list of


SUNDERLAND. 1876-1898.
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110
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90
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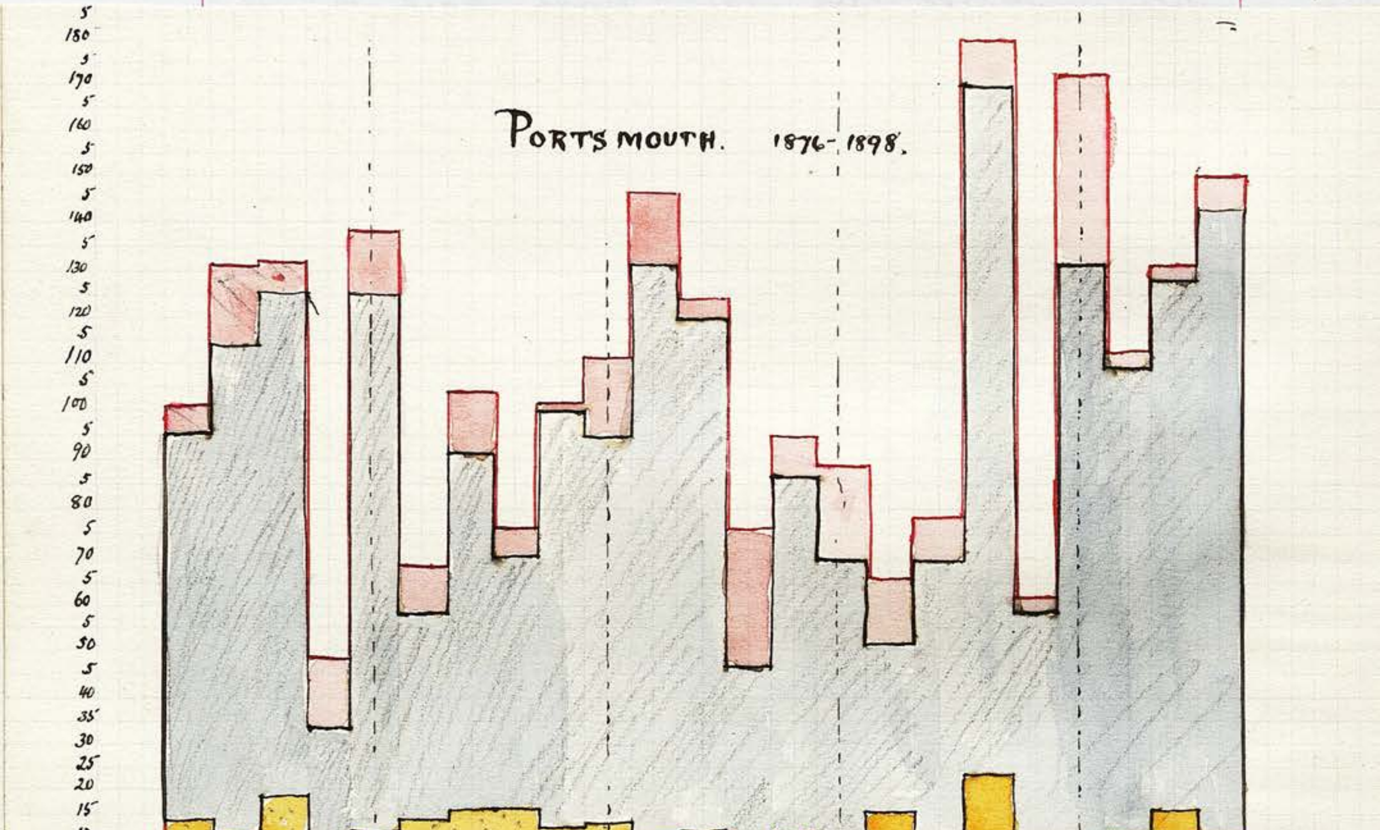
great towns, with an annual diarrhoea death rate (1876–1898) of 31·2 per 1000 births.

Sunderland.

Sunderland had for the period 1876–98 an average annual diarrhoea mortality of 31·1 per 1000 births, being only 3% higher than the average for the 31 great towns. The 3rd quarter mortality was 94. 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 mould mark, 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.'s report 1897)
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. 1876-1898.
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1885
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1890
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1895
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Portsmouth.

The average annual death rate 1876–1898 for this town was 29.7 per 1000 births, only 1% below the average for all the towns.
For the 3rd quarter the death rate was 9.7 per 1000 births.
The deaths are almost confined to the epidemic period.
The diarrhoeal mortality has remained about stationary; the charts shows there are no signs of the town's improvement in this respect.
Geology. Portsmouth is chiefly built on gravel, & greater part is only 15 feet above mean sea level. The level of subsoil water is always only a few feet from the surface.
Here and there are stretches of loam clay, but this is so thin that the foundations of the houses are on the gravel. The town is therefore built upon a pervious sub-soil.
The surface on which the town is

DUBLIN 1882-98.
190
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170
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110
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1882
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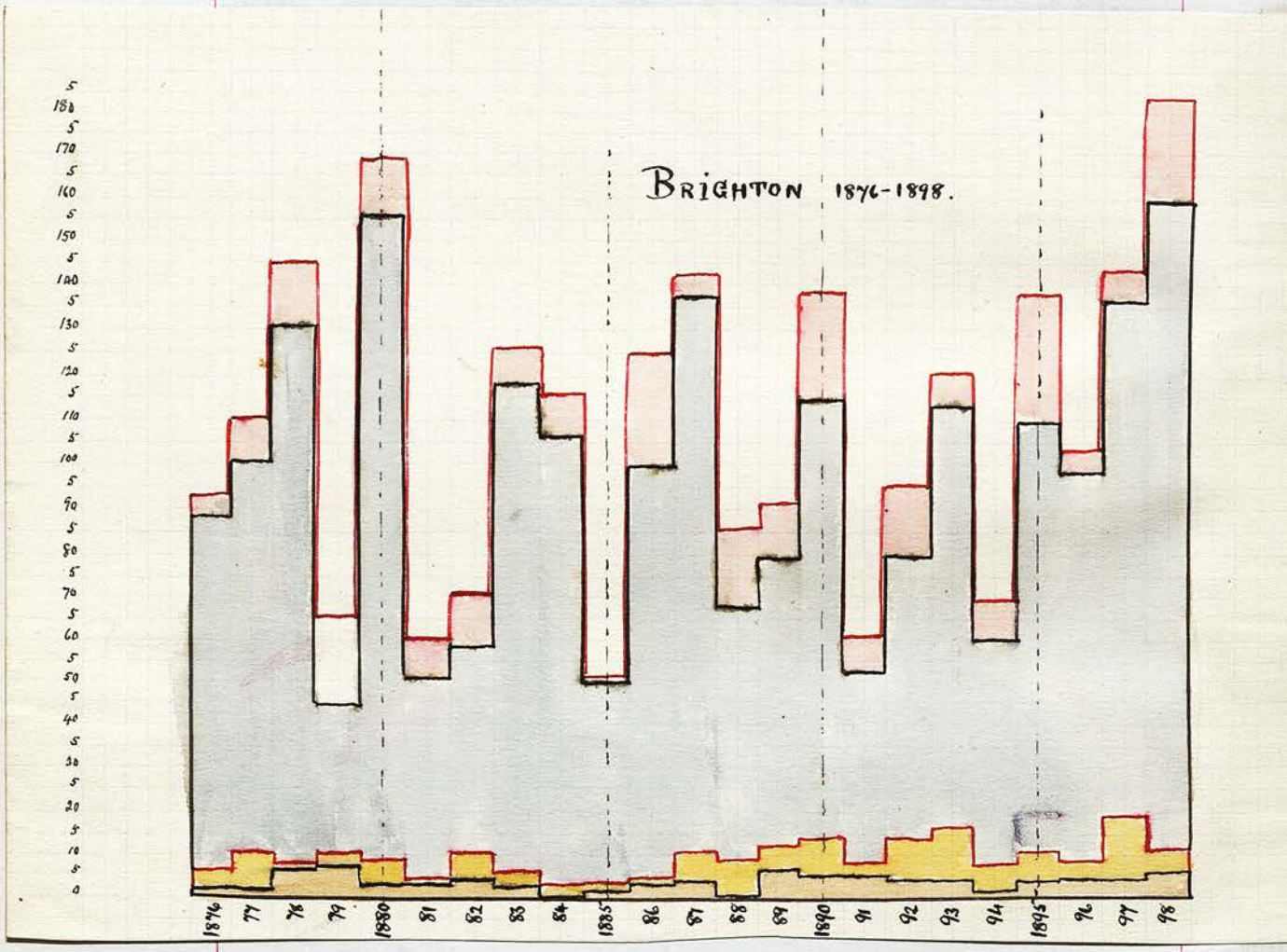
built is very flat.
Disposal of sewage. It is entirely a water-closet town.

Dublin.

Dublin is characterised by the endemic nature of its 'diarrhoea' mortality. There appears to be a special incidence of deaths in the 4th. quarter of the year; the death rate for this quarter being only exceeded by that in Bolton, Blackburn, & Preston, three of the very worst towns.
The annual death rate (shorter period, 1882–1898) averaged 27.4 per 1000 births, which is 18th. 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 sure of this.
Geology. Dublin and its suburbs are

built partly upon stiff clay, and partly upon gravel resting upon rock or clay; $\frac{2}{3}$rds of the population are housed upon the clay, $\frac{1}{3}$ upon the gravel. The gravel extends for some distances 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 larger 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, & on this part it is only when the tide is out that the subsoils are drained."

Disposal of Sewage. Dublin is now


BRIGHTON 1876-1898.
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170
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160
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130
5
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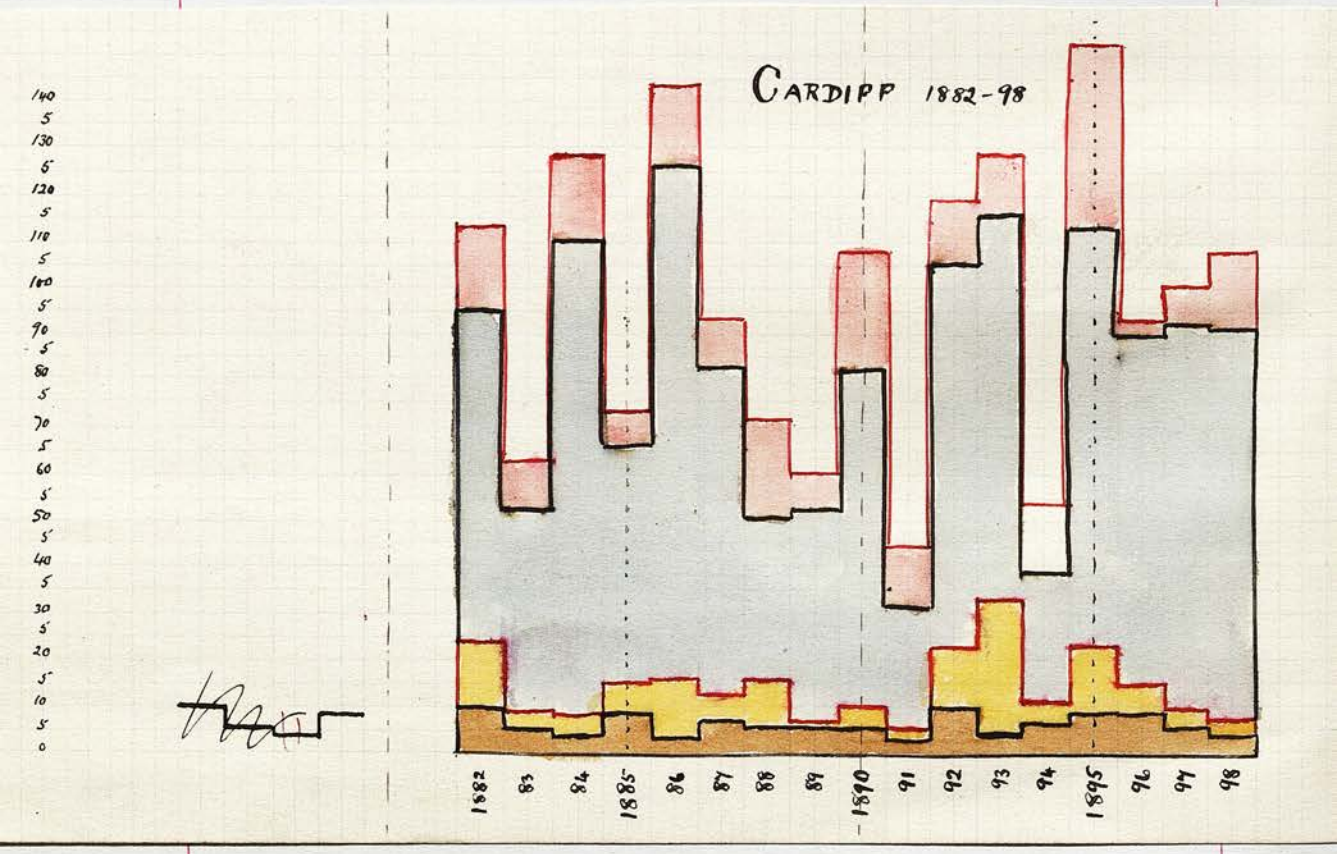
entirely a water-closet town.

Brighton.

The annual diarrhoea death rate averaged for the 23 years 1876-98 27.1 per 1000 births. Brighton occupies the 19th position on the list of great towns. The death rate for the 3rd quarter averaged 87 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~~ with coombe 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


CARDIFF 1882-98
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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.

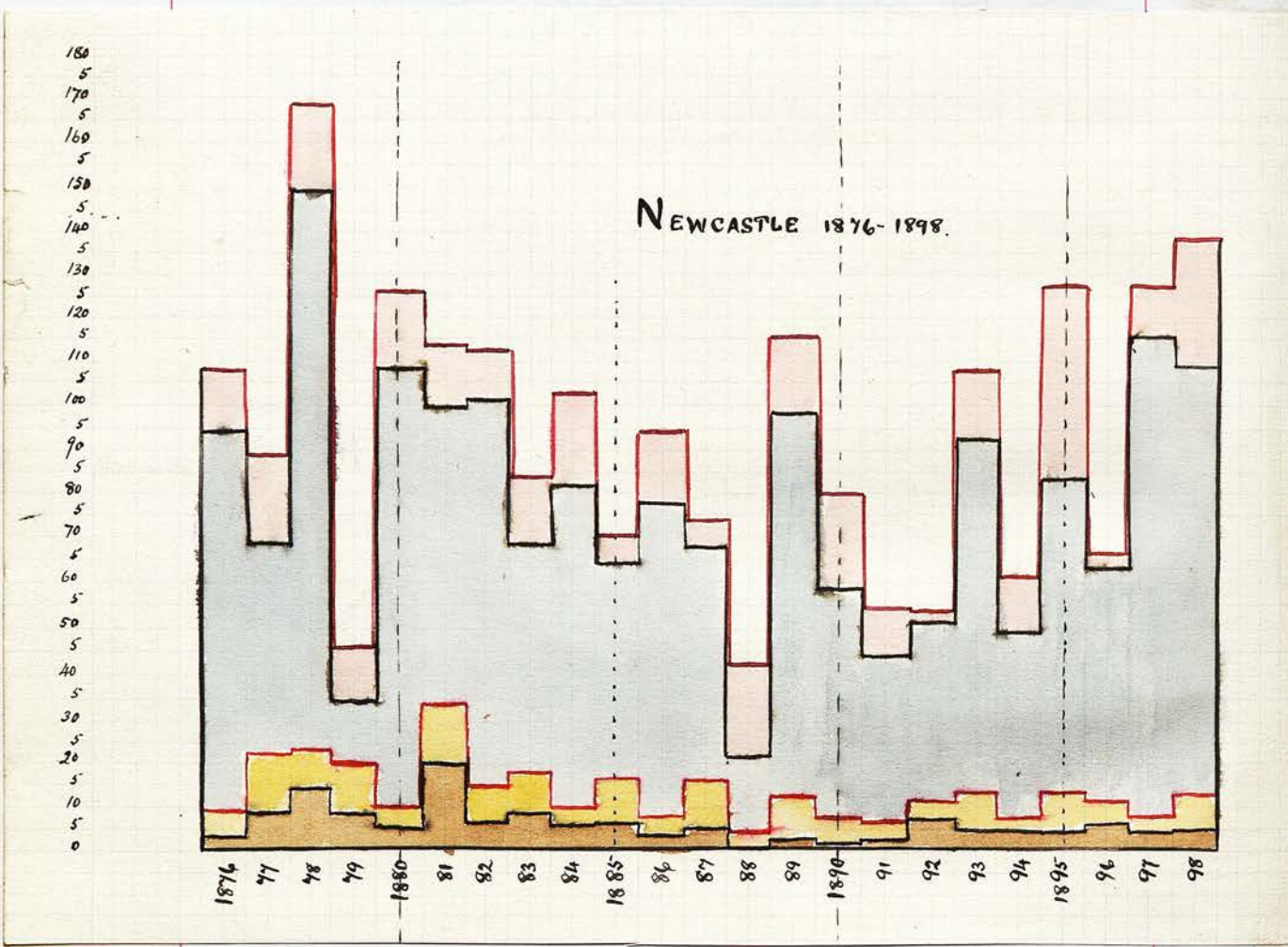
House refuse is removed once a week in galvanized iron dustbins.

Cardiff.

This Welsh seaport occupies the 20th 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 as 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 1876-1898.
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Newcastle.

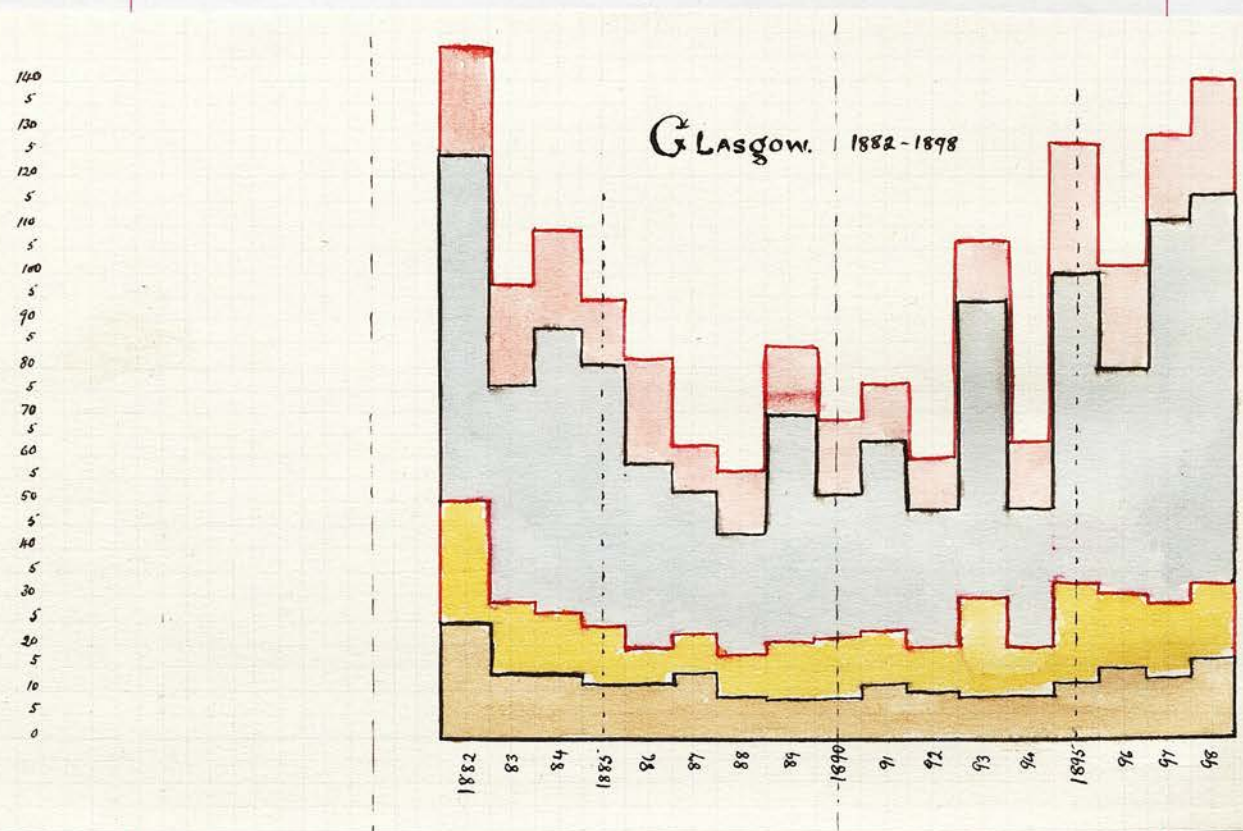
The records for this town show that the annual diarrhoea death rate has averaged 23·5 per 1000 births for the period 1876–1898, & the 3rd quarter 65 per 1000 births.

Geology. 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 charts 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. 1882-1898
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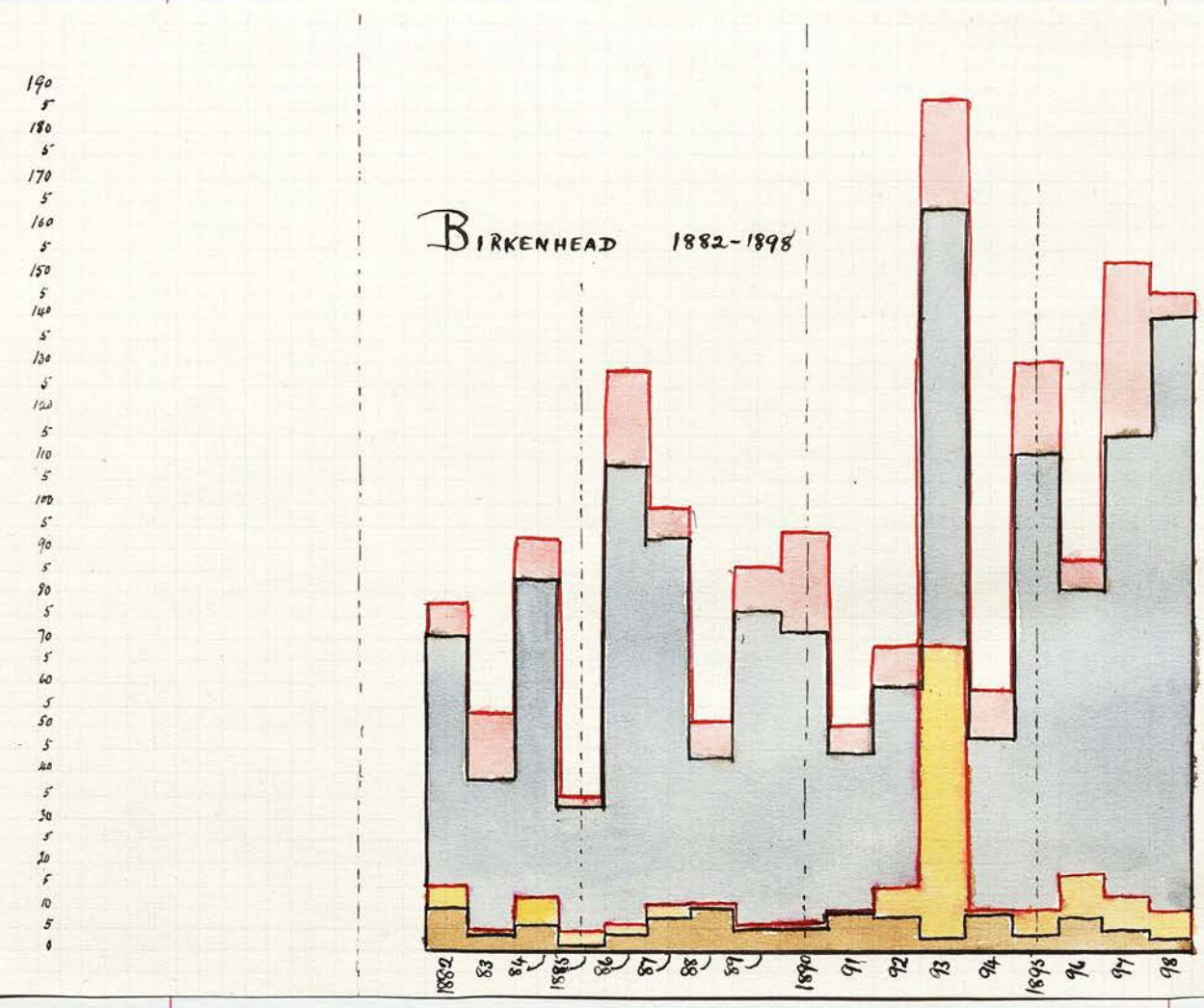
English towns. Along with the last town noted, Newcastle, Glasgow occupies the 21st place, having an annual death rate of 23·5 per 1000 births 1882–1898. (Newcastle had the same but the period of years was 1876–1898). The 3rd quarter death rate in Glasgow was 52 per 1000 births. The diarrhoea mortality 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 1882-1898
190
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130
120
110
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1882
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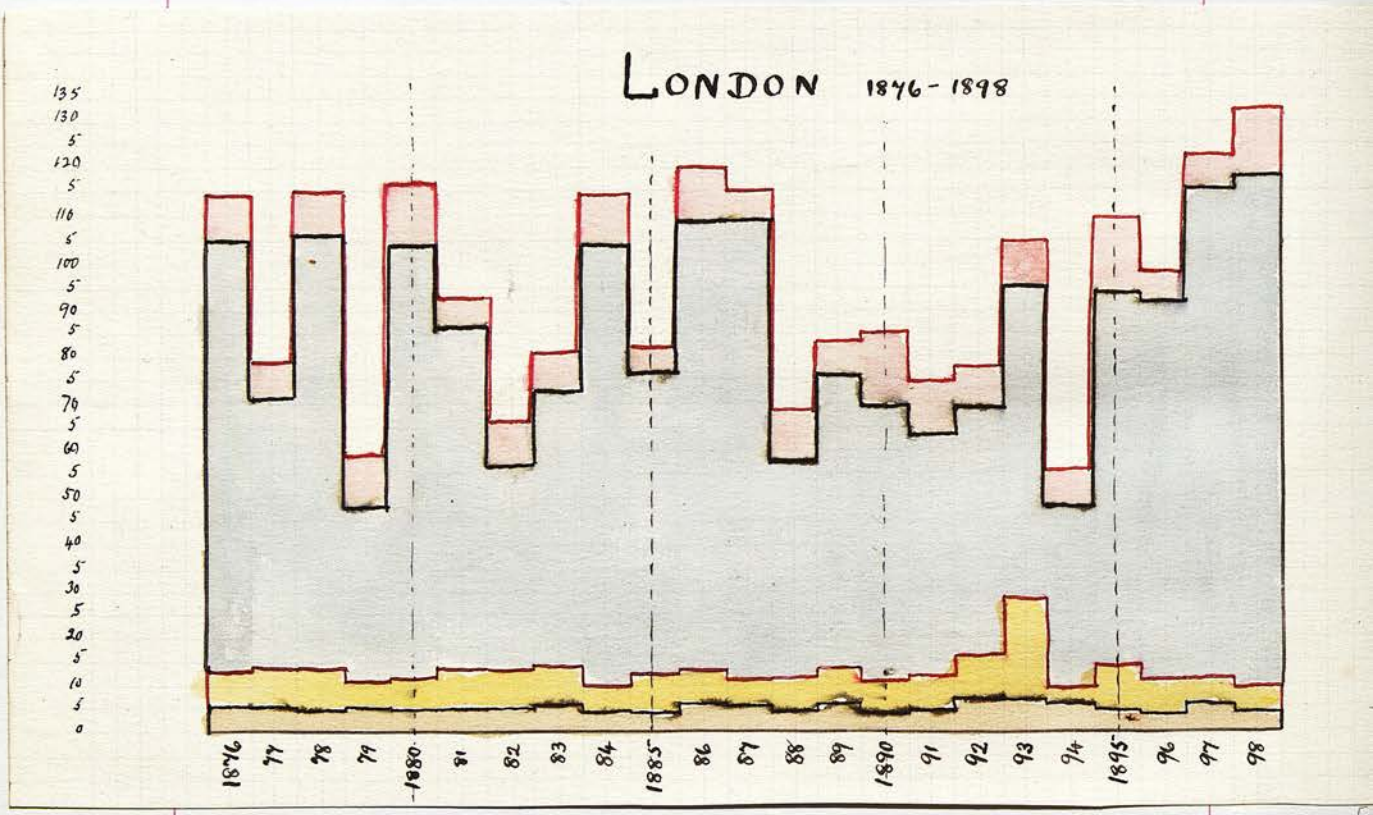
Birkenhead.

As regards its diarrhoeal mortality, Birkenhead offers a great contrast to its sister town, Liverpool. Liverpool being 9th on the list while Birkenhead occupies the 23rd position. Its annual diarrhoea death rate was 23·2 per 1000 birth for 1876-1898; 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 Gradients. 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 1876-1898
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125
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105
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75
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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. This death rate for 1876-1898 is 23.1 per 1000 births which is 23% 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 & 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 1876-1898 was 60.1° F;

the rainfall for the 3rd quarter of the

same period being 6·82 inches.

Geology. Mr H. B. Woodward is the author of an excellent little work on the subject of the subsoils of London published in the memoirs of the Geological Survey. This subject is most complex and I find it impossible to give the proportions of population living on pervious 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 county of London proper."

"A large part of Old London and the villages now incorporated in modern London are built on valley tracts of gravel and loam; the loam is

PLYMOUTH 1876-98.
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98

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 brickearth) is practically impervious."

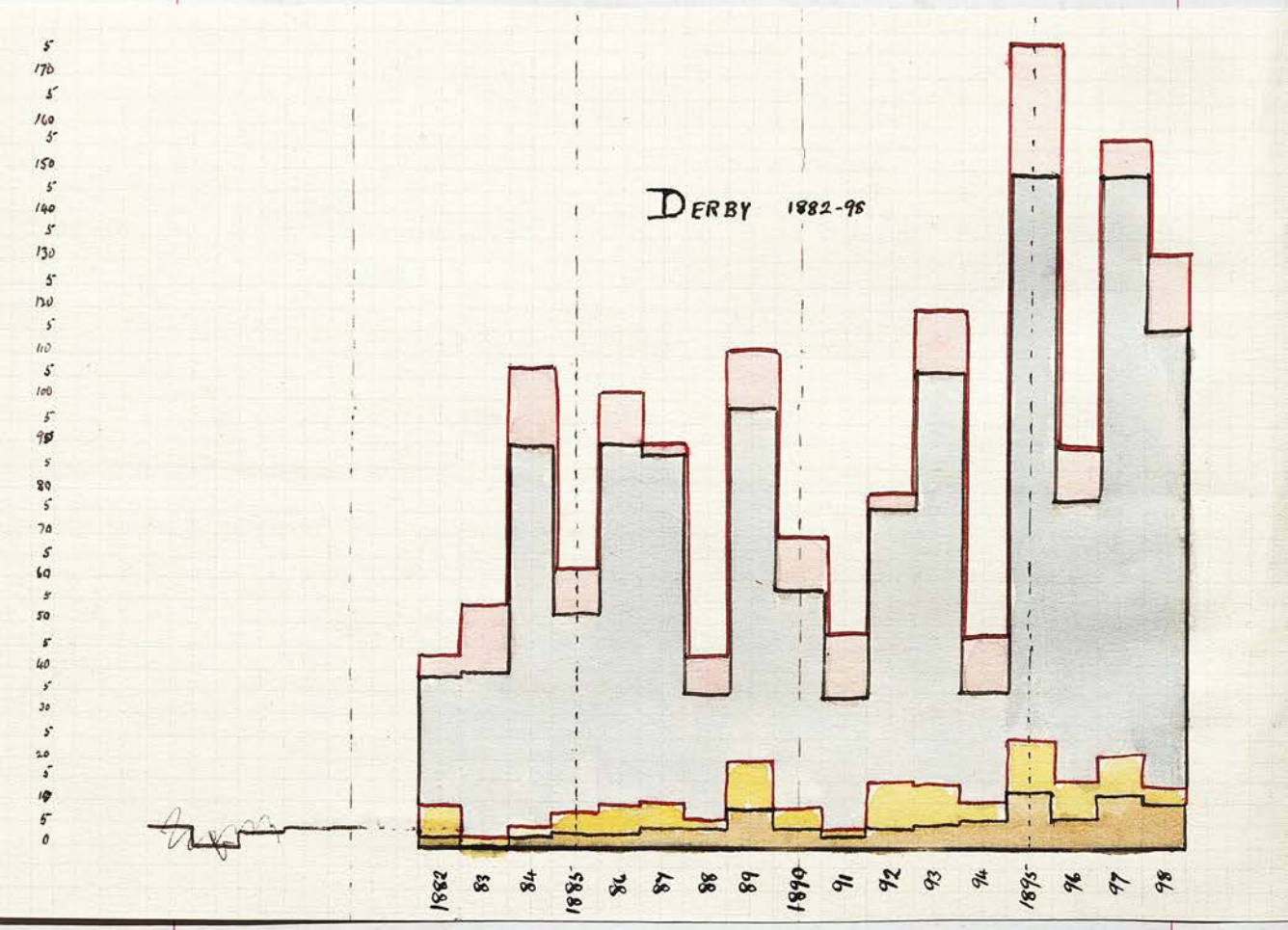
"The 'London clay' underlies the valley gravels and it forms the surface of the ground in many places in London."

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 66 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 ~~very~~ 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.


DERBY 1882-98
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1881
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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.

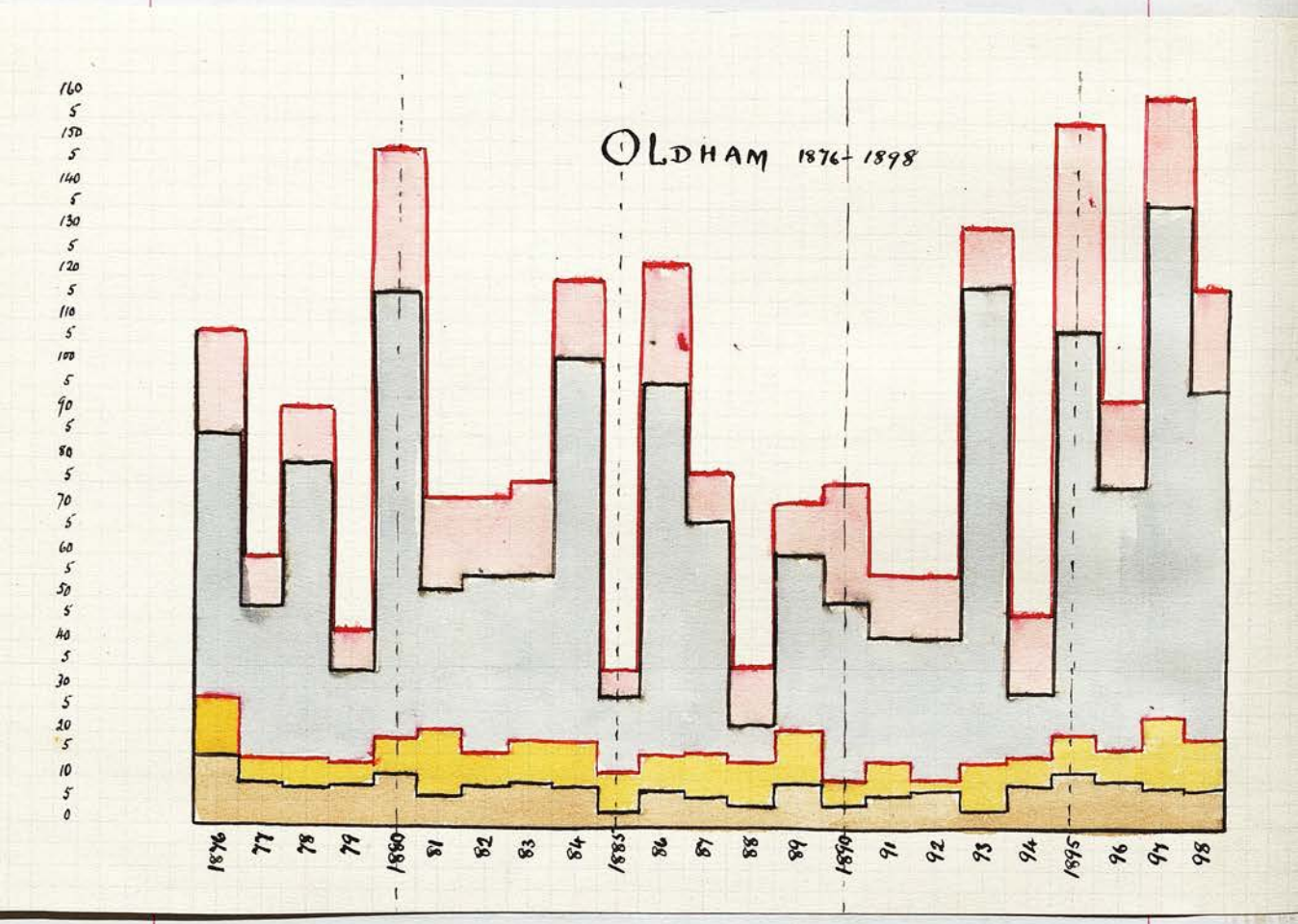
Plymouth is entirely a water-closet town.

Derby.

This town occupies a surprisingly good position. Its annual diarrhoea death rate being 22·3 per 1000 births; and its 3rd quarter death rate 6·7 per 1000 births (1882-1898).

Disposal of Sewage. Derby is a mixed town as regards sewerage; middens & W.C.'s are equally numerous; 1/5 of the houses have pail or pan closets.

Geology. There is a considerable amount of alluvium in the valley of the Derwent; on either side of the Valley are the Upper Keuper sandstone rocks, but overlying this is a Red, very clayey, Marl. ~~The greater~~


OLDHAM 1876–1898
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1876
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1880
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1895
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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 27th on the list with an annual death rate (1876–1898) of only 20 per 1000 births, & for the 3rd quarter 47 per 1000 births.

Disposal of Sewage. The system of sewerage is practically entirely by means of "pails."

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

EDINBURGH 1882 - 1898
120
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1882
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1885
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1890
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1895
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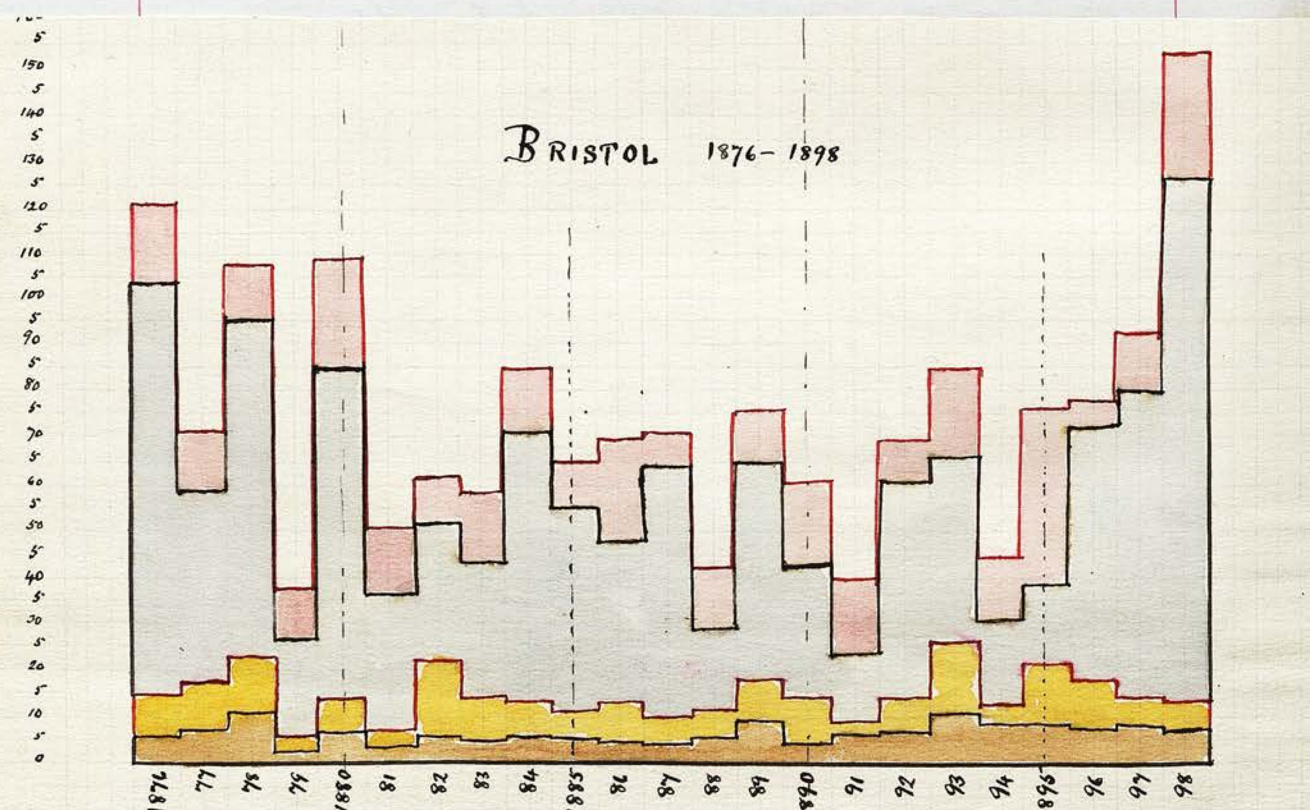
98

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 42 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,


BRISTOL 1876–1898
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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.

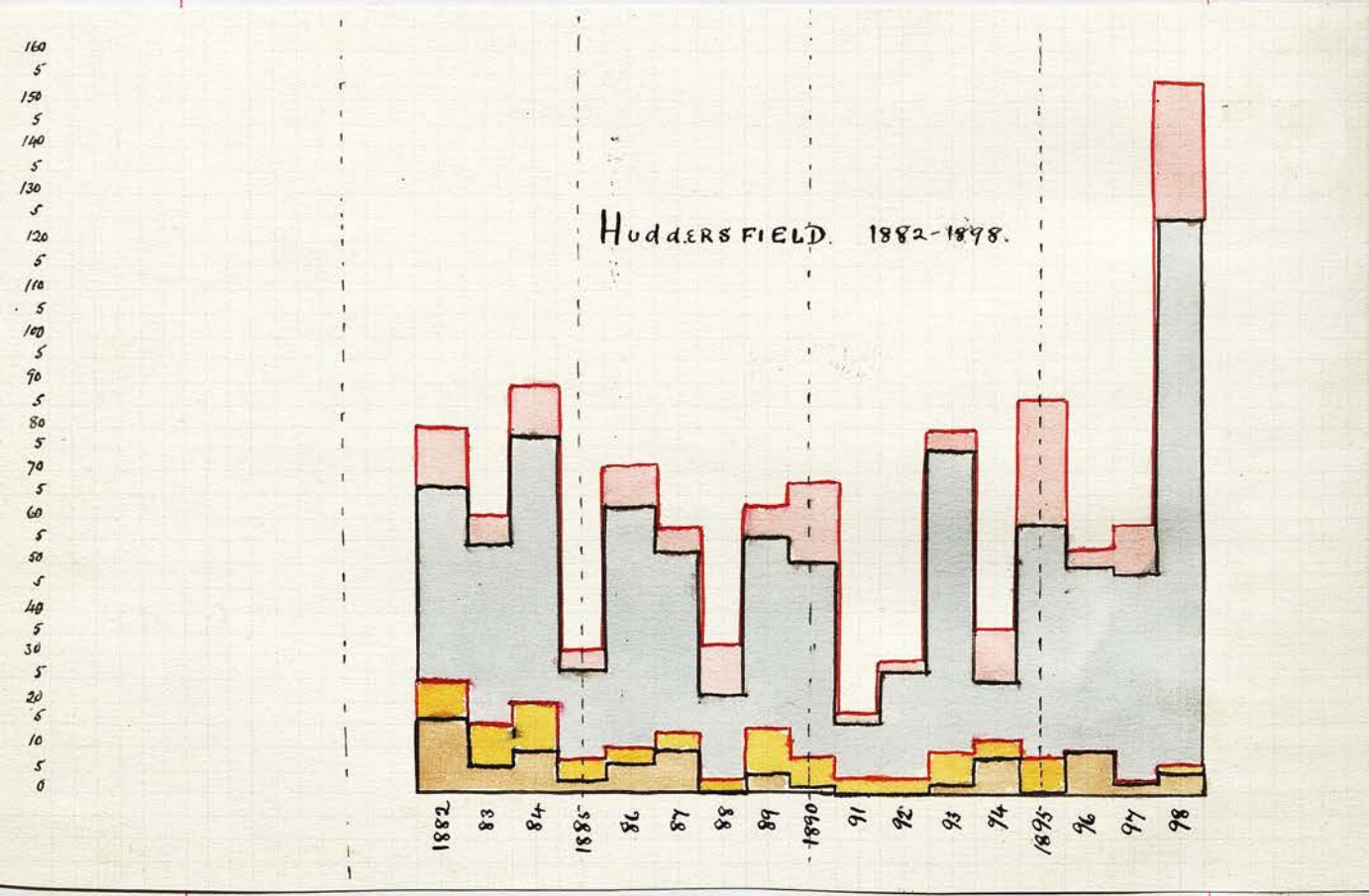
Bristol.

Bristol has the 3rd lowest annual death rate from diarrhoea, which is, for the 23 years 1876-1898, 19 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 new Red Sandstone, through which the New Cut, or artificial course of the Avon, has been cut. The high table-land of Clifton, Cobham 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 57.5° F.


HUDDERSFIELD. 1882-1898.
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1882
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1885
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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 1882-1898 averaged 15.7 per 1000 births; its 3rd quarter death rate being 43 per 1000 births. ~~Halifax~~ Huddersfield showed a large increase in its mortality last year (1898 v. chart).

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

Geology. "About $\frac{4}{5}$ths of the population are situated upon layers of coal, ranging from thin coal & fire clay, through soft bed flags, soft bed coal, middle hard bed coal & rock, to the better bed coal & fire clay strata,

HALIFAX 1882-98
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1882
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which are all comprised in the lower coal measures or gannister beds of the carboniferous rocks; these strata are rendered almost impervious by the clay overlying the coal."

"The Remainder of population is housed upon sand rock, flags, shales, & sandstone and is pervious."

"The gradients of the town are steep. Lowest part of Huddersfield is 150 abov feet, & highest 1000 feet above sea level." MOH's 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. Its 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 (Goux).

It will have ~~noted~~ 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 comparative mortality 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 1846.

The following table shows the towns in the order of their annual mortality from diarrhoea; the towns which have been under the longer period of observation have 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 per 1000 births, & the percentage deviation from the mean for all the towns.

	1876–1898	1862–1898	annual death rate and percentage deviation from mean		average 3rd quarter death rate and % deviation from mean	
1		Preston	60·0	+99	173	+97
2	Leicester		47·8	+59	166	+90
3		Bolton	41·2	+37	112	+28
4	Salford		39·3	+31	113	+29
5	Hull		38·9	+29	122	+39
6		Blackburn	38·5	+28	89	+2
7	Birmingham		36·9	+23	109	+24
8	Leeds		34·8	+16	109	+24
9	Liverpool		34·7	+15	102	+16
10	Sheffield		34·5	+15	111	+27
11	Wolverhampton		34·3	+14	104	+19
12	Nottingham		32·4	+8	101	+15
13	Norwich		32·2	+7	106	+21
14	Manchester		32·2	+7	88	±0
15	Bradford		31·2	+4	90	+3
16	Sunderland		31·1	+3	94	+7
17	Portsmouth		29·7	−1	94	+11
18		Dublin	27·4	−9	67	−24
19	Brighton		27·1	−10	87	−1
20		Cardiff	24·4	−19	68	−22
21		Glasgow	23·5	−22	52	−41
22	Newcastle		23·5	−22	65	−26
23		Birkenhead	23·2	−23	69	−21
24	London		23·1	−23	72	−18
25	Plymouth		22·9	−24	66	−25
26		Derby	22·3	−26	67	−24
27	Oldham		20·0	−34	47	−46
28		Edinburgh	20·0	−34	42	−52
29	Bristol		19·0	−37	47	−46
30		Huddersfield	15·7	−48	43	−51
31		Halifax	12·5	−58	40	−54
	The Great Towns		30·1	±0	84·7	±0

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 register as 'enteritis &c' a large number of deaths which would in former years have been registered as diarrhoea.

Stationary	Deteriorated	Improved.
Newcastle	Sunderland ++	Leicester
Dublin	Hull + Huddersfield +	? Cardiff
Glasgow	Liverpool + Sheffield ++	Preston
Edinburgh	Manchester ++	Plymouth
London	Salford +	Norwich
Birmingham	Birkenhead +	
Nottingham	Bolton +	
Portsmouth	Bradford +	
Bristol	Brighton ?	
~~Norwich~~	Wolverhampton ++	
Blackburn	Derby + Halifax +	
Leeds		
Oldham.		

Classification of Towns in the order of their average diarrhoeal 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 = 87·4, & for the 4th quarter = 13·5

	1st quarter		2nd quarter		3rd quarter		4th quarter	
1	Blackburn	16·5	Preston	19·6	Preston	173·0	Preston	35·9
2	Preston	13·2	Blackburn	15·0	Leicester	165·0	Blackburn	35·
3	Glasgow	12·1	Bolton	14·2	Hull	122·0	Bolton	31·5
4	Edinburgh	10·7	Glasgow	14·1	Salford	119·0	Dublin	25·6
5	Bolton	10·5	Manchester	13·2	Bolton	112·0	Salford	24·4
6	Dublin	10·4	Salford	12·9	Sheffield	111·0	Wolverhampton	20·6
7	Salford	9·5	Liverpool	12·4	Birmingham	109·9	Manchester	20·0
8	Manchester	9·0	Edinburgh	12·2	Leeds	109·0	Birmingham	19·6
9	Wolverhampton	8·3	Leicester	11·9	Norwich	106·0	Hull	19·4
10	Oldham	8·0	Birmingham	11·1	Wolverhampton	104·0	Edinburgh	18·7
11	Birmingham	7·9	Bradford	10·1	Liverpool	102·0	Bradford	18·1
12	Liverpool	7·0	Plymouth	9·5	Nottingham	101·0	Sunderland	18·0
13	Bradford	6·9	Wolverhampton	9·5	Portsmouth	96·9	Glasgow	17·7
14	Nottingham	6·7	Dublin	9·3	Sunderland	94·0	Liverpool	17·7
15	Bristol	6·4	Leeds	9·0	Bradford	90·4	Oldham	17·3
16	Newcastle	6·1	Cardiff	8·8	Blackburn	89·3	Norwich	16·5
17	Cardiff	6·0	Nottingham	8·7	Manchester	87·9	Leeds	16·5
18	Birkenhead	5·7	Bristol	8·5	Brighton	86·7	Nottingham	15·8
19	Derby	5·4	Norwich	8·5	London	71·6	Newcastle	15·7
20	Sheffield	5·4	Hull	8·5	Dublin	67·3	Cardiff	15·4
21	Hull	5·4	Oldham	8·3	Birkenhead	68·6	Bristol	15·3
22	Huddersfield	5·0	Birkenhead	8·3	Cardiff	68·2	Sheffield	14·7
23	Leeds	4·9	London	8·1	Derby	67·2	Leicester	13·1
24	Plymouth	4·8	Portsmouth	8·0	Plymouth	65·7	Brighton	12·9
25	London	4·8	Sheffield	7·7	Newcastle	65·2	Plymouth	12·4
26	Sunderland	4·7	Sunderland	7·6	Glasgow	51·7	Derby	12·1
27	Halifax	4·2	Newcastle	7·2	Oldham	50·7	Portsmouth	11·4
28	Portsmouth	4·0	Derby	6·0	Bristol	46·9	Huddersfield	10·3
29	Norwich	3·7	Brighton	5·9	Huddersfield	42·6	Birkenhead	10·2
30	Leicester	3·6	Halifax	5·4	Edinburgh	42·2	Halifax	9·9
31	Brighton	3·5	Huddersfield	5·1	Halifax	30·3	London	9·3

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, + 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 $\frac{165\cdot0}{3\cdot6} = 45\cdot9$

(2) Norwich $\frac{106\cdot0}{3\cdot7} = 28\cdot8$.

(3) Brighton $\frac{86\cdot7}{3\cdot5} = 24\cdot9$

(4) Portsmouth $\frac{96\cdot9}{4\cdot0} = 24\cdot2$

(5) Hull $\frac{122}{5\cdot4} = 22\cdot6$

(6)	Leeds	$\frac{109.0}{4.9}$	= 22.3
(7)	Sheffield	$\frac{111.0}{5.4}$	= 20.7
(8)	Sunderland	$\frac{94.0}{4.7}$	= 20.0
(9)	Nottingham	$\frac{101.0}{6.7}$	= 15.1
(10)	London	$\frac{71.6}{4.8}$	= 14.9
(11)	Liverpool	$\frac{102.0}{7.0}$	= 14.6
(12)	Birmingham	$\frac{109.0}{7.9}$	= 13.8
(13)	Plymouth	$\frac{65.7}{4.8}$	= 13.8
(14)	~~Birkenhead~~ Preston	$\frac{173.0}{13.2}$	= 13.7
(15)	Bradford	$\frac{90.4}{6.9}$	= 13.1
(16)	Wolverhampton	$\frac{104.0}{8.3}$	= 12.6
(17)	Salford	$\frac{119.0}{9.5}$	= 12.6
(18)	Derby	$\frac{67.2}{5.4}$	= 12.5
(19)	Birkenhead	$\frac{68.6}{5.7}$	= 12.2
(20)	Cardiff	$\frac{68.1}{6.0}$	= 11.4
(21)	Newcastle	$\frac{65.2}{6.1}$	= 10.8
(22)	Bolton	$\frac{112.0}{10.5}$	= 10.7
(23)	Manchester	$\frac{87.9}{9.0}$	= 9.8
(24)	Huddersfield	$\frac{42.6}{5.0}$	= 8.5
(25)	Bristol	$\frac{46.9}{6.0}$	= 7.8
(26)	Halifax	$\frac{30.3}{4.2}$	= 7.2
(27)	Dublin	$\frac{67.3}{10.4}$	= 6.5
(28)	Oldham	$\frac{50.7}{8.0}$	= 6.3
(29)	Blackburn	$\frac{89.3}{16.5}$	= 5.4
(30)	Glasgow	$\frac{51.7}{12.1}$	= 4.3
(31)	Edinburgh	$\frac{42.2}{10.7}$	= 3.9

Reasons for the Great Differences in Diarrhoeal 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 diarrhoeal 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 ~~the~~ 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 ~~of~~ on a flat surface or whether gradients good; (3) impervious or pervious nature of the subsoil. The towns are placed in

Towns in order of Diarrhoea mortality	System of Disposal of Sewage.	Contour of surface; whether gradients are good or bad.	Pervious or impervious Subsoil.
Preston	Middens	Flat	½ pervious ; ½ impervious
Leicester	W.C. (lately middens)	Flat	½ pervious ; ½ impervious
Bolton	Middens	Fairly Good.	partly pervious partly impervious
Salford	Middens	Flat	impervious
Hull	Middens	Very Flat	pervious (partially)
Blackburn	Pails.	Fairly Good.	do.
Birmingham	Mixed { W.C. / Pails.	Fairly Good.	pervious
Leeds	Mixed { ½ W.C. / ½ middens	Fairly Good	mostly impervious
Liverpool	W.C	?	pervious
Sheffield.	Middens	Very Good	pervious (?)
Wolverhampton	Pails	?	?
Nottingham	Pails	Fairly Good.	?
Norwich	Chiefly middens	Fairly Good	pervious
Manchester	Mixed { ½ pails / ¼ W.C. / ¼ middens	?	partially pervious
Bradford	Midden	?	?
Sunderland	Midden	Flat	mostly impervious
Portsmouth	W.C.	Very Flat	pervious
Dublin	W.C.	Flat.	⅓ pervious ⅔ impervious
Brighton	W.C.	Very Good.	pervious
Cardiff	W.C	?	?
Newcastle	W.C.	Fairly Good	impervious
Glasgow	W.C.	Fairly Good	?
Birkenhead	W.C.	Fairly Flat	mostly impervious
London	W.C.	?	mostly impervious (?)
Plymouth	W.C	Fairly Good	pervious
Derby	Mixed { ⅖ Middens / ⅖ W.C / ⅕ pails	Fairly Good.	impervious
Oldham	Pails	Very Good	impervious
Edinburgh	W.C.	Very Good	impervious
Bristol	W.C.	Very Good	impervious
Huddersfield.	Pails.	Very Good	impervious
Halifax	Pails.	?	?

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 + bad together, would come in; each town above the line having a death rate greater than the average for all the towns, + each town below the line have 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 one of them (Leicester) was until a few years ago a midden town.

Again, of the 16 towns having a

death rate above the average 9 are midden towns, and only 1 town (Derby) & that town only partially a midden town, has a death rate under the average. It is thus absolutely clear that the midden system favours diarrhoea 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 nuisance and to the saturation of the soil with filth."

With regard to 'pail' towns, 4 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.) with an efficiently carried out 'pail' system there is no likelihood of soil pollution; the system is simplicity itself + 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, ashpits, + cess pools, it is left for weeks, and sometimes months, to putrefy + 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 is causing the differences 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 diarrhoea 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 impervious subsoil ~~exists~~ is present 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 impervious subsoil, usually clay) rises, but does not rapidly drain away, but it slowly falls by very gradual drainage + by vaporation leaving the polluted 'natural soil' much as before, + not exerting much or any purifying influence upon it; examples of this condition may be said to be present in Leicester, Preston, Salford, Hull &c,

Again, on the other hand, what happens when an impervious 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, ~~the~~ viz. 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 ~~the~~ that of an underground stream as happens when the impervious subsoil exists, so that organic pollution is lessened but not to the same extent; the purification of the soil, ~~however~~, is not likely to be so thorough as when the impervious layer is present. A good example of this condition is Brighton, & may explain why that town, with its low general death rate, should suffer comparatively severely

from diarrhoea.

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

The three factors above referred to are the chief reasons for the great differences observed in the 'diarrhoea' 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 & 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 diarrhoeal mortality in Scotland than in England.

(d) Employment of married women. This has been referred to in previous pages and no doubt accentuates the diarrhoeal mortality in the Lancashire ~~et~~ '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 'Causation 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, he 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 differences 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 & mortality, it appears to me ~~to be~~ a reasonable ~~fr~~ 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 ashpits), 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 (especially during the epidemic season when the raising 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.