EPIDEMIOLOGY OF WHOOPING COUGH*
IN A RURAL AREA

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III. HISTORIES OF PREVIOUS ATTACK

IN outlining the method of study, it was observed that at the outset the positive and negative histories of individuals with respect to communicable disease were recorded. As in the case of current attacks, the informant for these histories of past attack in a given family or household was usually the housewife. At the end of the study the histories of each individual were re-checked and it is felt that, particularly for the younger persons, the records are as accurate as it was possible to make them. In the case of whooping cough, positive history data should be more reliable than in the case of diseases such as measles or scarlet fever whose differential diagnosis is more complicated, for the characteristic whoop makes the lay and professional diagnosis of manifest attacks quite simple. The prolonged and sometimes spectacular course is also less likely to be forgotten. It should, however, be borne in mind that this type of information can be no more accurate than the memories of the persons who furnish it.

1. *The Significance of Positive History Data.* The data are important in any study of the epidemiology of whooping cough in part because it is known that a very large proportion of the persons attacked by the disease become immune. Thus of the 280 cases in the present study only thirteen were known to have had a prior attack and in only six was the prior history unknown. For persons under 20 years of age—the group whose histories are considered to be most accurate—the incidence rates are shown in Table 7. The relatively low rate of 2.1 per 1,000 among individuals with positive history indicates a fairly high degree of immunity

or, if it is maintained that the immunity conferred by an attack is absolute, a relatively low error in the recording of histories. After the age of 20 years, the value of a positive history as evidence of immunity seems to decline rapidly with age. Seven out of the sixteen cases with known history in this latter group were recorded as having had a prior attack. Whether this is due to inexact recollection on the part of the informant, to the fact that the immunity conferred by an attack is not lasting, or to a combination of these factors, is uncertain.

Table 7. Incidence of whooping cough in persons under 20 years of age according to history of prior whooping cough attack, Cattaraugus County, 1929-1932.

History of Previous Attack	Rate per 1,000	Cases	Person-Years Observed
TOTAL	45.8	260	5,674
Positive	2.0	6	2,950
Negative	97.0	251	2,587[1]
Unknown	21.9	3	137

[1] Person-years of individuals with negative history who contracted whooping cough during the survey were counted as "negative" only until the period of the attack, after which they were counted as positive.

Whatever may be the limitations of positive history data as indices of the immune status of individuals, they do offer an alternative means for studying the prevalence of manifest whooping cough and for checking results obtained by other methods.

The preliminary gross data on recorded histories of attack in the Cattaraugus survey have been presented by Sydenstricker and Collins.[13] These authors give the percentages of individuals who, at the start of the survey were recorded as having had whooping cough, and compare them with similar urban figures with particular reference to Hagerstown. They show that although these percentages increase with age somewhat less rapidly in Cattaraugus than in the City, they tend to reach approximately the same figure for individuals 20 years of age and over.

When the history data for Cattaraugus were later checked with the informants in each household, there were slight changes and,

[13] Sydenstricker, Edgar and Collins, Selwyn D.: Age Incidence of Communicable Diseases in a Rural Population. *Public Health Reports,* United States Public Health Service, January 16, 1931, xlvi, No. 3, p. 100.

for this reason, as well as to give more detailed figures, the percentages of individuals who at a given age were recorded as having had whooping cough at any time prior to that age are presented again in Table 8.

The manner in which the percentage with positive history of attack at age 20 may be used in checking the observed incidence has been outlined above. A more detailed comparison may be made, as Henderson[14] and Collins[15] have shown, by either differencing the positive history percentages at each age and comparing the resulting figures with the age-specific incidence expressed in per cent, or by cumulating the latter and comparing it with the history percentages age by age. The method of cumulating the observed incidence has been followed in the first column of Table 8 and compared graphically with the curve of positive history percentages in Figure 4. Because the history data center on the stated age, whereas the incidence data center between the given ages, the correspondence between the two is more evident in the graph than in the table. It will be seen that the history figures are in general somewhat below the cumulated incidence, but that they show a fair agreement at the younger and older ages. Discrepancies may be due to one or more of three possibilities: (1) an incidence above the normal for the period of the survey; (2) a recent trend toward a younger age-incidence; and (3) a tendency on the part of the informants to understate the histories at younger ages. In explanation of the differences, under the age of one year, it should be recalled that whooping cough tends to recur in cycles and that infants might be expected to show relatively small proportions with prior history just before an epidemic occurrence. Such differences should, however, not persist for as long a period as the differences between these two sets of figures do.

[14] Henderson, E. C.: A Census of Contagious Diseases. *American Journal of Public Health*, September, 1916, vi, No. 9, p. 971.
[15] Collins, S. D.: Age Incidence of the Common Communicable Diseases of Children. *Public Health Reports,* United States Public Health Service, April 5, 1929, xliv, No. 14, p. 763.

Age	Cumulated Observed Incidence[1]	Per Cent with Positive History	Number with Positive History	Number with Known History
0	7.3	2.0	1[2]	50[2]
1	14.9	8.9	8	90
2	20.6	18.2	18	99
3	28.7	22.8	21	92
4	35.3	29.3	29	99
5	42.6	27.7	33	119
6	47.2	35.9	33	92
7	56.6	52.2	48	92
8	64.4	48.0	49	102
9	67.9	55.9	57	102
10	72.0	65.9	60	91
11	76.1	71.9	64	89
12	77.2	66.3	61	92
13	79.3	76.3	71	93
14	82.5	77.4	65	84
15	⎫	69.7	62	89
16	⎪	80.3	57	71
17	⎬ 83.4	79.6	74	93
18	⎪	85.4	41	48
19	⎭	82.5	52	63
20–24	83.4	79.5[3]	225	283

[1] The cumulated incidence figures are offset slightly to indicate the somewhat different age base for incidence as compared with history data mentioned in the text. The incidence data are for age as of last birthday while the history data are for age as of nearest birthday, and, therefore, six months younger.

[2] Average age three months.

[3] History data tend to show declining percentages at later ages presumably because an early attack is forgotten.

Table 8. Per cent of persons in the surveyed population at specified ages for whom a history of an attack of whooping cough prior to the beginning of the survey was obtained and comparison with cumulated observed incidence per hundred, Cattaraugus County, 1929-1932.
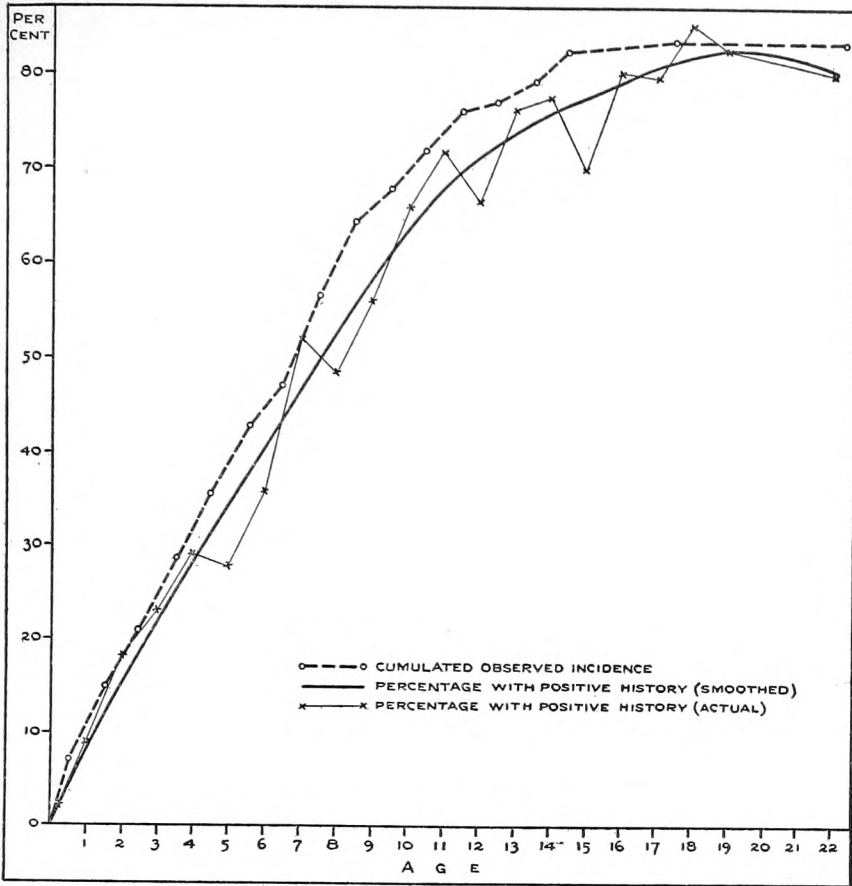
Fig. 4. Comparison of per cent of persons with positive history of whooping cough and cumulated incidence (per hundred) at ages under twenty-five years, Cattaraugus Morbidity Survey, 1929-1932.

It is evident that the history and observed incidence data do not entirely agree and that further information is needed to explain the lack of correspondence. The history data do show, however, certain detailed epidemiological facts which agree with the incidence observations. Thus the older age incidence of Cattaraugus whooping cough in comparison with that in Hagerstown is indicated by the slower rise of the rural history percentages with advancing age, a fact which was, as has been said, pointed out by Sydenstricker and Collins.[16] It was noted above that these differ-

[16] *Loc. cit.*

AGE	VILLAGE POPULATION			FARM POPULATION		
	Per Cent with Positive History	Number with Positive History	Number with Known History	Per Cent with Positive History	Number with Positive History	Number with Known History
ALL AGES	58.8	299	508	54.4	830	1,525
0– 4	14.0	16	114	19.3	61	316
5– 9	43.1	50	116	43.5	170	391
10–14	81.8	90	110	68.1	231	339
15–24	85.1	143	168	76.8	368	479

Table 9. Per cent of persons in the farm and in the village surveyed populations for whom a history of an attack of whooping cough was obtained prior to the beginning of the survey, August, 1929.

ences in age-incidence associated with concentration of population could be demonstrated in the area itself, the farm sections tending to have an older age-incidence than the villages. This same fact may be deduced also from the history data as shown by the slower rise of the "farm" percentages in Table 9 and Figure 5.

A further corroboration of the incidence data is found when the percentages with positive history are obtained by sex, as has been done in Table 10. Here the same slight but fairly consistent differences are noted as in the observed sex-specific incidence rates. Henderson[17] and Collins[18] by similar studies on histories of school children have shown a slight but consistent excess of percentages with prior history in females.

It may be concluded that the history data in Cattaraugus rather closely parallel the observed incidence data. It should be observed, however, that unusual care was exercised in recording and checking the histories of attack. Possibly very advantageous conditions for collecting the information have minimized the errors which others have found in this type of data.[19] Properly carried

[17] *Loc. cit.*

[18] Collins, S. D.: Past Incidence of Certain Communicable Diseases Among Children. *Public Health Reports,* United States Public Health Service, June 27, 1924, xxxix, Part I, p. 1553.

[19] In an article on the control and prevention of whooping cough (*The Medical Officer,* October 20, 1923, p. 181), Sajet and Gelderen note that the information obtained from an *enquete* of school children seemed unreliable.

out, this form of study will be found to give far more useful results than do the official notification figures as ordinarily obtained in this country, and the expense of conducting such a study is, of course, considerably less than that of periodic house-to-house canvass to determine current incidence.

2. *The Significance of Negative History Data.* If the positive history at ages under 20 years may be accepted as an indication of immunity, it cannot be so definitely stated that a negative history is good evidence of susceptibility. Sydenstricker[20] has observed that there appears to be an immunizing factor, aside from an overt attack of whooping cough, which
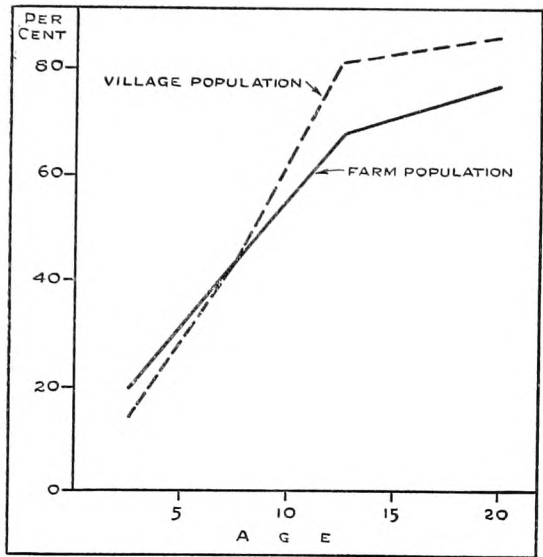

Fig. 5. Per cent of persons in the farm and in the village surveyed populations for whom a history of an attack of whooping cough was obtained prior to the beginning of the survey, August, 1929.

becomes increasingly manifest with increasing age. The evidence for this is found in the fall of the incidence rate for persons without previous history of whooping cough in attacked families in Hagerstown from 90 per cent at early ages to 25 per cent at ages 13 and 14 years.

Stocks[21] has given evidence to suggest that there may be a "temporary latent immunity" in some persons with no history of attack, and he also mentions a possible "inherent immunity" in such individuals, which is, presumably, permanent. The evidence

[20] Sydenstricker, E.: Effect of a Whooping Cough Epidemic Upon the Size of the Non-Immune Group in an Urban Community. Milbank Memorial Fund *Quarterly Bulletin*, October, 1932, x, No. 4, pp. 302-314.

[21] Stocks, Percy: On the Epidemiology of Whooping Cough in London. *Journal of Hygiene*, 1932, xxxii, p. 581.

AGE	MALES			FEMALES		
	Per Cent with Positive History	Number with Positive History	Number with Known History	Per Cent with Positive History	Number with Positive History	Number with Known History
ALL AGES	54.9	595	1,083	55.2	534	950
0–4	17.6	39	222	18.3	38	208
5–9	42.3	115	272	44.7	105	235
10–14	72.1	173	240	70.8	148	209
15–19	75.5	157	208	82.7	129	156
20–24	78.7	111	141	80.3	114	142

Table 10. Per cent of persons of each sex in the surveyed population for whom a history of an attack of whooping cough prior to the beginning of the survey was obtained, August, 1929.

for the temporary immunity is found in variations in the ratio of secondary to total cases in attacked households and in the subsequent incidence of whooping cough in children with no history of prior attack who escape infection when it first occurs in their households.

The use of the term "susceptible" as a designation for those with no history of attack may, therefore, appear ill-advised. However, it should be noted that both the observations of Sydenstricker and those of Stocks were made on children in urban families. The secondary attack rates of the households in Cattaraugus, to be given below, suggest that relatively few of these rural children under 15 years of age in an attacked household escape the disease if they have never before had it. It should also be observed that there is relatively little decline in the attack rates shown in Table 5 until after the fifteenth year. The age incidence of the immunity noted by both these writers would appear, like the age incidence of overt attacks of whooping cough, to be somewhat retarded in Cattaraugus. The convenient term of "susceptible" is, therefore, retained for these children although it is not one which can be generally used.

The proportion of "susceptibles" at the beginning of each of

the six-month periods of the study is known. The variations in this figure for children under the age of fifteen years in the area as a whole as well as in the villages and on the farms are given in Table 11, and shown graphically in Figure 6 together with the total cases occurring in each six-month period. The two largest villages in the area were both attacked within the first year so that the percentages fell quite rapidly in the village population. Outbreaks in the farm population were less extensive, being usually confined to portions of townships, so that the general level of the farm percentages was more uniform.

Although outbreaks of whooping cough were seldom limited by civil boundaries, the proportions of "susceptibles" in smaller subdivisions of the area may be found of interest. Ashford and Ellicottville townships had not, in general, been attacked for several years and showed very similar percentages when the survey began—65 per cent in the farm areas and 55 per cent in the villages. During the outbreaks of the first year these fell in Ashford to 48 and 35 per cent respectively, and in Ellicottville to 50 and 40 per cent. Although Ashford was, in proportion to its population, more severely attacked, it underwent another epidemic before the end of the survey which brought the percentages down still further. Ellicottville, on the other hand, showed slowly rising percentages until, at the end of the study, practically the original

Table 11. Percentages of "susceptibles" under fifteen years of age recorded at six-month intervals in the survey area as well as in the farm and village sections, Cattaraugus County, 1929-1932.

INTERVAL	AREA AS A WHOLE	FARM SECTIONS	VILLAGES
August 1, 1929	56.2	56.2	56.4
February 1, 1930	52.6	52.2	54.2
August 1, 1930	49.6	52.3	38.8
February 1, 1931	50.0	52.4	40.6
August 1, 1931	54.0	56.1	45.8
February 1, 1932	54.2	56.0	47.0
August 1, 1932	50.0[1]	52.0[1]	45.0[1]

[1] Figures at the very end of the study were estimated.

figures were reached. It then experienced another outbreak after the survey was completed.
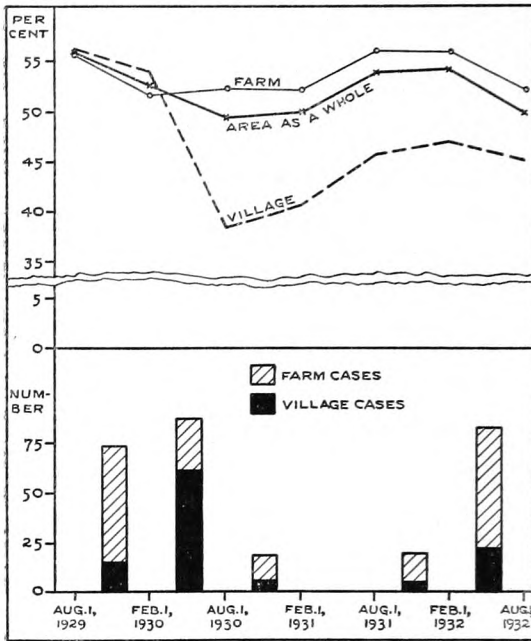
Humphrey, a purely farm township, had been attacked two years before the survey started and showed a "susceptible" percentage of 55—a somewhat lower figure than that of the farm sections of the two foregoing townships. As no cases were recorded here at any time during the study, this area showed steadily rising figures until, at the end, they had reached 65 per cent. Humphrey was attacked again a year after the close of the survey.

Fig. 6. Percentages of "susceptibles" under fifteen years of age recorded at six-month intervals in the survey area as well as in the farm and village sections, and number of cases in each interval, Cattaraugus, 1929-1932.

Great Valley and Mansfield, both largely farm townships, had had several outbreaks a few months before the beginning of the survey and both showed initial percentages of 48. In both there occurred sporadic localized outbreaks, rather more in Mansfield than in Great Valley, so that the terminal figures were 50 per cent and 55 per cent respectively.

The farm areas were seldom able to maintain for long "susceptible" percentages above 60 or 65, and outbreaks would reduce these to 45 or 50 per cent. Village percentages above 50 were seldom maintained and the figures here, following outbreaks, would sometimes fall to 35 per cent. As outbreaks in villages were more likely to be generalized than those in farm sections, a difference

in the level of percentages in the two types of population might be expected. This may be one factor in determining the older age incidence of farm cases.

In the small city of Hagerstown, Sydenstricker[22] observed that the percentages of "susceptibles" fluctuated between 33 and 41 per cent. These figures are evidently still lower than the villages ones quoted above. It is obvious that the prevalence of whooping cough in a community is by no means solely related to the proportion of "susceptibles" in it. Other factors undoubtedly have to be considered, and among these, the possibilities for contact or the relationship of individuals to one another would appear to be of the greatest importance. These will be reviewed, so far as the data permit, in the ensuing section.

[22] *Loc. cit.* The method followed by Sydenstricker in determining the percentages at six-month intervals was to add to the initial figures for "susceptibles" the births in the interval and subtract the cases, deaths, and children reaching the fifteenth year. The same adjustment was made of the present data. Sydenstricker subtracted an additional one-fifth of the cases because that number appeared to have acquired immunity without overt attack. This last step was not taken in the present instance because, as explained above, the factor of immunity without overt attack did not appear in the Cattaraugus data until considerably later than in Hagerstown. The figures are changed only 1 or 2 per cent when this last subtraction is made.

(To be continued)