THE EFFECT OF WEATHER ON WINTER EPIDEMICS

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EVERY winter the incidence of acute respiratory diseases increases, and it is reasonable to suppose that the weather conditions experienced at this time of the year play an important part in the onset and course of an epidemic of respiratory disease. Although several studies have been made into the effects of air pollution, relatively little work seems to have been carried out into the possible association between the less dramatic aspects of our weather and the incidence of respiratory illness.

One reason for this is that none of the existing sources of morbidity data gives a complete picture of the incidence of respiratory disease in a community, even though they reflect the presence of abnormally high or low values. Hospital records refer to cases only of serious respiratory diseases; and notifications of pneumonia are known to be incomplete. National insurance claims refer to all diseases, and even if those referable to people with respiratory diseases were separately available, they would include only those suffered by the insured population. Even records kept by general practitioners will not cover all cases with respiratory illnesses in a community, although they will include patients of all ages and covering the whole range of severity.

However, two important studies have been made in recent years. Hope Simpson (1958) examined the morbidity from colds during 1955 in a group of families in a country general practice in relation to seasonal temperature on a monthly basis. He found a close correspondence between the morbidity and the inversion of the earth temperature, and concluded that it seemed unlikely that the drop in temperature itself directly caused the increase of morbidity and thought it more likely that because of cold weather people tend to spend more time indoors where the air is dry due to artificial heating. He therefore compared graphically, again on a monthly basis, the morbidity from colds and the difference between relative humidity outdoors and indoors and found a close correspondence.

Holland, Spicer and Wilson (1961) analysed patients with respiratory disease admitted through the London Emergency Bed Service during 1955-

58. Again, the unit of time used was the calendar month and they carried out a partial regression analysis, testing the monthly level of admissions against atmospheric pollution, mean daily temperature, mean absolute humidity, total rainfall, mean daily barometric pressure and total sunshine hours. They found statistically significant associations between admission rates for adults and mean daily temperature and atmospheric pollution.

Material and Methods

Information about two of the variables mentioned above is available for the Birmingham area and, in view of the findings of these two studies, it seemed worthwhile examining these data in relation to weather conditions. Over the last five years, the daily number of admissions of patients with respiratory diseases through the Birmingham Bed Bureau has been obtained. The Bed Bureau directs patients to all acute hospitals in Birmingham and although not all emergency admissions take place through the Bureau the extent to which the Bureau is used certainly reflects the overall demand for admission. It has been proved that during the winter months when admissions from the Bureau increase there is no compensatory decrease of emergency admissions direct from general practitioners. The daily number of admissions is, of course, subject to considerable variation, depending upon many irrelevant factors and weekly figures have been obtained to give a more meaningful idea of the trend. Secondly, the Ministry of National Insurance provides the numbers of sickness insurance claims at each of its offices in Birmingham each week, so that it is possible to obtain the weekly number of claims for Birmingham as a whole.

It is first interesting to compare the trends in these two weekly indices over each of the last five winters from the beginning of November up to the end of March (Fig. 1). The scales have been chosen so that the means over the whole period are equalized and equal proportionate changes appear as the same magnitude. A close correspondence between the two graphs is evident for each winter and particularly for the three winters where the outbreak of respiratory illnesses may be described as explosive. It is also interesting that when increases occur the Bed Bureau graph slightly precedes the sickness claims graph.

The contours for the three winters 1958-59, 1960-61 and 1961-62 are very similar, although for the first of these winters the increasing trend started two or three weeks later than in the other two winters. The winter of 1959-60 was remarkable in view of the absence of any abnormally high values on either index, although both distributions are bimodal in 1960. During the winter which has just passed there was no dramatic

FIG. 1.—Weekly number of (1) respiratory cases (---) admitted through the Birmingham Bed Bureau, (2) new claims (—) for sickness benefit over the last five winters.

increase as in the other years; but in the case of Bed Bureau admissions a series of four peaks superimposed upon a general increasing trend from the middle of November is evident, and a pronounced peak occurred in the distribution of sickness claims during the first week of 1963.

Having examined the pattern disclosed by these two indices, it was decided to choose the distributions of Bed Bureau admissions for investigating the possible correlation of the incidence of acute respiratory disease with climatic conditions. The fact that weekly figures of sickness claims refer to all illnesses and to the insured population only were the principal reasons for this choice, although there are, of course, the drawbacks mentioned earlier to using the Bed Bureau figures.

At this point it is interesting to compare the cumulative weekly Bed Bureau demand for admission of patients with respiratory diseases in each of the last four winters (Fig. 2). The build-up of admissions over the whole 22 weeks during the second and third winters run very similar courses, and the cumulative values at 22 weeks are identical. In the 1959-60 winter the cumulative frequency for the fifth week is the same as for the other two winters, but then the curve falls far short of the other two. Finally, over the first eight weeks of the 1962-63 winter the curve corresponds closely with those for the winters of 1960-61 and 1961-62, but then the curve falls short until the fifteenth week when it crosses the other two and the final cumulative value is the maximum of the four winters.

The Birmingham Observatory publish a weekly return giving *inter alia* the mean temperature, relative humidities at 6 a.m., 12 noon and 6 p.m., absolute humidity, rainfall and hours of sunshine each day. All the requisite data were available for the last four winters and in the graphs that follow appropriate scales have been chosen so that equal proportional changes of the two variables being compared are equally represented. On these charts the week prior to the first increase in admissions through the Bed Bureau has been fixed for all winters on the same vertical axis regardless as to the actual weeks concerned.

FIG. 2.—Cumulative frequency chart for winter period (November to March inclusive). Bed Bureau respiratory cases. Four years' comparison.

Results of Comparison of Weekly Variations in Bed Bureau Admissions and Weather Conditions

The first study that was made was for a possible relationship between the mean weekly temperature and weekly Bed Bureau admissions of patients with respiratory diseases (see Fig. 3). By examining the two graphs for the four winters in this way

FIG. 3.—Weekly Bed Bureau (---) respiratory cases compared with temperature (—).

FIG. 4.—Weekly Bed Bureau respiratory cases compared with absolute humidity at noon.

one hoped to detect a pronounced difference between the pattern of temperature variation in the first winter from that in the second and third, and a similarity between the second and third winters in this respect. In fact in all four winters the mean weekly temperature hovered just around 40°F, during the first two weeks of the epidemic. In the first two and the last winters the mean weekly temperature then fell to about 35°F. However, in the second of these three winters only did the demand on the Bed Bureau increase dramatically, and for this winter (1960-61) the temperature curve flattened out at around 37-38°F.

Thus the contours of the temperature graphs for the first two winters are similar with a striking difference in the Bed Bureau curves; and there is a remarkable similarity between the Bed Bureau curves for the second and third winters with dramatic difference in the temperature graphs—in the third winter there is a pronounced fall in temperature corresponding to the peak of the Bed Bureau distribution.

Finally in the fourth winter the Bed Bureau demand is spread out over several weeks and this corresponds to the prolonged period of very cold weather. In fact the mean weekly temperature was below 40°F. for ten weeks, and the first week of December 1962 was notable for the abnormally high level of air pollution which may account for the first mode in the Bed Bureau distribution.

We now consider the variation of absolute humidity in relation to the variation in weekly admissions of respiratory cases through the Bed Bureau. Humidity is, of course, correlated with temperature so that there is a rough similarity between the graphs on the next chart (Fig. 4) and the temperature graphs. Again the scales have been chosen to show equal proportional changes of the two variables by equal movements. First, comparing the second and third winters, for which the Bed Bureau curves are similar, there is no similarity between the humidity graphs. The variation in humidity is more pronounced for the first winter than the second. In the third winter the absolute humidity drops from about 7.0 to 4.0 gm./cu.metre at the same time as the Bed Bureau curve increases. The humidity at the beginning of the fourth winter is relatively high and at the beginning of the first increase in the Bed Bureau graph, it drops to 5.3. While the very cold weather persisted the humidity remained around 4.0 and the Bed Bureau figure at around 150 cases per week.

The weekly variation in mean relative humidity (at 12 noon) has been plotted against the Bed Bureau distribution for each winter on Fig. 5. The deviations of the mean relative humidity

FIG. 5.—Weekly Bed Bureau respiratory cases compared with relative humidity at noon.

at 12 noon each week from the mean relative humidity over the whole 22-week period (approximately 80%) have been plotted, this time using a scale which magnifies the variation in relative humidity to a greater extent than that of the weekly Bed Bureau admissions.

Comparison of the pictures disclosed for the four winters shows that there is some tendency for Bed Bureau admissions to increase as the relative humidity falls, but it is difficult either from these graphs or from the figures themselves to detect any meaningful patterns which are correlated with the distribution of the Bed Bureau demand.

Discussion

This preliminary investigation of the possible associations of Bed Bureau admissions with three meteorological variables can only permit one to conjecture about the part that weather conditions play in determining the level of respiratory disease. Unlike some of the previous attempts at establishing associations, the week has been taken as the unit of time and not the month. The epidemics in the two middle winters considered are so 'explosive' that any averaging over monthly periods would hardly seem likely to throw any light upon any possible circumstances prevailing which would trigger off such a rapid spread of infection. It may well be that it is these very short-term variations which may be propitious to the start of an epidemic.

Even so, if we had combined the weekly results for these four winters we should have almost certainly have concluded that: there is a negative correlation between the Bed Bureau admissions and temperature; and humidity clearly plays some part in that a period of low humidity (usually associated with low temperatures) tends to be associated with high admissions values.

But we have seen that there are certain inconsistencies in such general statements when applied to particular winters.

During the winter of 1959-60 in which there was no evidence of influenza in the community the mean weekly temperature did not fall to freezing point at any time over the whole period. The temperature and the absolute humidity did fall quite sharply on two weeks without any later rise in Bed Bureau admissions. The relative humidity varied as much as in the later winters. There was at least one day of dense fog in each

of three weeks during the first 10 weeks of the period.

In the 1960-61 winter Influenza 'A' was isolated by the Virology department at Little Bromwich Hospital in the middle of December 1960. Prior to this there was a fall in temperature and humidity but these decreases were no greater than those which occurred in the previous winter and less fog was experienced than in the previous winter.

In the winter of 1961-62 the department isolated Influenza 'B' during the last week of 1961. Prior to this the temperature had been falling but only gradually, and the humidity remained high.

The winter of 1962-63 might be described as a 'continental winter' preceded by a week of dense fog. During the period of intense cold there were three peaks to the Bed Bureau graph. Although at about the same times, evidence of Influenza 'A' and Influenza 'C' was reported from the laboratory the unusual distribution of Bed Bureau admissions would seem to arise more from the fact that the intense cold produced cardiac-respiratory failure in the elderly. In fact the very low temperatures were not associated with an unduly high level of minor respiratory illness. This was evident from the graph of sickness claims shown earlier and can also be demonstrated from analysis of returns sent in by general practitioners to the College of G.P.s Records and Statistical Advisory Unit in Birmingham.

This preliminary investigation has underlined the complex nature of the possible associations of weather conditions with the incidence of respiratory disease in a community. It seems that general practitioner records provide the most satisfactory source of data depicting the level of respiratory disease. With data submitted by a representative sample of practitioners in an area it would be possible to examine the weekly incidence of disease in relation to these meteorological variables here considered, and by means of a computer associations can be tested using varying time intervals between the meteorological variable and the onset of disease. Furthermore, it is necessary to examine the possibility that it is not the actual daily or weekly values of temperature and/or humidity which are most closely associated with incidence, but the changes from day to day or from week to week.

REFERENCES

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