EPIDEMIOLOGY OF WHOOPING COUGH IN A RURAL AREA[1]

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D URING the last five years, there has been an annual average of 5,500 deaths from whooping cough in the United States Registration Area. It ranks among the outstanding causes of mortality among children in the first two years of life. Nor is death the only unfortunate result of the disease, for each one of the million and a half cases of whooping cough occurring every year in this country entails care and anxiety in the home and a long period of disability for the child. It is thus evident that this disease, although usually regarded as one of the minor afflictions of childhood, offers in reality a serious problem.

Whooping cough is commonly classed among the preventable diseases, but no practical preventive procedures have as yet been devised to check its epidemic prevalence. Much laboratory and epidemiological research must still be done to clarify and add to our knowledge of its modes of spread in communities. There has been a growing appreciation of the need of this type of study, and a number of epidemiological analyses of whooping cough have appeared within recent years, but it must be noted that they are for the most part based upon admittedly incomplete notification of cases in cities. Sydenstricker and Hedrick[2] have shown for

[2] Sydenstricker, Edgar and Hedrick, A. W.: Hagerstown Morbidity Studies, Supplement to Study No. II. Completeness of Reporting of Measles, Whooping Cough and Chicken Pox at Different Ages. *Public Health Reports,* June 28, 1929, 44, No. 26, pp. 1537-1543.

Hagerstown (where physicians contributed practically all of the official case reports) that only half of the cases in 1922-1923 were attended by physicians and that only 16.8 per cent of all the cases were reported. In the rural area which was surveyed in the present study, a similar situation appears. The proportion of recorded whooping cough cases seen by a physician was 44.7 per cent, and only 15.8 per cent of the cases so seen were reported.

In order, therefore, to have reasonably accurate data for the study of whooping cough epidemiology, it is necessary to resort to special methods of collecting case data. Special canvasses and repeated house-to-house surveys over periods of time, supplemented where possible by medical diagnoses, constitute a method first employed in the Hagerstown studies, and these yield fairly accurate information for the broader aspects of the epidemiological study of disease. The present paper is based upon data obtained by this means in a rural population.[3] The data here presented form a part of a morbidity study conducted by the research staffs of the United States Public Health Service and of the Milbank Memorial Fund in a rural section of Cattaraugus County in the western part of New York State. The area selected was made up of five townships totaling 224 square miles, and a population, at the 1930 Federal Census, of 5,500 persons. Of this number, 1,413 lived in three small villages, the largest with only 970 inhabitants. The remainder were distributed about the region on dairy farms or in small crossroad hamlets.

I. METHODS OF STUDY

This morbidity survey, as has been said, was conducted according to the general method employed in the similar study of

[3] A more intensive method of study which included clinical observation of all cases and suspected cases as well as detailed records of all contacts, was used in the investigation of three small local outbreaks. A report has been published upon one of these studies. *See:* Burroughs, Travis P., M.D.: An Epidemiological Study of a Rural Outbreak of Whooping Cough. Milbank Memorial Fund *Quarterly Bulletin,* January, 1932, x, No. 1, pp. 41-52.

Hagerstown, Maryland,[4] the chief difference being that, whereas only a sample of the Hagerstown population was kept under observation, an effort was made in the present survey to visit every household in the area. While there were many special aspects of the work, the technique of the communicable disease inquiry only is of present concern.

Beginning on September 1, 1929, households were visited and complete rosters obtained, with the birth date and communicable disease history of each living member and the date as well as cause of death of family members who had died. Any communicable disease occurring in the home after August 1, 1929, was also recorded on a special form with date of onset, source, duration, and treatment. The morbidity record, therefore, started on August 1st. When all households had been visited, revisiting began and records were kept of changes in the household rosters and of illnesses occurring in the intervals between visits. When individuals or families left the area, the date was noted and new families or individuals entering were added to the group under observation. Visits were spaced at regular intervals of four months when the roads permitted automobile travel, and individuals and families remaining in the area for the entire period were visited usually eight or nine times in the course of the thirty-two months. The staff continued to visit for other purposes after the termination of the study and kept a record of communicable disease that was complete for thirty-six months, or until August 1, 1932.

Special calendars left in the homes made possible a more complete and accurate record of illnesses, but it was found that there was a tendency to forget some of the milder conditions unless these had occurred just before the visit. On the whole, however, this factor did not enter into the recording of the more acute conditions, such as whooping cough. The informant was usually

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[4] Sydenstricker, Edgar: A Study of Illness in a General Population Group. *Public Health Reports*, September 24, 1926, 41, No. 39, p. 2069.

the housewife, and the family statement was accepted as final unless a physician had seen the case, in which event an attempt, usually successful, was made to obtain his diagnosis. Of course, where there was no medical attendance it was necessary to take the family's statement. While such a statement might be unreliable for the accurate identification of many ailments, it is felt that the diagnosis is sufficiently exact in overt cases of whooping cough. Thus practically none of the cases had so short a duration as to suggest that it may have been croup mistakenly diagnosed as whooping cough.

The chief problem presented by this type of recording in the case of pertussis would seem to be the extent to which the milder cases or *formes frustes* without the characteristic whoop were included. As an accurate diagnosis of these cases rests largely upon cough-plate studies, which could hardly have been incorporated in studies of this type, this question cannot be satisfactorily answered. However, the very high family secondary attack rate recorded among children under fifteen with no previous history of whooping cough suggests that, up to this age at least, these rural cases tend to be overt.

In calculating rates of incidence, the person-years of observation have been employed, rather than the census, for the reason that the population of the area varied to some extent, although not greatly, during the period of the survey. The rates so obtained become mean annual rates for the period. The high rates in epidemic years are thus averaged against the low ones in non-epidemic intervals, and what is obtained is a figure which represents the average annual expectation of morbidity from whooping cough in the population studied, provided the interval time is long enough.

In the following pages it is proposed to present: first, general observations on whooping cough morbidity; second, information obtained from remembered histories of former attack; and,

finally, some observations on the mode of spread of whooping cough in this fairly typical rural area.

II. MORBIDITY IN SURVEYED AREA AS A WHOLE

During the three-year period of the survey, a total of 280 cases of whooping cough were recorded by the method just described. In this group of cases no deaths were observed as a result either of the disease or of its complications. It is, therefore, necessary to confine the present discussion primarily to morbidity. However, the subject of mortality cannot be dismissed without observing that the high figures for whooping cough mortality in the early years of life are more the result of the great prevalence of the disease than of a high risk of death in persons who acquire it. The absence of deaths in this group of cases suggests that the case-fatality rate is, perhaps, lower than the figure of 0.66-0.80 per cent obtained by Wood[5] in rural Pennsylvania.

In this connection it is of interest to note that there were also no deaths observed in the 374 cases of whooping cough recorded in the Hagerstown survey and that only three deaths were recorded in the total of 830 cases of this disease in the survey of the Committee on the Costs of Medical Care.[6] The figure of 0.36 per cent for the case fatality derived from this latter survey is, of course, unsatisfactory because small chance variations in the number of deaths would affect it markedly, but it is in quite close agreement with the case-fatality rate of 0.33 per cent computed by Sydenstricker and Collins[7] from histories of attack and histories of deaths due to whooping cough in the Cattaraugus survey population.

It will be readily appreciated that a disease with so high a gen-

[5] Wood, H. B.: *Journal of Preventive Medicine*, March, 1932, vi, p. 87. The figure of one death to each 125 or 150 cases of whooping cough was obtained by counting only those deaths previously reported as cases.

[6] Personal communication from Selwyn D. Collins. The Costs of Medical Care survey included urban as well as rural populations.

[7] Sydenstricker, Edgar and Collins, S. D.: Age Incidence of Communicable Diseases in a Rural Population. *Public Health Reports*, January 16, 1931, 46, No. 3, p. 100.

eral mortality and so low a case fatality must be exceedingly prevalent.

1. *Mean Annual Incidence in Survey Area.* The total number of person-years of observation for the entire survey period was 14,821 and this, with the total of 280 cases, gave a mean annual rate of 18.9 per 1,000 person-years for the area and period. All but 20 of the cases occurred in individuals less than 20 years of age and for this younger age group, the mean annual rate was 46 per 1,000. It will later be shown that the proportion of persons at age 20 with remembered history of manifest whooping cough attack was about 80 per cent. This figure offers another method of calculating, very approximately, a mean annual rate for the past 20 years for persons under 20 years of age and thus of comparing the incidence observed during the survey with that in years prior thereto. Obviously if 80 per cent have the disease by age 20, the incidence was 4 per cent per year or 40 per 1,000. The method is only approximate because it implies accuracy of remembered history and stability of residence, but it is considered precise enough to indicate that the observed incidence of 46 per 1,000 was only slightly above the normal for the area.

The subject of mean annual rates is dwelt upon at some length because whooping cough, being an epidemic disease, has an exceedingly variable incidence during the shorter intervals of time, and may vary within such wide limits that annual rates, in a relatively small area such as the one at present under consideration, would have very little comparative value. Thus the annual rates for all ages for the three years of the survey were successively, 34.0, 3.8, and 19.7 per 1,000.

2. *Chronology of Cases by Months.* In Table 1, the cases are shown by month and year of onset. It will be seen that outbreaks of the disease occurred very nearly independently of season. Although few cases were recorded as starting in the late winter months of February and March, or in the late summer months

of August and September, it is quite possible that a longer period of study would have shown quite another seasonal distribution.

A more detailed account of the exact location of these outbreaks will be given below; for the present it suffices to note that they were confined to four main periods of preva-lence. The first began, es-sentially, with the begin-ning of the survey and ended in February, 1930; the second began in April, 1930, and ended in August, 1930; the third began in October, 1930, and ended in January,

Table 1. Whooping cough cases by month and year of onset, Cattaraugus County morbidity survey, 1929-1932.

First Year		Second Year		Third Year	
1929		1930		1931	
August	10	August	2	August	—
September	6	September	—	September	1
October	12	October	1	October	1
November	18	November	6	November	—
December	22	December	8	December	5
1930		1931		1932	
January	6	January	2	January	10
February	5	February	—	February	3
March	—	March	—	March	9
April	13	April	—	April	33
May	28	May	—	May	19
June	23	June	—	June	16
July	18	July	—	July	3
TOTAL	161	TOTAL	19	TOTAL	100

1931; and the fourth began in September, 1931, and ended, essentially, at the close of the survey.

3. _Geographic Distribution Within the Survey Area._ The 280 cases occurred in 121 households, variously distributed in four of the five townships comprising the surveyed area. The location of the farm households is shown in Figure 1, and the total number of attacked village homes is given separately. The map also shows roads and highways as well as the location of farm homes and hamlets which were not attacked.

It is evident that some large areas escaped a visitation of whooping cough entirely during the three years, and that other sections were but lightly attacked. When general rates are given for the area and period as a whole, therefore, they are to be construed as measuring incidence in a population rather than as measuring the risk of infection where exposure was universal.

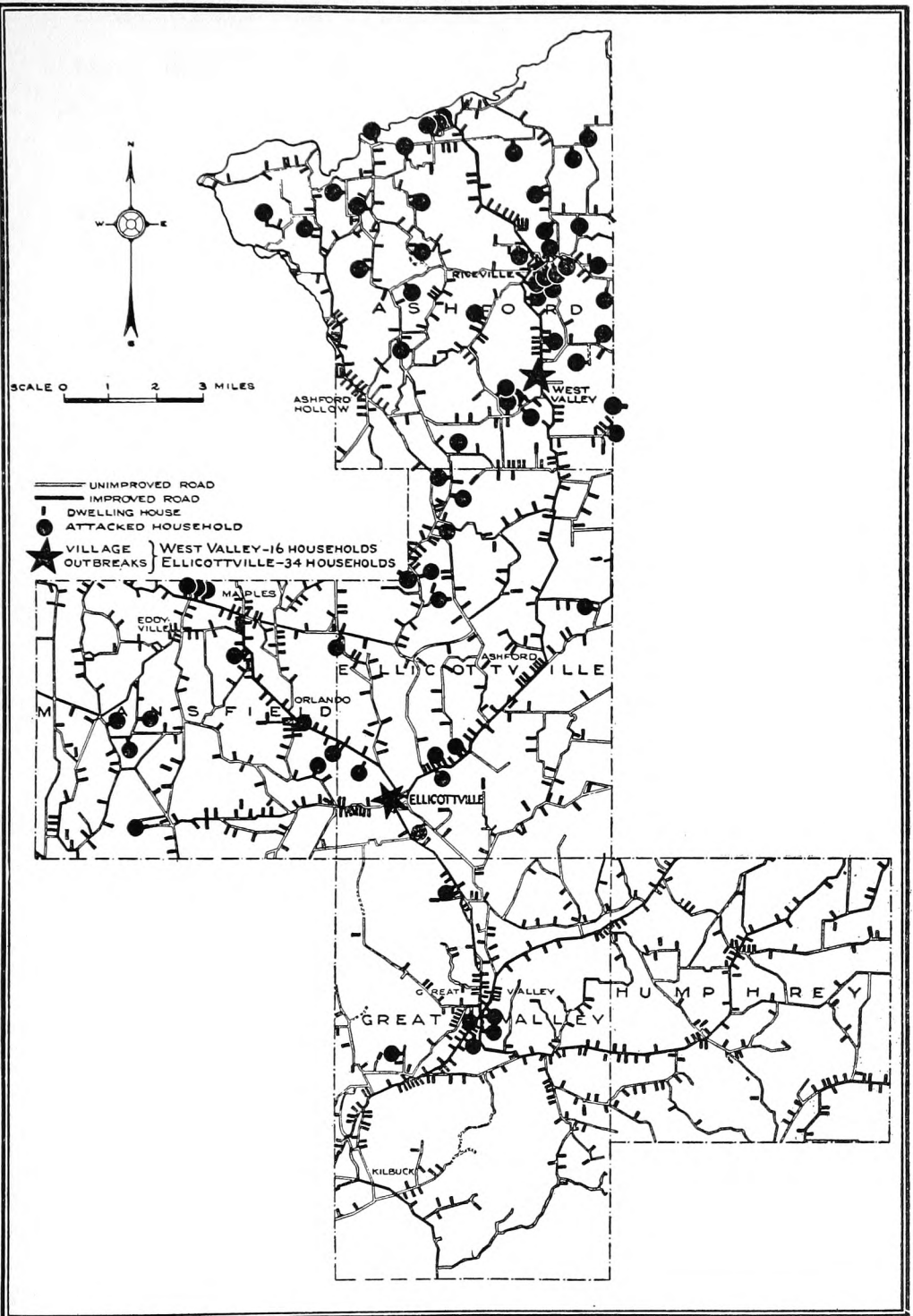Another outstanding fact is that relatively few homes were

Fig. 1. Morbidity survey area, Cattaraugus County, showing highways, unimproved roads, and farm households. The households attacked by whooping cough for the entire period of the survey and the location of village outbreaks are indicated for the entire period of the survey, 1929-1932.

invaded by the disease. Thus in Ashford, which suffered two epidemics of whooping cough and was therefore the most severely attacked section, only 19 per cent of 295 farm and village homes were attacked, although fully 45 per cent of the homes contained one or more children or young adults with no remembered history of whooping cough.[8] In the whole area only 10 per cent of the homes were attacked during the course of the survey.

4. *Age Incidence.* The person-years of observation for the entire survey area and period, the cases of whooping cough and the rates per 1,000 person-years are shown by age in Table 2.

Before discussing the age-specific rates, however, it will be of interest to note certain characteristics of the age distribution of the population

Table 2. Whooping cough case rates at specified ages in a surveyed population, Cattaraugus County morbidity area, 1929-1932.

Age	Rate per 1,000 Person-Years	Cases	Person-Years
ALL AGES	18.9	280	14,821[1]
0	73.1	19	260
1	76.1	22	289
2	57.4	16	279
3	81.4	24	295
4	66.5	21	316
0-4	70.9	102	1,439
5	73.4	24	327
6	46.3	15	324
7	93.5	30	321
8	77.9	24	308
9	34.7	11	317
5-9	65.1	104	1,597
10	41.4	13	314
11	41.1	12	292
12	10.8	3	278
13	20.7	6	290
14	31.5	9	286
10-14	29.4	43	1,460
15-19	9.3	11	1,178
20-24	—	—	984
25-44	4.8	17	3,551
45+	0.6	3	4,569

[1] Includes 43 person-years for which age was unknown.

and of the cases. The population of the area is a typically rural one in that it shows a relatively high proportion of children under the age of 15 years when compared with the population of the State as a whole. When the percentage dis-

[8] The reliability of a negative history of whooping cough as an index of susceptibility in this population will be discussed below.

tribution by age is compared with that of cities, the preponderance of children is much more marked. In spite of the presence of more young children in the population, however, the age distribution of *cases* shows exactly the opposite tendency. Thus only 102, or 36.4 per cent of these cases are less than five years of age whereas in cities a very significantly greater proportion is usually found in this age group. The mean age for this whole series is 9.25 years, but this figure is perhaps unduly influenced by two cases aged 70 and 74 respectively so that the median of 6.92 years for the series perhaps defines more accurately the center of variation. This tendency of whooping cough, as indeed of most of the other acute infectious diseases of childhood, to

Table 3. Relative age incidence of whooping cough in a surveyed population in Cattaraugus County, 1929-1932, contrasted with a surveyed population in Hagerstown, Maryland, 1921-1923.

Age Groups	Ratio of Rate for Each Age to Rate for All Ages[1]	Rate per 1,000 Person-Years	Number of Cases	Person-Years
SURVEYED POPULATION, CATTARAUGUS COUNTY				
ALL AGES		45.8	260	5,674
0- 1	163	74.7	41	549
2- 3	152	69.7	40	574
4- 5	152	70.0	45	643
6- 7	152	69.8	45	645
8- 9	122	56.0	35	625
10-14	64	29.4	43	1,460
15-19	20	9.3	11	1,178
SURVEYED POPULATION, HAGERSTOWN, MARYLAND				
ALL AGES		52.3	365	6,984
0- 1	229	119.6	89	744
2- 3	200	104.4	69	661
4- 5	217	113.7	98	862
6- 7	156	81.5	70	859
8- 9	63	33.1	25	756
10-14	13	7.0	12	1,713
15-19	3	1.4	2	1,389

[1] Total rate for all ages under 20 years = 100.

occur at later ages in country than in city populations has been often noted and is mentioned here simply to add to the meagre data at present available for rural populations.

Fig. 2. Relative age incidence of whooping cough in a surveyed population in Cattaraugus County, 1929-1932, contrasted with a surveyed population in Hagerstown, Maryland, 1921-1923.
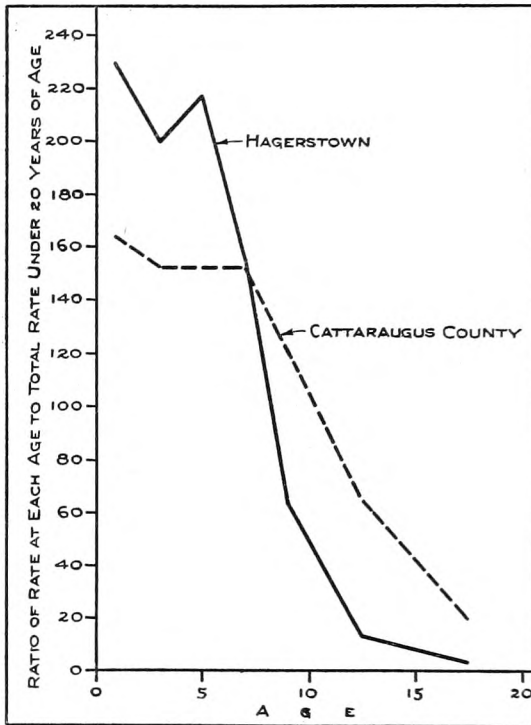
The age-specific rates in Table 2 reveal a relatively lower figure for ages under five years and a less rapid fall thereafter than do city rates. This point can best be illustrated by the comparison with similar figures obtained from Hagerstown, shown in Table 3 and Figure 2. As the prevalence in Hagerstown was considerably greater than in Cattaraugus, owing to the fact that whooping cough occurred throughout the surveyed population in the former, the rates here have been reduced to a comparable basis by taking the ratio of the rate at a given age to the rate for all ages under 20 years.

It can be shown that this same tendency toward an older age distribution of cases in the smaller aggregates of population is found to hold within the surveyed area itself. This appears in the comparison of age-specific rates for village and for farm populations of the Cattaraugus survey in Table 4 and Figure 3. Here again differences in prevalence in the two groups have been

AGE GROUPS	RATIO OF RATE FOR EACH AGE TO RATE FOR ALL AGES[1]	RATE PER 1,000 PERSON-YEARS	NUMBER OF CASES	PERSON-YEARS
		VILLAGE		
ALL AGES		66.1	93	1,407
0- 4	168	111.4	42	377
5- 9	170	112.6	42	373
10-14	34	22.5	8	355
15-19	5	3.3	1	302
		FARM		
ALL AGES		39.1	167	4,267
0- 4	144	56.5	60	1,062
5- 9	129	50.6	62	1,224
10-14	81	31.7	35	1,105
15-19	29	11.4	10	876

[1] Total rate for all ages under 20 years = 100.

Table 4. Relative age incidence of whooping cough in a surveyed village population compared with the incidence in the surveyed farm population, Cattaraugus County, 1929-1932.
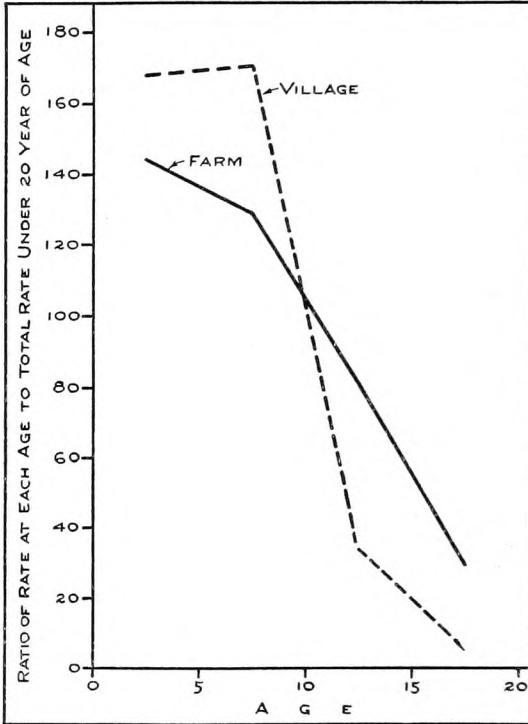
controlled by portraying the ratios of age-specific rates to the rate under 20 years of age.

One general feature of the survey which should be noted here is the attack rate in individuals with no previous history of whooping cough. These rates, by specified ages, are shown in Table 5. Individuals with no history of whooping cough, for the sake of brevity, are called "susceptible," the quotation marks indicating that this term may be subject to some criticism if taken too literally, for reasons to be detailed below. These rates are, again, average annual rates for the area as a whole and do not necessarily indicate the actual risk of infection in any one year. The incidence among "susceptibles" rises rapidly in the first five years of life and maintains a fairly high general level until the fifteenth year, when it drops abruptly.

5. *Sex Incidence in Whooping Cough.* The official mortality registration data of many countries show a somewhat higher whooping cough mortality for females than for males at most

of the ages of life. This excess mortality in females has long been recognized as a peculiarity of the disease and was at first considered to be due to anatomical differences between the two sexes. Of late, however, the tendency has been to find an explanation, at least in part, on the basis of a higher incidence of the disease in females.[9] To such an explanation the figures based upon reported cases give a certain amount of support, but it is possible that a disease which causes death more frequently in one sex may be more frequently attended by physicians when it occurs in that sex and therefore more frequently reported.[10]

Fig. 3. Relative age incidence of whooping cough in the surveyed village population compared with the incidence in the surveyed farm population, Cattaraugus County, 1929-1932.

It is of some interest to note that morbidity surveys show a definitely different sex incidence from the notification data. The first of these, the Hagerstown study,[11] reveals a prevalence that is actually somewhat greater among males at ages under 15 years. These results

[9] A careful discussion of this question of case incidence and mortality in the two sexes will be found in a paper by A. Bradford Hill, entitled, Some Aspects of the Mortality from Whooping Cough, in the *Journal of the Royal Statistical Society*, 1933, xcvi, Part II, p. 250 ff.

[10] In Cattaraugus 48 of the 123 males with whooping cough were medically attended and 66 of 130 females—percentages of 39 and 51 respectively. A total of 27 individuals were unknown as to medical attendance.

[11] Sydenstricker, Edgar: Sex Differences in the Incidence of Certain Diseases at Different Ages. *Public Health Reports*, May 25, 1928, xliii, No. 21, p. 1259.

are confirmed, so far as the children attending school in Hagerstown are concerned, by a separate study of school illnesses which was carried on there over a four-year period.[12]

The sex incidence at various ages for the rural Cattaraugus survey is shown in Table 6. It will be noted that there is a uniformly higher female rate at ages under 44 years but the differences are not significant in this rather small series of cases.

There is another source of information on this subject in the data on remembered history of attack. Manifestly, if females are more frequently attacked by the disease than males, there should be a greater proportion of the former with history of attack unless the excess female mortality is very high, which is known not to be the case. In Table 7 are shown the proportions at ages up to 25 years of

Table 5. Whooping cough case rates at specified ages for a "susceptible" surveyed population, 1929-1932.

Age	Cases per 1,000 "Susceptible" Person-Years	Cases	"Susceptible" Person-Years
ALL AGES	69.6	261[1]	3,752[2]
0	74.8	19	254
1	83.3	22	264
2	72.1	16	222
3	111.1	24	216
4	103.4	21	203
0-4	88.0	102	1,159
5	120.0	24	200
6	81.5	15	184
7	181.2	29	160
8	167.9	22	131
9	81.1	9	111
5-9	126.0	99	786
10	104.8	11	105
11	150.0	12	80
12	45.4	3	66
13	74.6	5	67
14	142.8	9	63
10-14	105.0	40	381
15-24	25.4	10	394
25-44	19.9	10	503
45+	—	—	529

[1] For the cases: 13 with stated previous history and 6 with unknown previous history excluded.
[2] For the population only the person-year period of those with known negative history of whooping cough has been included and that of individuals contracting the disease during the survey until the period of the attack.

males and of females with history of attack at the beginning of

[12] Collins, Selwyn D.: The Health of the School Child. Bulletin No. 200, U. S. Treasury Department, Public Health Service, August, 1931. *See* Table 11, p. 24.

Age	MALE			FEMALE		
	Rate per 1,000	Cases	Person-Years	Rate per 1,000	Cases	Person-Years
ALL AGES	17.6	136	7,727	20.4	144	7,051
0- 4	64.2	48	748	78.1	54	691
5- 9	64.6	53	820	65.6	51	777
10-14	28.1	22	782	31.0	21	678
15-24	4.3	5	1,174	6.1	6	988
25-44	3.3	6	1,816	6.3	11	1,735
45+	0.8	2	2,387	0.5	1	2,182

Table 6. Incidence of whooping cough among males and females at specified ages for the entire surveyed population, 1929-1932.

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	54.0	593	1,098	55.2	533	965
0- 4	16.3	39	239	17.0	38	224
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	78.4	109	139	80.1	113	141

Table 7. Per cent of persons of each sex in the surveyed population who gave a history of an attack of whooping cough prior to the beginning of the survey, August, 1929.

the survey. It is evident that a difference of somewhat the same kind and degree appears here as in the sex-specific morbidity rates.

The present data suggest therefore that in a larger sample there might be a slightly but significantly higher incidence among females in rural Cattaraugus but whether this is due to an actual difference in incidence or whether it indicates that fewer males show manifest attacks is an open question. The differences, for our purposes, would appear to be of a low enough order so that they may be disregarded in the present study.

(To be continued)