EPIDEMIC RESPIRATORY INFECTION IN A RURAL POPULATION WITH SPECIAL REFERENCE TO THE INFLUENZA A EPIDEMICS OF 1933, 1936–7 AND 1943–4

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(With 1 Figure in the Text)

The country district with which this paper deals is a part of Wensleydale in the North Riding of Yorkshire where one of us has been in general Medical Practice for 34 years.

Wensleydale is a broad valley running west and east watered by the River Yore (or Ure) into which flow tributaries from three side dales on the south. There is no considerable town in this area and the 3200 inhabitants live in villages which vary in size from mere hamlets to those housing 300 to 400 inhabitants. There is a number of scattered farms and the height of these and the villages is from 600 to 1000 ft. above sea-level.

Farming, as will be expected, is the chief occupation and the pattern is of the family farm; the farms, almost entirely dairy and sheep farms, are worked mainly by the farmer and his sons with the employment of little hired labour.

A certain number of men finds employment in the quarries and on the roads but, beyond some corn-milling and two dairies and the requisite number of shop-keepers, there are no other commercial undertakings.

There is constant communication with the two small country towns, Hawes and Leyburn, situated at either end of the Dale and just outside the area under consideration.

These are shopping centres and each has a weekly Market, including an Auction Mart for stock.

There are seven village schools in the area, most of them serving a large district, and a Grammar School whose pupils come from far and wide, from both of the small towns and even beyond. As can be imagined this Grammar School, great as its part is in the life of the district, is frequently a prime factor in the spread of infectious disease.

In the winter months especially there is much inter-communication between the villages at dances, whist drives and concerts, much more so lately as the result of increasing motor transport.

There is an excellent motor-bus service, which has been shown on numerous occasions to be responsible for germ transference from passenger to passenger.

The almost total absence of poverty is a marked feature of the district and standards of living and comfort are high.

The data used for this study were obtained from the records of all infectious disease in the area which have been kept by one of us since April 1931. As previously described by Pickles (1939), each case is marked on squared paper by an appropriate symbol in the space corresponding to the day of onset. The area has been divided into eight villages or groups of adjacent villages, each unit having a population of a few hundred persons ranging from 272 to 628, the population figures being those of 1931.

The present study is limited to the period from 1933 onward in which the nature of the influenza epidemics in England is known. This also coincides approximately with the period over which these detailed records have been kept. Prior to this there were in 1924, 1927, 1929 and 1931 what the country doctor would have no hesitation in describing as 'influenza' epidemics, although of these no accurate data were kept.

These years were definitely peak years in England and Wales, least so 1931, when in Wensleydale also the epidemic was of lesser degree.

The year 1922, a peak year in the country at large, for some reason unexplained left Wensleydale almost unscathed.

We are indebted to Dr Percy Stocks of the General Register Office for information as to the country at large gathered from the number of influenza deaths.

During the period these Wensleydale records in chart form have been kept, there was an epidemic in 1933 touching lightly on most of the district, a very large epidemic in 1937, both of these in the early months of the year, and an epidemic in 1943 beginning in November.

The contributor who observed and recorded these epidemics—some of them before the isolation of virus A—would, even on clinical grounds, have no doubt in his mind that he was dealing with true influenza and would say that his experience so exactly accords with the descriptions in the study

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of 'epidemic influenza' (Medical Research Council, 1938) that in his records he has thought fit to name the disease 'influenza' in the years mentioned above and in all others 'febrile catarrh'.

To quote from his Milroy Lectures (1942): 'In the illness of 1940 and similar years, the patients tell us that they have been battling for several days but have had to give in at last. As I have seen it, in true influenza there is great uniformity in the symptoms, the patient is prostrate, there is a short unproductive cough, the tongue is foul and coated, aching in the limbs is intolerable and epistaxis is common. The febrile catarrh of 1940 and other years, I should summarize by saying that the chest symptoms were a great deal more and the general symptoms a great deal less alarming. There were many patients with definite tonsillitis and otitis media. In the whole of the 1937 influenza epidemic there was no instance of either. It would be simple and pleasing if the virus which has been associated with influenza could be proved to be always present in the one and always absent in the other, but this cannot as yet be said to have been demonstrated.'

On 3 November 1943, eight girls in a state of collapse were seen in the sick room at the Grammar School and on this occasion there was no hesitation in making a diagnosis of true influenza, although at the time there was no indication from the weekly records of the presence of epidemic influenza in the country at large.*

These girls had been infected by a schoolmistress who returned on 1 November from a week-end spent in Manchester and were in the main the origin of a brisk epidemic in the Dale.

There was a striking instance of a schoolmistress in 1933 who similarly gave rise to an epidemic of influenza among her schoolchildren and their relatives, and it was quite obvious from the charts that this village suffered slightly in 1937. This and similar instances led to the present investigation.

ANALYSIS OF DATA

The number of cases each month in each of the eight localities was first enumerated. Fig. 1 represents the occurrence of cases diagnosed as respiratory infection for each month over the period dealt with. The broken line, which can be regarded as the upper limit of 'normal' non-epidemic incidence, represents the sum of the mean number of cases each month and 2·58 times the square root of the error variance in an analysis of the variance of the number of cases by month, year, district and their first order interactions for non-epidemic years. It is immediately evident that all or most of the localities show an excess of cases in the four winters 1932–3, 1936–7, 1943–4, 1945–6. These epidemic years correspond to those in which well-studied outbreaks of influenza occurred in the United Kingdom. The first three were influenza A outbreaks (Wilson Smith, Andrewes & Laidlaw (1933); Stuart-Harris, Andrewes & Wilson Smith (1938); Stuart-Harris (1945)); while the most recent was due to influenza virus B (Dudgeon, Stuart-Harris, Glover, Andrewes & Bradley, 1946). No etiological studies were made of the outbreaks in Wensleydale, but if the weighted annual incidence rate is correlated with the peak number of deaths weekly in the great towns (Stuart-Harris, 1945) the coefficient is $+0{\cdot}894$, which is highly significant ($P < 0{\cdot}001$), so there is no reason to doubt that they were part of the major English epidemics and due to the corresponding types of influenza virus. A few sharp outbreaks occurred in one or more communities during other winters, but these have been neglected in defining epidemic and non-epidemic years.

Since influenza and respiratory infections generally are characteristic of the winter months, it was convenient to arrange the yearly incidence according to the year July–June. In this way it is immaterial whether in a given winter a respiratory epidemic occurs in November and December as in 1943 or in January and February as in 1933 and 1937.

On this basis Table 1 was calculated to show the annual incidence rate of recorded respiratory infection in each group of communities for each year. An examination of this table shows that there were rather sharp differences in incidence amongst the eight communities in the epidemic years, and there is the superficially striking relation that the three communities Aysgarth, Carperby and Redmire with the lowest incidence, 1·37, 1·84, 1·14 per 100 population in 1933, had the highest incidence, 17·81, 21·32 and 20·28 per 100 population in the following influenza A epidemic in 1936–7. The particularly high incidence in West Burton (group C) in 1933 was followed, on the other hand, by almost the lowest incidence in 1936–7.

A study was therefore made of correlation coefficients between the rates in each locality in successive pairs of epidemic years. In view of the fact that minor influenza A activity was recorded in England in 1940–1 and that three of the communities showed moderately raised incidence, this year was included in the comparison (Table 2).

It appears therefore that there is a significant negative correlation between the 1933 rates and those for the next influenza A epidemic. In other words, the passage of the first epidemic left a well-marked resistance to the second. In all probability Aysgarth, Carperby and Redmire escaped infection

* Before the end of the year the weekly deaths in the County Boroughs and great towns reached the figure of 1148, i.e. in the week ending 11 December.

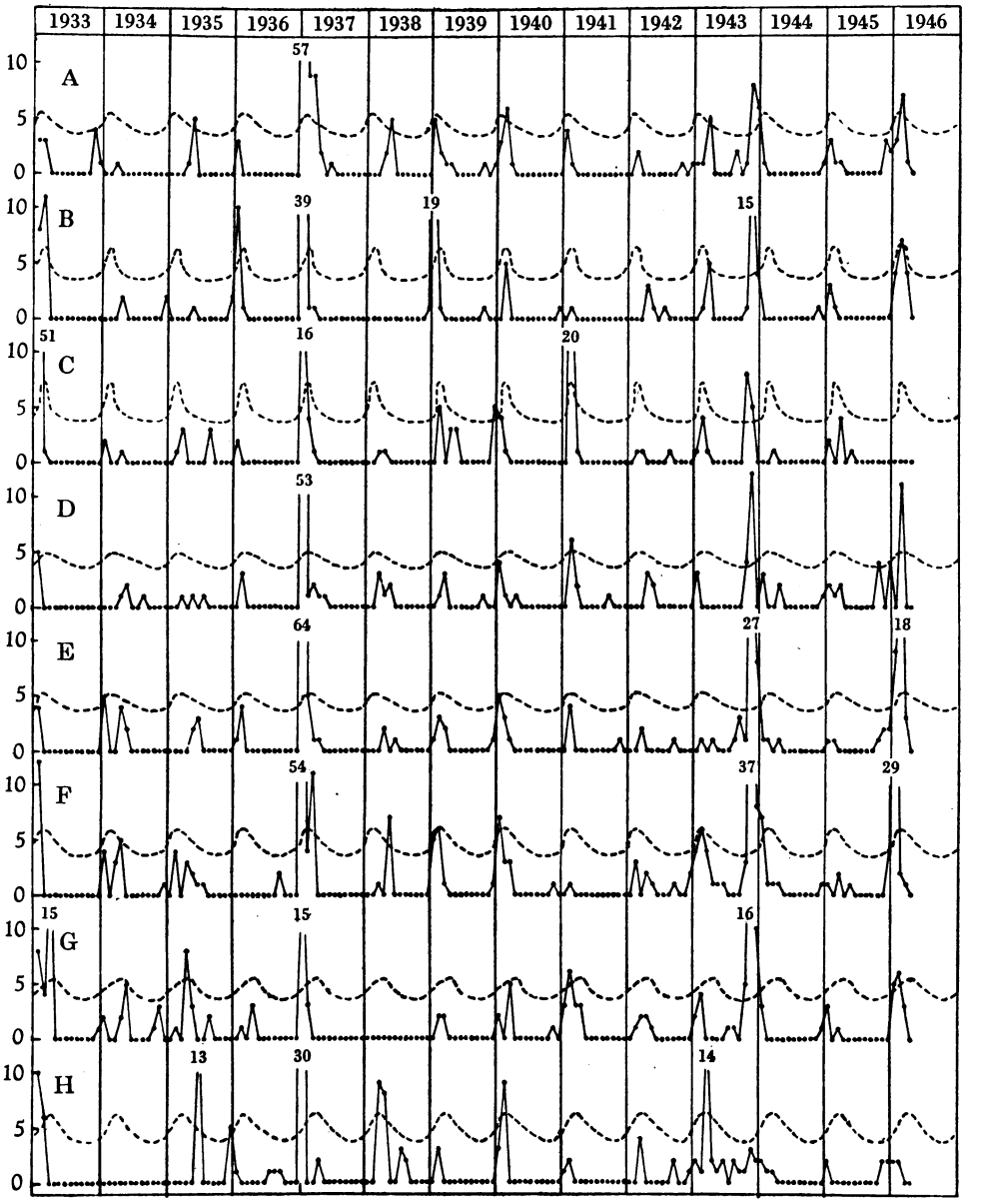

Fig. 1. Incidence of respiratory infection in Wensleydale, Yorkshire, by months, 1933–46. The figures shown represent the actual number of cases recorded in each district. A. Aysgarth, Thornton Rust, Cubeck, population 438; B. Thoralby, Bishopdale, population 298; C. West Burton, Walden, population 367; D. Carperby, Woodhall, Thorseby, population 272; E. Redmire, Castle Bolton, population 350; F. Askrigg, Abbotside, Nappa Scaur, Worton, population 628; G. Bainbridge, Raydaleside, population 500; H. West Witton, Swinithwaite, population 377. For the significance of the dotted line, see text.

in the 1933 epidemic completely and were as a result heavily affected in 1936–7. This seems to provide a strong indication that the resistance of a community against influenza may remain at a significant level for at least 4 years after a widespread epidemic.

If we regard 1940–1 as an epidemic year for influenza A, there are successive negative correlations between the years 1933–6/7, 1936/7–1940/1, 1940/1–1943/4, the latter two, however, being doubtfully significant.

When 1936–7 rates are compared with the next frank A epidemic 1943–4, i.e. 7 years later, there is a probably significant *positive* correlation. Any immunizing effect of the 1936–7 epidemic has disappeared or perhaps been obscured by the occurrence of minor prevalences of influenza A in 1940–1 or at some other time. The positive correlation probably depends on non-immunological factors presumably social in character which determine a higher incidence in some communities than in others.

positive correlation, again suggesting social factors playing similar parts in both epidemics.

It is of interest that when the average annual incidence for each district during non-epidemic years is calculated there is no significant correlation with the incidence in 1943–4 and 1945–6. This may indicate that whatever the social factors which are operative in producing a differential incidence in epidemic years, they do not significantly influence the sporadic incidence of respiratory infection in non-epidemic years.

Table 1. *Yearly attack rates per* 100 *population arranged by districts*

	1933	1933–4	1934–5	1935–6	1936–7	1937–8	1938–9
Aysgarth	1·37	1·37	1·37	0·68	17·81	1·60	2·05
Thoralby	6·38	0·67	1·01	4·36	13·76	—	7·05
West Burton	14·17	0·82	1·09	1·36	5·72	0·54	3·00
Carperby	1·84	1·10	1·10	1·47	21·32	2·21	1·47
Redmire	1·14	3·14	1·43	1·43	20·28	0·86	1·71
Askrigg	2·87	1·91	1·75	0·16	11·31	1·27	1·75
Bainbridge	5·40	2·00	3·20	1·20	3·60	—	0·80
West Witton	4·24	—	3·45	1·59	9·28	4·51	2·12

	1939–40	1940–1	1941–2	1942–3	1943–4	1944–5	1945–6
Aysgarth	2·74	1·14	0·45	2·05	4·11	1·37	3·65
Thoralby	2·01	0·67	1·68	2·35	6·71	1·68	5·03
West Burton	2·72	5·72	0·54	1·91	3·81	1·91	—
Carperby	2·57	2·94	2·21	1·10	7·72	2·21	6·99
Redmire	2·86	1·14	0·86	0·86	12·29	0·57	10·00
Askrigg	2·23	0·32	0·96	3·18	9·24	0·80	5·73
Bainbridge	1·40	3·20	1·20	1·20	7·20	1·00	2·80
West Witton	3·18	0·80	1·06	6·63	3·45	0·53	2·12

Note. Influenza A epidemics occurred in the winters of 1932–3, 1936–7, 1943–4 and influenza B epidemic in 1945–6.

Table 2. *Correlation coefficients between the rates in each locality in the years shown*

	r	P
1933–1936/7	−0·693	$<0·06$
1936/7–1940/1	−0·628	$\approx 0·10$
1940/1–1943/4	−0·311	$>0·10$
1936/7–1943/4	+0·669	$\approx 0·07$
1943/4–1945/6	+0·884	$<0·01$

Table 3. *Incidence of respiratory infection in non-epidemic years*

Aysgarth	1·63	Redmire	1·71
Thoralby	3·16	Askrigg	1·74
West Burton	2·51	Bainbridge	1·95
Carperby	1·95	West Witton	3·38

Correlation coefficients with 1943–4, 0·521, $P>0·10$; with 1945–6, 0·448, $P>0·10$.

Comparison of an A epidemic 1943–4 with a B epidemic 2 years later shows, as one would expect, no evidence of immunization and a highly significant

An examination of Fig. 1 for points not covered in the preceding discussion shows rather marked discrepancies in the behaviour of West Witton, etc. from that of the other districts. We note an isolated epidemic in June 1935, the only summer outbreak in the period covered, and well-defined spring peaks in the non-epidemic years of 1938, 1940 and 1943. The last of these is of particular interest, for it seems to replace the November 1943 peak of the influenza A epidemic. It is more than likely that this outbreak in March 1943 was one of the isolated A outbreaks which have been shown to precede recent major outbreaks.

West Burton, etc. shows two anomalies, a sharp outbreak in February 1941 which is hardly evident in any other district, and an equally distinctive absence of cases in the influenza B epidemic of 1946. It is tempting to think that there is a causal relationship between the two occurrences, but there is little evidence of the existence of influenza B in England at that time.

DISCUSSION

There has been considerable recent discussion on the periodicity of influenza A and B epidemics (Commission, 1946; Stuart-Harris, 1945). The general impression one obtains is that the occurrence of an epidemic is determined: (*a*) by the waning of mass immunity from the previous epidemic to a suitably low level; (*b*) by the existence of virus in the community; and (*c*) by ill-defined social and meteorological conditions necessary to allow the initiation of the epidemic.

These conditions apply to major communities and for most purposes the whole of Western Europe and North America can be regarded as a single community as far as influenza is concerned. It is an interesting confirmation of the extent and uniformity of recent influenza epidemics in the northern hemisphere that each of the major outbreaks is clearly visible in the figures of respiratory infection in a relatively isolated Yorkshire dale.

The only new finding from the present study is the evidence that the level of group immunity in a small community may be sufficiently high 4 years after an epidemic to diminish significantly the incidence of another epidemic of the same type. The failure of an influenza A epidemic to have any influence on an influenza B epidemic 2 years later is what might be expected, but the occurrence may suggest possibilities for the retrospective diagnosis of influenza A and B epidemics when only epidemiological data are available.

SUMMARY

A statistical study has been made of the records of respiratory infection in a portion of Wensleydale, Yorkshire, over the period 1933–46, which included three major English influenza A epidemics and one B epidemic.

Each of these epidemics is recognizable in the Yorkshire records. When the incidence in the eight groups of villages comprising the district is compared there is a significant negative correlation between incidence in 1933 and 1936–7, which is taken as indicating the persistence of group immunity following an influenza A epidemic for 4 years.

There was a significant positive correlation between the incidence of the 1943–4 (A) and 1945–6 (B) epidemics.

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