THE DECLINE IN THE TUBERCULOSIS DEATH RATE IN CATTARAUGUS COUNTY

by EDGAR SYDENSTRICKER, *Statistician in the United States Public Health Service and Statistical Consultant to the Milbank Memorial Fund*

DURING the past five years a public anti-tuberculosis program has been developed in Cattaraugus County, New York, by the Board of Health of that County, that, according to the judgment of competent critics, embodies and practices modern principles and procedures of tuberculosis prevention, relief and cure.

During the same period and in the same area all five annual death rates from tuberculosis have been lower than the rates as predicted from the experience of the previous twenty-two years. For each of the last three years the tuberculosis death rate has been lower than in any year of its previous recorded history which goes back as far as 1900. Furthermore these three successive low rates constitute an event which has not been paralleled in this area since 1900.

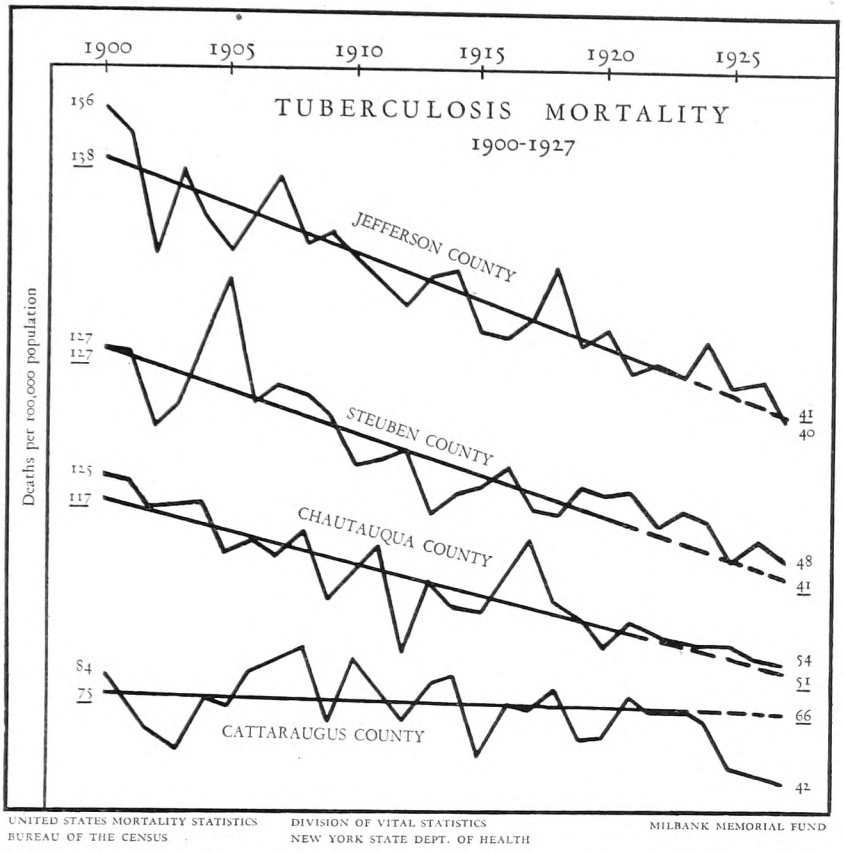
To most persons, especially to those who are conversant with the modern anti-tuberculosis program, this decline will appear as a result due in large measure to the development of an efficient public health administration in Cattaraugus County, more particularly of its anti-tuberculosis work. For, the prolongation of the lives of tuberculous individuals, the prevention of new cases, and the arresting of incipient cases, by modern methods of controlling the disease, are well established facts in the experience of those who are intimately engaged in these activities. But to the coldly scientific mind, accustomed to caution and trained in the habit of doubt, any conclusion as to a causal relationship between

the two series of events should rest on more complete evidence and should be established by more elaborate methods of appraisal. The situation may be likened to that in which the laboratory research worker finds himself. He may be honestly convinced of the soundness of his hypothesis and of the accuracy of his results but at the same time he realizes that his work must stand the test of scientific scrutiny not only for his own intellectual satisfaction but also in order that it may be established in other critical minds.

In a sense, therefore, the tuberculosis experience of Cattaraugus County, as well as that of any area or population group, may be regarded as an "experiment" in that it requires the application of the principles and the methods of scientific experimentation in measuring results of a specific factor especially when that factor has been deliberately introduced in order to bring about a definite result.*

The measurement of the results of anti-tuberculosis efforts, however, is not an easy task. We are accustomed to attempt it in terms of mortality, although we realize, or ought to realize, that a death rate is a poor index of what we are trying to evaluate. It is a faulty statistic for the reason that it may indicate on the one hand the prevalence of the disease, and on the other hand its fatality. It measures neither the one nor the other accurately. Furthermore, the annual number of deaths is so small in an area the size of Cattaraugus County as to be subject to wide variation from fortuitous circumstances. Again, it is a poor measure because the greatest emphasis in an anti-tuberculosis program is on preventing the disease, and on arresting it in those persons in whom the tubercle has been activated; the tuberculosis death rate can therefore measure only a fraction of the full

*Annual Report, Milbank Memorial Fund, 1926, Part II: The Measurement of the Results of Public Health Work.



Deaths from tuberculosis, all forms, in Cattaraugus County and in three other counties in New York State, per 100,000 population, 1900–1927. The straight lines indicate the trend of the death rate based on the period 1900–1922.

force of the campaign. Moreover, in the measurement of anti-tuberculosis efforts we observe the effects of various preventive and curative activities upon a stream of many continuous cases, each of which has its own course over a period of time. From this point of view the measurement of anti-tuberculosis work in adolescent and adult ages should be by different methods from those by which we measure an effort to prevent a definite event, such as a case of diphtheria or a death from measles. For the anti-tuberculosis campaign is not an effort directed toward a single objective; its objectives

MORTALITY *from* TUBERCULOSIS *in* CATTARAUGUS COUNTY

1900-1927

In the following table are given the data upon which the tuberculosis mortality rates for Cattaraugus County for 1900-1927 are based. The deaths of Indians are excluded for the reasons that it is believed that registration of deaths among Indians on the reservation situated in the County has been incomplete and that the Indian population has not been included in the health activities of the County. The Indian population has been deducted in the manner stated in a footnote. Deaths of non-residents in the J. N. Adam Memorial Hospital at Perrysburg, which is primarily an institution for residents of Buffalo, have been excluded, but no other correction for residence of decedents has been made.

Year	Population		Deaths					Death Rate per 100,000
	Total (1)	Exclusive of Indians (2)	Indians (3)	Non-residents (4)	Total Indians and non-residents	Total (5)	Net including Indians and non-residents	
1900	65,645	64,645	3		3	57	54	83.5
1901	65,673	64,673	3		3	49	46	71.1
1902	65,701	64,701	3		3	41	38	58.7
1903	65,729	64,729	3		3	37	34	52.5
1904	65,757	64,757	3		3	50	47	72.6
1905	65,785	64,785	3		3	48	45	69.5
1906	65,813	64,813	3		3	58	55	83.9
1907	65,841	64,841	3		3	61	58	89.4
1908	65,869	64,869	3		3	63	60	92.5
1909	65,897	64,897	3		3	43	40	61.6
1910	66,035	65,035	3		3	61	58	89.2
1911	66,592	65,592	3		3	53	50	76.2
1912	67,148	66,148	3		3	46	43	65.0
1913	67,705	66,705	3	1	4	56	52	77.9
1914	68,262	67,262	3	1	4	59	55	81.8
1915	68,818	67,818	3	2	5	39	34	50.1
1916	69,375	68,375	0	5	5	53	48	70.2
1917	69,932	68,932	3	4	7	54	47	68.2
1918	70,488	69,488	1	3	4	57	53	76.3
1919	71,045	70,045	4	4	8	48	40	57.1
1920	71,546	70,546	4	7	11	52	41	58.1
1921	72,000	71,000	2	4	6	58	52	73.2
1922	72,453	71,453	3	15	18	66	48	67.2
1923	72,907	71,907	3	9	12	61	49	68.1
1924	73,360	72,360	4	14	18	64	46	63.6
1925	73,814	72,814	2	14	16	49	33	45.3
1926	74,267	73,267	5	25	30	62	32	43.7
1927	74,720	73,720	3	25	28	59	31	42.1

(1) Population estimates on following basis: Period 1900-1920, on Federal censuses; 1920-1925, on Federal census of 1920 and State census of 1925.

(2) Assumed deduction of Indian population: 1,000 annually. Census enumeration showed the Indian population to be 1104 in 1900, 1013 in 1910 and 1162 in 1920 (XX Census Volume III: 678).

(3) For period 1900-1915, number of deaths of Indians estimated at 3 annually.

(4) Non-residents dying at the J. N. Adam Memorial Hospital in Perrysburg.

(5) Mortality data from the following sources: Period 1900-1914 from U. S. Mortality Statistics; 1915-1924, from New York State Department of Health; 1925-1927, from Cattaraugus County Department of Health.

Mortality from tuberculosis (all forms) at different ages in Cattaraugus County in 1916-1924 and 1925-1927.
(Indian deaths and non-residents dying at the J. N. Adam Memorial Hospital are excluded.)

Age	Rate per 100,000		Total Number of Deaths		Population Estimated July 1	
	1916-24	1925-27	1916-24	1925-27	1920	1926
All Ages	67.1	43.7	426	96	70546	73267
0— 4	14.5	14.5	9	3	6913	6887
5— 9	15.0	0	9	0	6673	7143
10—19	35.3	12.5	40	5	12577	13342
20—29	129.3	59.0	127	19	10912	10741
30—39	121.1	78.8	110	25	10095	10580
40—49	61.6	66.6	47	18	8478	9005
50—59	65.3	42.1	41	9	6977	7122
60—69	53.4	51.7	23	8	4790	5158
70 & over	67.4	81.1	19	8	3131	3290
Unknown			1	1		

are several, each calling for a different kind of activity. It includes efforts to prevent incipient tuberculosis, to prevent the development of incipient cases into more serious stages; to arrest active cases, and to relieve cases in very advanced stages, and so far as possible to prolong their lives also. Obviously any single measure is inadequate for evaluating precisely the complete results of so varied a program.

In reviewing the experience thus far of Cattaraugus County, therefore, it is essential to keep in mind that the mortality rate for a period as short as three years, or even as five years, can reflect the results of specifically those anti-tuberculosis activities which affect the prolongation of lives of tuberculous individuals. In other words, the tuberculosis mortality rate in so limited a period can measure, and with a fair degree of definiteness, the effect of public health efforts upon the *fatality* of active cases only, rather than the activities that seek to prevent incipient cases or new "active" cases.

With the limitations set before us by these necessary definitions, it is proper to examine the tuberculosis death rates of Cattaraugus County from at least two points of view:

(a) the statistical significance of the decline in the gross rate, and (b) the nature of the decline as indicated by the changes in the rates among persons of different ages. Other analyses of the mortality record will be made later when further experience is available, and the case and morbidity data are now being studied for the purpose of ascertaining more precisely the results of other kinds of anti-tuberculosis activities.

So far as we know, no marked change in the ordinary conditions that affect the tuberculosis death rate, other than those which were generally prevalent and common to similar communities, has occurred in Cattaraugus County in the five years 1923-1927. Provisionally at least, therefore, we are warranted in assuming that the only factor of major importance, so far as possible effects upon the tuberculosis death rate are concerned, was the development of a modern anti-tuberculosis administration during this period.

Now in judging of the statistical significance of the decline in the tuberculosis death rate in Cattaraugus County in 1925-1927, we have so far attempted to answer three questions: (1) Could any of these low rates have been a variation arising solely from the small numbers involved, since only about 30 deaths have occurred in each of the three years? (2) Do these three rates constitute a unique occurrence judging by past variations in the tuberculosis rates in Cattaraugus County itself? (3) Is the Cattaraugus County experience of the past three years unique in comparison with generally similar areas in the same period.

The data for Cattaraugus County are given in the accompanying table, together with certain explanations as to the sources of the statistics used and certain corrections and eliminations made in order to render the statistics as comparable as possible throughout the period covered.

In applying any one of these tests, it is necessary to ascertain as accurately as possible what the trend of the tuberculosis death rate was in Cattaraugus prior to 1923, as well as in the other counties with which comparisons were made. For Cattaraugus County it was found that the tuberculosis death rate since 1900 had been practically on a level* with annual variations above and below this level which is indicated by the straight line on the accompanying chart. The experience of Cattaraugus was unusual in this respect. For in twelve other counties with whose tuberculosis mortality rates a comparison is made later in this report, the mortality was higher at the beginning of the period and a definite decline is shown since 1900. Why Cattaraugus has had such a favorable rate, we are unable to say until certain inquiries now under way may afford some explanation. But, feeling assured that the mortality record is reasonably accurate, this fact need not concern us here except in a respect which may be stated as follows: The intensive anti-tuberculosis work in Cattaraugus County was undertaken in an area where the death rate from the disease was already relatively low and had been on a low level for some years, and the further reduction of the death rate under such conditions becomes an experiment of unusual interest. Now, if no change in the trend of tuberculosis mortality had occurred subsequent to 1922, we would expect the value of this level to be about 67† per 100,000 in 1925-1927. As a matter of fact, the actual rates (45.3, 43.7 and 42.1) were from 34 to 37 per cent below the expected trend values.

Applying the first test, the probability that rates in three successive years as far below the trend values as the ob-

*A straight line fitted to the rates for 1900-1922 showed that the slope (value of b) was -0.33 ± 0.09 per 100,000 per year.

†66.8 ± 6.4 for 1926, using .67449 of $\sqrt{\frac{pq}{n}}$ where n = estimated population as of July 1, 1926.

served deviations would occur, as a result of fluctuations due to small numbers, is about 4 in a million. So that the decline can not be ascribed to these "chance" fluctuations.

Changes in the mean annual tuberculosis death rate by age groups in Cattaraugus County 1916-1924 over 1925-1927.

Age Group	Actual change in Rate per 100,000	Relative Change Per Cent
Under 5	0	0
5— 9	−15.0	−100
10—19	−22.8	− 64
20—29	−70.3	− 54
30—39	−42.3	− 35
40—49	+ 5.0	+ 8
50—59	−23.1	− 35
60—69	− 1.7	− 3
70 and over	+13.7	+ 20

Applying the second method, the probability that rates in three successive years as far below the trend values as the observed deviations would occur, using the annual deviations in the period 1900-1922 as the basis, is about 1 in 100,000.* In other words, if we can apply the theory of probability to such a problem as this, and assuming the independence of the events considered (and, statistically speaking, they may be so assumed), the occurrence of three rates as low as these for 1925-1927 may be judged as constituting a distinctly unique event.

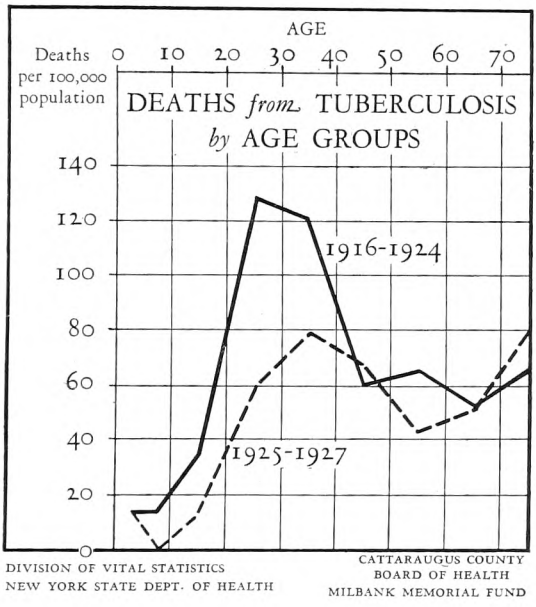
Applying the third method we have used very roughly as "controls," twelve other counties in New York State, namely, Otsego, Ontario, Delaware, Fulton, Chenango, Columbia, Herkimer, Montgomery, Tompkins, Steuben, Chautauqua and Jefferson. A preliminary selection of these counties was made on the grounds that they were generally comparable with Cattaraugus in that they did not contain any cities with a population of 50,000 or over, had established a county tuberculosis sanitorium during the period of consideration (1900-1927), do not constitute or contain a

*The value of *sigma* of annual deviations from the trend of the rates per 100,000 in 1900-1922 is 11.34.

suburban area, and included no State institutions or large private sanatoria. The annual variations were considered in the same way as those for Cattaraugus County. On the accompanying diagram three of them have been plotted as illustrations (page 43). A preliminary analysis indicates that the rates for 1925, 1926 and 1927 in these twelve counties were either above or not significantly below the expected rate for these years.*

The latter comparison has not been carried to the point of completion by any means. In order that more precise and complete comparisons will be possible, it is expected to refine them and to continue them in ensuing years, to study the comparability, in important respects, of these counties, as well as possibly other areas, with Cattaraugus; and to obtain data on the character and volume of the anti-tuberculosis work in some of the counties generally comparable in other relevant respects with Cattaraugus County.

Deaths from tuberculosis, all forms, by age groups in Cattaraugus County, per 100,000 population, in 1916–1924 and 1925–1927.



Of greater significance, in the writer's opinion, than the

*For Tompkins County each of the tuberculosis death rates as recorded for 1924-1927 was below the trend value but the difference in each instance was not statistically significant. Taking the four successive rates together, however, an apparently significant change is indicated.

results of purely statistical tests, such as the first two employed in the foregoing paragraphs, is the fact that the decrease in the Cattaraugus County tuberculosis death rate has taken place in the younger ages. This fact is clearly indicated by the accompanying table and diagram which compare the mean annual rates for 1916-1924 with those for 1925-1927 at different ages. The actual changes in the rates, as well as the relative changes, were as shown in the accompanying table.

The rate among children under 5 years of age shows no change, but it was already low in comparison with other areas,* the largest number of deaths in any year during the period 1916-1927 having been 3. The decreases in the succeeding age periods up to 40 years were considerable and were consistent. This is in contrast to the absence of such changes in the older age periods (40 years and over). If we make a division of the ages in three groups—under 5 years, 5 to 40 years, and 40 years and over—which is roughly characteristic of the ways the disease manifests itself in different periods of life, the decline in the tuberculosis rate in 1925-1927 was confined to the ages of later childhood, adolescence, and young adults, the decrease amounting to about 50 per cent of the mean rate for the previous nine years, and being in itself statistically significant.†

*For example: the 1924 rate among white persons under 5 years of age in the registration states of 1920 was 38 per 100,000; the 1925 rate among all persons under 5 years of age in New York State (exclusive of New York City) was 40 per 100,000.

†Since the downward trend of tuberculosis mortality for all ages in the period 1916-1922 was of negligible importance, and since no definite trend was indicated for the rates at any age, the comparison made above seems justifiable. The difference in the mean rates for the ages 5-39 years is 8 times its probable error, as shown below:

Age Group	Mean Annual Rate per 100,000		
	1916-1924	1925-1927	Difference
0 – 4	14.5	14.5	0.0
5 – 39	78.9 ±3.1	39.1 ±3.8	39.8 ±4.9
40+	61.8 ±3.7	58.3 ±6.0	3.5 ±7.0

It may be stated that most of the differences in the mean rates for the more refined age groups in the ages 5-39 are also statistically significant when judged according to their ratios to their probable errors, and that the age distributions of the deaths in the two periods (using the quinquennial and decennial divisions) are significantly different when the Chi Square test is applied.