THE INFLUENCE OF WEATHER CONDITIONS ON THE MORTALITY FROM BRONCHITIS AND PNEUMONIA IN CHILDREN.

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(With 3 Diagrams.)

The mortality from the two diseases of the respiratory system, bronchitis and pneumonia, in children is commonly accepted to be largely dependent on the incidence of unfavourable weather conditions which predispose to infection, but there is not unanimity of opinion as to the meteorological factors which are most closely associated with their onset.

The following paper is based on the results of an investigation which was undertaken to try to determine whether any further information on this subject might be obtained by the method of correlation. The data chiefly utilised were obtained from the four Scottish cities, Glasgow, Edinburgh, Aberdeen and Dundee, and from London, and consist (1) of the monthly totals of the deaths of children under five years of age from bronchitis and pneumonia, respectively, in each city; (2) of the weekly totals of the deaths of children in London from the respective diseases; and (3) of the monthly totals of deaths from respiratory diseases, or bronchitis and pneumonia summed together, in children under five years in each of the four Scottish cities; and of the weekly totals of deaths from the two diseases combined in London children. For Glasgow, Edinburgh and Aberdeen, figures were taken for a period of 54 years, 1857–1910; for Dundee for 45 years, 1866–1910; and for London for 44 years, 1876–1919. The numbers of deaths in each month for the several cities as well as in each week for London were extracted from the annual reports of the Registrars-General for Scotland and England and, before use, were corrected for the increase of the population under five years that took place during the period of years under review. The meteorological factors, which were recorded for the cities for the same period of years and with which the totals of these fatal cases were correlated, were also extracted from the annual reports of the Registrars-General and comprised:

1. Temperature:
   (*a*) the monthly and weekly mean temperature;
   (*b*) the monthly and weekly mean minimum temperature.
2. The monthly and weekly mean relative humidity.
3. The monthly and weekly mean rainfall.

In addition to these data for the five cities, the death-rates from bronchitis, pneumonia and respiratory diseases, respectively, in children under five years of age in the 55 registration counties of England and Wales for the decennium, 1901–1910; and the death-rates from respiratory diseases in the same age group in the 42 registration counties of England in the decennium, 1891–1900, were also extracted from the decennial reports and were correlated with the mean annual temperature and mean annual rainfall for the corresponding counties. These meteorological factors for the counties were determined in a special manner to be described later.

The present investigation in regard to the two diseases was restricted to their incidence in children in the age period 0–5 years, because this group is well defined, has a high mortality, and comprises individuals, who, in the great majority of instances develop a similar type of pneumonia, viz., broncho-pneumonia, are probably, in large measure, similarly susceptible and similarly exposed to the influence of the weather in the different cities; and on whom the effect of other adverse agencies may be regarded as more or less equal. The recorded mortality from respiratory diseases in children, moreover, while influenced doubtless in some degree in the more recent years by the fashion of recording measles, whooping cough, etc., the primary cause, as the cause of death instead of bronchitis or pneumonia, the terminal cause, as may possibly have been done not infrequently in earlier years, has not, like that for adults, been markedly modified during the last three decades by epidemics of influenza. The data are thus more truly comparable than would be those of adults for the longer period of years that has been considered. It is intended, however, to issue later a separate study of the relationship of weather conditions to the mortality from respiratory diseases in people at the other extreme of life for the shorter period of years up to 1890 about which time influenza became epidemic.

A survey of the data suggests that there has been a transference of cases from bronchitis to pneumonia in recent years in accordance with change of fashion in diagnosis. This is a strong argument in favour of combining the figures for the two diseases for the purposes of the investigation. It has been decided, however, to examine the mortality data for each disease separately, as well as for the two combined, in the cities to see what differences may be elicited as it is not certain that they are influenced exactly in the same way by weather conditions.

With regard to the data utilised, it must be conceded that the totals of fatal cases may not be a very accurate index of the number of cases that actually occurred as the mortality in both bronchitis and pneumonia is variable and need not run exactly parallel to the incidence of the two diseases. It must also be acknowledged that some of the cases recorded as terminating fatally in any one month, may not, owing to the variable duration of the respective diseases, have originated in that month. By taking the aggregate deaths for such a long period as a month, however, it was hoped that the great majority

of the cases ultimately fatal would be correlated with the mean values of the weather factors coincident with the onset of the diseases therein, although great accuracy in this respect could not be expected. For the Scottish towns, with the possible exception of Glasgow, it was practically essential to use the monthly figures as the data for the weekly deaths were not sufficiently numerous for the purpose of correlation. In the case of London, however, where the numbers were greater, the correlation coefficients were also calculated between the number of weekly deaths and the meteorological factors in the corresponding week and each of the two preceding weeks, as will be described more fully later.

Before discussing the correlations found, the varying mortality from the two diseases throughout the year may be referred to briefly as the figures for the four Scottish cities and London are available. The seasonal incidence is

Table I.

Showing the annual death-rates in each month and the proportionate mortality in each quarter of the year from bronchitis and pneumonia in children under five years of age in London, Glasgow, Edinburgh, Aberdeen and Dundee.*

Bronchitis.

	Glasgow		Edinburgh		Aberdeen		Dundee		London	
Month	Death-rates	Proportion of deaths in four quarters of year	Death-rates	Proportion of deaths in four quarters of year	Death-rates	Proportion of deaths in four quarters of year	Death-rates	Proportion of deaths in four quarters of year	Death-rates	Proportion of deaths in four quarters of year
Jan.	16·75		10·63		10·42		16·16		8·41	
Feb.	17·47	31·44±·12	11·37	31·32±·27	10·12	35·34±·38	14·82	33·35±·31	8·28	34·26±·08
Mar.	16·14		9·94		9·14		12·34		8·37	
Apr.	15·03		9·04		7·39		11·16		6·46	
May	13·04	24·24±·11	7·50	22·45±·24	5·31	20·61±·32	8·47	21·38±·27	4·59	19·70±·01
June	10·75		6·36		4·61		8·14		3·36	
July	8·11		5·12		3·44		5·83		2·91	
Aug.	6·93	14·34±·09	4·30	13·66±·20	2·92	11·48±·25	5·15	12·84±·22	2·68	11·56±·06
Sept.	7·93		4·51		3·28		5·69		2·87	
Oct.	12·51		7·21		5·00		9·66		6·08	
Nov.	17·24	29·98±·12	12·84	32·56±·27	10·03	32·57±·38	14·64	32·43±·31	9·61	34·48±·08
Dec.	18·28		13·16		12·33		17·83		9·52	

Pneumonia.

Jan.	9·91		5·26		3·97		7·44		7·38	
Feb.	10·71	29·86±·15	5·31	29·78±·36	4·19	32·27±·56	7·39	32·90±·44	7·36	32·81±·09
Mar.	9·55		5·54		4·14		6·54		7·65	
Apr.	9·05		4·67		3·79		6·03		6·53	
May	8·24	23·93±·14	4·32	24·26±·34	2·85	23·77±·51	5·50	24·47±·40	4·92	22·31±·08
June	6·88		4·14		2·43		4·36		3·78	
July	5·40		3·43		2·11		4·01		3·36	
Aug.	4·15	14·43±·12	2·70	15·82±·29	1·44	14·58±·42	3·18	15·13±·34	3·11	13·89±·06
Sept.	5·03		2·43		2·01		2·64		3·00	
Oct.	8·62		3·76		2·73		4·33		5·02	
Nov.	11·73	31·78±·16	5·76	30·13±·36	3·96	29·38±·54	6·31	27·50±·42	7·98	31·00±·09
Dec.	11·75		6·78		4·51		7·22		8·16	

* Calculated from the average number of deaths in the respective months for 55 years (50 years in London) corrected for increase of population, and the population under 5 years in 1911.

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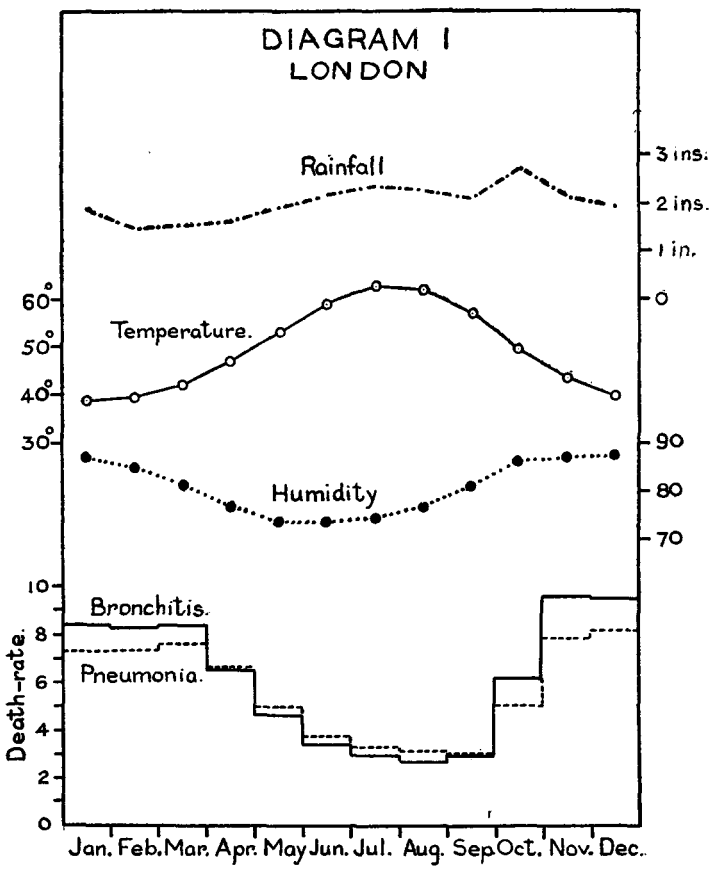
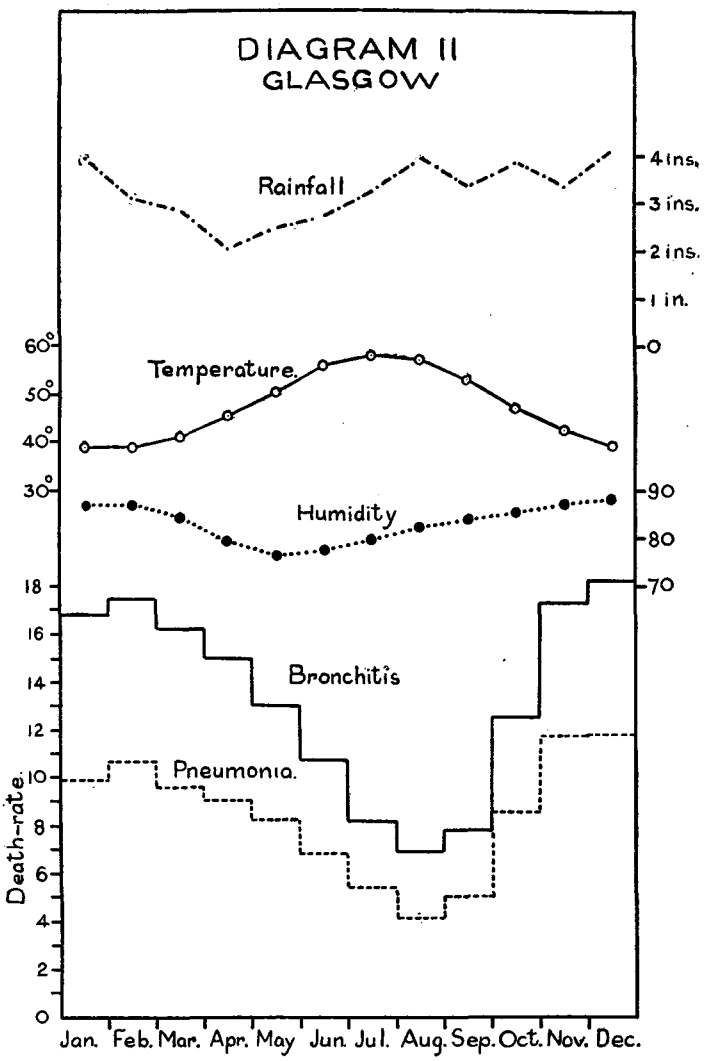
very evident in both bronchitis and pneumonia, both diseases being most fatal in the first and last quarters of the year and least fatal in the third quarter. Table I shows, for each of the diseases in each of the Scottish cities and in London, the percentage of fatal cases occurring in each quarter of the year taking the average of all the 55 years. In the second quarter of the year there seems to be a slightly higher proportionate mortality from pneumonia than from bronchitis in Edinburgh, Aberdeen, Dundee and London



but not in Glasgow. The differences are not large, but, in view of the size of their probable errors, may be regarded as statistically significant. It is said to be a feature of pneumonia that its prevalence is prolonged further into the spring than that of bronchitis and there appears to be in the data for all the cities, except Glasgow, evidence in support of this view. The variation in mortality throughout the year is shown in greater detail in the annual death-rates for each month from bronchitis and pneumonia which are given in Table I. Graphs have also been drawn for London, Glasgow and Dundee to illustrate the seasonal incidence of the mortality from the respective diseases in relation to the corresponding mean temperature, relative humidity

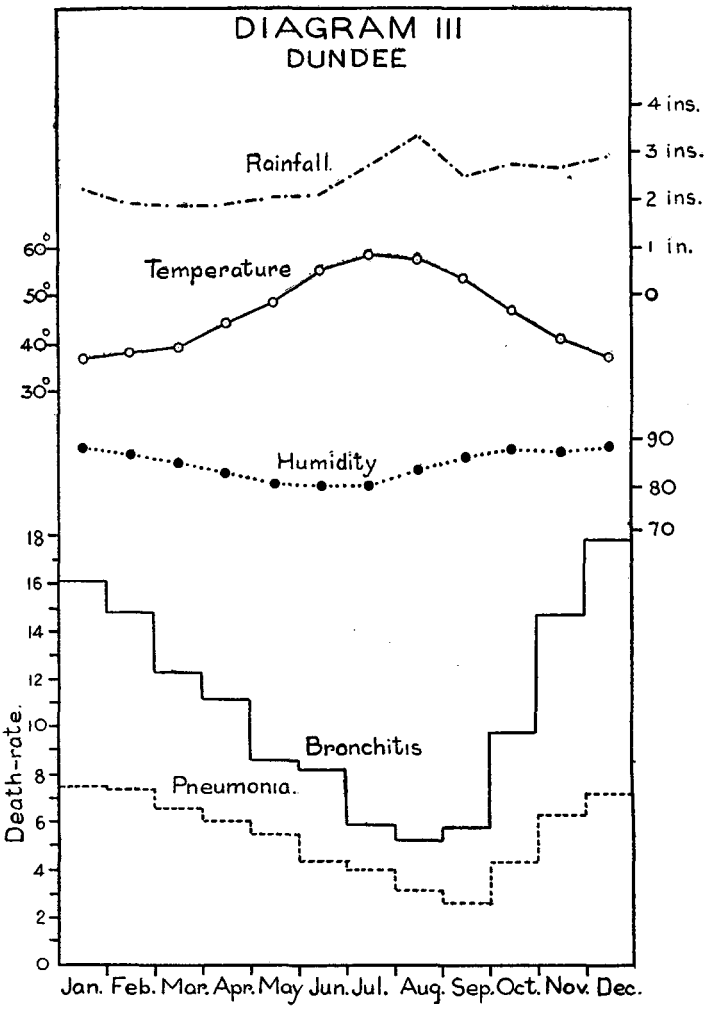
and mean rainfall (Diagrams I, II and III). The death-rates have been calculated from the average number of deaths corrected for the increase of the population for approximately 50 years, and from the populations in the respective cities in 1911. In the four Scottish cities the maximum death-rate from bronchitis is found in December, that in London in November, and the



minimum in all in August. As regards pneumonia, the maximum death-rate is found in December in Glasgow, Edinburgh, Aberdeen and London, and in January in Dundee, while the minimum death-rate is found in all the cities in August or September. There is thus abundant evidence in the data that the weather conditions obtaining in the winter months are accompanied by an increased mortality from both bronchitis and pneumonia and it now

remains to be seen if the method of correlation will serve to differentiate the most potent predisposing factors amongst those under review.

The coefficients of correlation found between the number of fatal cases in each month from the respective diseases and the two diseases combined on the one hand, and the several meteorological factors under consideration on the other, are shown in Table II and the subsequent tables. For the



numerous correlation coefficients calculated, the probable errors have not all been tabulated as it seems sufficient to state that, if the attainment of a value not less than three times its probable error, the conventional standard, be regarded as the criterion of statistical significance of a correlation coefficient, with 54 years' statistics such as are available for Glasgow, Edinburgh and Aberdeen, a coefficient requires to be about 0·25 and with 45 years' statistics,

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as are available for London and Dundee, 0·30 in value before it can be stated with any degree of certainty that any real significance should be attached to, or any legitimate conclusions drawn from it. A short discussion on the relationships found will be given for each disease separately beginning with the monthly data.

Table II.

Showing the correlation in the several months of the year between the number of monthly deaths from bronchitis in children under five years of age in Glasgow, Edinburgh, Aberdeen, Dundee and London, respectively, and the corresponding monthly mean temperature.

Month	Glasgow (1857–1910) (1)	Glasgow (using differences from mean of 5 years) (1 *a*)	Edinburgh (1857–1910) (2)	Aberdeen (1857–1910) (3)	Dundee (1866–1910) (4)	Mean of 4 coefficients for Scottish cities (5)	London (1876–1919) (6)
January	−·247	−·296	−·125	+·035	−·213	−·138	−·252
February	−·181	−·329	−·021	+·028	−·015	−·047	−·186
March	−·138	−·242	−·151	−·073	+·103	−·065	−·234
April	+·150	—	+·198	−·256	+·291	+·096	−·259
May	−·131	—	+·031	+·032	−·173	−·060	−·564
June	−·075	—	+·224	+·072	+·167	+·097	−·023
July	+·092	—	−·069	+·112	+·128	+·066	−·196
August	−·019	—	−·088	+·177	+·187	+·064	−·325
September	−·139	—	+·088	+·126	−·016	+·015	−·014
October	−·148	+·039	−·158	−·121	+·016	−·103	−·348
November	−·321	−·064	−·064	+·285	−·034	−·034	−·124
December	−·290	−·293	−·221	−·067	−·334	−·228	−·382
Mean of coefficients for six months (first 3 and last 3 of year)	−·221	−·198	−·123	+·015	−·080	—	−·254
Mean of coefficients for 12 months	−·121	—	−·030	+·029	+·009	—	−·242

For Glasgow, Edinburgh and Aberdeen with 54 years' statistics and for Dundee and London with 45 years' statistics, correlation coefficients require to be approximately equal to 0·250 and 0·300 respectively, to be regarded as statistically significant. The same standard applies to the succeeding tables.

Mortality from bronchitis and temperature—mean and mean minimum.

The coefficients of correlation between the number of monthly deaths from bronchitis and the two temperature records—mean and mean minimum—have all been calculated and are shown in Tables II and III but it is obvious, from a survey of the coefficients that those for mean minimum temperature exhibit in general a similar trend to, and would suggest the same conclusions as, those for the mean temperature. While the minimum temperature coefficients may not infrequently be a little greater than the corresponding values shown for the mean temperature it will be sufficient to confine the discussion largely to the relationship of bronchitis to the latter making only occasional reference to mean minimum temperature where such seems advisable.

If cold weather predisposes to the onset of bronchitis, as is generally believed, then there is probably a level or critical point below which the temperature must fall before it has any injurious influence, or its effect is shown in an increased mortality from the disease. As this low temperature level or threshold is more likely to be attained and more commonly and more extensively transgressed in the colder months than in the summer when it is probably rarely reached on the average, the coefficients of correlation in the winter months are presumably a more accurate index of the effect of the fall of temperature on the death-rate. Though the coefficients for all the months have been tabulated, special attention will thus be directed to the coefficients for the colder months (and in the weekly data to those for the colder weeks)

Table III.

Showing the correlation in the several months of the year between the number of monthly deaths from bronchitis in children under five years of age in Glasgow, Edinburgh, Aberdeen and Dundee, respectively, and the corresponding mean minimum temperature.

Month	Glasgow (1)	Edinburgh (2)	Aberdeen (3)	Dundee (4)	Mean of 4 coefficients for Scottish cities (5)
January	−·292	−·116	+·032	−·213	−·147
February	−·228	−·110	+·100	+·045	−·048
March	−·227	−·196	−·026	+·070	−·095
April	+·023	+·179	−·130	+·407	+·120
May	−·181	−·110	+·176	−·201	−·079
June	−·214	−·056	+·045	+·139	−·022
July	−·042	−·221	+·206	−·028	−·021
August	−·207	−·186	+·204	+·174	−·004
September	−·257	−·007	−·008	−·118	−·098
October	−·160	−·132	−·112	+·126	−·070
November	−·408	−·147	+·338	+·010	−·052
December	−·388	−·211	+·004	−·344	−·235
Mean of coefficients for six months (first 3 and last 3 of year)	−·284	−·152	+·056	−·051	—
Mean of coefficients for 12 months	−·215	−·109	+·069	+·006	—

which are, on the average, greater than and more regular in value than those for the warmer periods of similar duration.

For each of the four Scottish cities, the mean values of the correlation coefficients between each pair of variables for the whole series of twelve months and for the six colder months—the first three and the last three of the year—were computed. The mean values of the corresponding coefficients for each month of the year in the four cities were also determined. On comparing the coefficients, it is found that considerable variation occurs from month to month in those for each city and that there does not appear to be much evidence of agreement in corresponding months in the different cities. While the values of the correlation coefficients for the several months in Glasgow are with two exceptions negative in sign, the values in the other three towns

change irregularly from positive to negative in different months of the year. These values are, however, most frequently within the range + 0·2 and − 0·2 and are probably statistically insignificant. While the regular sequence of negative coefficients for the different months in Glasgow would suggest the tendency to an inverse relationship between the number of deaths from bronchitis and the monthly mean temperature, a relationship which is perhaps still closer between bronchitis and the monthly mean minimum temperature, it cannot be stated that there is definite evidence that such an association obtains in the other three towns. The inverse relationship described is, as would be anticipated, more clearly indicated in the coefficients for the first three and last three months of the year in Glasgow. While the correlation coefficients for January and December in Dundee and that for December in Edinburgh are negative in sign and exceed 0·2 in value, the coefficients for Aberdeen in these months are obviously insignificant. The correlation coefficients between the number of deaths from bronchitis and the mean temperature for the different months in London, though they show considerable variation in value, are uniformly negative in sign. The mean value of the coefficients for all the months is − 0·242, and for the first and last three months − 0·254. This suggests a tendency towards an inverse association between the number of deaths from bronchitis and the mean temperature of the corresponding month, the lower the mean temperature, the greater the number of deaths; this seems to support the conclusion that would be drawn from the coefficients calculated from the Glasgow data.

On investigation, there appeared to be some evidence of an approximately five yearly periodicity in the figures for bronchitis deaths in Glasgow, and it seemed possible that this might have some effect in determining the magnitude of the correlation coefficient. In an attempt to exclude this possible influence, correlation coefficients were calculated for each of the six colder months for the period of 50 years between the deviations from the number of deaths from bronchitis in the month in any year and the average number of deaths in that month in the five adjacent years, of which the given year is the centre and the mean temperature of the corresponding month (Table II, col. 1 *a*). The correlation coefficients remained negative and statistically significant in four out of the six months, indicating that the correlation found between the mortality and the mean temperature is real and is not to be accounted for by the periodicity in the figures.

Mortality from pneumonia and temperature—mean and mean minimum.

The coefficients of correlation between the monthly deaths from pneumonia in children and the corresponding mean and mean minimum temperatures for the four Scottish towns were calculated and the two sets of values for these cities and the values for mean temperature in London are shown in Tables IV and V. It will be seen that the mean values of the twelve monthly coefficients and of those for the six colder months of the year in each of the four

Table IV.

Showing the correlation in the several months of the year between the number of monthly deaths from pneumonia in children under five years of age in Glasgow, Edinburgh, Aberdeen, Dundee and London, respectively, and the corresponding monthly mean temperature.

Month	Glasgow (1)	Glasgow (using differences from mean of 5 years) (1 *a*)	Edinburgh (2)	Aberdeen (3)	Dundee (4)	Mean of 4 coeffi-cients for Scottish cities (5)	London (6)
January	−·185	−·302	+·111	+·139	+·072	+·034	+·156
February	−·391	−·467	−·104	−·004	−·193	−·173	−·131
March	−·111	−·188	+·166	−·009	+·153	+·050	−·154
April	−·408	—	−·161	−·161	−·115	−·211	+·098
May	+·027	—	−·248	−·066	−·026	−·078	−·199
June	−·129	—	−·335	−·137	−·012	−·153	−·054
July	−·055	—	−·308	−·120	−·024	−·127	+·134
August	+·025	—	+·068	−·068	+·029	+·014	−·059
September	+·210	—	+·089	+·180	+·125	+·151	+·168
October	+·103	+·105	+·045	+·014	−·059	+·026	+·052
November	+·161	−·130	+·238	+·314	+·225	+·235	−·191
December	−·020	−·204	+·034	+·040	−·087	−·008	−·046
Mean of coefficients for six months (first 3 and last 3 of year)	−·074	−·198	+·082	+·082	+·019	—	−·052
Mean of coefficients for 12 months	−·064	—	−·034	+·010	+·007	—	−·019

Table V.

Showing the correlation in the several months of the year between the number of monthly deaths from pneumonia in children under five years of age in Glasgow, Edinburgh, Aberdeen and Dundee, respectively, and the corresponding mean minimum temperature.

Month	Glasgow (1)	Edinburgh (2)	Aberdeen (3)	Dundee (4)	Mean of 4 coefficients for Scottish cities (5)
January	−·113	+·095	+·108	−·017	+·018
February	−·398	−·094	−·089	−·217	−·200
March	−·033	+·153	−·063	+·093	+·038
April	−·206	−·112	−·147	−·299	−·191
May	+·132	−·258	−·173	−·006	−·076
June	−·027	−·180	−·115	−·059	−·095
July	+·042	−·347	−·140	−·066	−·128
August	+·110	+·024	−·189	−·036	−·023
September	+·169	+·046	+·072	−·068	+·055
October	+·162	+·042	−·033	+·157	+·082
November	+·218	+·279	+·283	+·208	+·247
December	+·119	−·031	−·003	−·016	+·017
Mean of 6 coefficients (first 3 and last 3 of year	+·008	+·074	+·034	+·035	—
Mean of 12 coefficients	+·015	−·032	−·041	−·027	—

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Scottish towns are less than 0·1, showing that no consistent relationship, either inverse or direct, between the number of deaths and the temperature is evident, on the average, in the months throughout the year. For the mean temperature, the series of means of the corresponding coefficients for each month in the four towns are small in value and variable in sign; in only two months, April and November, does the mean value exceed 0·2, and of these, the sign is negative in the former and positive in the latter. The correlation coefficients between the monthly mortality from pneumonia and mean temperature in London vary irregularly in sign and in no month attain a value as high as 0·2. While the coefficients for a few individual months in Glasgow and Edinburgh suggest a tendency therein to an inverse relationship between pneumonia and mean temperature, the only conclusion that can be drawn from the coefficients as a whole is that, if any consistent relationship exists between the mortality from pneumonia and the temperature that prevails, it is not disclosed by correlating the monthly deaths with the monthly mean or minimum temperature.

Mortality from respiratory diseases and temperature.

With the view of excluding the influence, on the correlation coefficient, of the transference of cases from bronchitis to pneumonia in the data that has occurred in recent years, the correlation coefficients between the monthly

Table VI.

Showing the correlation in the several months of the year between the number of deaths from respiratory diseases in children under five years of age in Glasgow, Edinburgh, Aberdeen and Dundee, respectively, and the corresponding mean monthly temperature.

Month	Glasgow (1)	Glasgow (using differences from mean of 5 years) (1 *a*)	Edinburgh (2)	Aberdeen (3)	Dundee (4)	Mean of 4 coefficients (5)
January	−·374	−·360	−·098	+·050	−·135	−·139
February	−·354	−·412	−·169	+·006	−·086	−·151
March	−·243	−·197	−·050	+·018	+·128	−·037
October	−·079	+·069	−·069	−·006	−·015	−·042
November	−·213	−·078	−·047	+·339	+·016	+·024
December	−·394	−·343	−·137	−·227	−·356	−·279
Mean of 6 coefficients	−·276	−·220	−·095	+·030	−·075	—

deaths from bronchitis and pneumonia summed together, and the mean temperature of the corresponding month have been calculated for the six colder months of the year for each of the four Scottish towns (Table VI). While some of the coefficients for the months in Glasgow appear to be statistically significant and the mean of the six is − 0·276, suggesting that the number of deaths from the respiratory diseases in children in this city is inversely

associated with the mean temperature, only one or two of the coefficients for the months in the other three cities can be regarded as significant.

Mortality from bronchitis and relative humidity.

The interpretation of the correlation coefficients between these variables in the different cities, as shown in Table VII, presents some difficulty. For Glasgow alone, the problem, at the first glance, seems simple as the coefficients for the several months, are uniformly positive in sign and all exceed 0·3 in value; that for February being as high as 0·7 and that for November 0·4. They may thus all be regarded as statistically significant and seem to indicate a definite, direct association between the degree of relative humidity and the

Table VII.

Showing the correlation in the several months of the year between the number of monthly deaths from bronchitis in children under five years of age in Glasgow, Edinburgh, Aberdeen, Dundee and London, respectively, and the corresponding mean monthly relative humidity.

Month	Glasgow (1)	Glasgow (using differences from mean of adjacent 5 years) (1 *a*)	Edinburgh (2)	Aberdeen (3)	Dundee (4)	Mean of 4 coefficients for Scottish cities (5)	London (6)
January	+·343	+·014	+·331	+·235	−·193	+·179	−·199
February	+·693	+·152	+·048	+·417	−·068	+·273	−·003
March	+·361	−·143	−·017	+·190	−·213	+·080	−·419
April	+·485	—	+·081	+·346	−·161	+·188	+·170
May	+·419	—	−·315	+·197	−·418	−·029	−·060
June	+·527	—	−·027	+·051	−·233	+·080	+·128
July	+·393	—	+·008	+·174	−·123	+·113	−·037
August	+·428	—	−·046	+·164	+·010	+·139	+·075
September	+·511	—	−·071	+·157	−·305	+·073	+·043
October	+·390	−·034	−·184	—	−·206	—	−·269
November	+·399	−·043	−·046	−·083	−·212	+·015	−·324
December	+·324	−·211	+·056	+·083	−·259	+·051	−·071
Mean of coefficients for six months (first 3 and last 3 of year)	+·418	−·044	+·031	+·140	−·192	—	−·214
Mean of coefficients for 12 months	+·439	—	−·015	+·161	−·198	—	−·081

mortality from bronchitis—the higher the relative humidity, the greater the mortality from the disease. The mean of the coefficients for the twelve months is + 0·439 and that for the six colder months, including the first three and the last three of the year + 0·418. This is less than the mean of the twelve coefficients as some of the coefficients for the intermediate months are relatively large. The correlation coefficients for Aberdeen are, with one exception, positive, and, though only two or three of them may be regarded as definitely significant, the uniformity in the sign of the coefficients seems to suggest the

existence of a tendency towards a direct association between a high relative humidity and a high death-rate from bronchitis in children. For Dundee, however, the coefficients for all the months, with one exception, are negative and exceed 0·20 in value in half the months and 0·30 in two instances; while those for Edinburgh vary irregularly in sign and exceed 0·25 in value in two months only, viz., in January where the coefficient is positive and in May where it is negative. The coefficients for the different months in London are generally negative though some are positive. In two months, namely, March and November, the coefficients exceed 0·30 in value and are negative in sign. There is thus no evidence in these last named towns of a direct association between the mortality from bronchitis and the index of relative humidity, such as might be concluded from the Glasgow and Aberdeen data; if the coefficients suggest any association at all, it is an inverse relationship.

Mortality from pneumonia and relative humidity.

If discussion were confined to the relationship between these variables as seen in the Glasgow data, the interpretation would be comparatively easy as the correlation coefficients for all the months are negative in sign with one exception, in six of the months exceed 0·25 in value and are statistically significant (Table VIII). This would suggest that the mortality from pneumonia is inversely associated with the degree of humidity, *i.e.* the relatively

Table VIII.

Showing the correlations in the several months of the year between the number of monthly deaths from pneumonia in children under five years of age in Glasgow, Edinburgh, Aberdeen, Dundee and London, respectively, and the corresponding mean monthly relative humidity.

Month	Glasgow (1)	Glasgow (using differences from mean of 5 years) (1 *a*)	Edinburgh (2)	Aberdeen (3)	Dundee (4)	Mean of 4 coefficients for Scottish cities (5)	London (6)
January	−·357	−·039	−·374	−·182	+·235	−·170	−·153
February	−·109	+·079	−·078	−·356	+·221	−·081	+·053
March	−·416	−·156	−·107	−·043	+·250	−·079	+·171
April	−·315	—	−·082	−·283	+·242	−·110	−·121
May	+·020	—	+·180	−·041	+·344	+·126	+·007
June	−·280	—	−·170	+·130	+·181	−·035	−·007
July	−·167	—	−·056	+·002	+·177	−·011	−·416
August	−·201	—	+·035	+·237	+·391	+·116	−·042
September	−·254	—	+·241	−·189	+·271	+·017	−·211
October	−·298	−·099	−·071	−·117	+·050	−·109	+·149
November	−·207	+·113	−·254	−·254	+·303	−·103	+·078
December	−·171	+·030	−·104	−·200	+·416	−·015	−·040
Mean of six coefficients (first 3 and last 3 of year)	−·260	−·012	−·165	−·192	+·246	—	+·043
Mean of 12 coefficients	−·230	—	−·070	−·108	+·257	—	−·044

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drier the atmosphere may be the greater the mortality. This suggestion receives some support from the coefficients found for Aberdeen which are, with a few exceptions, negative in sign and in some months exceed 0·25 in value. The monthly coefficients for Dundee are, however, as consistently positive, with an equal claim to significance and suggest that the prevalence of pneumonia is favoured by a relatively humid atmosphere. The majority of the coefficients for Edinburgh are negative in sign but only two, viz. those for January and November can be considered to approach a significant value. About half the coefficients for London are negative and the other half positive, but only one, viz. that for July, which is negative, can be considered significant. It is evident, therefore, that while humidity would appear to have an inverse association with the mortality from pneumonia as is shown in the results for Glasgow, a view which is, to some extent, supported by the coefficients found for Aberdeen, this apparent association is not confirmed by the coefficients found for Dundee. It is worthy of note that, while the Glasgow data show a positive correlation between bronchitis and relative humidity in the several months, the correlation between pneumonia and this meteorological factor is as consistently negative. This would appear to indicate that, while a relatively moist atmosphere predisposes to bronchitis, the onset of pneumonia, on the other hand, is favoured by a relatively dry atmosphere. This difference, if real, may be regarded as, to some extent, in favour of the view that the two diseases are distinct, and in opposition to that which attributes nearly all deaths from bronchitis under five years of age to broncho-pneumonia in which the physical signs are indefinite.

Mortality from respiratory diseases and relative humidity.

The correlation coefficients between the combined figures for the monthly deaths from bronchitis and pneumonia and the relative humidity in the six colder months for each of the four Scottish cities are shown in Table IX. For Glasgow, five of the six coefficients appear to be statistically significant and the mean value of the six is + 0·315, suggesting a definite tendency for a high relative humidity to be associated with a high death-rate from the respiratory diseases. This direct relationship was also found between bronchitis and relative humidity, and the deaths from bronchitis being more numerous than those for pneumonia, the preponderance seems to determine the direct relationship for the two diseases combined, as the relationship suggested between the deaths from pneumonia and the mean relative humidity is inverse. The values of the monthly coefficients for the other three cities are practically all statistically insignificant and the mean values for each city are less than 0·1.

As it seemed possible that the correlation coefficients between bronchitis and relative humidity, pneumonia and relative humidity and respiratory diseases and relative humidity for the Glasgow data, which were relatively high in comparison with those found for the other Scottish cities, might be

determined, in some degree, by the five yearly periodicity which appeared to exist in the mortality figures, other correlation coefficients were calculated, for the first three and last three months of the year, between the differences in the number of deaths, (1) from bronchitis, (2) from penumonia, (3) from respiratory diseases, in any month in one year, and the average number of deaths in the corresponding month in the adjacent five years of which the given year is the centre, and the relative humidity in the corresponding month. The correlation coefficients found in this manner from the bloxamed monthly figures between bronchitis and relative humidity, pneumonia and relative humidity, and respiratory diseases and relative humidity, were much less in value than those found from the actual figures and were not statistically

Table IX.

Showing the correlation in the several months of the year between the number of deaths from respiratory diseases in children under five years of age in Glasgow, Edinburgh, Aberdeen and Dundee, respectively, and the corresponding mean monthly relative humidity.

Month	Glasgow (1)	Glasgow (using differences from mean of adjacent 5 years) (1 *a*)	Edinburgh (2)	Aberdeen (3)	Dundee (4)	Mean of 4 coefficients (5)
January	+·434	+·019	+·159	+·095	−·142	+·137
February	+·501	+·120	+·067	+·123	+·086	+·194
March	+·271	−·139	−·072	+·294	−·054	+·110
October	+·150	−·054	+·171	−·024	−·154	+·036
November	+·295	+·035	−·151	−·150	−·003	−·002
December	+·241	−·119	−·022	−·076	−·143	000
Mean of coefficients for six months (first 3 and last 3 of year)	+·315	−·023	+·025	+·044	−·068	—

significant for any month, the averages for the six coefficients in the three cases being − 0·044, − 0·012 and − 0·023, respectively (cols. 1 *a* in Tables VII, VIII and IX). While this would appear to indicate that the correlation coefficients between the mortality from bronchitis, pneumonia and respiratory diseases, respectively, and relative humidity in Glasgow are due to the periodicity in the mortality data, the effect of which is probably eliminated by bloxaming the data and correlating the differences, this does not seem to be an adequate explanation of the reduction in the coefficients that takes place by using this method, as it will be recollected that the correlation coefficients between the same averaged data and mean temperature, remain significant. As there is no definite periodicity visible in the figures for relative humidity for any month in the series of years to account for the reduced values of the coefficients, it is possible that the application of the bloxaming process to the mortality figures results in the smoothing out of the deviations and that the consequent reduction in the coefficient is, to some extent, for-

tuitous. A high relative humidity in Glasgow may be indicative of the presence of fog or other muggy, unpleasant conditions which, as is well known, are more prevalent in this city than in the other Scottish cities and may be responsible, in part, for the differences found in their coefficients of correlation.

Mortality from bronchitis and rainfall.

The coefficients of correlation between the monthly mortality from bronchitis and the amount of rainfall in each month in the different towns are shown in Table X. The coefficients for the several months in each town vary irregularly in sign and show considerable variation in value. The means of

Table X.

Showing the correlation in the several months of the year between the number of monthly deaths from bronchitis in children under five years of age in Glasgow, Edinburgh, Aberdeen, Dundee and London, respectively, and the corresponding mean monthly rainfall.

Month	Glasgow (1)	Edinburgh (2)	Aberdeen (3)	Dundee (5)	Mean of 4 coefficients for Scottish cities (5)	London (6)
January	+·321	+·151	−·032	+·125	+·141	−·135
February	+·238	−·141	+·153	+·203	+·113	−·192
March	−·148	−·235	+·087	−·112	−·102	−·431
April	+·025	+·141	−·011	+·187	+·086	+·006
May	−·173	−·189	+·077	+·059	−·057	+·077
June	+·061	+·081	−·094	+·218	+·067	−·007
July	+·106	+·149	−·009	+·120	+·092	+·040
August	+·038	−·042	+·140	−·115	+·005	−·031
September	+·189	+·238	+·074	+·101	+·151	+·065
October	+·079	−·028	−·031	+·147	+·042	+·132
November	−·073	−·026	−·230	+·306	−·006	−·036
December	+·113	+·106	+·010	+·070	+·075	−·415
Means of coefficients for six months (first 3 and last 3 of year)	+·088	−·029	−·007	+·123	—	−·180
Mean of 12 coefficients	+·065	+·017	+·011	+·109	—	−·077

the coefficients for all the months in any one of the Scottish towns, and of the corresponding coefficients in the same month for the four towns rarely exceed 0·1 in value and cannot be regarded as statistically significant. The only warrantable conclusion seems to be that the average amount of monthly rainfall has no appreciable or consistent influence in determining the mortality from bronchitis in children.

Mortality from pneumonia and rainfall.

A survey of the coefficients of correlation between the number of deaths from pneumonia in each month and the registered rainfall in the corresponding month for the several towns, as given in Table XI, shows no evidence of a consistent relationship between them. There is a suggestion, from the values of the coefficients found for some individual months, in the Scottish cities

that, in these months, there may be a tendency towards an inverse association between the mortality from pneumonia and the amount of rainfall—the less the rainfall the greater the mortality—but there is no definite evidence of this in the coefficients for the months generally.

The correlation coefficients that have been found between the number of deaths in each month from bronchitis and respiratory diseases, respectively, and the monthly mean temperature in Glasgow and London, while suggestive of the existence of some inverse relationship between these variables, indicating a tendency for the mortality to be increased with the prevalence of colder weather, are perhaps not of sufficient magnitude to warrant the conclusion that such a tendency is unequivocally present. In addition to the

Table XI.

Showing the correlation in the several months of the year between the number of monthly deaths from pneumonia in children under five years of age in Glasgow, Edinburgh, Aberdeen and Dundee, respectively, and the corresponding mean monthly rainfall.

Month	Glasgow (1)	Edinburgh (2)	Aberdeen (3)	Dundee (4)	Mean of 4 coefficients for Scottish cities (5)
January	−·366	−·083	−·058	−·166	−·168
February	−·053	−·245	−·198	−·100	−·149
March	−·131	+·082	+·142	−·006	+·022
April	+·022	+·195	+·064	+·002	+·071
May	+·090	+·009	+·015	+·067	+·045
June	−·021	+·092	−·064	+·104	+·028
July	+·055	−·086	+·032	−·127	−·032
August	−·100	+·049	−·118	−·041	−·053
September	+·045	−·221	−·231	−·220	−·157
October	−·046	+·074	−·112	−·039	−·031
November	−·306	−·262	−·160	+·186	−·136
December	−·119	+·125	−·048	+·135	+·023
Mean of coefficients for six months (first 3 and last 3 of year)	−·170	−·052	−·072	+·002	—
Mean of 12 coefficients	−·078	−·023	−·061	−·017	—

possibility that some fatal cases, owing to the variable duration of the disease, may not be correlated with the appropriate temperature coincident with their onset and so may tend to obscure the real relationship between the mortality from the disease and the temperature, another possible source of inaccuracy is that, in correlating the monthly mean and minimum temperature with the mortality from the diseases, the effect of sudden changes of temperature of such short duration as to influence only to a small extent, if at all, the monthly means is not elicited; although it would appear, from clinical experience and observation, that these sudden or less prolonged changes may exert a considerable influence on the mortality from and the prevalence of bronchitis and pneumonia. It seemed probable that more detailed information of the influence of the temperature accompanying the onset of the diseases might be obtained from the correlations between the mortality from the two diseases

in the shorter period of a week and the mean temperature of the corresponding week as well as that of each of the two preceding weeks. These, as has been mentioned, have been calculated from the data for London for the first thirteen and last thirteen weeks of the year only, as it was in this period of the year that the real effect of reduced temperature on the respiratory death-rate was likely to be shown. We now come to consider the relationship between the several meteorological factors and the weekly mortality data. The correlation coefficients are shown in Tables XII and XIII and the relationships found therein will be discussed briefly.

Table XII.

Showing the correlation coefficients between the number of weekly deaths from bronchitis and respiratory diseases, respectively, amongst children under five years of age in London and the several meteorological factors under investigation, for the weeks at the beginning and end of the year.

	Variables: No. of deaths from bronchitis and							Variables: No. of deaths from respiratory diseases and	
	mean temperature of corresponding week	mean temperature of preceding week	mean temperature of two weeks before	mean minimum temperature of same week	relative humidity of same week	relative humidity of preceding week	recorded rainfall of same week	mean temperature of the same week	mean temperature of the preceding week
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Week of Year	*r*	*r*	*r*	*r*	*r*	*r*	*r*	*r*	*r*
1st	−·402	−·309	−·513	−·493	+·152	+·059	+·006	−·394	−·411
2nd	−·297	−·470	−·177	−·170	+·390	+·142	−·207	−·215	−·487
3rd	−·078	−·395	−·370	−·090	+·139	+·137	−·128	−·025	−·258
4th	−·008	−·181	−·290	−·059	−·096	+·140	−·092	+·075	−·157
5th	+·026	−·141	−·225	−·034	+·457	+·109	+·063	+·045	−·148
6th	−·083	−·039	−·090	−·112	+·312	+·386	−·119	+·026	−·106
7th	−·095	−·242	−·111	+·181	+·234	+·180	+·171	−·032	−·182
8th	−·178	−·252	−·302	−·340	+·357	+·191	−·189	−·375	−·256
9th	−·185	−·313	−·322	−·142	+·047	+·373	−·158	−·186	−·417
10th	−·298	−·324	−·269	−·370	−·067	+·132	−·386	−·410	−·321
11th	−·214	−·412	−·257	−·259	−·152	−·204	−·230	+·031	−·386
12th	−·018	−·174	−·347	−·017	+·178	−·254	−·119	+·010	−·148
13th	−·169	−·182	−·186	−·177	+·017	+·083	−·021	−·235	−·191
40th	−·146	−·248	000	−·135	+·282	+·242	+·094	−·329	−·247
41st	−·187	−·273	−·305	−·144	−·070	+·197	+·004	−·243	−·267
42nd	−·362	−·220	−·175	−·359	+·251	−·008	+·115	−·340	−·206
43rd	−·114	−·421	−·186	−·020	+·109	+·149	+·114	−·044	−·369
44th	−·337	−·210	−·281	−·149	+·093	+·032	−·086	−·363	−·152
45th	−·353	−·511	−·213	−·309	+·175	+·076	+·019	−·296	−·532
46th	−·096	−·401	−·305	−·139	+·147	+·106	−·087	−·149	−·429
47th	−·192	−·321	−·345	−·126	+·117	+·053	−·019	−·398	−·339
48th	−·351	−·360	−·176	−·313	−·017	−·026	−·088	−·311	−·452
49th	−·441	−·376	−·189	−·327	−·331	−·084	−·227	−·379	−·450
50th	−·467	−·522	−·306	−·535	+·126	−·364	−·281	−·424	−·487
51st	−·324	−·633	−·481	−·234	+·236	+·190	−·225	−·236	−·587
52nd	−·302	−·582	−·412	−·324	+·192	+·229	−·042	−·192	−·539
Mean of coefficients for 26 weeks (first 13 and last 13 of year)	−·218	−·327	−·263	−·200	+·126	+·087	−·081	−·207	−·328
Means of coefficients for 52 weeks	−·127	—	—	−·115	+·175	—	−·022	—	—

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Table XIII.

Showing the correlation coefficients between the number of weekly deaths from pneumonia amongst children under five years of age in London, and the several meteorological factors under investigation for the weeks at the beginning and end of the year.

	Variables: No. of deaths from pneumonia and						
	mean temperature of corresponding week	mean temperature of the preceding week	mean temperature of two weeks before	mean minimum temperature of same week	relative humidity of the same week	relative humidity of the preceding week	recorded rainfall of same week
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Week of Year	*r*	*r*	*r*	*r*	*r*	*r*	*r*
1st	+·038	−·160	−·033	+·090	−·308	−·437	−·036
2nd	+·165	−·258	−·218	+·031	−·129	−·272	−·039
3rd	+·075	−·013	−·127	+·107	−·088	−·198	−·218
4th	+·085	+·072	+·154	+·134	−·116	−·120	−·023
5th	−·001	−·170	−·040	−·048	−·050	−·127	−·022
6th	−·012	−·172	−·248	+·025	−·344	−·010	+·064
7th	−·172	−·174	−·108	−·204	−·256	−·217	−·198
8th	−·282	−·167	−·158	−·287	−·104	−·265	−·227
9th	−·161	−·386	−·373	−·217	−·119	−·243	−·112
10th	−·216	−·264	−·282	−·150	+·163	−·078	+·032
11th	+·128	−·367	−·257	+·082	−·032	+·077	−·088
12th	+·095	+·070	−·222	+·174	+·055	−·082	−·061
13th	−·188	−·090	+·030	−·281	−·158	−·175	+·017
40th	+·104	−·094	+·009	+·155	+·048	+·063	+·063
41st	−·103	+·065	−·059	−·091	−·057	+·106	+·015
42nd	+·130	+·110	+·159	+·207	+·271	−·062	+·151
43rd	−·036	+·016	+·113	−·072	−·096	+·033	−·002
44th	−·151	−·012	+·146	−·074	+·162	+·012	+·009
45th	+·037	−·259	−·088	+·023	+·044	−·108	−·097
46th	−·161	−·279	−·136	−·183	−·181	−·040	−·229
47th	−·487	−·288	−·251	−·517	−·286	−·346	−·142
48th	−·147	−·529	−·096	−·211	−·047	−·266	+·080
49th	−·091	−·212	−·410	−·026	−·110	−·109	−·076
50th	+·100	+·050	−·093	+·094	−·279	−·046	+·232
51st	+·113	−·224	+·134	+·120	−·074	−·248	−·216
52nd	−·002	−·103	−·034	−·059	−·309	+·016	+·021
Mean of coefficients for 26 weeks (first 13 and last 13 of year)	−·043	−·148	−·096	−·045	−·092	−·123	−·042
Mean of coefficients for 52 weeks	+·006	—	—	+·006	−·083	—	+·005

Weekly mortality from bronchitis and temperature—mean and mean minimum.

The correlation coefficients between the number of deaths in each week from bronchitis in children under five years of age in London, and the mean and mean minimum temperatures of the corresponding weeks are negative in about 42 out of 52, or 80 per cent., of the weeks in the year. The means of the coefficients for the 52 weeks are only − 0·127 and − 0·115, respectively, so that a significant inverse relationship between the mortality and the temperature is not evident generally in the weeks throughout the year. The correlation coefficients for a number of the weeks at the beginning and at the end of the year, the colder weeks, are, however, of sufficient magnitude to be

regarded as statistically significant and to indicate an inverse association between the mortality and temperature. The coefficients between the number of fatal cases in each week and the mean temperature of the preceding week and of the week before that show that the mortality is more highly correlated with the temperature of the previous week, than with the temperature of the corresponding week or that of two weeks before. The majority of the coefficients are statistically significant and the mean for the 26 weeks is − 0·327. For the mortality and the temperature of two weeks before, the mean of the coefficients is − 0·263, while that of the coefficients between the weekly mortality and the temperature of the corresponding week is, as has been mentioned, − 0·218.

An attempt was made to obtain evidence of the influence of the sudden or less prolonged changes of temperature on the mortality from bronchitis in children by correlating the number of weekly deaths from this disease in children in London with the differences in temperature in preceding weeks and with other temperature deviations, but the values obtained did not show an appreciably closer relationship between the mortality from bronchitis and such deviations of temperature than was found between the mortality and the mean temperature of the corresponding weeks.

It is probable that some relationship, determinable by correlation, may exist between the number of deaths from bronchitis in weekly or monthly periods and the aggregated or accumulated temperature below a certain critical temperature in the same or some antecedent period of a similar duration. Absence of all information at the present time, however, as to the temperature level which may be regarded as critical for the respective diseases and the amount of work that would be necessary to determine it by trial, preclude this method of investigation.

Weekly mortality from pneumonia and temperature—mean and mean minimum.

The coefficients of correlation between the weekly mortality from pneumonia and the mean and mean minimum temperatures of the corresponding weeks throughout the year do not show such a high proportion of negative sign as is found for bronchitis. For both temperatures—mean and the mean minimum—the negative coefficients are about equal in number to the positive coefficients and the means for the two series of 52 are identical and practically zero, viz. + 0·006. For the 26 colder weeks, the mean values of the coefficients are − 0·043 and − 0·045. There is thus no evidence that, in general throughout the year, the mortality from pneumonia in any week is related to the mean or the mean minimum temperature of the corresponding week. On correlating the number of weekly deaths from pneumonia with the mean temperatures of each of the two preceding weeks for the same period of the year, there is no evidence that the mortality from pneumonia is more closely related to

the mean temperature of the preceding week than to the temperature of the same week or to the temperature of two weeks before.

With reference to this result, it is interesting to note that Dr Greenwood[1] obtained definitely significant correlation coefficients on correlating the death-rate per million from *all forms of pneumonia* in each of the first twelve and last twelve weeks of the year respectively, for a series of 40 years, 1850–1889, in London, with the mean temperature of the immediately preceding week. The coefficients for the weeks in the first quarter and last quarter of the year were − 0·371 and − 0·458 respectively. The relatively high magnitude of these values apparently depends, in large measure, on the inclusion in the mortality data of deaths of old people who succumb readily to the pneumonia which is predisposed to by the fall in temperature of the previous week.

Weekly mortality from respiratory diseases and mean temperature.

The correlation coefficients between the weekly deaths from the two respiratory diseases, bronchitis and pneumonia summed together, and the mean temperatures of the corresponding and the preceding week are shown in Table XII. The weekly mortality is apparently more closely related to the temperature of the preceding week than to the temperature of the corresponding week. The mean values of the two series of correlation coefficients are practically identical with those found for bronchitis and mean temperature and are apparently determined, in large measure, by the preponderance of the component figures for bronchitis over those for pneumonia in the combined totals.

Weekly mortality from bronchitis and pneumonia and relative humidity.

Of the series of 52 correlation coefficients between the weekly mortality from bronchitis and the relative humidity in the same week, 45 are positive and the mean is + 0·175, while the mean of the coefficients for the 26 colder weeks is + 0·126. Though there would appear to be, in the coefficients for a few of the weeks, some indication of the existence of a tendency towards a direct association between the mortality from bronchitis and the degree of relative humidity, the reverse of what has been found for bronchitis and mean temperature, there is no evidence of a tendency to such a relationship between the mortality from bronchitis and the relative humidities of either the corresponding or the preceding week in the weeks generally.

In contrast to what is found for bronchitis the majority of the correlation coefficients between the number of weekly deaths from pneumonia in children and the relative humidity in the corresponding week are negative. The mean of the coefficients found for the first thirteen and last thirteen colder weeks of the year is − 0·092, while the mean of the coefficients between the mortality from pneumonia and the temperature of the preceding week for the same

[1] Greenwood, M. Report on the Pandemic of Influenza, 1918–19, Chap. VII, p. 162. The Relation between Meteorological conditions and the Death-rate from Respiratory Diseases with particular reference to Influenza. *Ministry of Health Reports*, No. 4.

period of the year is only − 0·123. There is thus no evidence that, throughout the period of the year investigated, any definite relationship exists between the weekly mortality from pneumonia and the recorded relative humidity of the corresponding or preceding week.

Weekly mortality from bronchitis and pneumonia and mean rainfall.

The coefficients of correlation between the weekly mortality from bronchitis and pneumonia, respectively, in London children and the rainfall in the corresponding week show no evidence that the mortality from either disease is related to the average weekly amount of rainfall.

Mortality from bronchitis and pneumonia in registration counties of England and Wales, and mean annual temperature.

Fortunately it has been possible to investigate the influence of the meteorological factors, temperature and rainfall, on the mortality from bronchitis and pneumonia in children under five years using other data than those described for the cities. These comprised the death-rates from bronchitis, pneumonia and respiratory diseases—the two combined—in the 55 registration counties of England and Wales for the period 1901–10, as recorded in the decennial supplement to the report of the Registrar-General of England, and the corresponding particulars for respiratory diseases in the 42 counties of England in the decade 1891–1900; the Welsh counties not being given separately for this period.

The average annual rainfall for each several county has been estimated by superimposing the outlines of the areas with different amounts of rainfall as shown on the map of the British Isles prepared by Dr H. R. Mill, Director of the British Rainfall Organisation, on another map of large size showing the boundaries of the counties. From the latter map it has been possible by the aid of the planimeter to obtain the area of each county, the areas therein with different amounts of average annual rainfall and from these to calculate the average annual fall of the county. The figures for mean annual temperature for the respective counties have been obtained by a similar method from a map prepared by Prof. A. J. Herbertson, published in Bartholomew's Meteorological Atlas. In this map the actual temperature in different places is shown and not, as is usual, the temperature reduced to sea level. It will be readily understood that the mean actual temperature calculated for a complete county from these different values, can only be accepted as a fair criterion of the climate to which the majority of the children therein are subject if these are more or less evenly distributed throughout the county as is the case in many counties of England and Wales.

The coefficients of correlation found between the mortality from bronchitis and pneumonia, respectively, and mean annual temperature in the registration counties are shown in Table XIV. It is seen that the coefficients between mean temperature and (1) bronchitis, (2) pneumonia, (3) bronchitis

Table XIV.

Showing the correlation coefficients between the death-rates from bronchitis, pneumonia, and respiratory diseases, respectively, in childen under five years of age in the registration counties of England and Wales in the decades 1901–10, *and* 1891–1900 *and the mean annual temperature and mean annual rainfall.*

Variables	Correlation coefficient r
Death-rate from:	
bronchitis in 55 counties of England and Wales and mean annual temperature (1901–10)...	$-\cdot314\pm\cdot082$
pneumonia " " " " " ...	$-\cdot240\pm\cdot086$
respiratory diseases in 55 counties of England and Wales and mean annual temperature (1901–10)	$-\cdot280\pm\cdot084$
respiratory diseases in 42 counties of England and mean annual temperature (1891–1900)	$-\cdot350\pm\cdot091$
bronchitis in 55 counties of England and Wales and mean annual rainfall (1901–10) ...	$-\cdot120\pm\cdot090$
pneumonia " " " " ...	$+\cdot150\pm\cdot089$
respiratory diseases in 55 counties of England and Wales and mean annual rainfall (1901–10)	$+\cdot051\pm\cdot091$
respiratory diseases in 42 counties of England and mean rainfall (1891–1900)	$+\cdot065\pm\cdot104$
bronchitis in 55 counties of England and Wales and percentage of county urban (1901–10)	$+\cdot570\pm\cdot061$
pneumonia " " " "	$+\cdot600\pm\cdot058$
respiratory diseases in 55 counties of England and Wales and percentage of county urban (1901–10)	$+\cdot627\pm\cdot055$
respiratory diseases in 42 counties of England and percentage of county urban (1891–1900)	$+\cdot653\pm\cdot060$
Mean actual temperature in:	
55 counties of England and Wales and percentage of county urban (1901–10)	$+\cdot119\pm\cdot090$
42 " " " " (1891–1900)	$-\cdot153\pm\cdot102$
Death-rate from:	
bronchitis in 55 counties of England and Wales and mean annual temperature with percentage of county urban constant (1901–10)	$-\cdot468\pm\cdot071$
pneumonia in 55 counties of England and Wales and mean annual temperature with percentage of county urban constant (1901–10)	$-\cdot392\pm\cdot077$
respiratory diseases in 55 counties of England and Wales and mean annual temperature with percentage of county urban constant (1901–10)	$-\cdot459\pm\cdot072$
respiratory diseases in 42 counties of England and mean annual temperature with percentage of county urban constant (1891–1900)	$-\cdot334\pm\cdot092$

and pneumonia together or respiratory diseases for the period 1901–10 and (4) respiratory diseases for the period 1891–1900, respectively, are all negative. They are all approximately of the value $-0{\cdot}3$ and three, at least, appear to satisfy the criterion of statistical significance, the fourth and smallest—that between pneumonia and temperature—being not quite but approximately three times its probable error. These values would seem to indicate that there is an inverse relationship between the mortality from the diseases in the registration counties and their mean actual temperature. It is well known, however, that the amount of respiratory disease is influenced by the presence or absence of urban or industrial conditions and so variations in regard to these in the different counties might account, in some degree, for the apparent relationship found. In the supplement to the Registrar-General's report for 1901–10 there is given, however, for each registration county, the proportion of the county which is urban, taking London as 100. The correlation coefficients found between the mortality in the different counties from bronchitis, pneumonia and respiratory diseases, respectively, and the proportion of the county urban, were determined and were found to be approximately $+0{\cdot}6$.

As the proportion of the county urban may be regarded as a very rough index of the intensity of industrial conditions therein, it has been possible, by the method of partial correlation, to determine the relationship between the mortality from the respiratory diseases and the mean annual temperature, some allowance having been made for environmental conditions. The partial correlation coefficients that result are still statistically significant and being negative indicate that there is a real inverse association between the mean annual temperature and the death-rates from the diseases, the higher mortality being found in the colder counties.

Mortality from bronchitis and pneumonia in registration counties and rainfall.

The correlation coefficients between the death-rates from bronchitis, pneumonia and respiratory diseases, respectively, in the registration counties and the corresponding rainfall are quite insignificant showing that there is no apparent relationship between the mortality from these diseases and the amount of rain that falls; thus confirming the conclusions that have been drawn from the results from the monthly and weekly data in the several towns investigated.

Summary and Conclusions.

In the preceding pages, an analysis has been made of the correlation coefficients found between the number of fatal cases from bronchitis, pneumonia and respiratory diseases, or the two summed together, in children under five years of age in London, Glasgow, Edinburgh, Aberdeen and Dundee, and the meteorological factors, mean and mean minimum temperature, mean relative humidity and mean rainfall, for a period of from 40 to 50 years; and between the death-rates from bronchitis, pneumonia and respiratory diseases amongst children at the same period of life in the registration counties of England and Wales in the decennia, 1901–10 and 1891–1900, and their mean annual temperature and mean annual rainfall and it seems warrantable to draw the following conclusions.

1. The meteorological factor, amongst those investigated, that seems to exercise the greatest influence in predisposing to an increased mortality from, and presumably an increased incidence of, bronchitis in children in the cities, is the prevailing temperature. In accordance with the average duration of the disease, the mortality is most intimately related to the mean temperature of the preceding week and is, on the average, as closely related to the temperature of two weeks before as it is to that of the corresponding week. The relationship is inverse, the lower the mean temperature the greater the fatality from bronchitis. As suggested by Dr Leonard Hill, the cold weather probably compels children to remain indoors in stuffy, overheated rooms where infection is intensified and health weakened by heat stagnation, a lowered metabolism and want of sunlight.

2. While there is a suggestion from some of the correlation coefficients found, that pneumonia in children may have some inverse relationship to mean temperature this association is not shown in the monthly or weekly data generally.

3. There is a definite inverse relationship between the mortality from the respiratory diseases, or bronchitis and pneumonia summed together, and the mean temperature; and, as occurs with bronchitis, the relationship to the mean temperature of the preceding week is closer than to that of the corresponding week.

4. The mortalities from bronchitis, pneumonia and respiratory diseases (bronchitis and pneumonia summed together), in children under five years in the registration counties of England and Wales, are inversely associated with the mean annual temperature in the corresponding counties. This association still persists after allowance is made for the proportion of each county which is urban, a proportion which has been taken as a rough index of industrial conditions therein.

5. The mortalities from bronchitis and pneumonia in children in the cities examined and in the registration counties are not influenced in any consistent manner or degree by the amount of rainfall.

6. While the coefficients of correlation between the corrected monthly deaths from bronchitis and respiratory diseases, respectively, and the corresponding mean monthly humidity in Glasgow seem to suggest the existence of a significant direct association between these variables, viz. the moister the atmosphere, the higher the death-rate from bronchitis; such a relationship is not definitely indicated in the coefficients found for the other cities. The magnitude of the coefficients for Glasgow is apparently determined, in some degree, by the periodicity in the mortality figures. It is probable, however, that the periodicity is not wholly responsible for the correlation found as the correlation coefficients between the mean temperature and the deviations in the same monthly data from the five-yearly moving average—the method adopted to eliminate the effect of the periodicity—are not very different from those found by using the actual figures. There would appear to be some evidence for the view that a high relative humidity, when associated with a low temperature, has some influence in predisposing to an increased mortality from the respiratory diseases.

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