THE PART PLAYED BY METEOROLOGICAL CONDITIONS ON RESPIRATORY MORTALITY IN LIVERPOOL.

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(With 1 Chart.)

In the annual report of the Chief Medical Officer of the Ministry of Health for 1925 (p. 22) the incidence rates of notifications of pneumonia in four-weekly periods are compared for large geographical groups in England and Wales. These rates show the divergence between the north and north-west and the remainder of the country, and also the fact that the north-west (Lancashire and Cheshire) usually compares badly with the north. During 1923 "in none of the thirteen periods was the rate for the north-west less than 15 per cent. in excess of the all-England rate and in ten it was equal to or greater than the rate for the north." That these remarks still apply may be seen from the figures for 1930 (Table I). If one compares some of the large Lancashire towns with London the contrast is even greater (Table II). The towns giving the largest number of notifications of pneumonia are Liverpool and Manchester. These towns alone contributed 48 per cent. of the total number of notified cases of pneumonia in Lancashire during 1930. Their combined population forms about 30 per cent. of the total. Great caution is, however, required in drawing deductions from rates of notification of pneumonia, as considerable differences exist between one place and another in the extent to which the obligation to notify is complied with. Mortality rates provide a sounder basis of comparison.

It is well known that certain conditions of industrial life are associated with high mortality. Cotton manufacture is the chief industry of the north-western area. The mortality from respiratory diseases among special groups of cotton workers ranks amongst the highest of the occupational groups tabulated by the Registrar-General in the report on Occupational Mortality for 1921–3. For example, among male cotton operators called strippers, grinders and cardroom jobbers—a large and skilled group of workers—the standardised mortality from respiratory disease was nearly three times as high as that for all occupied and retired males. Bronchitis was nearly five and a half times as high as that for all males. In many of the large Lancashire towns more than half the working population are engaged in textile manufacture, but although Liverpool and Manchester are the two largest industrial towns in the country, neither comes under the heading of "cotton" towns.

Table I. *Incidence rates of pneumonia expressed as a percentage of those for England and Wales. (Taken as* 100.)

Areas	Weeks of the year, 1930: 1–4	5–8	9–12	13–16	17–20	21–24	25–28	29–32	33–36	37–40	41–44	45–48	49–52	Total
London	143	99	82	90	84	61	71	87	82	82	92	106	126	96
Southern	35	53	57	52	52	44	38	40	43	40	41	37	37	46
Eastern and Midland	96	85	89	97	88	90	87	86	84	85	87	87	79	89
North-western	115	131	144	134	150	160	166	151	168	163	167	168	188	150
Northern	142	147	129	128	135	151	152	158	144	149	136	130	116	137
Wales	59	91	108	94	90	74	72	66	73	71	67	73	62	80
England and Wales	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Table II. *Incidence rates of pneumonia expressed as a percentage of those for London. (Taken as* 100.)

Areas	Weeks of the year, 1930: 1–4	5–8	9–12	13–16	17–20	21–24	25–28	29–32	33–36	37–40	41–44	45–48	49–52	Total
Liverpool	103	269	236	148	223	302	335	238	308	350	393	399	266	245
Manchester	127	221	319	276	357	481	381	332	293	304	249	176	273	264
Preston	28	40	51	113	123	68	73	56	173	211	73	70	83	74
Blackburn	81	104	112	127	48	151	129	76	196	149	110	176	108	110
Bolton	34	36	77	60	59	104	38	65	181	44	93	67	54	60
Bootle	184	117	316	209	149	449	454	296	578	265	267	192	597	277
Oldham	29	86	191	124	101	169	97	167	211	169	183	108	121	114
St Helens	37	126	169	177	197	488	317	153	350	293	253	172	199	179
Salford	95	95	112	224	152	357	284	121	186	158	208	154	121	165
London	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Great changes have occurred in industrial conditions during the last fifty years, hours of labour have been reduced and working conditions have been improved. Hygienic and sanitary improvements are reflected in the death-rates. In Liverpool mortality from all causes has declined from 28·5 per 1000 in 1871–80 to 14·1 in 1921–5 and was 15·1 in 1929. During the period 1871–1925 mortality from tubercular diseases declined more than 50 per cent., diseases of the digestive system declined 66 per cent., while mortality from respiratory diseases was 5·7 in 1871–80, 3·5 in 1921–5 and 4·2 in 1929, a decline of 29 per cent. between 1871 and 1929.

In Manchester mortality from respiratory diseases was about the same as in Liverpool in 1871–80, 5·4 per 1000; in 1921–5 it was 3·0 and in 1929 3·2. The epidemic of influenza in the winter of 1929 would account for the rise in respiratory mortality that year, but there is no doubt that diseases of the respiratory system show less decline than other diseases. Liverpool, being a seaport, probably employs a larger proportion of lower grade labour than the "cotton" towns. The majority of aliens in Lancashire are located in Liverpool and Manchester, forming 1·0 and 1·3 per cent. of their respective populations.

In 1921 the Irish immigrants amounted to 3·9 per cent. of the population in Liverpool and 2·3 per cent. in Manchester. In Oldham and Preston the Irish population only formed 1·1 and 1·3 per cent. respectively.

If the percentage living more than two in a room is taken as a measure of poverty in the large towns of Lancashire, St Helens ranks highest on the list (21 per cent., Census 1921), Wigan comes next (15·3 per cent.), Liverpool third (12·1 per cent.) and Manchester ninth (7·9 per cent.). Liverpool is far more overcrowded than Manchester, but compared with St Helens its environmental conditions are vastly superior. Sir Leonard Hill has shown that the reform of the air and light supply is needed particularly to resist respiratory disease. "The air we breathe is polluted by microbes and dust in shut up dwellings, and the light of the sun is cut off by buildings, clothes, windows, dust and smoke. The economic loss due to smoke pollution is enormous." Hill estimates the total economic loss due to smoke pollution in Britain as probably not less than £100,000,000 a year, while "the loss of *health* produced by it is incalculable." In the annual report for 1927 the Chief Medical Officer noted that at Liverpool the total deposits averaged 50 tons per month. Manchester received 55 per cent. only of the daylight falling on Timperley. According to the report on Atmospheric Pollution for the year ending March 1930 the amount of solids deposited in Liverpool (Netherfield Road Station) was 1840 metric tons per hundred square kilometres. This was the highest amount recorded at any station during the year. Netherfield Road is situated in what is probably the smokiest part of Liverpool. At the Cambridge St. station, a less sordid part of Liverpool, the deposits were 1022 tons during the same year, while, as a contrast, only 450 tons were recorded at Southport.

The part played by smoke in the production of fog in large cities is only too well known. During the winter of 1929 thirty-seven days of fog were observed in Manchester. Professor Haldane, writing on the Meuse fog disaster, observes: "It appears that the disaster was caused by the ordinary products of combustion from the chimneys of factories and other industrial undertakings scattered about in the sparsely populated neighbourhood of the district near Liége where the disaster occurred and the possibility of a similar disaster happening in this country is a matter of great public interest. If a similar concentration of similar products of combustion were to occur in the air of any large town in this country, the deaths would be numbered not in tens but in thousands."

What portion of the excess mortality from respiratory causes may be allotted to atmospheric or climatological conditions? We cannot get a precise numerical evaluation of fog, and the amount of sunlight is only recorded for a limited number of places for recent years. The only measurements of climatic condition available for any length of time relate to temperature, rainfall and humidity. The seasonal curve of mortality from respiratory diseases has a close inverse relation to that of temperature. Excess mortality from respiratory diseases is frequently attributed to unfavourable weather conditions. The

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variations of temperature in London were found to have a definite influence on mortality from pneumonia in persons of middle life and old age, that the lower the temperature the greater the mortality from pneumonia. Young found that meteorological conditions appeared to have little effect on the mortality of children under 5 years. In view of the high respiratory incidence and mortality in Liverpool a study of the part played by meteorological factors is of particular interest.

The data available for Liverpool were the weekly deaths from pneumonia, broncho-pneumonia, and bronchitis at ages under 1 year, 1–5 years, ages 40–60 and all ages over 60 for the period 1909–29 (omitting the years of the Influenza Pandemic 1918–19). The meteorological data consisted of mean temperature, rainfall, and mean temperature of evaporation (a measure of relative humidity). It was necessary to group the figures into periods of four weeks, as the weekly deaths were not sufficiently numerous for the purpose of correlation. The deaths were corrected for changes in population during the period under review. The means and standard deviations for each period are given in Table III.

Table III. *Means and standard deviations of variables.*

Four-weekly period	Temperature		Evaporation		Respiratory deaths, ages under 1 year		Respiratory deaths, ages 1–5		Respiratory deaths, ages 40–60		Respiratory deaths, ages 60 +	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
1	41·17	2·50	39·60	2·25	59·61	15·34	46·00	11·83	37·17	13·52	142·89	31·43
2	40·74	2·42	38·66	2·18	65·67	31·17	60·78	37·35	44·22	15·13	171·50	58·14
3	42·10	2·42	39·62	2·41	60·67	30·87	54·78	21·12	40·22	14·62	160·22	52·56
4	45·35	2·63	42·13	2·27	47·28	15·15	48·56	13·47	33·33	9·18	133·94	31·25
5	50·37	1·32	46·41	1·60	37·44	11·30	38·50	11·44	28·67	9·05	98·44	18·27
6	55·62	2·57	51·31	2·09	25·83	9·29	30·61	10·48	22·72	7·03	78·56	12·59
7	58·69	1·91	54·31	1·53	24·33	9·34	27·06	12·71	17·72	5·79	62·06	14·12
8	60·32	2·14	56·27	1·78	19·28	6·78	20·06	7·71	13·89	5·81	52·00	14·65
9	58·44	2·04	55·11	1·93	17·39	5·81	18·61	8·97	14·39	7·48	48·94	12·07
10	54·59	1·75	51·46	1·74	23·33	8·47	22·06	6·53	19·39	6·63	56·83	16·53
11	48·91	2·40	46·61	2·68	38·06	18·58	29·06	14·44	18·72	7·47	73·56	20·17
12	43·05	3·44	40·93	3·41	60·44	26·05	42·61	15·78	27·72	10·37	115·28	38·44
13	42·09	4·62	39·86	2·81	70·83	18·96	48·11	9·69	34·17	10·76	131·89	42·57

The combined mortality from pneumonia, bronchitis and broncho-pneumonia were first correlated with (1) the mean temperature for the corresponding four weeks, (2) with a lag of one week in temperature, (3) with a lag of two weeks in temperature. The coefficients of correlation for (1) are given in Table IV. All the correlations at the younger ages with one exception are insignificant. There is no evidence that temperature of the same weeks has any effect on mortality among young children. In the two older age groups there is considerable variation in the correlation coefficients, but during the months when respiratory mortality is high, *i.e.* the first and last quarters of the year, the correlations are consistently negative.

As the sample dealt with is small the usual test of significance of the correlation coefficients does not apply. Fisher's table of values of the correlation coefficients for different levels of significance in small samples has been used throughout this study. What we require to know is the probability that a particular correlation should arise by random sampling from an uncorrelated population. If there were no correlation in the universe the odds would be about 50 to 1 against a sample of 18 yielding a correlation of 0·5 or more by chance. In a sample of 18 a correlation of 0·47 would be expected once in 20 trials, a correlation of 0·54 once in 50 trials and 0·59 once in 100 trials. Any correlation of 0·5 or more has been regarded as statistically significant in this analysis.

Table IV. *Correlation coefficients between deaths from bronchitis and pneumonia and broncho-pneumonia and mean temperature for the same four weeks. Years* 1909–17 *and* 1920–8.

Four-weekly periods	Ages			
	Under 1 year	1–5	40–60	60 +
1	− ·1961	− ·2519	− ·5420	− ·6747
2	+ ·0002	− ·1381	− ·6733	− ·7850
3	− ·0139	− ·4026	− ·6453	− ·7145
4	+ ·2757	+ ·0749	+ ·2179	− ·2759
5	+ ·2839	+ ·3576	+ ·4915	+ ·2003
6	+ ·1652	− ·2651	− ·1559	− ·1110
7	+ ·1995	+ ·2240	− ·2039	− ·2620
8	− ·0570	+ ·3376	+ ·4050	+ ·0954
9	+ ·1384	+ ·2281	+ ·3372	+ ·0310
10	− ·0095	+ ·0210	− ·0231	− ·0441
11	− ·1047	− ·0300	− ·3417	− ·2110
12	− ·1730	− ·0953	− ·3200	− ·4931
13	− ·1888	+ ·3232	− ·1829	− ·6198

Table V. *Correlation coefficients between deaths from bronchitis and pneumonia and broncho-pneumonia and temperature one week in advance of deaths. Years* 1909–17 *and* 1920–8.

Four-weekly periods	Ages			
	Under 1 year	1–5	40–60	60 +
1	− ·2267	− ·1347	− ·4519	− ·6786
2	− ·2265	− ·2761	− ·7123	− ·8527
3	− ·1139	− ·3460	− ·6623	− ·7051
4	+ ·2098	− ·0655	− ·4462	− ·4867
5	+ ·2515	+ ·1550	+ ·3845	+ ·1562
6	+ ·0930	− ·3534	− ·0354	− ·1848
7	+ ·2955	+ ·3232	+ ·0158	+ ·1022
8	− ·1343	+ ·2154	+ ·1885	− ·2101
9	+ ·3082	+ ·2394	+ ·2747	+ ·0965
10	− ·1535	− ·0756	− ·0631	− ·0916
11	− ·0813	− ·0357	− ·3068	− ·2220
12	− ·2326	− ·0863	− ·4115	− ·6510
13	− ·0844	+ ·0929	− ·2294	− ·6072

In both adult age groups in Table IV there is a high and significant correlation between mortality and temperature in the first three periods, *i.e.* during the first twelve weeks of the year. In the oldest age group the correlation for the last period is also significant.

Tables V and VI show the result for a lag of one and of two weeks in temperature. Although the correlations are fairly consistent in sign for the first four and last four periods of the year showing an inverse association, there does not appear to be any significant association in early childhood. In the adult age groups there is evidence of significant association for the first three periods and in the age group 60+ for the last two periods of the year. If one takes the mean of these correlations in Tables IV, V and VI the figures are rather higher for mortality with temperature of the previous week than for those of the same week or for a lag of two weeks. Is it possible from such knowledge to predict mortality?

Table VI. *Correlation coefficients between deaths from bronchitis and pneumonia and broncho-pneumonia and temperature two weeks in advance of death. Years* 1909–17 *and* 1920–8.

Four-weekly periods	Ages: Under 1 year	1–5	40–60	60+
1	−·2236	−·0960	−·3145	−·6413
2	−·2843	−·2550	−·6884	−·8552
3	−·1590	−·4467	−·6428	−·7309
4	+·1421	−·0893	−·4458	−·5427
5	+·1251	−·1214	+·1840	−·0852
6	+·1740	−·3424	+·0526	−·1180
7	+·1034	−·0021	+·0420	+·1764
8	−·0874	+·2464	+·0888	−·3970
9	+·2909	+·1082	+·2393	−·0257
10	−·0764	−·0134	−·0426	+·0143
11	+·1287	−·0122	−·2089	−·0527
12	−·3007	−·2030	−·3840	−·7351
13	−·1056	+·0943	−·3092	−·5060

Table VII.

(*a*) *Mortality and temperature one week in advance of deaths.*

Period	Ages 40–60. Equation	Mean error of prediction	Per cent. mean error	Ages 60 and over. Equation	Mean error of prediction	Per cent. mean error
1	$d=-2{\cdot}74t+151{\cdot}05$	9·3	25	$d=-9{\cdot}57t+540{\cdot}50$	17·8	12
2	$d=-3{\cdot}39t+182{\cdot}16$	8·9	20	$d=-15{\cdot}61t+805{\cdot}97$	26·4	15
3	$d=-3{\cdot}47t+184{\cdot}83$	8·4	21	$d=-13{\cdot}27t+713{\cdot}91$	30·7	19
4	$d=-1{\cdot}51t+100{\cdot}29$	6·8	20	$d=-5{\cdot}62t+382{\cdot}65$	20·1	15
12	$d=-1{\cdot}61t+99{\cdot}09$	7·9	28	$d=-9{\cdot}43t+533{\cdot}79$	25·9	22
13	$d=-0{\cdot}88t+70{\cdot}77$	8·7	25	$d=-9{\cdot}25t+515{\cdot}12$	25·9	20

(*b*) *Mortality and temperature two weeks in advance of deaths.*

Period	Ages 40–60. Equation	Mean error of prediction	Per cent. mean error	Ages 60 and over. Equation	Mean error of prediction	Per cent. mean error
1	$d=-2{\cdot}10t+125{\cdot}15$	9·8	26	$d=-9{\cdot}95t+560{\cdot}02$	19·4	14
2	$d=-3{\cdot}06t+167{\cdot}40$	9·2	21	$d=-14{\cdot}60t+759{\cdot}44$	25·1	15
3	$d=-3{\cdot}01t+165{\cdot}45$	9·4	23	$d=-12{\cdot}32t+672{\cdot}35$	30·5	19
4	$d=-1{\cdot}77t+110{\cdot}16$	6·8	20	$d=-7{\cdot}35t+452{\cdot}45$	19·0	14
12	$d=-2{\cdot}13t+124{\cdot}36$	7·9	28	$d=-15{\cdot}14t+800{\cdot}97$	20·9	18
13	$d=-1{\cdot}23t+85{\cdot}77$	8·3	24	$d=-7{\cdot}98t+465{\cdot}95$	28·3	21

Table VII gives the equations connecting mortality with temperature of the previous week for the first four and last two periods of the year. These periods were taken because they showed the greatest association. The first equation tells us that for a drop in temperature of one degree in the week the average increase of mortality in the following week will be 2·74 deaths at ages 40–60. The expected deaths for each year were calculated from this equation and compared with those actually recorded. The mean error of

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prediction was 9·3, *i.e.* taking the mean of the differences between the actual and calculated figures without regard to sign. The percentage mean error between the theoretical and observed values was also calculated and in no period was the average estimate nearer than 72 per cent. of the truth.

In the age groups 60 and over the equation for the first period gave an average increase of mortality of 9·6 for a drop of one degree in temperature, and the mean error of prediction was 17·8, percentage mean error 12. In the third period of the year the estimate has an average error of 30·7. No closer estimates were obtained when mortality was predicted from a knowledge of the temperature two weeks in advance of death. In Period I the average change in mortality at ages 40–60 was 2·10 for a fall of one degree in temperature. At ages 60 and over it was 9·95. The percentage mean errors were 26 and 14 respectively. These attempts at prediction agree with those computed by Russell on London data. He took deaths at ages 55 and over, and temperature of the previous week for certain weeks between October and March. Even when the amount of fog was included it was only possible to predict mortality within a marginal error of roughly 30 per cent. In the Liverpool data, even when the correlation coefficients are high, the predictions are within an average error of about 20 per cent., an error much too large for the method to be of any practical value.

Table VIII. *Correlation coefficients between deaths from bronchitis and pneumonia and broncho-pneumonia with rainfall of previous week. Years* 1909–17 *and* 1920–8.

Four-weekly periods	Ages: Under 1 year	1–5	40–60	60 +
1	−·0289	+·1983	+·1360	−·1747
2	+·4274	+·2347	−·4331	−·4405
3	−·0220	−·0332	+·0118	+·0030
4	+·4513	−·0424	−·0907	−·1871
5	−·0265	+·1705	+·1215	+·2299
6	−·2594	−·4047	−·2224	−·3586
7	+·0047	−·1451	+·1344	+·0780
8	−·0717	−·3729	−·3172	−·5261
9	−·3558	−·2264	−·2502	−·1911
10	−·1470	−·2110	−·4084	−·0956
11	−·2243	−·0516	−·2625	−·2214
12	−·1842	−·3117	−·3054	−·3148
13	−·0128	−·0446	+·1259	+·0732

The correlations between rainfall and respiratory mortality have only been computed for rainfall of the previous week and for two weeks in advance of death. The results are given in Tables VIII and IX. From the eighth period onward the correlations are practically all negative in every age group, but only two fulfil our standard of significance. If there is any association with rainfall—and from the evidence here it appears to be very slight—the tendency seems to be an inverse one.

The next measurement of meteorological conditions analysed in relation to respiratory mortality was the mean daily temperature of evaporation. This figure is derived from the wet and dry bulb readings by the use of tables and gives the temperature at which the air would be saturated. Table X shows the results when corresponding four-weekly periods are taken. Mortality of infants and in early childhood does not seem to be influenced by this factor. In the older age groups there is a high negative association in the first three periods of the year in both age groups and for the last two periods in the oldest age group. The correlations for the first and last four periods are all negative.

Table IX. *Correlation coefficients between deaths from bronchitis and pneumonia and broncho-pneumonia with rainfall two weeks in advance of deaths. Years* 1909–17 *and* 1920–8.

Four-weekly periods	Ages: Under 1 year	1–5	40–60	60 +
1	+·2141	+·2522	+·0914	−·1367
2	+·3297	+·0574	−·4879	−·3464
3	+·1092	−·0455	+·0221	−·1552
4	+·4929	−·0748	+·0392	−·1377
5	−·2346	−·3586	−·3884	−·4480
6	−·0299	+·0424	+·1337	+·1797
7	+·1351	+·0238	+·1850	+·0908
8	+·0032	−·0441	−·0245	−·0256
9	−·0526	−·1998	−·0978	−·1892
10	−·4797	−·4764	−·7676	−·3802
11	−·0847	−·4815	−·4473	−·4457
12	+·1689	+·1196	−·1278	−·1270
13	−·1137	+·0350	+·2147	+·0342

Table X. *Correlation coefficients between deaths from bronchitis and pneumonia and broncho-pneumonia and evaporation for the same four weeks. Years* 1909–17 *and* 1920–8.

Four-weekly periods	Ages: Under 1 year	1–5	40–60	60 +
1	−·1292	−·1458	−·6361	−·6949
2	+·0016	−·0858	−·6937	−·7638
3	−·0389	−·4276	−·6675	−·7330
4	+·3426	−·0012	−·2186	−·3339
5	+·1148	+·4316	+·2491	+·0994
6	+·1141	−·2575	−·2470	−·3031
7	+·0987	+·1826	−·1190	−·0774
8	−·0338	+·3359	+·3623	−·0094
9	+·1703	+·4316	+·3857	+·1304
10	−·0525	−·0910	−·0655	−·0513
11	−·0570	−·0430	−·2825	−·1340
12	−·1608	−·1351	−·3856	−·5155
13	−·1340	+·1108	−·2094	−·6397

These results are closely analogous to those found for temperature. The same agreement was found when a lag of one or two weeks in evaporation was taken (Table XI), though in most cases the correlations were slightly higher than those for temperature. It seemed an unnecessary amount of labour to compute the correlations for each period of the year. Only the first four and last three periods of the year were analysed. Temperature and evaporation appear to be important factors of adult mortality during the winter months of the year, particularly the first quarter of the year.

Temperature and evaporation are closely interrelated, the correlation between them is of the order of 0·9. The next stage of the analysis was to compute first order correlations to see how much either of these factors affected mortality when the influence of the other was eliminated. It will be seen from Table XII that the zero order correlations (Table III) are considerably reduced, and not one of the periods analysed retains any significant correlation. Table XIII gives the results for a lag of one week and Table XIV when a lag of two weeks was taken. With a lag of one week the residual

Table XI. *Correlation coefficients between deaths from bronchitis and pneumonia and broncho-pneumonia and* (1) *evaporation one week in advance,* (2) *evaporation two weeks in advance.*

Four-weekly periods	(1) Ages 40–60	(1) Ages 60 +	(2) Ages 40–60	(2) Ages 60 +
1	−·5597	−·7132	−·5623	−·5509
2	−·7465	−·8599	−·4594	−·5371
3	−·6930	−·7183	−·5725	−·5952
4	−·4666	−·5038	−·0791	−·1784
11	−·2575	−·3197	−·6869	−·6538
12	−·4979	−·6688	−·7880	−·8734
13	−·3114	−·7114	−·1218	−·5231

Table XII. *Partial correlations:* (1) *respiratory mortality and temperature of same weeks' evaporation constant,* (2) *respiratory mortality and evaporation of same weeks' temperature constant.*

Four-weekly period	(1) Ages 40–60	(1) Ages 60 +	(2) Ages 40–60	(2) Ages 60 +
1	+·1670	−·1119	−·4248	−·2503
2	+·0369	−·2826	−·2287	+·0338
3	+·0381	+·0061	−·2262	−·2340
4	−·0206	+·1608	−·0354	−·2513
11	−·2864	−·3310	+·2089	+·2912
12	−·2215	+·0228	−·3132	−·1740
13	−·0180	−·2105	−·1049	−·2879

correlations between mortality and temperature when evaporation is held constant show no definite association. When a lag of two weeks is taken there remains persistent high negative correlation in the first four periods of the year between mortality of old people and temperature after evaporation is neutralised. When we consider mortality and evaporation after eliminating the effect of temperature, the correlations for a lag of one week are with one exception negative, but only three come within the criterion of significance. A lag of two weeks shows no definite results. Altogether these partial correlations cannot be said to throw much light on our problem. Anyone with experience of medical statistics will realise the limitations of the method of multiple correlations. A further attempt was made at prediction by the inclusion of evaporation as well as of temperature. The inclusion of a knowledge of evaporation is no improvement in the estimate of mortality. The forecasts based on temperature alone are practically the same as those based on the combined effect of the two factors (Table XV).

Table XIII. *Partial correlations:* (1) *respiratory mortality and temperature one week in advance, evaporation constant,* (2) *respiratory mortality and evaporation one week in advance, temperature constant.*

Four-weekly period	(1) Ages 40–60	(1) Ages 60 +	(2) Ages 40–60	(2) Ages 60 +
1	+·1571	−·1095	−·3979	−·3165
2	+·5679	+·0982	−·6254	−·2332
3	+·1677	+·0229	−·3165	−·1946
4	+·0144	−·0054	−·1531	−·1491
11	−·2809	+·4788	+·2250	−·5217
12	+·2588	−·0506	−·3940	−·2079
13	+·2529	+·3688	−·3283	−·5692

Table XIV. *Partial correlations:* (1) *respiratory mortality and temperature two weeks in advance, evaporation constant,* (2) *respiratory mortality and evaporation two weeks in advance, temperature constant.*

Four-weekly period	(1) Ages 40–60	(1) Ages 60 +	(2) Ages 40–60	(2) Ages 60 +
1	−·0094	−·4863	−·4916	−·3109
2	−·5943	−·8010	−·1732	−·2257
3	−·3829	−·6501	+·1496	+·4467
4	−·4529	−·5225	+·1190	+·0479
11	+·2242	+·4293	−·6896	−·7291
12	+·3033	−·4253	−·7722	−·7610
13	−·2873	−·3503	+·2446	−·5808

Table XV. *Mortality with temperature and evaporation two weeks in advance.*

Period	Ages 40–60. Equation	Mean error of prediction	Per cent. mean error
1	$d = -0{\cdot}06t - 2{\cdot}37e + 132{\cdot}66$	9·7	26
2	$d = -2{\cdot}73t - 0{\cdot}86e + 187{\cdot}39$	9·1	20
3	$d = -4{\cdot}61t + 1{\cdot}80e + 159{\cdot}65$	9·2	23
4	$d = -1{\cdot}96t + 0{\cdot}40e + 101{\cdot}44$	6·9	21

Period	Ages 60 and over. Equation	Mean error of prediction	Per cent. mean error
1	$d = -7{\cdot}53t - 2{\cdot}82e + 568{\cdot}83$	17·5	12
2	$d = -13{\cdot}42t - 3{\cdot}08e + 830{\cdot}91$	24·9	15
3	$d = -27{\cdot}56t + 17{\cdot}23e + 616{\cdot}96$	27·8	17
4	$d = -7{\cdot}58t + 0{\cdot}51e + 441{\cdot}19$	18·6	14

An attempt was made to measure the effect of fog on the respiratory mortality in Liverpool. It was shown by Russell on London data that fog itself had no appreciable effect on the respiratory death-rate, but if the prevalence of fog was associated with a low temperature and frost, the death-rate of adults was influenced very considerably. In a later paper he investigated the relative influence of fog and low temperature on respiratory mortality. He concluded that on the whole a low temperature exercised the greater influence. Data regarding days of fog in Liverpool were not directly available. The degree of visibility is recorded daily by the meteorological office, but this is not a satisfactory measure from our point of view as it includes occasions of bad visibility due to some specific cause such as rain or drizzle as well as actual fog. Dr Donovan kindly supplied information as to the number of days in each week in which the recorded figure of visibility was

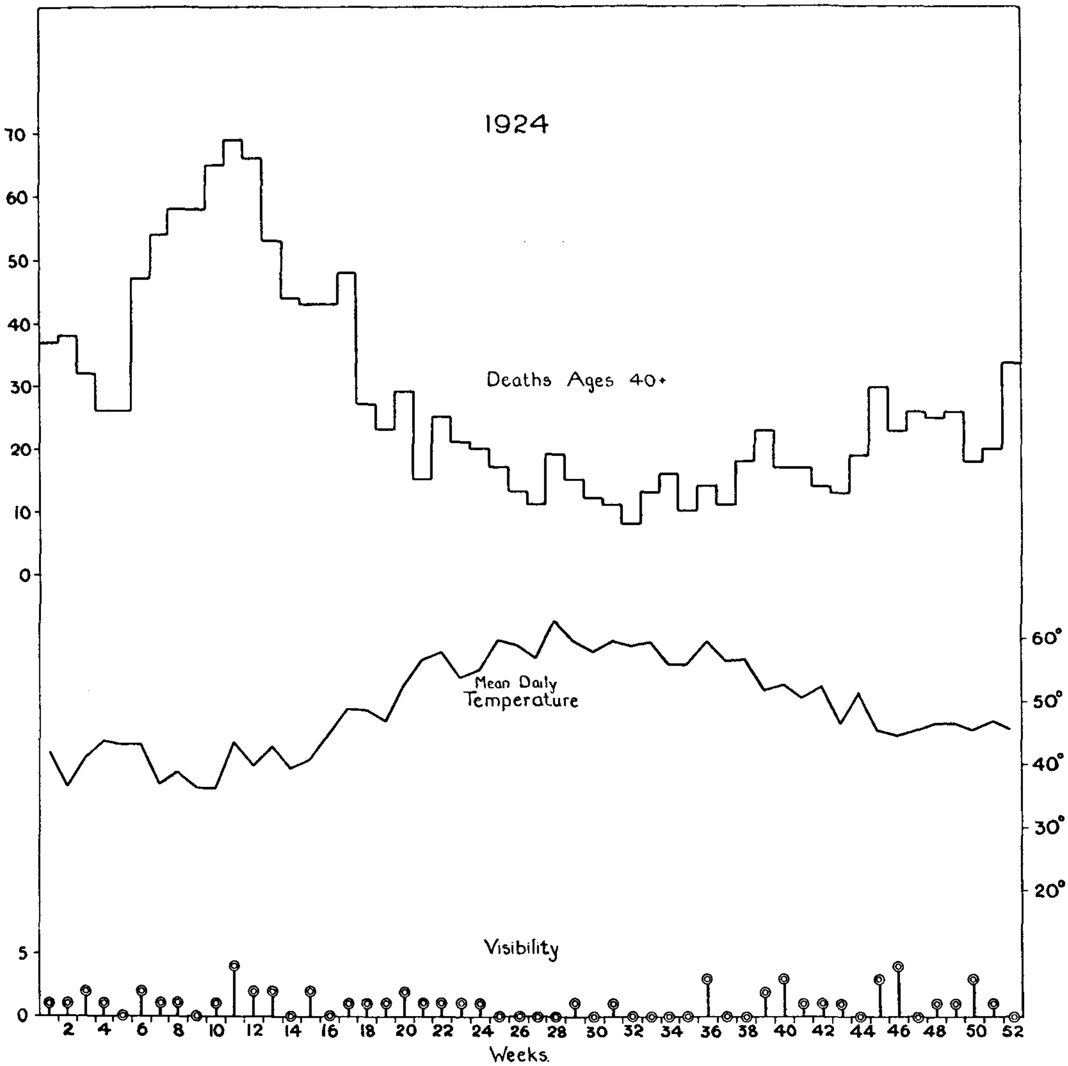

Chart 1. Weekly respiratory mortality, temperature and visibility in Liverpool in 1924.

3 or less for the years 1921–9. Correlations were calculated between days of low visibility and respiratory mortality for certain periods of the year. The general tendency was a rise in mortality with low visibility, but the relationship was too irregular for any definite conclusion, due probably to the unsatisfactory nature of the index. Chart 1 illustrates the curve of respiratory mortality

and temperature in Liverpool during 1924, the worst year of visibility of the present experience. There were fifty-five days when the visibility was below 3. Days of low visibility are plotted at the bottom of the table. During this year it will be seen that in the weeks of bad visibility there is usually a rise in mortality.

The results of this analysis of Liverpool data are in agreement with those of studies on London data. There does not appear to be any demonstrable association between respiratory mortality in young children and meteorological conditions. Variations in temperature and evaporation have considerable influence on adult mortality at certain periods of the year. Rainfall does not seem to be an important factor.

Prediction of mortality from a knowledge of temperature and evaporation are not close enough to be of any practical value. The average change in mortality for a fall in temperature below the normal of the season of the year can be shown, but the actual result may depart considerably from the average value.

In conclusion we have to thank our colleagues, Miss Rogers and Miss Brown, for making and checking the calculations.

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