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THE MANAGEMENT OF THE TYPHOID FEVER EPIDEMIC AT WATERTOWN, N. Y., IN 1904.

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[*Read March 11, 1908.*]

Mr. President, Members of the Association, and Guests: Before taking up the subject of my paper, I hope the Association will allow me to express my thanks for its kind invitation to come here and tell about the Watertown epidemic. This epidemic may at first seem to be an old story. There is nothing new in the general idea of a typhoid epidemic caused by a public water supply derived from a badly polluted river, and if I had nothing more novel than merely that to relate I should not have come. But there were some features connected with the epidemic, and particularly with its sanitary management, which I believe will be new to you. On these questions particularly I shall welcome a free expression of your opinion.

There is no body before which an account of this kind could be presented to greater advantage, a statement which is warranted by the fact that the New England Water Works Association is composed of practical and scientific men, many of whom have had valuable experience with typhoid and keep themselves abreast of the best measures of avoiding it. It is generally recognized that New England is a source and center of inspiration in sanitary matters, and so far as the prevention of typhoid is concerned, this Association has done its full share to build up and maintain that good reputation.

The typhoid epidemic which is here described occurred in the first few months of 1904 at Watertown, N. Y. It was an uncommonly serious outbreak, numbering about one half as many cases as occurred in the epidemic at Ithaca the year before, and placed Watertown third among the cities of the United States which had typhoid death-rates in excess of 200 per 100 000 of population in the year 1904.

The typhoid history of Watertown for some years prior to this epidemic furnishes an example of the results which generally follow when a polluted river is used as a source of drinking water. The conditions of pollution were evident, but their significance was, apparently, not thoroughly appreciated until too late.

Perhaps the greatest interest which attaches to the epidemic lies in the energetic measures which were taken to stamp it out. If the city had seemed indifferent to the danger of typhoid, it certainly was anxious to make all possible amends when the inevitable catastrophe occurred.

As to the circumstances which led the city to continue for years to use the polluted river as a source of water supply, little has been said or written, so far as I am aware, and it is not my purpose to discuss this matter here. It is possible that indifference to the quality of the water was more apparent than real. The water works were in the hands of a municipal water board composed of citizens of the highest character and intelligence. They had sought and obtained expert sanitary advice on more than one occasion. There is reason to believe that the board was neither unmindful of the danger nor unwilling to take steps to remove it, but it appears that a decision as to the exact nature of the radical measures of protection needed could not, for some reason, be decided on.

The population of Watertown, according to an estimate made by the Census Bureau of the United States Department of Commerce and Labor, was 24 194 on January 1, 1904. The area of the city is somewhat over 3 000 acres; its assessed valuation of property exceeded $10 000 000. It is a manufacturing city, owing its prosperity largely to water-power developments on the Black River at this point. The location of Watertown with respect to the Black River is shown in Fig. 1.

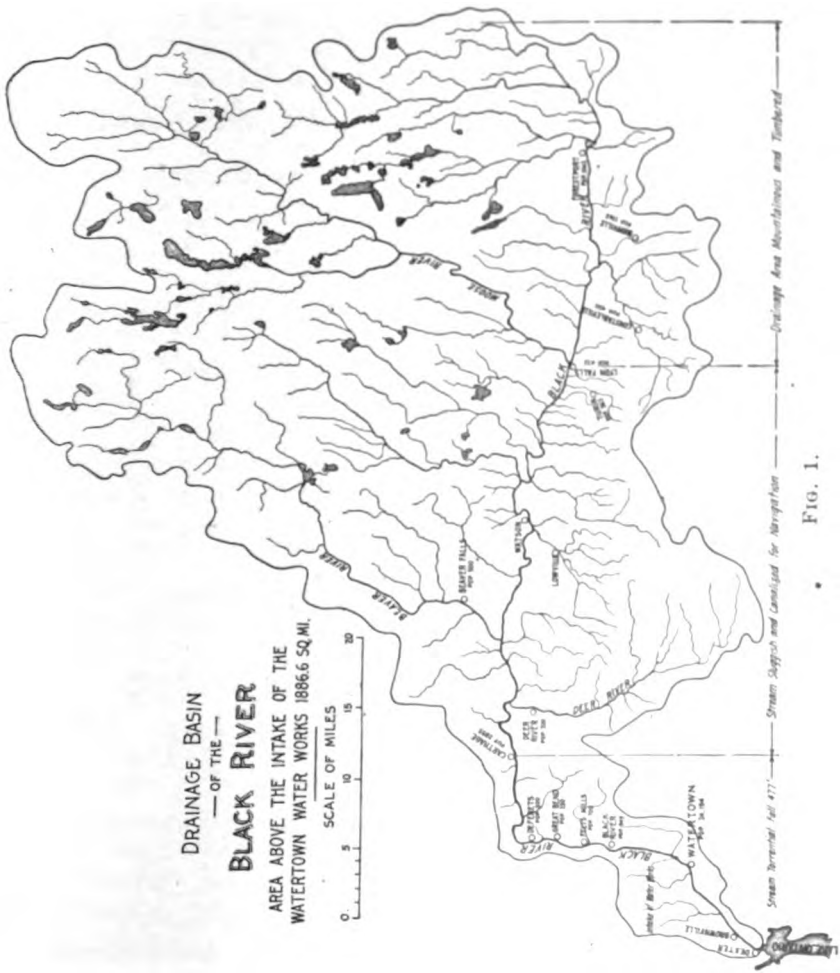


FIG. 1.

I.

PREVIOUS HISTORY OF TYPHOID AT WATERTOWN.

For many years typhoid fever had been unduly prevalent at Watertown, as is shown in Table I, in which the statistics for the city and state are given for twenty years.

TABLE I.

STATISTICS OF TYPHOID FEVER AT WATERTOWN, N. Y., FOR THE TWENTY YEARS 1885–1904.

Year.	Population.	Deaths from All Causes.	Deaths from Typhoid.	Per Cent. of Deaths from Typhoid to Deaths from All Causes.	Deaths from Typhoid per 100 000 Living.
1885	12 700	196	5	2.55	39
1886	13 100	229	5	2.18	38
1887	13 500	216	6	2.77	44
1888	13 900	296	8	2.70	58
1889	14 300	217	5	2.31	35
1890	14 700	234	7	2.99	47
1891	15 400	271	7	2.58	45
1892	16 100	376	12	3.19	74
1893	16 800	333	10	3.00	59
1894	17 500	323	15	4.61	85
1895	18 200	312	31	9.90	169
1896	18 900	331	11	3.32	58
•1897	19 600	312	16	5.12	82
1898	20 300	340	22	6.47	108
1899	21 000	351	19	5.41	90
1900	21 000	397	24	6.04	110
1901	22 400	347	13	3.74	57
1902	23 200	317	16	5.04	69
1903	23 900	356	19	5.33	79
Average for Watertown for nineteen years,				4.17	71
Average for N. Y. state for same period,				1.3	25
For the epidemic year, 1904, at Watertown			47	12.81	194

NOTE. Since the epidemic the typhoid death-rate has been, per 100 000 of population, as follows: 1905, 24; 1906, 50; 1907, 37.

After 1894 there had been more typhoid than formerly. For the nine years preceding the epidemic of 1904 the average typhoid

death-rate had been 83 per 100 000 of population. The average for the whole state of New York for the twenty years prior to 1904 was 25, or less than one third that for Watertown. There had been, in the nine years previous to the epidemic, an average of 56 deaths from typhoid to 1 000 deaths from all causes in Watertown, while for the whole state, for the twenty-year period mentioned, the ratio had been 16 to 1 000. The records of the Board of Health show that typhoid existed at every season of the year, and that at various times it had been epidemic.

In 1895 two epidemics of typhoid occurred. One of these extended through April and May, and the other from August to December. The total number of deaths from typhoid fever in that year was more than twice that for the year preceding and three times that for the year which followed.

During the epidemic which occurred in the spring of 1895 suspicion centered upon the public water supply and the Board of Water Commissioners caused an investigation to be made to determine whether this was the source of the trouble. This investigation was made by the late Prof. Wyatt Johnston, the distinguished sanitarian, of McGill University, Montreal. The autumn epidemic was investigated by a committee of the Watertown Board of Health.

These two investigations, although made nearly ten years before the epidemic with which we are here chiefly concerned, throw such a strong light upon the conditions which led to the outbreak of 1904 that it seems desirable to pause for a moment to consider them.

The spring epidemic of 1895. The number of cases of typhoid which occurred in the spring epidemic of 1895 was, according to Professor Johnston's report to the Water Commissioners, 63. According to the records of the health office the number was 55. The Board of Health committee which investigated the epidemic which took place later in the year referred to the number in the spring outbreak as 80. The exact number cannot be ascertained, nor is it necessary that it should be. It is sufficient to note that an epidemic undoubtedly occurred in the spring of 1895.

Many circumstances led Dr. Johnston to suspect that the public water supply was the cause of the epidemic. Among fifty persons

suffering from typhoid fever, milk had been received from twenty-one peddlers, of whom only three had more than three cases on his route. The cases were distributed and not confined to any one section of the city. All of the patients had been regular drinkers of the public water supply. No one was ill who made it a regular practice to drink only boiled or filtered water. Most of the cases appeared after an unusual rise in the river; a freshet occurred between April 10 and 13, and most of the cases were recognized between April 20 and May 1.

The net result of Dr. Johnston's investigation was the opinion that the epidemic had come from the water supply. The supply had become infested with typhoid germs, in his judgment, from people in the many mills and other buildings which existed on the Black River above Watertown. He pointed out that unless these sources of pollution were remedied, typhoid fever would continue to be prevalent in Watertown and epidemics would occur from time to time. The danger to public health lay not in the volume of refuse which entered the stream, but in its quality; a large amount of factory drainage was far less liable to lead to disease than a small amount of sewage from water closets or the contents of privies. The existence of many possible points of pollution prevented the Black River from being regarded as a source of safe drinking water at Watertown unless the water was purified.

Dr. Johnston recommended the consideration of a plan for filtering the water, and advised that, pending such purification, a thorough inspection be made of the watershed, followed by the removal of all sources of direct pollution, especially privies, and the rigid suppression of nuisances in the neighborhood of the intake. Finally, he recommended that the intake be moved so as to be less liable to receive water from a polluted brook which entered the river nearby, and farther from the drainage of a neighboring cemetery.

Some of these recommendations were carried out, as we shall see later on. It was impossible, however, to remove the sources of pollution, " especially privies," which, as it will also appear, increased greatly in number as the Black River above Watertown was developed for mill purposes in succeeding years.

The second epidemic of 1895. According to the report of the

committee of the Board of Health which investigated the second epidemic of 1895 there were, in this latter outbreak, 180 persons attacked. Thirty-seven cases were accounted for on the theory that in September the milk supply of one of the numerous milk peddlers in Watertown became contaminated. The other cases were believed to have been caused by a contamination of the public water supply. The worst sources of pollution of the Black River were carefully described and mapped by Messrs. Boyer and Armstrong for this committee.

In concluding their report the committee recommended that the water supply be protected against the pollution which had, on two separate and recent occasions, caused much sickness and death in the city. The cases are reported to have occurred as follows: August, 56; September, 30; October, 63; November, 20; December, 12.

II.

THE PUBLIC WATER SUPPLY FROM THE BLACK RIVER.

The Water Works.

The drinking water supply of Watertown is taken from the Black River at a point about two miles about the city, as shown in Fig. 2. Here there is an arm of the river which has been dammed off from the main stream, making a stretch of quiet water about three quarters of a mile long, from two hundred to six hundred feet wide, and something less than eight feet deep. This is called the settling basin, and from its lower end the water for the city is drawn. The dam failed and was destroyed in December, 1901. It was rebuilt in 1902.

From a pumping station on the river bank the water was, at the time of the epidemic of 1904, pumped to a reservoir situated at an elevation of about 150 feet above the level of the stream. From here it flowed to the consumers by gravity. The reservoir capacity was about 5 000 000 gallons and the average daily consumption about 4 000 000 gallons. Theoretically, water taken in at the pumps should reach the majority of consumers within forty-eight hours.

No irregularity in the operation of the plant occurred after the dam forming the settling basin failed in 1901. A plant of rapid

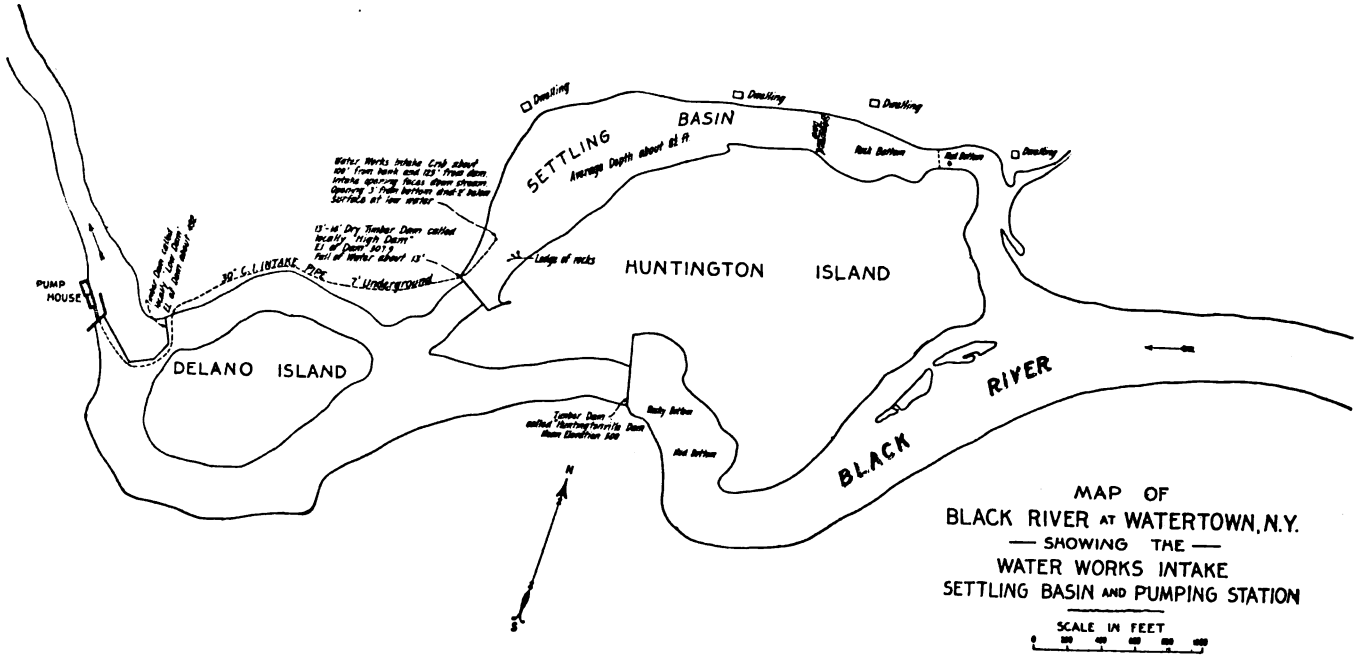


FIG. 2.

filters, designed by Allen Hazen, was begun in the autumn of 1903, and has been in service at the pumping station since the fall of 1904.

Quality of the Water.

The water of the Black River is naturally clear but colored with vegetable matter from the forests of the Adirondacks. It is soft and remarkably free from mineral matter except for a small amount due to mill drainage.

The quality of the water is likely to change rapidly with the changes which take place in the volume of the flow of the river. The flow varies from about 600 cubic feet per second to 18 000 cubic feet per second. The turbidity seldom rises above 200 parts per million as measured by the silica scale, and is usually very much lower than this figure. The water is improved somewhat in quality by passing through the sedimentation basin, but such figures as are at hand do not indicate that there is often a reduction exceeding about 50 per cent. in the numbers of bacteria. The chlorine in the river water is well above 0.3 parts per million, which is the normal in this vicinity. Presumptive tests for coli indicate fairly well the polluted condition of the river. Many analyses of the water have been made in connection with the operation of the filter plant, which was put in operation subsequent to the epidemic, but I am indebted to Mr. Francis F. Longley, who was for a time in charge of the operation of these works, for my information concerning this matter. Table II shows the results of some of Mr. Longley's chemical analyses.

TABLE II.

RESULTS OF CHEMICAL ANALYSES OF BLACK RIVER WATER.

(Parts per million.)

Date.	Albuminoid Ammonia.	Free Ammonia.	Nitrites.	Nitrates.	Chlorine.
October 4, 1904	0.186	0.030	0.001	0.15	0.90
November 2, ,,	0.112	0.012	0.001	0.05	1.05
November 28, ,,	0.074	0.002	0.002	0.10	1.20
December 18, ,,	0.092	0.020	0.002	0.05	0.90
January 9, 1905	0.116	0.014	0.003	0.10	1.00
February 10, ,,	0.078	0.006	0.001	0.25	1.25
February 28, ,,	0.072	0.006	0.001	0.15	1.15
March 20, ,,	0.216	0.128	0.003	0.20	1.10

So far as I am aware, no analyses of Black River water were made which adequately show the condition of the Watertown supply immediately before or during the epidemic. One sample was taken through the ice near the intake on February 15 and sent for analysis to Dr. R. M. Pearce, of the Bender Hygienic Laboratory at Albany. Dr. Pearce reported that this sample gave 14 200 bacteria per cubic centimeter on gelatine, and 280 on agar. The bacteria liquefied the gelatine with a "moderate putrefactive odor." Gas of the type characteristic of the colon bacillus was found.

The analysis shown in Table III, made by Mr. Longley during rises in the river one year later, perhaps give some idea of the conditions.

TABLE III.

RESULTS OF ANALYSES FOR BACILLUS COLI COMMUNIS IN WATER FROM THE INTAKE OF THE WATERTOWN WATER WORKS.

(By the word "gas" is meant 20 per cent. or more gas in dextrose broth.)

Month.	Average Discharge of River in Cu. Ft. per Second.	Results of Analyses.			
		Number Samples Examined.	Per Cent. Samples of 0.1 c.c. showing Gas.	Per Cent. Samples of 1.0 c.c. showing Gas.	Per Cent. Samples of 10 c.c. showing Gas.
October, 1904	4 700	11	9	91	100
November, ,,	1 920	18	33	100	100
December, ,,	1 650	20	35	95	100
January, 1905	2 640	17	47	100	100
February, ,,	2 380	15	20	93	100
March, ,,	4 010	20	50	90	100
April, ,,	11 350	15	27	80	100
May 1-10, ,,	6 905	6	0	66	100
		122	32	92	100

Physical characteristics of the Black River. The Black River rises in the heart of the Adirondacks, flows in an irregular, southwesterly direction, and empties into Lake Ontario. The distance from the mouth of the stream to the head of its principal tributary is 132 miles. Its total drainage area as given by the Report of the Board of Engineers on Deep Waterways, is 1903.2 square miles. The drainage area with some of the larger villages is shown in

FIG. 1. Intake of the Watertown Water Works, showing the Supply Main in the Foreground.

FIG. 2. Pump House of Watertown Water Works.

Fig. 1. The area above the intake of the water works is given by the same authority as 1 886.6 square miles.

The drainage area may be divided into two parts: a sparsely populated catchment area, which lies almost exclusively in the Adirondack Mountains, and a much more thickly populated, steep, narrow valley from Carthage, past Watertown to Lake Ontario. Parts of the upper portion of this catchment area have a rapid fall which sends down the waters from the rains and melting snows rapidly. In the distance of twenty miles from Carthage to Lake Ontario there is a fall of 477 feet. Through this valley the river flows in a turbulent and sometimes destructive manner. A large amount of the power due to the fall has been developed and is utilized by mills.

In 1902 there were on the drainage area of the Black River and its tributaries, according to the report of the New York State Water Storage Commission of 1903, forty-four dams, furnishing an aggregate of 76 000 horse-power to mills situated on the streams. The value of these mills was estimated at $12 302 100 and the annual value of their product at $15 101 440. There were 5 349 hands employed. Many of these mills were situated at Watertown, but, as will be seen presently, there were several villages along the Black River between Watertown and Carthage where mills, factories, and dwellings crowded the banks. There were a few mills beyond Carthage, at Lyon Falls, and elsewhere.

Sanitary condition of the Black River above Watertown. Through the coöperation of the Watertown Board of Health and the Water Commissioners of the city a careful sanitary inspection was made in 1895 of the shores of the Black River from Watertown to Carthage, a distance of seventeen miles. In this distance there were four villages which, with isolated country houses, had an aggregate population of over five thousand persons. Sketches of a few of these villages as they existed in 1895 are shown in Fig. 3. It appears, upon reliable testimony, that the population in this district had increased about fifty per cent. by 1904. An entirely new village, with a population of between four and five hundred persons, had grown up about a large paper mill at Deferiets, about ten miles above Watertown. To accommodate these people a sewerage system had been built to carry their sewage to the river.

In fact, sewage and other drainage entered from all the villages and mills without any restriction.

In the territory between Watertown and Carthage there were, in 1895, 165 buildings which drained into the stream. There were

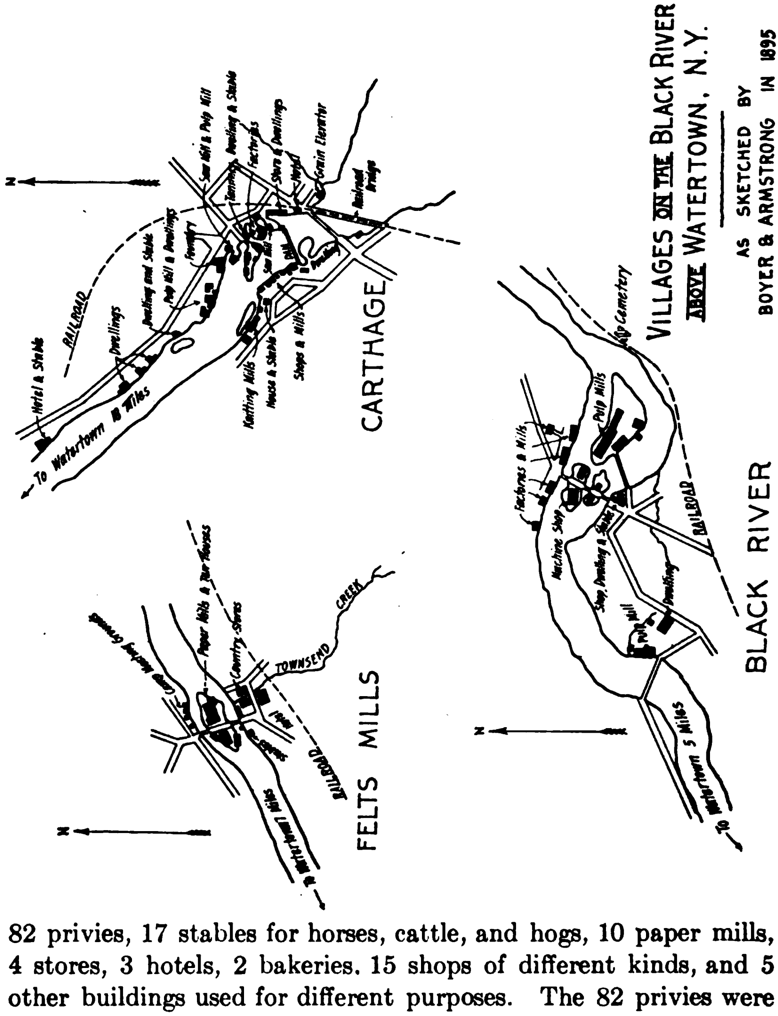


FIG. 3.

82 privies, 17 stables for horses, cattle, and hogs, 10 paper mills, 4 stores, 3 hotels, 2 bakeries. 15 shops of different kinds, and 5 other buildings used for different purposes. The 82 privies were used by about 740 persons and were located directly over the stream, or on its bank, and discharged their contents into the river.

FIG. 1. Town of Black River, looking from the South Side of the Stream. This is five miles above the intake of the Watertown Water Works.

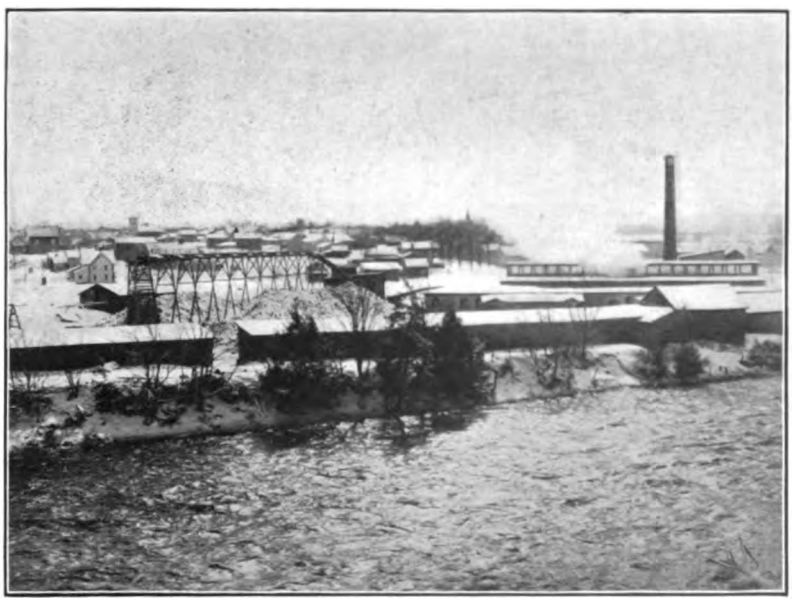


FIG. 2. Felts Mills, Seven Miles above the Intake of the Watertown Water Works.

The manure from the 17 stables was either thrown into the river or piled upon the bank, whence it drained into the stream. In addition to the 740 people whose excreta ordinarily passed directly into the river, about 6 000 to 7 000 people from different parts of the country attended annually a camp meeting held on the banks of the stream at Felt's Mills, seven miles above the intake of the Watertown water works. At this point four privies stood directly on the slope of the bank.

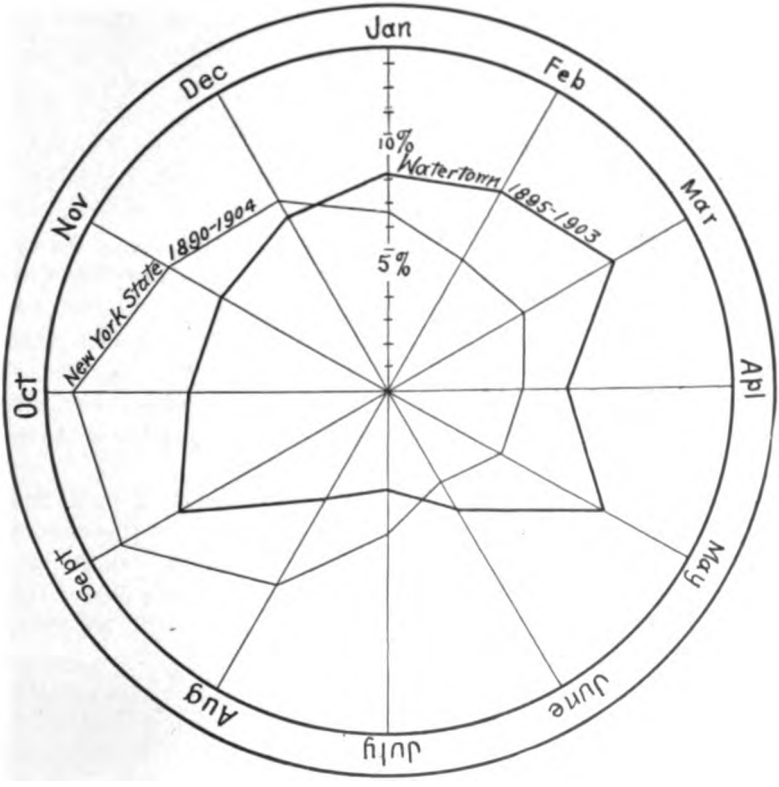


FIG. 4. Distribution of Typhoid Deaths through the Year in Watertown and New York State. The Distribution in the United States corresponds closely with that in New York State. The Peculiarities of the Watertown Curve suggest that the River Water has been a Leading Cause of Typhoid.

It seems unnecessary to point out the danger which these insanitary conditions represented. Aside from the probability that cases of typhoid fever existed every year among the persons who used the privies and sewers, not to mention persons who were chronic bacillus producers, the river was made the disposal place of refuse of every kind. Manure entered it from stables. It is well known that the manure of stables commonly contains human dejecta. It should also be remembered that when typhoid fever occurs in the country, it is usual to throw the stools and urine down the banks of the nearest stream to get rid of it. The Black River was, then, a very dangerous stream from which to take drinking water.

Ineffectiveness of State rules adopted for the protection of the Black River water supply. At the request of the Water Commissioners of Watertown, the State Board of Health, in 1896, formulated rules for the protection of the waters of the Black River from pollution above the intake of the water supply of the city of Watertown. These rules and regulations were made in virtue of Section 70 of Chapter 661 of the state laws of 1893, which empower the State Board of Health "to make rules and regulations for the protection from contamination of any or all public supplies of potable waters and their sources within the state" and "to impose penalties for the violation thereof and the non-compliance therewith."

As is the custom in New York state, the rules were published for six weeks in the principal papers of the district, in this case at Watertown, Carthage, and Lowville, and a certificate to this effect, together with a certified copy of the rules, having been filed in the office of the county clerk of Jefferson County, on April 30, 1896, the rules became law.

The Water Commissioners of Watertown thereafter had the legal right to insist that all dangerous pollution be kept out of the Black River above Watertown. But, as another provision of the public health law compelled the commissioners to bear the expense which this work incurred and also to make good any financial loss to mills and villages which might result, the cost of enforcing the regulations made protection of the water supply in this manner seem impracticable. The law was not enforced.

FIG. 1. Great Bend, from the North Side of the Stream. This is about eight miles above the intake of the Watertown Water Works.

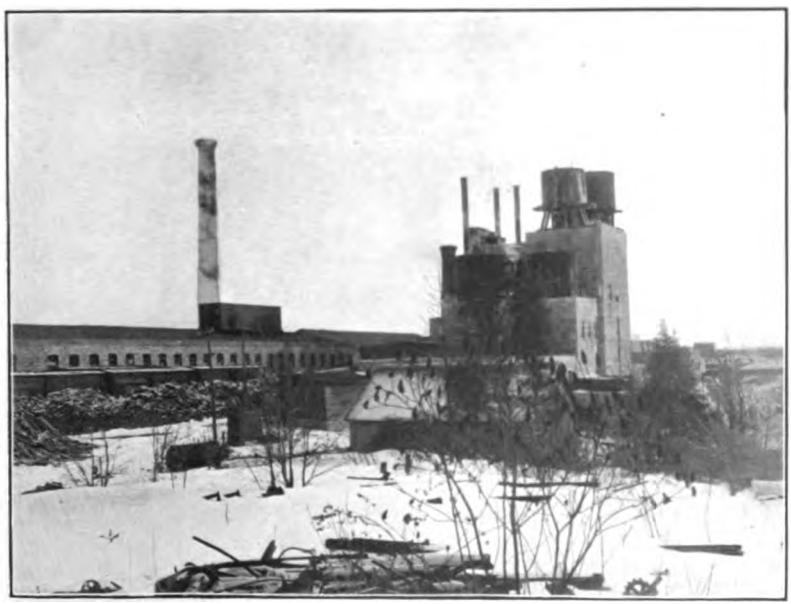


FIG. 2. Deferiets, Ten Miles above the Intake of the Watertown Water Works. A sewer empties into the Black River at this point.

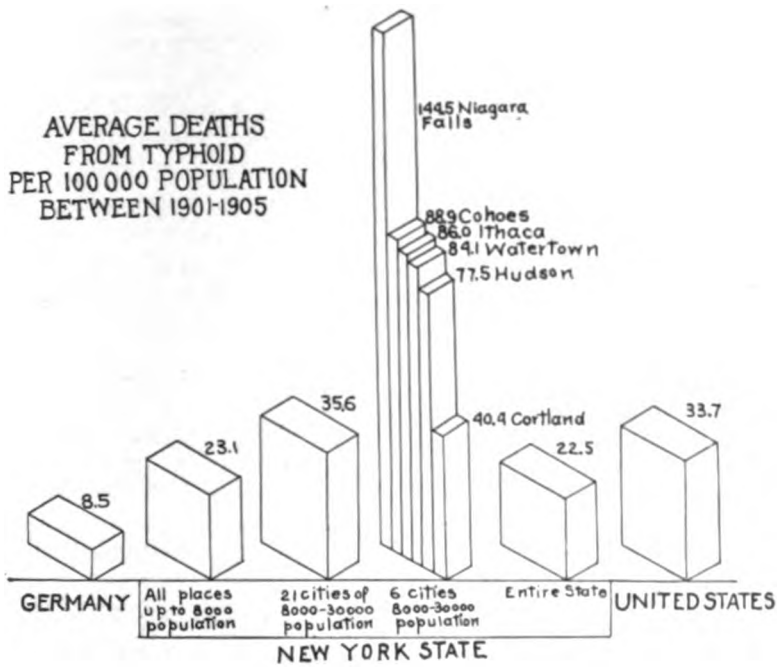


FIG. 5. Comparison between Typhoid Death-Rates for Germany, New York State, and United States. Also rates for six small cities in New York as compared with twenty-one other cities of the same in class New York State. The prevalence of typhoid at Watertown is thus made evident.

III.

THE EPIDEMIC OF 1904.

A study of the weather conditions preceding the epidemic of 1904 discloses some matters of particular interest.

The Weather.

To begin with, in the month of October, 1903, there were excessively heavy rains. These were followed by a long term of cold weather: the November of 1903 was decidedly colder than the average November. After the 18th of November the maximum daily temperature on the drainage area of the Black River was

generally below 32 degrees. The precipitation was light. The weather through most of the month of December was severely cold, the average temperature for the whole state being lower than for any similar period since the records of the United States Weather Bureau were begun. According to the Climate and Crop Service of the United States Weather Bureau, the ground was frozen and covered with snow throughout the month. In the drainage basin of the Black River an unusual amount of snow fell even for that remarkably cold and snowy section.

The intense cold which characterized the early part of December abated for nearly a week in the latter part of the month. Beginning with the 20th, the temperature rose every day above freezing at Lowville until the 26th. On the 20th there was a fall of .73 inch of rain at Lowville and .85 at Number Four. This was accompanied by a warm south wind. In the five days, December 20–24, 1.5 inches of rain, or its equivalent of snow, fell at Lowville, and in the three days, December 19–21, the fall at Number Four was 1.31. An excessively cold snap then followed and lasted throughout the month.

A large amount of water was washed from the snow-covered hillsides and banks of the streams by these rains and thaws. Sewers were flushed and ice in the vicinity of the sewer outlets was melted and carried off. According to records made by the Division of Hydrography of the United States Geological Survey, the discharge of the Black River at Felt's Mills, seven miles above Watertown, rose from about December 20. The rise was rapid and continuous until December 25, after which the flow diminished with slight remissions until January 9, 1904.

The source of the infectious matter. About a month after the outbreak of the epidemic, there were sent out a number of inspectors to determine, if possible, whether any cases of fever had occurred which could have led to the contamination of the water supply with typhoid germs. The search extended along the banks of the Black River as far as Carthage. One of the inspectors, Mr. W. E. Fuller, in a communication to *Engineering News*, March 3, 1904, page 205, has recorded what was found up to the latter part of February, 1904.

Going up stream from Watertown, the nearest cases of typhoid

FIG. 1. Carthage, from the West Side of the River.

FIG. 2. West Carthage, from Carthage. A sewer discharges under the further end of the bridge. This is eighteen miles above the intake of the Watertown Water Works.

were found at Black River, about 4½ miles above the intake of the water works. Five cases existed there: the first started during the latter part of December and the other four began in the first half of January, 1904.

No cases of typhoid were found in the next two villages, Great Bend and Felt's Mills.

At Deferiets, where there was a sewerage system emptying into the river about 10 miles above the intake of the Watertown water works, there was a small epidemic of typhoid at about this time. One case had occurred in September, 1903, a second in the first half of December, two more in the second half of December, and twelve in January and February. Deferiets has a population of about 500.

At the twin villages of Carthage and West Carthage, about seventeen miles above the water works, fifteen or sixteen cases of typhoid were said to have occurred from September to February. These villages are not provided with public sewers, although several private sewers empty into the river.

It thus appears that typhoid had existed at more than one of the villages between Watertown and Carthage before the outbreak at Watertown. How far typhoid had been prevalent in the thirty or forty settlements or villages on the drainage area above Carthage is not, and never will be, known.

Apparently there was within this watershed what has occurred in many other river valleys,— an epidemiological wave of typhoid. It is not difficult to understand how these waves occur. When typhoid is introduced at any point, the infectious matter gets into the water courses, which are, of course, the natural sewers of the country. As the sewers of one town become the water supplies of others, the disease is transmitted by the water down the valley in the direction of the flow of the stream. To some extent there is also an upward, downward, and lateral transmission of the disease, due to movements of the population and the transportation of milk from one village to another.

With a whole valley infected with typhoid, as was the valley of the Black River at the time of the Watertown epidemic, it is plain that the lower parts of the river are likely to become very heavily contaminated with typhoid germs and, owing to the numerous

points of pollution, may remain so for a long time. We have under these circumstances not an example of a sudden, intense, and brief contamination such as produce the most sensational explosions of typhoid, but a more continuously operating cause and a corresponding continuous effect. Instances of epidemics of this type have frequently been afforded by cities which draw their water supplies from large rivers. The statistics of the Watertown epidemic, although admittedly imperfect, seem to indicate that the public water supply of the city may have been contaminated in this manner.

Judging from the fact that many cases of typhoid occurred at Black River and Deferiets at about the time that the epidemic began at Watertown, it is barely possible that there was one large common source of germs which supplied all these places. In other

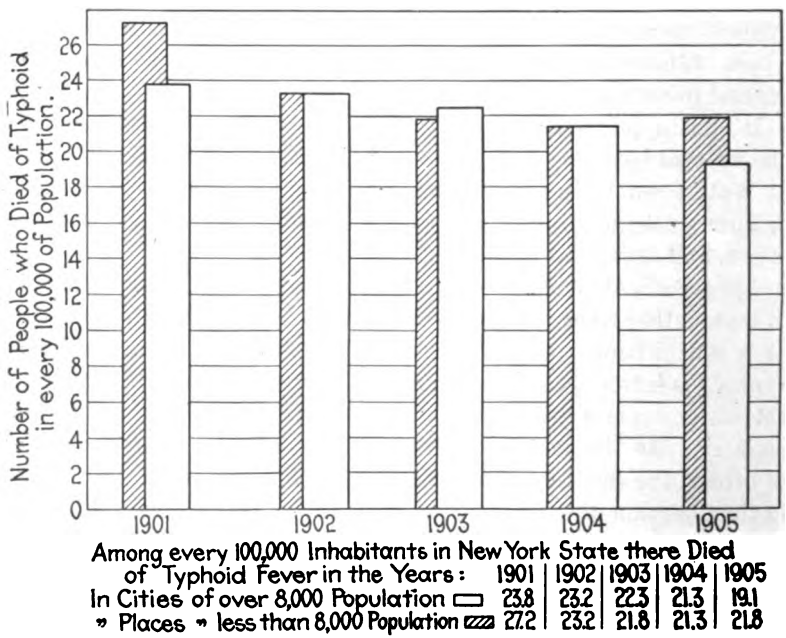


FIG. 6. Comparison between Rural and Urban Typhoid Death-Rates in New York State for Five Years, showing that in the year of the Watertown epidemic, typhoid was not unusually prevalent in city or country districts.

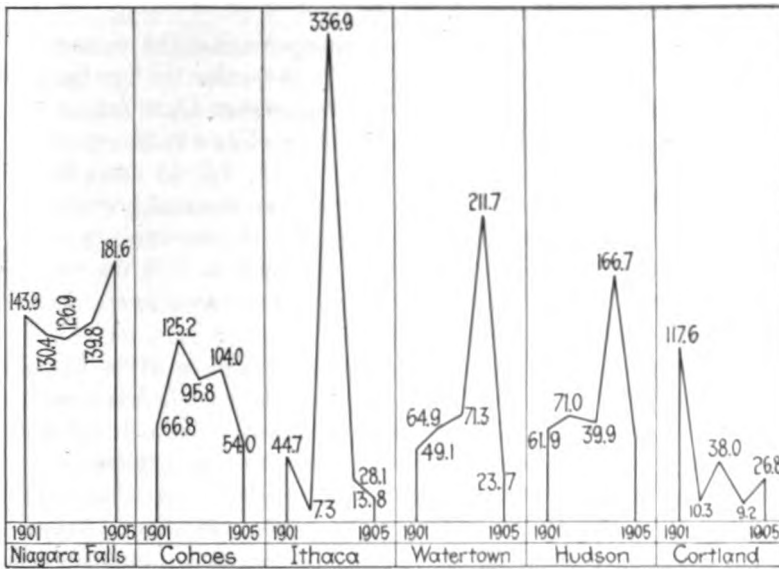


FIG. 7. Comparison between the Records of the Six Cities in New York State which had the Greatest Number of Deaths from Typhoid between the Years 1901 and 1906. According to the average rate, Watertown occupied fourth place; according to the rate for each year, Watertown was second.

words, it may be that the infectious matter which caused the Watertown epidemic originated above both Deferiets and Black River.

On the other hand, the germs which produced the Watertown outbreak may have come exclusively from some nearby point, such as Deferiets.

Setting aside this interesting but uncertain element as to the exact origin of the germs, the fact is clear that the epidemic at Watertown came from the public water supply.

The outbreak and course of the epidemic of 1904. According to the testimony of physicians, there had been an unusual amount of diarrheal disease in Watertown during the fall and early winter of 1903–4. During November and December typhoid fever had been much less prevalent than usual at this season of year. From

the reports of physicians made to Dr. E. S. Willard, health officer of the Board of Health of Watertown, it appears that the number of cases of typhoid for November was 7. In December the number reported was 15. On January 1, 8 cases were reported, and on the 2d, 13. In the following few days the number of new cases reported each day varied from 1 to 13. On January 15, 23 cases were reported. The newspapers now announced an unusual prevalence of typhoid, and, suspecting that the public water supply was to blame, the people were advised by the mayor to boil the water which they used for drinking purposes. The cases were widely scattered through the city.

The daily incidence of cases during the first few weeks is not clearly known, nor in fact are the dates of onset of the cases accurately established for any part of the outbreak. It was not customary for physicians to report their cases of typhoid with regularity before the epidemic and they did not do so afterward.

To a sanitarian unfamiliar with the peculiar conditions which occur in typhoid epidemics the failure of physicians to report their cases seems inexplicable if not inexcusable. The fact is, however, that physicians are extremely busy at such times in attending to the pressing needs of the sick, and are sometimes called upon to spend so much time in ministering to their patients that they feel unable to allow themselves proper time for sleep or meals. Often several visits are necessary before the nature of the sickness can be discovered. When a patient is at last found to be suffering from typhoid the date of onset may be forgotten. The full name and exact address of each patient is rarely known to an attending physician. To expect that every case of typhoid will be promptly and satisfactorily reported, therefore, is unreasonable, however desirable such reports may be from the public health standpoint. For a board of health to get even fairly satisfactory returns generally requires much telephoning, interviewing, and circularizing and sometimes a house-to-house canvass.

After the board of health work became systematized, each case reported was tabulated on two sets of cards. One of these sets was then arranged alphabetically according to the names of the patients and one set according to the street addresses. The sanitary circumstances surrounding each case were carefully inves-

tigated by the Board of Health and records kept of the principal points of information ascertained in connection with it. Many errors in the returns were corrected in this way. The genuine cases of typhoid were finally spotted on a large wall map and placed on a chart. In the stress of the hour some cases were probably overlooked by the physicians and the exact dates of others accidentally misstated. Some cases were reported several times and the addresses were frequently wrong. Some cases of disease other than typhoid were reported as typhoid. A curve plotted from the corrected returns in the possession of the Board of Health shows, as such curves always do, large numbers on some days and almost none on days immediately preceding and succeeding these. It is practically certain that people do not fall sick during typhoid epidemics in this extremely irregular way.

In the hope of eliminating some of the errors in the records, I have taken as an approximation to the probable number of cases each day an average of the number of cases for three days — the day before, the day itself, and the day after the date on which the number of cases is desired. The corrected returns and these averages with averages for each five days are given in Table IV. From these data I have plotted curves to give some idea of the progress of the epidemic. (See Fig. 8.)

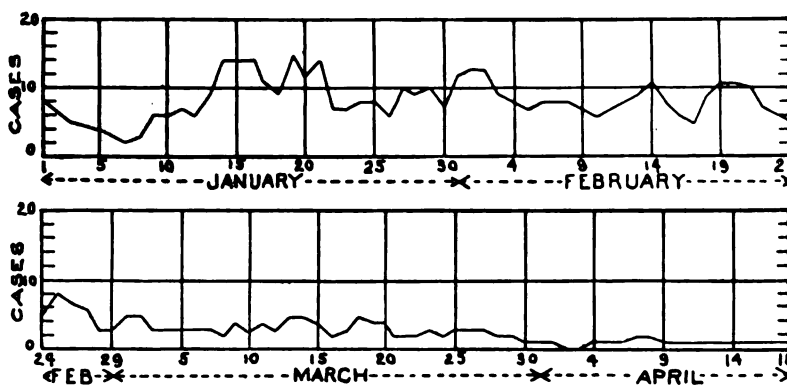


FIG. 8. Progress of the Epidemic of 1904. The Board of Health campaign was started about February 22. The upper curve represents the course of the epidemic before, and lower curve its course after, the repressive measures were put in force.

TABLE IV.

CASES OF TYPHOID FEVER AT WATERTOWN, N. Y., FROM JANUARY 1, 1904, TO APRIL 18, 1904.

Date.	From Corrected Reports of Physicians.	Cases Averaged for Three Days.	Date.	From Corrected Reports of Physicians.	Cases Averaged for Three Days.
1904			1904		
January 1	8	10	January 31	6	12
,, 2	13	7	February 1	22	13
,, 3	0	5	,, 2	10	13
,, 4	1	1	,, 3	8	9
,, 5	2	2	,, 4	8	8
Total	24	25	Total	54	55
January 6	3	3	February 5	9	7
,, 7	3	2	,, 6	4	8
,, 8	1	3	,, 7	12	8
,, 9	4	6	,, 8	7	8
,, 10	13	6	,, 9	5	7
Total	24	20	Total	37	38
January 11	1	7	February 10	8	6
,, 12	7	6	,, 11	5	7
,, 13	10	9	,, 12	9	8
,, 14	9	14	,, 13	9	9
,, 15	23	14	,, 14	10	11
Total	50	50	Total	41	41
January 16	9	14	February 15	13	8
,, 17	10	11	,, 16	1	6
,, 18	14	9	,, 17	5	5
,, 19	4	15	,, 18	9	9
,, 20	26	12	,, 19	12	11
Total	63	61	Total	40	39
January 21	7	14	February 20	13	11
,, 22	8	7	,, 21	7	10
,, 23	5	7	,, 22	10	7
,, 24	8	8	,, 23	3	6
,, 25	11	8	,, 24	6	5
Total	39	44	Total	39	39
January 26	6	6	February 25	6	8
,, 27	8	10	,, 26	12	7
,, 28	15	9	,, 27	3	6
,, 29	5	10	,, 28	3	3
,, 30	10	7	,, 29	3	3
Total	44	42	Total	27	27

TABLE IV. — *Continued.*

Date.		From Corrected Reports of Physicians.	Cases Averaged for Three Days.	Date.		From Corrected Reports of Physicians.	Cases Averaged for Three Days.
1904				1904			
March	1	8	5	March	26	5	3
,,	2	5	5	,,	27	2	3
,,	3	2	3	,,	28	3	2
,,	4	2	3	,,	29	1	2
,,	5	4	3	,,	30	1	1
Total		21	19	Total		12	11
March	6	4	3	March	31	2	1
,,	7	2	3	April	1	0	1
,,	8	3	2	,,	2	0	0
,,	9	2	4	,,	3	1	0
,,	10	6	3	,,	4	1	1
Total		17	15	Total		4	3
March	11	1	4	April	5	0	1
,,	12	4	3	,,	6	1	1
,,	13	3	5	,,	7	2	2
,,	14	8	5	,,	8	2	2
,,	15	3	4	,,	9	1	1
Total		19	21	Total		6	7
March	16	0	2	April	10	0	1
,,	17	3	3	,,	11	2	1
,,	18	4	5	,,	12	0	1
,,	19	7	4	,,	13	0	1
,,	20	2	4	,,	14	2	1
Total		16	18	Total		4	5
March	21	2	2	April	15	0	1
,,	22	2	2	,,	16	0	1
,,	23	3	3	,,	17	2	1
,,	24	3	2	,,	18	1	1
,,	25	1	3				
Total		11	12	Total		3	4
				Grand total,			595

There is little doubt that the epidemic broke out about January 1, although it was not investigated until over a month later. The daily increase in the number of cases was apparently rapid up to about January 20, when there was a slight decrease until the 25th,

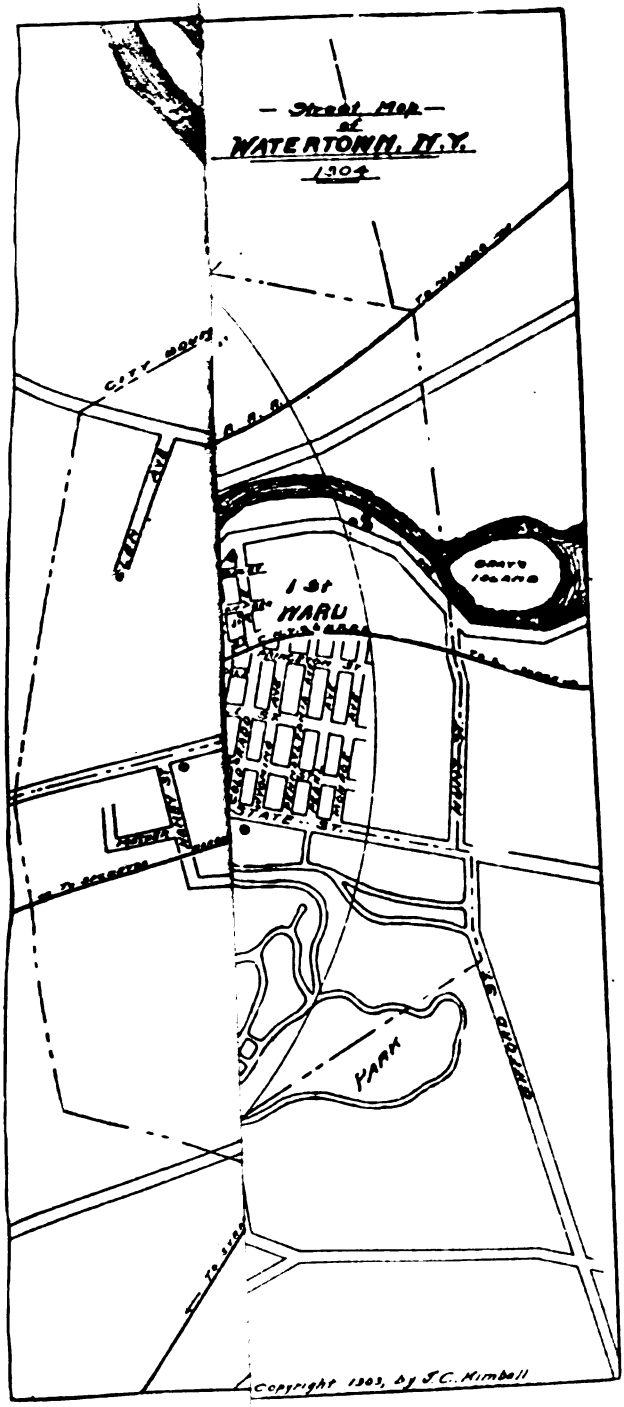
followed by another increase which lasted until about Feburary 1. The daily number of cases then declined slowly and remained comparativelv constant between February 9 and 25. After this there was a considerable reduction. The epidemic may be considered to have ended April 18. It had run 110 days.

The total number of cases of which I have reliable record was 595. The number of deaths to May 1 was 44. The case fatality, based on these figures, was 7.4 per cent.

Subsequent to April 18, 102 cases were reported up to January 1, 1905. The number of deaths from typhoid, in addition to those already mentioned, was 3 up to January 1, 1905. Since 1904 the number of cases and deaths from typhoid reported at Watertown have been as follows: 1905, 108 cases, 6 deaths; 1906, 130 cases, 13 deaths; 1907, 103 cases, 10 deaths.

When the cases of typhoid were spotted on a map it was seen that the fever had visited every part of the city. (See Plate V.) The poorer sections suffered most, and the aristocratic parts least, a result which was largely accounted for by the fact that the poorer sections were the most crowded and there were consequently more people to be attacked in a poor section on a given area. In the best residential quarters, also, more personal care was exercised to avoid the fever. The drinking water of many of the people was boiled or carefully filtered. Institutions, such as children's homes, and the jail, had their full share of typhoid.

There were some parts of the city which suffered to a greater extent than could be fully explained on the score of crowding and lack of personal precautions, and it seemed reasonable to conclude that some peculiarity of the distribution system of the water supply carried to these sections exceptionally large doses of infectious matter, or that insanitary conditions about the houses increased the people's chances of infection. No extensive local foci such as germ-infested wells were found, such as I had discovered at Ithaca. The people, as a rule, were in much better financial circumstances and lived more comfortably and there was much less typhoid transmitted from person to person than I had seen in the epidemic at Butler. Nevertheless, the fever was undoubtedly transmitted to some extent from person to person in spite of the utmost efforts of the Board of Health. The greatest danger in



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this regard probably occurred when a patient was nursed at home. Under these circumstances the person who acted as nurse sometimes did the cooking for the rest of the family and, for convenience and warmth, the patient was occasionally nursed in a room close to the kitchen. As far as practicable these dangers were reduced to a minimum by the operations of the Board of Health.

IV.

MEASURES TAKEN TO CHECK THE EPIDEMIC.

At a meeting of the local Board of Health, held on February 1, it was decided to make an official investigation into the cause of the outbreak. It was fully realized that a serious epidemic was at hand. The health officer had notified the State Department of Health of the prevalence of typhoid under date of January 30.

State Action. On February 8 the health officer was empowered " to employ a sanitary expert at once to investigate the situation and take such measures as may be reasonable and necessary to eliminate the epidemic." In response to the information furnished the State Department of Health on January 30, Prof. Olin H. Landreth, consulting engineer of the State Department of Health, made the city a visit on February 13.

Professor Landreth caused a canvass to be made to ascertain the number and distribution of the cases and the date of attack in each case. He also advised that postal cards be sent to every family in the city, cautioning the people to boil the water used for drinking, for washing vegetables which were to be eaten uncooked, and for washing dishes, etc. Professor Landreth's suspicion rested upon the public water supply as the cause of the outbreak and he appointed canvassers to visit the settlements and shores along the Black River to search for any cause of typhoid which might have led to the contamination of the public water supply. At the same time data were collected which put the milk supplies out of question as the cause of the epidemic.

On February 20 Professor Landreth again visited Watertown. On this occasion the investigation which he initiated on his former visit was supplemented. Various sanitary measures were recommended and much salutary advice was given on sanitary matters.

Steps were begun toward cleaning and disinfecting all premises on the Black River where typhoid fever cases were found to have existed.

Other short visits were subsequently made to Watertown by Professor Landreth in his official capacity. On these occasions the need of extending the inspection and disinfecting work on the Black River drainage area were urged. But the city was less interested in cleaning up the drainage area than in attending to sanitary work within its boundaries. Eventually, by mutual consent, the direction of the work on the drainage area was placed wholly in Professor Landreth's hands, the city of Watertown agreeing to coöperate with the State Department of Health to the extent of paying the cost of this work.

Unable to secure from the state an expert who could give his undivided time to the work of checking the epidemic, and believing that the situation required such attention, the Board of Health engaged me for this purpose.

Plan of the campaign carried on by the city. A sanitary campaign was planned with the double object of checking the epidemic and restoring public confidence. Much of the work was based on my experience in the typhoid epidemic at Ithaca, N. Y., where I acted as the official representative of the State Board of Health and initiated through the local Board of Health an active campaign against the fever. I had been called to the Ithaca work, apparently, because I had had some experience with typhoid when I was the sanitary engineer of the New York City Department of Health.

The measures for controlling the epidemic which were carried out at Watertown during my connection with the city were largely based on the results of Koch's now famous studies at Trier, and the opinion which had grown out of my experience, that typhoid is not only infectious, but contagious, and transmissible from person to person.

The immediate objects of the campaign were the prevention of infection through the river water and from cases of typhoid already in the city. It was accepted by me as abundantly proved that the water supply had given rise to the original cases.

I advised that every typhoid patient be sent to hospital or

strictly isolated at home. No patient should be discharged from medical care until bacteriological tests showed that his excretions were no longer dangerous. All mild and suspicious cases of fever should be treated like typhoid. Secondary sources of disease, such as contaminated wells and milk supplies, were to be guarded against. All infectious matter should be destroyed by disinfection at its source. It was not practicable to put all these measures into effect; at least, not at once; nor ever with that completeness which was desirable. They were, nevertheless, kept always in mind and give the key to the principal work which was done by the Board of Health during my connection with it.

The sanitary work of the inspectors acting under the direction of the State Department of Health on the drainage area of the Black River and the natural flow of the river during two months of time seemed to me to have been sufficient to have removed every source of danger from the public water supply which it was practicable to remove. Still, in order to obtain the greatest measure of safety procurable, various steps were taken to secure protection from the public water supply. The distributing mains were flushed from the hydrants, one section of the city being taken at a time, and the work done in a thorough manner. The people were urged to continue to boil that portion of the water which it was necessary to use for drinking, dish-washing, and other purposes which might, by any possibility, lead to infection. The builders of the filtration plant were requested to push the completion of their work so that the plant could be made available at the earliest date.

Spring water supply. A supply of drinking water from springs of proved purity in the outskirts of the city was established and the water peddled from house to house at the nominal cost of one cent per gallon to the consumers. The price received for this water did not quite cover the expense of supplying it, but the outlay was trifling compared to the benefits received. As I had found in the epidemic at Ithaca, the distribution of spring water was greatly valued by the people.

To bring the water from the springs and deliver it from house to house a number of tank wagons were built. The tanks were made of galvanized iron of cylindrical shape. The capacity of these

tanks varied from 100 gallons to about 400 gallons each. They were filled through an opening at the top which was large enough to admit apparatus for cleaning. Each tank was sterilized at least twice a week with steam from a large paper mill in the central part of the city. The quality of the water was determined by daily analyses made from samples taken from the delivery wagons. The water was drawn from the tanks by means of large faucets.

At one time ten wagons were required to supply the demand for water. To facilitate the sale of the water, tickets were sold in quantity; these were exchanged by the water peddlers for the number of gallons wanted at each house. The tickets were used but once. The wagons followed fixed routes laid out on maps. Most of the city was covered in this way three times a week.

Examination of wells. Lists were made of the wells situated on private premises and on business property and arrangements were made to examine these waters. This examination consisted of, first, an inspection to determine the kind and depth of the well, its location with reference to houses, stables, and privies; the nature of the soil, and other points which would aid in interpreting the data obtained from an analysis of the water. At a later date a representative of the Board of Health visited the well and collected a sample of the water in a sterilized bottle. This sample was generally analyzed within four hours. It was examined for chlorine, hardness, number of bacteria, and the presence of coli by the presumptive test. An opinion was drawn from the results of the analysis and the record of the inspection and this opinion was then communicated to the owner of the well by postal card. Some wells were examined several times. Most wells were of unsatisfactory quality. It was necessary in a few cases to condemn and order wells closed. This was always done after a full discussion of the circumstances before a formal meeting of the Board of Health, the well being provisionally closed from the time when its condition was first determined.

Hospital arrangements. Owing to the unusual number of patients requiring to be accommodated, and the limited amount of space available for them, the two regular city hospitals were, at the height of the epidemic, greatly overcrowded. The City Hospital with forty regular beds had sixty patients. A hospital

operated by an order of Sisters of Charity, with thirty-five beds under normal conditions, was caring for fifty patients. The insanitary conditions which generally obtain in overcrowded fever hospitals were unmistakably exhibited in both of these institutions. A succession of cases of a peculiarly malignant form of erysipelas, generally accompanying typhoid, occurred in the City Hospital and in the Sisters' Hospital. Neither hospital had proper means of isolating cases of contagious disease. It therefore became necessary for the Board of Health to make arrangements for the accommodation of erysipelas and typhoid cases elsewhere. This work was done with the utmost dispatch.

Through the cordial coöperation of the Department of Charities, the headquarters of the Department on Massey Avenue were vacated and quickly made available for the erysipelas patients.

In preparing this house for its new use, every movable article was first taken out. The floors were then cleaned and painted,

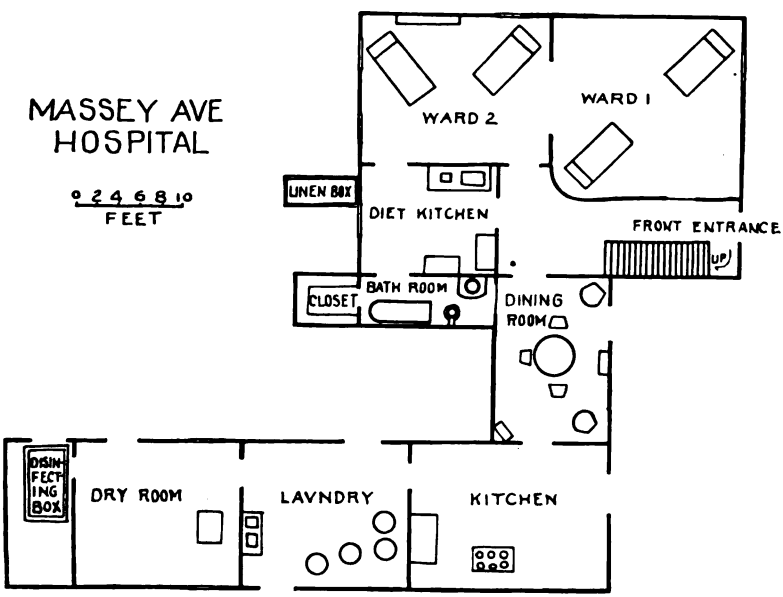

FIG. 9. Temporary Hospital on Massey Avenue opened for the Care of Erysipelas Patients, chiefly sent from the Overcrowded Permanent Hospitals of the City.

the plumbing overhauled, a disinfecting chamber large enough to contain a double mattress was constructed, a laundry was fitted out, and the house was furnished with high beds and all other appurtenances of a first-class temporary hospital. (See Fig. 9.)

In drafting the hospital regulations for this house, three general principles were kept prominently in mind: First, every part of the building was to be kept in a state of surgical cleanness. Second, no excretions, bedding, food, clothing, or other possible source or vehicle of infection was to leave the building, or the ward, if that was practicable, without disinfection. Third, every window and door was to be kept open as much as possible, and the patients, protected by screens, were to be given as much fresh air as they and their attending physicians would permit.

The results were entirely satisfactory. The disease did not spread to any of the attendants or nurses as had been the case before this temporary hospital was opened. Eleven severe cases of erysipelas were treated in this hospital. Seven were complicated with typhoid fever. The majority were in an advanced stage of the disease when admitted. One patient died. The rest recovered.

In order properly to care for the typhoid fever patients who could neither be accommodated at the permanent city hospitals nor isolated satisfactorily at their homes, a special typhoid hospital was opened. Much difficulty was experienced in finding a suitable building for this purpose. It was finally decided to use a new high school building which had just been completed at a cost of about $100 000, but not yet equipped with school furniture. Serious objection to this proposition was made by the Board of Education, but the health authorities decided that its conversion into a hospital was a necessary step and took temporary possession of the property.

The class rooms on the main floor of the school building were divided into male, female, and children's wards. A surgical ward was equipped and kept ready for emergency in case operations for perforation became necessary. Each patient had a minimum of 64 square feet of floor space and 770 cubic feet of air space. Separate rooms were reserved for patients who were very sick. Diet kitchens with gas stoves and instantaneous water heaters were established in the main hallways. Accommodations for the nurses

were provided on the second floor. A kitchen, a dining room, and a laundry were arranged in the cellar; later, the dining room and kitchen for the nurses and attendants were moved to the top floor. (See Fig. 10.)

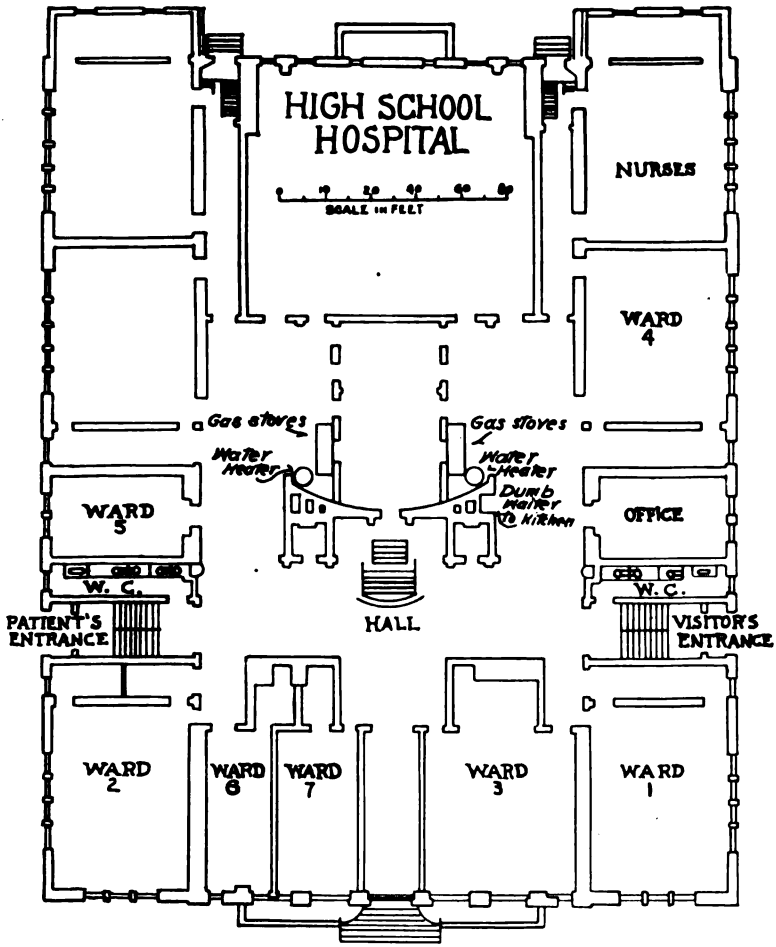

FIG. 10. The School Building which was taken by the Board of Health and turned into an Emergency Hospital for Typhoid Patients. About one hundred patients were treated. No case of typhoid occurred among the nurses, doctors, or attendants.

Rules and regulations for the management of this hospital were drafted on similar lines to those adopted for the erysipelas hospital, but they were less severe. Abundance of air in all parts of the building, thorough cleanliness in the wards, halls, closets, and nurses' dormitories, and prompt disinfection of the excretions and articles possibly contaminated with the excretions, and skillful nursing were the principles most insisted upon.

The disinfectants used were fresh milk of lime for the stools and urine, and 1 to 1 000 bichloride of mercury solution for cloths, hands, and floors. Sheets, pillow cases, and the garments of the patients, when removed, were placed in cloth bags at the bedsides and taken at once to the cellar where they were disinfected and washed. Sputum and cloths soiled with excreta, urine, or sputum were put into paper bags at the bedsides and removed in iron ash cans to a furnace in the building and burned. The cups, dishes, spoons, and other articles used in feeding the patients were kept separate for each case and regularly sterilized by boiling. The floors of all the wards were mopped with 1 to 1 000 bichloride each day. No sweeping was permitted in any part of the building. Care was taken to avoid the production of dust, by the use of damp cloths. No receptacles for milk or water were allowed to leave the building. The hospital was furnished with a fresh supply of spring water daily.

Dr. Philip C. Washburn, a graduate physician, was placed in charge of the hospital. Dr. Washburn slept in the building and was thus able to render prompt and valuable emergency aid on several occasions at the bedsides of the patients. Fortunately, no surgical operations were required. Besides Dr. Washburn, Drs. Spencer and Bibbins, prominent members of the medical profession in Watertown, kindly volunteered to serve as official medical consultants in case of need. The presence and advice of these gentlemen in connection with the medical care and nursing of the patients proved to be of great value.

None but picked graduate nurses was employed at either of the two hospitals conducted by the Board of Health. With a single exception they proved themselves capable, conscientious, and unfailing in the performance of their duties. The total number of nurses employed was 22, of which 17 were connected with the High School hospital and 5 with the erysipelas hospital.

FIG. 1. Massey Avenue Temporary Hospital, used for Erysipelas Patients. Strict isolation and disinfection were practiced. No one contracted erysipelas from these patients after they were brought here.

FIG. 2. New High School on Sterling Avenue, used as an Emergency Hospital for Typhoid Patients. About one hundred patients were treated here, mostly on the first floor.

The number of typhoid patients treated at the High School hospital was 97. There was but one death. None of the employees contracted the fever.

The expense of equipping and maintaining the hospitals was borne by the city. Each patient or his friends was expected to pay what he could afford for the nursing and care which the city provided, reckoned on a basis of $4.00 per week. Medical attendance was extra, and, except in indigent cases or emergencies, was provided by the patient or his family. Any physician in good standing was permitted to send and attend cases of typhoid at this hospital. For the removal of the patients from their homes, a specially constructed ambulance was provided without charge.

It is impossible to refrain from referring to the valuable help given by the ladies of Watertown in fitting out these two hospitals. Much help in the way of purchasing supplies, sewing, and aid of a kind that men cannot give was contributed by them with a promptness and generosity which added much to the success of the undertaking.

The bacteriological laboratory. A bacteriological laboratory was established for the analysis of water, milk, blood, urine, and other work in connection with the suppression of the epidemic. All the apparatus was of the best quality and purchased new. Dr. Herman Requi, of the University of Chicago, was placed in charge of the laboratory and was given enough help to enable him to turn out prompt and accurate reports. The work of this laboratory was done at the expense of the city and without charge to any individual.

Widal examinations to assist in the diagnosis of suspected cases of typhoid fever were given first place in the routine of the laboratory. No limit was placed upon the number of examinations which would be made for any physician or patient. If a specimen of blood reacted negatively, the physician who sent it was advised to furnish another specimen from the patient at a later date.

As I had found elsewhere, the only practicable way to obtain many specimens of blood for the Widal test was in the form of drops of blood dried on cards. Several races of typhoid and typhoid-like bacilli were kept in culture and were used when the

ordinary typhoid bacillus failed to agglutinate in proper dilution with the serum dissolved from the dried blood. Up to April 21, there had been examined 251 samples of water, 98 specimens of blood, and 95 specimens of urine.

Board of Health disinfectants. Disinfection was practiced in several ways. At the outset an effort was made to introduce uniform methods of disinfection in as many of the fever houses as possible. Because of the unreliability of the proprietary disinfectants sold in the shops, the Board of Health established a central disinfectant bureau and from this point distributed, without cost to the consumers, disinfectants throughout the city. Several wagons were employed to carry freshly slaked lime and concentrated bichloride of mercury to each house in which a case of typhoid fever was known to exist. Every fever house was thus visited twice a week, sometimes oftener. The disinfectants which were sent out on the wagons were known as "white fluid" and "blue fluid," and were of such concentration that, upon adding to either four times its volume of water, it would be of proper strength for use. The milk of lime, or white fluid, when ready for use, was composed of one part of freshly slaked lime to eight parts of water. The bichloride of mercury solution employed consisted of one part of bichloride of mercury to one thousand parts of water; this was made acid with hydrochloric acid and colored blue with common washing bluing. Directions for using both of these disinfectants were printed in large type on stout sheets of cardboard and left at each house where the disinfectants were employed.

Fumigation with formaldehyde was performed by the Board of Health at each house after a case of fever unless there was good reason to believe that this precaution was unnecessary. The method of generating the formaldehyde first used was that regularly employed by the Watertown Board of Health. It consisted in the use of a lamp with paraform pastils from which the gas was expelled. Later, because of the large number of houses which needed to be fumigated, a more rapid method was adopted. After the room had been closed as air tight as possible, and rugs, draperies, bedding, and other similar articles had been hung on chairs or suspended in the middle of the room, a large sheet was hung up. From a small watering pot there was then poured upon this sheet

a solution of formalin of 40 per cent. strength, in the proportion of at least 3 pints for every 1 000 cubic feet of air space, not allowing for the space taken up by the furniture and other articles in the room. After twenty-four hours all the windows were opened and the place thoroughly ventilated for at least two days. A careful scrubbing of the woodwork with soap and water and a brushing of the upholstery and drapery followed.

As a test of the efficiency of the fumigation, threads freshly impregnated with typhoid bacilli from twenty-four hour broth cultures were exposed in the room during the vaporization of the formaldehyde. After the disinfection the threads were immediately placed in sterile broth in the laboratory. If there was no growth this was taken to mean that the fumigation had probably been sufficient to destroy such bacilli of typhoid as may have been in the room as a result of its occupancy by the typhoid fever patient.

Other sanitary measures. The steps thus far described were the principal ones taken to prevent the spread of the fever, but they were not all. In many other ways the Board of Health endeavored to check the epidemic. The physicians were urged to report their cases accurately and promptly, and if they did not all comply, it was less the fault of the local board than to the neglect of this custom which commonly prevails in American cities.

Complaints of alleged nuisances were diligently investigated, and an effort made to have all houses and back yards put in order. The regulations of the Board of Health were revised, collated, and digested. The questions of garbage collection and disposition were studied, and the existing and other possible means of disposing of household wastes were inquired into.

Learning that smallpox existed in the vicinity of Watertown, an isolation hospital on the outskirts of the city was kept especially for the reception of patients suffering from this disease. Fortunately, it was not needed, but in anticipation of an emergency it was overhauled, cleaned, and put in readiness.

The sanitary awakening which resulted from the epidemic was the more remarkable from the fact that Watertown had been, in spite of its long and sinister typhoid history, a more than ordinarily well-regulated city.

Coöperation received in the sanitary campaign. As soon as the Board of Health began active work for the control of the epidemic, gratifying evidences of coöperation became apparent in many directions. The hospital authorities asked the board for help in difficulties connected with the overcrowded conditions of the hospitals, and offered such aid as they could give in other directions. Requests came from the press and the pulpit for interviews and addresses on sanitary topics. Organizations, corporations, and private citizens tendered their services and desired to be instructed in ways in which they might be of assistance in the general sanitary campaign. It was thus comparatively easy to carry to the people a knowledge of those principles of sanitation which were peculiarly applicable to the situation.

In endeavoring to give the instruction desired, particular emphasis was placed upon the value of simple but thorough methods of cleanliness and order, indoors and out. It was early pointed out that it was desirable that the storm doors and windows which had closed many houses from the outer air during the whole of the long, severe winter be removed as soon as possible. As the spring advanced, the people were advised to begin their annual housecleaning early and make the work more than ordinarily thorough. Improved methods of collecting and disposing of the wastes so produced were undertaken by the city.

On the educational side, conferences were held with the physicians who practiced in Watertown and vicinity, and addresses were made before the local medical societies. The subjects dealt with on these occasions included the discussion of the nature and origin of typhoid fever; the paths and channels by which the infectious germs are communicated; the value of the Widal test; the importance of watching the urine for typhoid bacilli; the need and methods of eliminating typhoid germs from the urine when found; the necessity for sending to the Board of Health prompt and accurate reports of cases of typhoid fever; disinfection; the purification of water and sewage and the disposal of garbage and other municipal wastes.

From the first the physicians coöperated with the health board in a most encouraging and helpful manner. It is largely due to the help thus received that the work of the Board of Health was

successful and the number of cases of comrade or house infection was kept small.

The Chamber of Commerce and various other less prominent bodies entered cordially into the work. The Chamber, in fact, had been largely instrumental in causing the sanitary campaign to be undertaken.

The officers of the St. Regis Paper Company of Deferiets placed themselves under the direction of the Board of Health and carried out in the village surrounding their plant a careful plan to exclude infectious matter from continuing to enter their sewers which flowed into the Black River.

Charles F. Bingham, mayor; John B. Rogers, president of the Board of Health; Dr. E. S. Willard, health officer; and Mr. Theodore Ely Knowlton, representing the Chamber of Commerce, were indefatigable in giving personal attention to the work. To all the employees of the board credit is due for services of an unusually arduous nature; it is impossible to name all, but a special word of appreciation belongs to E. J. DeLong, principal office assistant.

DISCUSSION.

THE PRESIDENT. The paper is now before the Association for discussion. Perhaps Dr. Sedgwick will speak to us first.

PROF. WILLIAM T. SEDGWICK.* Mr. President and fellow members: It has been said repeatedly that the human race does not seem able to learn by recorded experience. It has got to suffer and learn by its own repeated and individual personal experience. And it seems to me that this epidemic wonderfully illustrates that point. The date of the epidemic was comparatively recent; and ever since 1885, when the great typhoid epidemic took place at Plymouth, Pa., it had been as clear as daylight to anybody that it was not wise to drink polluted water. Nevertheless, here was one of the proud cities of New York which continued to do that in full face of all the danger that must necessarily be connected with drinking it. It was apparently necessary for that city to sacrifice a lot of lives in order to be brought to the point of cleaning up its water supply.

There is nothing peculiar to Americans in this. It was the same

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in Hamburg in 1892. Hamburg had long been using a highly polluted water; typhoid was very high, and other diseases were abnormally high; but it took an epidemic of Asiatic cholera of international fame to cause the introduction of a purified water supply into that city. It seems to be a characteristic of civilized man everywhere that he is not able to learn by recorded experience.

We are having the same sort of experience with our schoolhouses to-day. It took the sacrifice of one hundred and sixty children in the central part of the country to teach school boards everywhere that it was important to look out for exits from schoolhouses and to have fire drills rightly conducted. I suppose to-day the lives of all school children are infinitely safer with respect to fire than they were a month ago, because of the sacrifice of these victims.

The moral of all these things is that we need to keep high standards in water supplies, and in every branch of civilized life; that we need better administration, we need higher moral tone among those charged with public responsibilities. And I believe that this Association has long stood for that higher tone. I believe there is not a member of it who, if supplying water under the conditions described by Dr. Soper, would not spend wakeful nights, and possibly even resign his position, rather than continue to supply water to his people in the face of dangers as grave as those which confronted Watertown. If there be any such man, it is high time he resigned his place. We have got to keep high standards in this matter, and I think we are all indebted to Dr. Soper for making that fact so clear to us. There is nothing new in the water pollution part of his story. We all know that it is the same thing which we have heard over and over and apparently have got to hear for many years to come, before we in America, and others in other parts of the world, learn that it is not safe even for one day to continue the consumption of a water exposed to serious pollution without first purifying that water and protecting it in some way.

Dr. Soper's great work has been in showing that typhoid fever ought to be treated as a contagious disease. If I am not mistaken, his work has been more thorough in this respect than that of any member of this Association, and probably of any other man in this country. And it was also early work. In his very effective

measures applied at Ithaca, and repeated here at Watertown, he has shown from the start a logical mind in that he has been led to carry through to the uttermost the obvious measures which were required to drive typhoid fever out of a community; and I know of no one who has been so painstaking and so thorough in this respect.

It happens that his work is just now extremely timely because, owing to the emphasis at present laid upon typhoid carriers, and for various other reasons, mainly bacteriological, which I need not stop to detail, the world is waking up to the fact that typhoid fever ought to be treated as a contagious disease. And here again we have to say that we have been very slow, all of us, and perhaps reprehensible even, in having put off so long the recognition of this fact, and the pushing of it to its logical conclusions, for the moment we examine the history of typhoid fever we find that from the very beginning it was recognized by many who investigated it to be a highly contagious disease.

We water-works people, however, are to be pardoned in large measure in this direction, because physicians have for a long time been in the habit of saying, when called to a family having typhoid, and when questioned as to the danger for the other members of the family, " You need have no fear; typhoid is not a contagious disease, it is only infectious." These physicians were in the wrong, as we know to-day, and as we might have known for a good while if we had only given heed to the best of physicians. It is a curious and interesting fact that when typhoid was first worked out in 1829, and separated from jail fever and ship fever and the other forms of typhus fever with which it was previously confounded, — I say it is an interesting and it has been an unfortunate fact, that a large part of the differentiation between the two was made to consist in the fact, or the alleged fact, that typhus fever, the old-fashioned jail and ship fever, is contagious, while typhoid is not. Now in a very rough and rude way that is true. Typhoid is not as contagious as typhus is, and it is not as contagious as smallpox or scarlet fever or as a good many other of the so-called and admittedly contagious diseases. But owing to the emphasis laid upon this differential point between the two diseases, physicians themselves took the ground that typhoid was comparatively

non-contagious and typhus comparatively contagious; and, as time went on, the idea was spread abroad, very naturally, that typhoid is not contagious, and physicians generally have thought so and have said so over and over again. Whereas, the truth is this: Typhoid is not as contagious as many other diseases, but it is truly contagious, nevertheless. It is a contagious disease, and it is a matter of satisfaction to me, and must be to every one who has treated it as such for a number of years, that some of us, at any rate, have said so, and were in print years ago as having insisted on that fact.

Now Dr. Soper, fortunately free from traditional prejudice in this matter, and following up the logical conclusions drawn from bacteriology, no doubt, has from the outset acted as if typhoid is practically a contagious disease, and as if the way to fight it is to treat it as such; and in his work at Watertown and at Ithaca and elsewhere he has honored the water-works profession, and the laity, of which he is a member, by having acted up to his convictions. Therein lies his distinction, because some of the rest of us who have known the facts, perhaps just about as well, have not so acted, or, at least, have not acted to the same extent. And I am glad he showed you in somewhat elaborate detail his hospitals of various sorts, and that he has told in his paper of the pains taken to disinfect and to get rid of infection. This is most honorable to him as an engineer and as a member of the water-works profession. In doing this he has actually led the way for boards of health to-day. It required a man like him to teach the Watertown board of health how to handle an epidemic of this sort. And the same thing was true in Ithaca, I believe, and elsewhere.

We have here the rounded whole. We have the clear proof of water infection; we have then the scientific and logical following through to the uttermost of the consequences of that conclusion, with insistence upon such a treatment of the epidemic as is required by our modern knowledge. The bacteriological progress which has been made, and especially certain discussions in Germany, have shown that it is easy to find the causal germ in early stages of the disease. And boards of health are beginning to wake up to the fact that typhoid has got to be treated in every respect as a contagious disease. Though admitting that it is not as con-

tagious as some other diseases, it is still to all intents and purposes contagious.

From another point of view, work of this kind tends to shed light upon that residual amount of typhoid fever which remains in a community after the water supply is perfected. In the case of Washington, for example, I have no doubt that it will eventually turn out, as the editorials in *Engineering News* have encouraged us to believe, that a large part of the typhoid fever still lingering there, after the water has been thoroughly purified, will prove to be spread by ordinary, old-fashioned contagion. All of which is important for us as water-works men. If typhoid fever in Washington remains high after a good filter is introduced, discredit falls perforce upon the filter. We need to know about this residual typhoid; we need to know what causes it, and if by proper disinfection and proper treatment, such as Dr. Soper has so very well outlined, we are able to reduce typhoid fever in any community to zero, or very nearly to zero, as I believe we shall be able to do when once these processes of disinfection have been installed, then the work will be of value not only as a lesson to boards of health, but as serving to protect those of us who are interested primarily in pure water. In more than one instance it has turned out that the purification of the water supply has not adequately diminished typhoid fever in the city affected, and one of the reasons is, apparently, a lack of this very thoroughness, this masterly grasp of details, which Dr. Soper has shown can be made effective, and which he was one of the first to display. It is for this reason, it seems to me, that the paper is of special value and of much timeliness, and I, for one, feel greatly indebted to Dr. Soper for his careful presentation of it here and now.

PROF. C.-E. A. WINSLOW.* Dr. Soper's account of the Watertown epidemic has interested me greatly and I am sure that others must feel, as I do, gratified that he should have reported his investigations through the medium of the New England Water Works Association. We have all of us grown to look with the pleasantest anticipations to Dr. Soper's visits to Boston, for he has always something to tell us which we want to hear.

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The Watertown case as presented to-day appeals to me particularly as an indication of the new attitude which sanitarians are rightly adopting toward typhoid fever. Here is primarily a water-borne epidemic, and yet most of Dr. Soper's paper has dealt with preventive measures which have nothing to do with water supply. This means that the views which Professor Sedgwick and I had the honor to present to this Association in 1906 * have gained general acceptance to-day and that sanitarians now realize that water is only one factor in the causation of typhoid fever. In many communities this disease has no relation whatever to water supply, and even where polluted water is the prime cause, its influence is multiplied and extended by a host of other channels of infection.

The water-borne typhoid is easy to deal with. Cities which continue to drink sewage do so with their eyes open or in willful and deliberate ignorance. The factors which produce prosodemic typhoid, on the other hand, typhoid which spreads from person to person by various vehicles, are much more obscure and less easy to control. It is fortunate that in this particular case the authorities of Watertown atoned for their early neglect by prompt remedial measures after the epidemic of 1904. It is significant that in so doing they did not content themselves with retaining the ablest engineering talent in connection with purer water, but called in also our guest of the afternoon, who has made a national reputation as a specialist in the eradication of residual typhoid.

It is this prosodemic or residual typhoid which now constitutes the great bulk of the disease in the United States. Even in Watertown since the filtration of the water supply it still causes excessive death-rates, according to Dr. Soper's figures. Rates of 50 per 100 000 in 1906, and of 37 per 100 000 in 1907, demand some explanation. The truth is, we are only at the beginning of our knowledge of typhoid fever, in spite of the fact that probably no disease except tuberculosis has received so much attention. There is one factor in particular to which almost no attention has hitherto been paid, but which I am inclined to think is soon to receive a new share of attention, and this is the varying predisposition of the

* JOURNAL, March, 1906, Vol. XX, p. 51.

host. I should like to occupy a moment in calling your attention to this neglected point.

It is well known that typhoid fever, where not due mainly to polluted water, follows the curve of temperature with remarkable closeness. Recent investigations at Washington and at Youngstown, Ohio, have shown this with great clearness, and the phenomenon appears to be a universal one all over the world. Comparing different geographical areas, too, it is well known that typhoid on the whole is most prevalent in warm climates, but I did not myself realize how close this relation was until I analyzed, a day or so ago, the census returns for the Atlantic states according to their geographical position. As indicated in the table below, the typhoid rates for the white population average in the North Atlantic states about 30 per 100 000, and, with the exception of Pennsylvania, lie between 17 and 31; Pennsylvania's high rate of 44 is, of course, due to the large quantity of polluted water which was consumed in that state in 1900. The second group of states from Ohio to North Carolina shows an average death-rate of 54, and the individual rates range from 42 in Maryland to 76 in Kentucky. Finally the southeasterly and Gulf states show an average death-rate of 81, with individual variations from 57 in Florida to 93

TABLE V.

TYPHOID IN THE ATLANTIC STATES IN RELATION TO LATITUDE.

Death-rate per 100 000. Among whites only.

(United States Census for 1900.)

NORTHERN GROUP.		MIDDLE GROUP.		SOUTHERN GROUP.	
State.	Typhoid Rate.	State.	Typhoid Rate.	State.	Typhoid Rate.
Maine,	29	Ohio,	43	Tennessee,	84
New Hampshire,	17	Maryland,	42	South Carolina,	72
Vermont,	31	Delaware,	53	Georgia,	80
Massachusetts,	22	Dist. of Columbia,	69	Florida,	57
Rhode Island,	24	West Virginia,	62	Mississippi,	87
Connecticut,	27	Virginia,	48	Louisiana,	71
New York,	25	Kentucky,	76	Alabama,	93
Pennsylvania,	44	North Carolina,	70		
New Jersey,	21				
Group,	30	Group,	54	Group,	81

in Alabama. Of course such gross death-rates as these are affected by many other factors than temperature. The water supplies in individual cases are worse than in others, but on the whole I think there can be no doubt of the general lesson to be drawn from this table. Pennsylvania, with its heavily polluted water supplies, is found, it will be noticed, in the northern group, and the District of Columbia in the middle group. There seems no escape from the conclusion that there is a striking direct relation between temperature and the prevalence of typhoid fever.

In reviewing the question of seasonal prevalence in 1902, Professor Sedgwick and I were inclined to explain the autumn maximum as follows:

"The bacteriology and the etiology of typhoid fever both indicate that its causal agents cannot be abundant in the environment during the colder season of the year. The germs of the disease are carried over the winter in the bodies of a few patients and perhaps in vaults or other deposits of organic matter where they are protected from the severity of the season. The number of persons who receive infection from the discharges of these winter cases will depend, other things being equal, upon the length of time for which the bacteria cast in these discharges into the environment remain alive and virulent. The length of the period during which the microbes live will depend largely upon the general temperature; as the season grows milder, more and more of each crop of germs sent at random into the outer world will survive long enough to gain entry to a human being and bear fruit. The process will be cumulative. Each case will cause more secondary cases; and each of the latter will have a still more extensive opportunity for widespread damage. In our opinion the most reasonable explanation of the seasonal variations of typhoid fever is a direct effect of temperature upon the persistence in nature of germs which proceed from previous victims of the disease."

My own confidence in the theory that the seasonal prevalence of typhoid is due to the effect of temperature upon the germ alone was somewhat shaken by a study of the admirable report upon the origin and prevalence of typhoid fever in the District of Columbia by Dr. Rosenau and his associates, published by the Hygienic Laboratory of the Public Health and Marine-Hospital Service. It appeared that in 1906 the typhoid curve did indeed follow in general the relation of the temperature, but that its greatest rise was not gradual but sharp, coinciding with the period of extreme hot

weather in the middle of July. The conception of the seasonal curve as due to the action of temperature upon the germ in the environment presupposes a very gradual change, and it is difficult to see how a sudden period of hot weather could produce a sudden reaction. If, on the other hand, the temperature affects typhoid incidence in part by a direct lowering of the vital resistance of the host, such a phenomenon might be expected. I have recently come upon striking confirmatory evidence of this latter theory. An extremely suggestive monograph on enteric fever in India has recently been published by Major Ernest Roberts of the Indian Medical Service (Calcutta: Thacker, Spink & Co., 1906). In this most important contribution to the etiology of typhoid fever, Major Roberts emphasizes his own belief in the importance of the vital resistance factor in the spread of typhoid. As he puts it: "Both host and parasite are definitely subject to the influence of the environment as it produces any seasonal changes; that both live and thrive by adaptation only; and that the problem of acclimatization or colonization is the same for both, — a contest for supremacy by immigrant races." The most striking evidence which Major Roberts adduces for the support of this view is included in the following table which shows that whereas the typhoid among the European troops in India follows the general rule and is concentrated in warm weather, that in the native troops follows an exactly reverse course. This seems difficult to explain on any theory of germ distribution. If germs are most abundant in warm weather they should affect both English and natives at that time. If, on the other hand, the relation of temperature to vital resistance of the host is a prime factor, we might expect just such a relation as is indicated in the table. Certainly English troops must be much more affected by the hot weather of India than the natives, and it is possible that the natives may in their turn be unfavorably affected by the colder season in many parts of the peninsula.

TABLE VI.

PERCENTAGE OF TOTAL MORTALITY.

	HOT SEASON. (May to Oct.) Per Cent.	COLD SEASON. (Nov. to April.) Per Cent.
European troops	62	38
Native troops	37	63

It seems to me clear that we have in the etiology of typhoid to reckon with three factors: First, the number of active germs present in the environment; second, the vehicles, water supply, milk supply, filth, etc., available for transmission of germs to the patient; and third, the vital resistance of the patient himself. It is perfectly possible according to this theory for an individual in good health to receive typhoid germs without succumbing to the disease, just as we know to be the case in tuberculosis and other disorders of the respiratory tract. A period of extreme hot weather, on the other hand, either by direct effect on the organism or through favorable indirect influence on fermentations in the digestive tract, upsets the defensive mechanism of the alimentary canal and we get a sudden sharp increase of typhoid fever. This, without in any way excluding the direct effect of temperature upon the germ in the environment, helps to explain the prevalence of fall fever and the increase of typhoid in warm climates. It helps also perhaps to explain the general excess of typhoid fever in this country as compared with that which obtains in northern Europe. It still remains true that a very large amount of the typhoid which exists in this country constitutes a national reproach. The prospects for the future, however, are bright and we may look to see residual typhoid wiped out in the future as water-borne typhoid is rapidly being eliminated to-day. When this is done it will be by just such forceful and thorough and painstaking campaigns as that which Dr. Soper has carried out at Ithaca and Watertown.

Mr. George C. Whipple * (*by letter*). The writer has been interested in reading Dr. Soper's paper, partly because of his general interest in the subject of epidemics and their relation to public water supplies, and partly because he is familiar with the present conditions in Watertown. From the facts which have been so ably presented many important lessons may be drawn. Some of these have been already mentioned by Professor Sedgwick and others. The more that epidemics of typhoid fever are studied, the more sanitarians are coming to appreciate the fact that this disease is contagious as well as infectious. In every large epidemic many of the cases, especially the late cases, are

* Consulting Engineer, New York City.

caused not by the original infection, but, as we say, by " secondary infection," that is, by direct contagion from early cases. This was strikingly shown in the typhoid fever epidemic that occurred in Gelsenkirchen, Germany, a few years ago. This epidemic was caused by an infection of the public water supply, but a careful study of the situation showed that a large proportion of the cases that developed near the end of the epidemic were due to contagion. This is interestingly shown by the following diagram, Fig. 11.

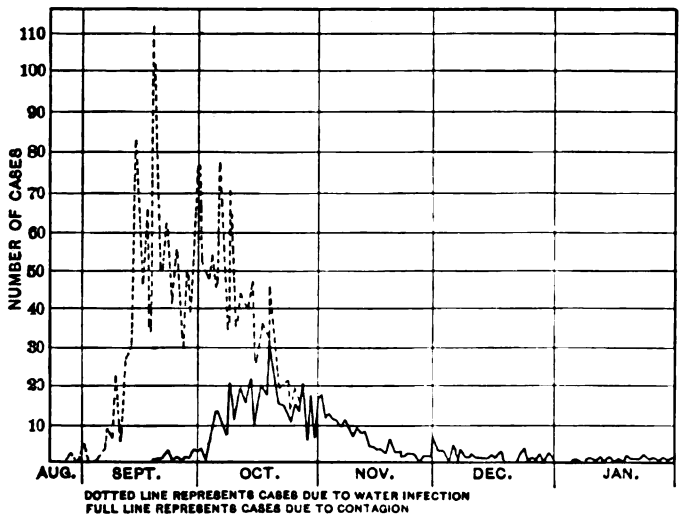


FIG. 11. DIAGRAM SHOWING THE PROGRESS OF THE TYPHOID FEVER EPIDEMIC IN GELSENKIRCHEN, GERMANY.

It was the prevention of these cases of secondary origin to which the work of Dr. Soper in Watertown was chiefly directed. How far he was successful in accomplishing the result cannot be definitely shown from the data presented, but there is no reason to doubt that many lives were saved by the sanitary reforms that were inaugurated under his direction.

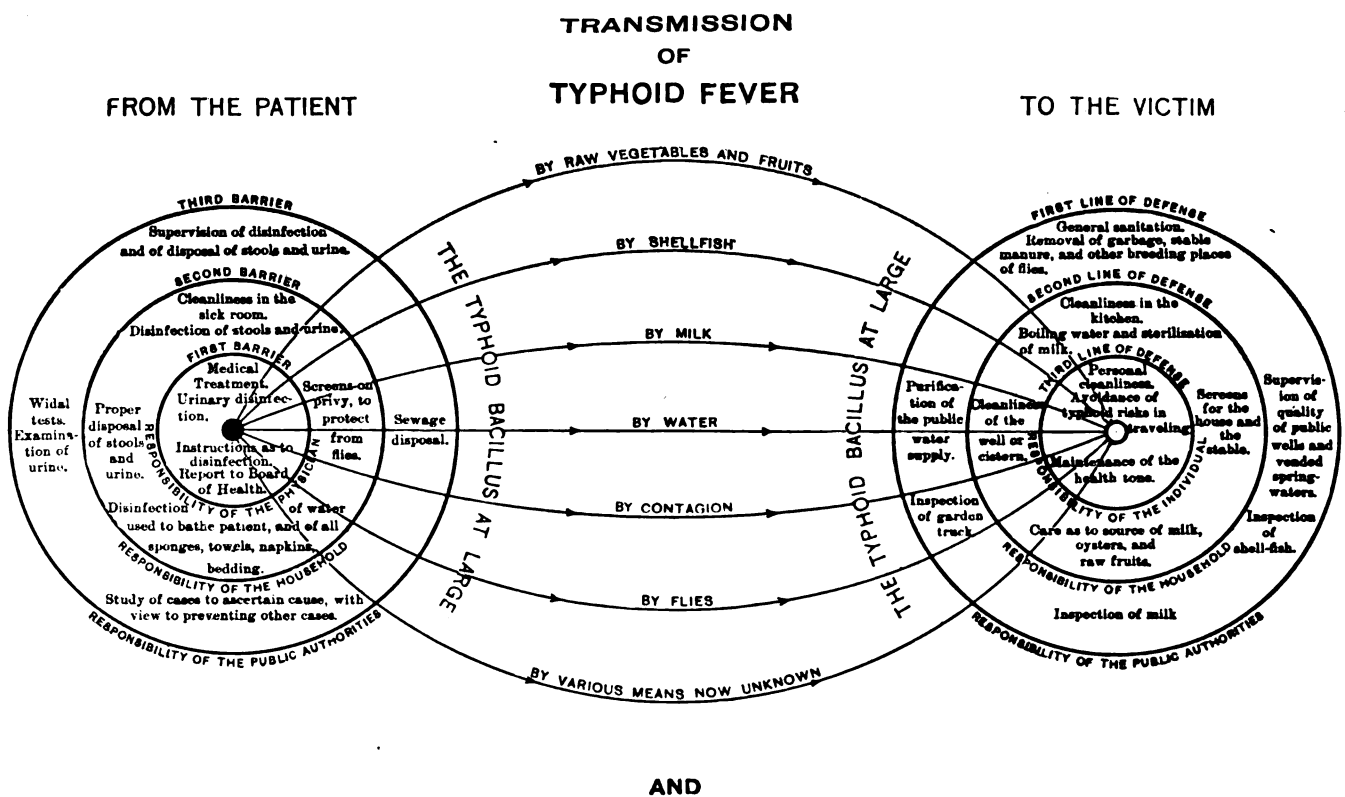
It was unfortunate for the city that more stringent measures to quell the disease were not taken earlier in the history of the epidemic. The long duration of the epidemic shows that the water supply must have been in a continually infected condition for many weeks, as the city had but a small storage reservoir and

the water was pumped for most part directly into the mains. Apparently the measures taken to avoid the secondary cases were more elaborate and probably more effective than those taken to do away with the infection of the river water. The early history of the epidemic is an illustration of the procrastination which so frequently occurs even in the most intelligent communities. Apparently the epidemic had been running for nearly a month before any active measures were taken to get control of the situation. It would seem as if the occurrence of more than twenty cases during the first three days of January would have been followed by an immediate investigation. In these matters, however, the city of Watertown is not very different from other communities, nor can it be claimed that the officials were more lax than they are in most cities. In all health departments there is a tendency to regard the reported cases of infectious diseases as facts for history rather than as facts for prophecy. Such data are valuable for purposes of record, but they are far more valuable as indications of what is likely to happen in the immediate future. Unless the data reported by physicians are carefully studied from this point of view they lose a large part of their value.

Of the methods used by Dr. Soper in checking the epidemic little need be said, as they speak for themselves. The ways in which the typhoid fever germ is transmitted are now pretty well understood, and the methods of preventing these germs from finding their way from some patient to a new victim are pretty well known by water-works men, and have been the subject of repeated discussion in this Association. The writer is inclined to think that up to the present time too little attention, perhaps, has been given to the barriers that should be established to prevent the scattering of the germs from the patient; that is, to disinfection. The stamping out of this disease can only be done by coöperative work, in which physicians, nurses, engineers, and many others play a prominent part. In order to illustrate this fact the writer has made use of the simple diagram which is here presented, Fig. 12.

Mention has been made of the fact that a filtration plant was put in operation in Watertown in 1904.

Since the introduction of this filtration plant the typhoid fever



AND

MEANS OF PROTECTION

FIG. 12. (FROM "TYPHOID FEVER: ITS CAUSATION, TRANSMISSION, AND PREVENTION," BY GEORGE C. WHIPPLE.)

death-rate has been very materially decreased. It has not fallen quite as low, however, as it has in some other cities after the water has been subjected to purification. This has been due partly to the occurrence of cases apparently caused by contagion, as many of them were located near the outskirts of the city where there was no water supply; partly to the importation of cases that developed elsewhere; and partly, perhaps, to the existence of private water supplies for fire purposes in a number of mills that are connected with the city mains and provided with the usual check valves. The water for these fire supplies is taken from the river in the heart of the city and is obviously open to pollution. No direct evidence has been obtained that these mill supplies have been actually the cause of any cases of typhoid fever, but in view of the fact that such connections have caused trouble elsewhere, it cannot be denied that they are a source of danger, or that they may have played some part in the continuance of typhoid fever in Watertown. Certain it is, however, that the filter plant has shown a hygienic efficiency that compares well with similar filters elsewhere. The filter plant is in charge of a trained chemist and bacteriologist who very regularly and frequently makes analyses of the water before and after filtration. As this filter has not been described to the members of this Association I have taken the liberty of inviting Mr. F. H. Jennings, the chemist in charge of the plant at the present time, to contribute to this discussion a statement covering the operation of this filter since its installation in 1904.

Mr. F. H. Jennings * (*by letter*). It would be interesting to compare analyses of the Black River water as supplied to Watertown in the winter of 1903–4, if they were available, with analyses made subsequent to that time, especially the bacteriological analyses. The raw water counts obtained at the city filtration plant in Watertown in the months of December, January, February, and March show only moderate numbers of bacteria in the winters of 1904–5 and 1905–6, but much higher numbers in the winters of 1906–7 and 1907–8, as shown in the following table. The counts obtained in the summer months did not show a corresponding variation, though the counts obtained in the summer months

* Superintendent of Filtration Plant, Watertown, N. Y.

of 1907 were rather higher than in the preceding summers. At the same time, the positive presumptive tests for colon in one cubic centimeter samples of the raw water were more frequent in the winters when the counts were low than when they were high, averaging for the winter of 1904–5, 94.5 per cent., and for the winters of 1906–7 and 1907–8, 41.5 per cent. of the tests made.

TABLE VII.

BACTERIA IN BLACK RIVER WATER AT WATERTOWN, N.Y.

		1904.	1905.	1906.	1907.	1908.
January	Average		7 480	2 721	64 150	23 900
	Maximum		27 700	12 600	18 900	49 200
February	Average		2 200	2 033	21 410	40 800
	Maximum		4 920	5 000	52 600	138 300
March	Average		7 800	3 950	66 470	
	Maximum		30 900	17 000	134 100	
December	Average	2 960	708	39 800	30 480	
	Maximum	16 500	5 300	59 500	71 800	

A preliminary survey of the watershed made in the spring of 1907, covering sixty miles of the river above Watertown, in an effort to locate some specific cause of these higher counts, showed that they were general on the main stream and all the principal tributaries. During the winter of 1906–7 there was comparatively little snow, but during the winter just passed the snow was deep all over the Black River country. The general temperature was about the same in the two winters, so we could find no explanation of the higher counts in climatic conditions. During both winters the river was completely frozen over.

The chemical and physical characteristics of the water also vary widely. There are a number of paper and pulp mills on the river above Watertown, both chemical and mechanical processes being used. The effect of the chemical waste is quite apparent in times of low water in the river. A change of color of twenty-five parts per million (platinum scale) in four hours is not unknown here. This may mean an increase of 30 per cent. in the color in four hours. This color change is frequently accompanied by a decrease in the alkalinity of the raw water.

Since the installation of the filtration plant there has been a marked reduction in the typhoid death-rate, as shown by Table I in the paper under discussion, and a still more marked reduction in the typhoid morbidity rate, as is shown by the following table based on figures obtained from the annual reports of the local health officer:

TABLE VIII.

Year.	Population.	Cases of Typhoid.	Cases per 100 000.	
1900.....	21 696 (census)	193	877	
1901.....	22 400 (estimate)	150	670	
1902.....	23 200 „	306	1 319	
1903.....	23 900 „	231	967	
1904.....	25 000 „	703	2 812	(Epidemic year. Filter plant in operation September 12.)
1905.....	25 447 (census)	108	424	
1906.....	27 500 (estimate)	130	473	
1907.....	30 000	103	343	

In considering the morbidity rate it should be remembered that Watertown is the center of a large district having no hospitals except those in Watertown, so that a considerable proportion of the cases reported are imported, —brought to the local hospitals for treatment and reported from there. For instance, in 1907, the only year for which I have the figures, there were 20 such cases, or 19.4 per cent. of the total cases reported. If these 20 cases be deducted the morbidity rate becomes 277 instead of 343.

I know of no local explanation of the higher mortality and morbidity rates for 1906 than for the other years since the filtration plant was established. I understand that typhoid was more prevalent than usual throughout northern New York in 1906, so it seems to have been a general condition rather than a local condition.

Previous to the installation of the filtration plant high monthly typhoid morbidity rates were rather general, occurring at no particular season; but since the installation of the plant the high morbidity rates have occurred in the fall months, when other causes than water supply are most active, as shown in Table IX.

The filtration plant in Watertown has been in operation now about three and one-half years, and it may be of interest to consider

TABLE IX.

CASES OF TYPHOID BY MONTHS.

Month.	1902.	1903.	1904.	1905.	1906.	1907.	1908.
January	13	23	180	7	7	18	2
February	16	47	302	4	10	7	3
March	37	29	101	17	4	8	
April	30	18	31	7	6	7	
May	26	3	19	3	2	6	
June	18	9	3	0	1	9	
July	22	23	11	3	3	0	
August	28	22	3	8	15	9	
September	39	21	21	12	26	15	
October	30	14	13	20	26	15	
November	20	7	14	10	18	3	
December	27	15	5	7	12	6	

the operation a little more in detail. The figures given in the following tables show this clearly. These figures are in all cases the monthly averages obtained from the records kept at the filtration plant. Table X shows the principal water quantities for the period.

During the winter of 1904–5 the water consumption was very high owing to leakage and waste, largely the latter. A campaign against this waste resulted in a lower consumption, but as the city grows larger the consumption is going up again, so that there have been times this last winter when it was difficult to keep up the supply of filtered water.

It will be noticed that during the last three months for which figures are given above, the period of service has been longer than usual; in fact, it has been necessary to make a rule that the filters should be washed at the end of forty-eight hours whether or not there was need of it to keep up the supply of filtered water. We ordinarily wash when the water falls to a certain level in the clear water well, experience having shown that, with us, this is better than washing at a certain loss of head on the filters.

The low values for the amount of water filtered between washings in the months of June, July, August, and September, 1907, were due to difficulties in the operation of the plant ensuing from the low stage of the river.

TABLE X.

Month.	Amounts of Water Filtered in Million Gallons per Day.	Percentage of Wash and Waste Water.	Number of Filters Washed Daily.	Period of Service in Hours.	Amount of Water Filtered between Washings, in Million Gallons.
1904.					
October....	4.418	6.7	12	15.40	0.371
November..	4.622	3.6	8	24.58	0.575
December..	5.250	3.8	11	18.59	0.475
Average .	4.760	4.7	10	19.52	0.473
1905.					
January ...	5.458	3.2	8	21.57	0.674
February ..	6.090	4.6	15	13.62	0.409
March	4.980	4.2	12	16.45	0.417
April	4.157	3.0	6	27.91	0.643
May.....	4.322	3.8	10	18.38	0.432
June.....	4.662	4.6	11	17.63	0.457
July.....	4.541	3.9	7	20.05	0.428
August	4.296	5.3	11	16.81	0.414
September .	4.283	3.4	7	25.04	0.568
October....	3.797	3.5	7	21.26	0.546
November .	3.909	3.7	7	25.96	0.548
December..	4.234	3.3	7	26.37	0.601
Average .	4.561	3.9	9	20.92	0.512
1906.					
January ...	4.302	3.3	7	26.95	0.617
February ..	4.326	3.2	7	26.17	0.617
March	4.274	3.1	7	24.49	0.602
April	3.850	2.8	5	29.79	0.749
May.....	3.282	3.2	7	24.43	0.653
June	4.177	4.3	9	22.56	0.595
July.....	4.184	4.5	10	20.04	0.501
August	4.096	4.5	10	20.91	0.495
September .	4.058	4.3	9	23.77	0.526
October....	3.793	3.8	7	24.59	0.563
November .	3.485	2.5	5	39.98	0.726
December..	4.108	2.9	6	29.46	0.773
Average .	3.995	3.5	7	29.10	0.618
1907.					
January ...	4.142	2.3	5	33.66	0.942
February ..	4.908	2.9	7	26.18	0.782
March.....	5.219	3.5	10	19.19	0.605
April.....	4.630	2.6	7	28.93	1.079
May.....	4.536	3.0	8	26.31	0.700
June.....	4.534	4.0	9	22.73	0.474
July.....	4.530	5.3	12	15.95	0.356
August	4.743	4.9	13	13.42	1.355
September .	4.493	5.4	13	13.49	0.342
October....	3.910	3.6	7	22.07	0.528
November .	3.482	2.7	5	32.36	0.763
December..	3.887	2.2	3	47.79	1.217
Average .	4.418	3.5	7.6	25.17	0.679
1908					
January ...	4.214	2.9	4	43.12	1.117
February ..	4.910	2.2	5	37.06	1.063
Average .	4.562	2.55	4.5	40.09	1.009

Table XI shows the amounts of coagulant used and effect of filtration on the water.

Our highest raw water colors occur in the summer and autumn when the river is lowest, and at these times the color is also subject to considerable variations, necessitating careful watching of the raw water and regulation of the amount of alum used. The maximum raw water color (day's average color) was 140, and the minimum, 38.

The turbidity of the raw water is, as a rule, low. One day has shown a turbidity of 200. The minimum was 1; the average since the plant has been in operation, 10.

The alkalinity of the raw water has varied widely from a maximum of 80 to a minimum of 14. In 1905 the average raw water alkalinity was 39; in 1907 it was 28. There are, at times, from 1 to 5 parts of "suspended alkalinity" in the water, the exact source of which we have not been able to learn. In the earlier years of the operation of the plant it was never necessary to add alkalinity to the water except for a week or so in the spring when the snow was going off, but in 1907 it was necessary to add alkalinity (soda-ash) during parts or all of seven months — March, April, and May in the spring, and September, October, November, and December in the fall and winter.

It will be noticed that the amount of coagulant was increased greatly in the winters of 1906–7 and 1907–8. This was due to the greatly increased number of bacteria in the raw water as shown in Table VII. Ordinarily sufficient alum to reduce the color to a satisfactory amount, below 10, is more than enough to guarantee the hygienic efficiency of the plant, so that we can regulate our alum feed according to the color of the raw water.

From the time the plant was put into operation until the first of March, 1908, there have been tested at the plant 14 474 samples of water, including about two hundred fifty samples analyzed in connection with investigations of the pollution of the river. Samples of raw and filtered water are taken every four hours throughout the twenty-four for chemical and physical tests. Bacterial analyses are made daily except Sunday. These show that the bacterial efficiency of the plant is good and that the removal of coli is general also.

TABLE XI.

Month.	Color.		Turbidity.		Alkalinity.		Coagulant Used.	
	Raw.	Filtered	Raw.	Filtered	Raw.	Filtered	Pounds per Million Gallons.	Grains per U. S. Gallon.
1904								
Oct.	103	15	18	0	28	14	376	2.63
Nov.	64	7	7	0	31	17	257	1.80
Dec.	51	8	4	0	35	19	242	1.69
Av.	72	10	9	0	31	17	291	2.04
1905.								
Jan.	53	8	5	0	40	24	238	1.67
Feb.	47	9	3	0	35	19	234	1.64
March	44	10	12	0	37	21	261	1.83
April	57	6	22	0	23	9	244	1.71
May	67	11	5	0	28	14	240	1.68
June	90	14	14	0	33	15	309	2.16
July	104	13	8	0	36	14	379	2.65
Aug.	82	16	9	0	42	19	358	2.51
Sept.	80	11	9	0	42	17	352	2.46
Oct.	80	9	9	0	47	20	351	2.46
Nov.	77	10	8	0	49	22	349	2.41
Dec.	52	9	8	0	56	34	242	1.69
Av.	69	11	9	0	39	19	296	2.07
1906.								
Jan.	51	7	23	0	54	37	257	1.80
Feb.	48	10	9	0	44	28	260	1.82
March	42	6	13	0	41	25	259	1.81
April	44	3	16	0	33	22	235	1.64
May	51	8	12	0	29	22	215	1.50
June	73	10	11	0	34	23	300	2.10
July	87	9	9	0	38	24	346	2.42
Aug.	79	11	5	0	42	22	364	2.55
Sept.	75	9	2	0	27	9	356	2.49
Oct.	74	13	7	0	34	17	322	2.25
Nov.	64	9	18	0	36	20	322	2.25
Dec.	60	7	9	0	35	19	323	2.26
Av.	62	9.5	11	0	37	22	297	2.11
1907.								
Jan.	56	4	22	0	29	11	325	2.26
Feb.	45	4	8	0	29	10	361	2.53
March	47	1	19	0	29	9	414	2.90
April	56	0	22	0	27	18	363	2.55
May	61	0	10	0	29	12	364	2.55
June	65	2	5	0	29	11	348	2.44
July	87	8	3	0	30	11	358	2.51
Aug.	84	14	6	0	33	13	354	2.48
Sept	89	12	7	0	30	10	365	2.56
Nov.	87	7	12	0	24	11	363	2.56
Dec.	71	5	14	0	28	15	366	2.57
Av.	69	5	11	0	28	12	362	2.53
1908.								
Jan.	54	1	4	0	30	14	358	2.51
Feb.	56	4	9	0	29	13	376	2.64
Av.	55	2.5	6.5	0	29.5	13	367	2.57

Full records of the operation of the plant are kept. The filter attendants are required to keep an hourly record of the amount of coagulant used, the quantity of water entering the plant, the amounts of water in the coagulating basins and clear water well, the losses of head on the individual filters, and full details of all washings of the filters. These are all checked up daily by the superintendent of the plant, who also keeps records of all water quantities passing through the plant, the amounts used in washing and waste, the amount of water pumped into service, the amounts of water on hand at the end of the day in each of the various basins, the amounts of coagulant used and on hand, and full records of the bacteriological, chemical, and physical tests made on the water.

Besides the superintendent there are three filter attendants, each working an eight-hour day.

The plant also possesses an alum storehouse capable of holding six months' supply of alum if need be. This was deemed advisable as the rigor of northern winters sometimes interferes materially with freight traffic.

The cost of operation of the plant since it started has been as given below in Table XII.

TABLE XII.

Chemicals	$13 924.52
Salaries and supervision	12 607.55
Repairs, new sand, extra labor, grading, and new construction	1 889.05
Coal	1 102.83
Freight, cartage, and miscellaneous	1 035.45
	$30 559.40

This makes the cost of filtration per million gallons, without allowing for depreciation and interest on the capital invested $5.57.

DR. E. S. WILLARD * (*by letter*). I have not had an opportunity to read this paper carefully, but from my knowledge of Dr. Soper and his work I have no doubt that the epidemic and the campaign against it have been accurately described. This is, in fact, the only account of the outbreak which has appeared, so far as I know.

It may be of interest to state that the general course followed by the city of Watertown in its crusade against the fever was in

* Health Officer, Watertown, N. Y.

accordance with a suggestion made by Dr. Soper himself several months before the epidemic broke out. When we first realized that an epidemic might be upon us and that extraordinary measures might be necessary to put a stop to it, I remembered a paper which I had heard read at the third annual conference of Health Officers of New York State, at Albany in October. The title of this paper was "The Management of Typhoid Fever Epidemics," * and it was delivered by Dr. Soper soon after he returned from the typhoid epidemic at Ithaca.

Many of the steps which should be taken to put a stop to an epidemic of typhoid were described in the paper. It was pointed out, however, that the details suited to every situation could not all be described and that the best thing for a local board of health to do in case of epidemic was to call on the state for an expert to come and direct the sanitary campaign. If the state could not supply such a person, an outside expert should be called upon. To quote from the address, Dr. Soper said:

"I am aware that in expressing an opinion favorable to what may be considered a state management of epidemcis I am recommending a course which appears to be different from that ordinarily followed in this commonwealth. But the difference is more seeming than real. It has been the custom on occasions of severe epidemic for the State Department of Health to send a representative to investigate the cause of the trouble and to recommend measures for the elimination of the cause. The visit of the expert has usually been brief, two or three days ordinarily being considered sufficient for his investigation.

"The suggestion that I make is that the state send a representative to remain long enough at the seat of epidemic to insure the adoption of measures which will bring it under control, whether this takes three days or three months."

When the epidemic began at Watertown, the State Department of Health was informed that typhoid was prevalent and a question was asked as to what, if anything, should be done about it. In response to this appeal the state sent Professor Landreth, who made an investigation into the cause of the epidemic and gave much good advice but whose other duties would not permit him to remain continuously at Watertown to fight the epidemic to a finish. There then remained the second alternative to consider,

* *Medical News*, New York, January 2, 1904.

namely, for the city to employ an independent expert. This was done by engaging Dr. Soper. He came within forty-eight hours and remained with us two months.

From first to last the relations between the state and local boards of health were cordial and, as far as the city was concerned, satisfactory. Dr. Soper acted in an advisory capacity, strengthening and supplementing the board with the results of his special training and experience and taking charge, as far as legal restrictions would permit, of a large amount of the executive work which was involved in carrying out his recommendations. The activities of the board were, of course, greatly increased in scope and number. No new laws or special ordinances were passed. The theory was that there would be enough sanitary regulations to meet the case if those already enacted were properly enforced. After the campaign was over the board returned to its usual and customary operations.

MR. M. N. BAKER* (*by letter*). It seems a great pity that Watertown, Ithaca, and Butler did not have the services of Dr. Soper before instead of after their typhoid fever outbreaks. It is certainly to be hoped that the time is not far distant when communities of this size and larger will each and all have in their employ scientifically trained men of experience and tact who will constantly guard them against both epidemic and endemic preventable diseases.

The slowness of both the city and state authorities to act at the time of the Watertown outbreak seems almost unaccountable. The State Health Department was not called upon until January 30, after some two hundred cases of typhoid had been reported within the month. The representative of the State Health Department did not arrive in Watertown until February 8, and even then he seems to have done little but give some general advice, after which he hurried away, to go back later for another brief visit.

The local authorities seem to have made no use whatever of the rules for the protection of the water supply formulated by the State Health Department. Why not? Their failure in this respect, and the apparent failure of other communities to make any very great use of like rules, suggests the utter inadequacy of this plan

* Editor *Engineering News*, New York, N. Y.

for protecting public water supplies in the state of New York. In the case of so large a drainage area and so small a community as were involved at Watertown, it is perhaps too much to expect that local authorities could effectively protect themselves against pollution under such rules as were authorized by the New York statute; particularly in view of the fact that the expenses for removing or preventing pollution are placed upon the community whose water supply is to be benefited thereby.

An explanation from some source seems to be demanded of the high typhoid death-rates that have prevailed in Watertown since the filtration plant was put in operation. In the light of our present knowledge of such matters it would appear that other sanitary reforms than an improvement in the public water supply are greatly needed at Watertown.

Water-works officials ought to realize, as few of them yet seem to do, the importance of doing all in their power to see that local boards of health do some effective work in tracing each case of typhoid fever to its source of infection. If this were done many a water supply which has been otherwise put in question would be exonerated, and, far more important still, many lives would be saved.

Mr. Kenneth Allen * (*by letter*). A public calamity that affords so excellent an object lesson in the exposition of its cause and in the means taken to eradicate the evil and bring about far better conditions than previously existed may be looked upon, from one point of view at least, as a blessing in disguise. The reduction in the typhoid death-rate from an average in 1885 to 1903 of 71, and in 1904, 194 per 100 000, to 24, 50 and 37 per 100 000 the following years, is an index of the direct effect of the house-cleaning the city of Watertown went through, but the indirect effect with its saving of life in other communities is much greater.

In this connection the various means taken to disseminate knowledge concerning the epidemic and its control, by lectures and by inviting the coöperation of the Chamber of Commerce, the Department of Charities, etc., must have gone far toward stamping out the epidemic and in counteracting the unaccountable

* Division Engineer, Sewerage Commission, Baltimore, Md.

attitude of *laissez faire* which existed. It is difficult to so convince the average citizen of the necessity of boiling a suspicious drinking water that he will see to it that it is regularly done. And if, perchance, this point is gained, the chances are nine to ten that he will not insist on equally sterile water for washing dishes, brushing teeth, and drinking when traveling.

For this reason the supplying of pure spring water at a nominal cost during epidemics of this kind is a step of much importance, and should always be done when practicable. So, too, in the preparation and distribution of disinfectants, as " white liquid " and " blue liquid," with simple directions to facilitate their safe and effective use by ignorant persons, good judgment was shown.

The failure to profit by the warning of the epidemic of 1895, and the continued high typhoid rate, seem inexcusable, but in this Watertown has not shown herself different from the average community. In matters of this kind safety is only secured by the constant vigilance of some responsible authority having power to act. The most obvious person to be clothed with such authority is the health officer. But in cases of water supplies and stream pollution the offense is so often committed beyond the jurisdiction of the local authority that, as in this case, the state must be appealed to through its Board of Health, whose executive officer, as well as the local health officer, should have power to execute the laws and ordinances governing the offense without further resort to higher powers. Beyond this come in the questions connected with the pollution of interstate streams, as the Mississippi, Missouri, Ohio, Delaware, Susquehanna, concerning which disputes, if not amenable to arbitration, must be referred to some Federal authority. Such cases are becoming more and more frequent with increased densities of population, and it is quite possible they may be best handled in connection with the question of water transportation and water-power by a Federal commission independent of, but coöperating with, and coördinating the efforts of, the several departments of the government. Such a division of authority would be elastic, in harmony with the general theory of our government, and would at the same time avoid division of responsibility. Moreover, it is directly in line with the present development in many of our states.

In the Watertown case the ineffective legislation of 1896 is instructive. With laws no doubt in the main good, and with power to act, yet they were rendered inoperative by imposing an unknown but possibly very great cost on the commissioners to whom their execution was intrusted. That fatal provision blocked the way at once to any abatement of the offensive conditions, and it was only after these became alarming and the higher authority of the state stepped in that efficient results were secured.

Fortunately the city and state coöperated in harmony, the former paying the latter for sanitary work on the watershed above by special agreement. The more definitely the line of responsibility can be drawn, however, between state and local jurisdiction in such matters, the better, and it would seem as if this might be accomplished at least to a greater degree than exists at present.

MR. FRANCIS F. LONGLEY* (*by letter*). Dr. Soper's interesting paper sets forth in admirable manner the facts regarding this virulent outbreak of the dread typhoid in Watertown. It is of especial interest to the writer because of his connection with the water department of that city in charge of the operation of the filters during the year following the epidemic herein described. The filters, which were in course of construction at that time, were finished and put in operation early in the following September. They are of the "mechanical" type, and were fully described in the columns of the *Engineering Record* of dates May 21 and 28, 1904.

In watching the typhoid fever situation in Watertown during the first year of operation of the new filtration plant, the writer was impressed with one unusual fact. That was, that the typhoid death-rate fell from an average of 83 per 100 000 to 24 per 100 000 in that first year, in marked contrast to the gradual fall in typhoid death-rates in many other cities after the complete or nearly complete removal of the source of infection in the water supply.

The question that naturally arises is, What was the cause of this clean-cut drop in the typhoid curve? Was it the purification of the water supply alone, or were there other large contributing causes? The advocates of pure water and of filtration would be glad enough to take the credit for it in its entirety, but may they

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do this? The epidemic described in this paper was severe enough to thoroughly frighten the people of Watertown, frighten them into far greater precautions against infection by typhoid from all sources than they would have used except under the influence of such a fearful calamity. And it is logical enough to believe that these precautions that individuals took of their own free will had a very appreciable effect in preventing many cases that would otherwise have been contracted. This is not a new idea, nor is it hard to find evidence tending to support it. For instance, take the typhoid record Dr. Soper has presented for Watertown, supplementing it with the rates for the three years that have passed since the epidemic year, as shown in Fig. 13.

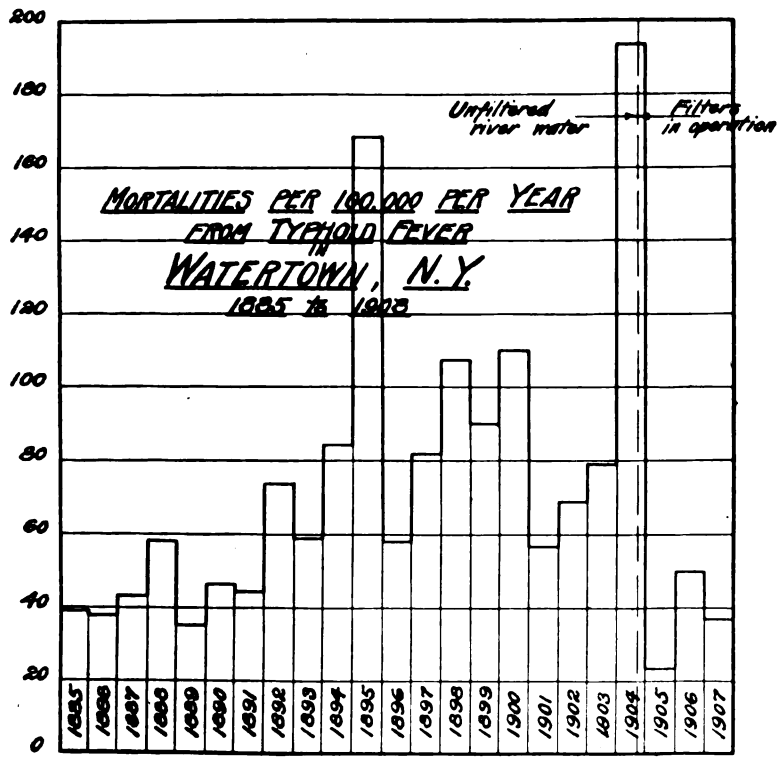

FIG. 13.

Dr. Soper speaks of the epidemics in 1895. They are very evident on this curve. Vigorous preventive measures were applied, largely through individuals. The result was that the curve for the following year dropped very low for Watertown. But it did not stay low. With the sense of security that came with the low rate of 1896, the individual seemed less impressed with the necessity for the vigorous precautions of the year before, and consequently we see the typhoid rate climbing up again.

No distinct epidemic has been noted for the years 1898–1900, but the conditions are plain, with an average typhoid death-rate for the three years in excess of 100 per 100 000. No doubt this caused a campaign, following the high rate of 1900, against the infection, with the result of bringing the rate down in 1901 to 57 per 100 000. Then again the curve rises for several years until it culminates in the epidemic which forms the subject of this paper.

In the year following the epidemic year the typhoid death-rate dropped, as is shown, to 24 per 100 000, which is lower than it had been in more than twenty years for which records are available, and considerably less than one half the low rates reached in 1896 and 1901. A mass of most conclusive evidence points to the improvement in the water supply as the large factor in this reduction of the death-rate; but is it not very probable that the preventive measures prosecuted so vigorously the year before had a decided influence in reducing that portion of the typhoid that was not affected by the improvement in the water supply? And is this not borne out by the fact that the rate jumped up again the two succeeding years, indicating as before the wearing off of the educational effects of the epidemic year in the security apparent in the minds of the public from the improved conditions and the lowered death-rates?

The curve of typhoid fever death-rates for Washington, D. C., has during the past twenty-five years shown variations of this same nature that were not explainable by any known changes in the quality of the water, and for which the ideas suggested above do seem to afford a reasonable explanation. The curves for many other cities, too, show similar variations.

There are many factors, such as meteorological, climatic, and racial conditions, as well as the questions of pure water and proper

drainage, that influence typhoid rates in ways that are too devious to follow, and there is no intention of arguing the elimination of such considerations nor of pretending to dismiss with one simple argument a question which is of the most serious complexity. This discussion is presented simply with the idea of bringing out the importance of two points: First, the educational effect upon a community of a distinctly epidemic typhoid condition, with all the object lessons attendant thereon; and second, the error that has been so commonly made in placing the entire blame for high typhoid rates upon the water supply, even when that is known to be badly polluted. It is evident enough that the degree to which the water supply alone may be blamed varies with the amount of pollution; but even assuming this to be a very considerable degree, the other causes tending to produce typhoid are generally not insignificant, and they should not be overlooked, as has so often been done.

A great deal has been said upon the subject of typhoid fever in Washington since the installation of the filtration plant nearly three years ago. This city had long been afflicted with a high typhoid rate, and the water supply, drawn from the Potomac, had been blamed for it. Naturally all agreed in predicting a great reduction in the typhoid with the use of the purer water supply. And naturally all were disappointed and mystified upon seeing the typhoid appear with no diminution in quantity or intensity during the first year of operation of the filters. This had the effect of bringing down much unfortunate and sensational criticism of the water supply, and the new filters were advertised far and wide as a failure.

The results of the studies on the quality of the water, both before and after filtration, the results of investigations that have been carried on for two years by the Public Health and Marine-Hospital Service, the close consideration of the problem by the health department of the District of Columbia, the deliberations of the Medical Society of the District, and the opinions quite unanimously formed by the many sanitarians and experts who have given this subject their consideration, all point to the conclusion that the early assumptions were wrong. The filters were not a failure, but were doing most excellent work. The advent of

filtered water did not cause a marked and prompt reduction in typhoid because the Potomac water was not a large factor in the causation of the disease. The importance of certain other factors, which had before been neglected in favor of the polluted water theory, was accepted and emphasized.

When, years ago, the relation was pointed out between polluted water supplies and typhoid fever, and emphasized by epidemic after epidemic of the most virulent nature, with the most convinc ing evidence to prove this relation, the dangers lurking in polluted water were preached far and wide; and in the light of the evidence adduced, the theory of water-borne typhoid was almost universally accepted.

This was right and proper. The facts in a great many spectacular outbreaks of typhoid fever have been so closely in accordance with this theory as to eliminate every doubt of its application to the cases in question. There is an element of danger, however, in the too complete acceptance of this theory. There is danger of forgetting almost entirely that the disease may have its origin in many other causes. In their highly commendable enthusiasm over the application of this theory, some of the ablest writers in the country on sanitary subjects have entirely ignored this possibility. And therefore it is that the writer wishes to comment in this way upon the too complete acceptance of the water-borne typhoid theory to the exclusion of other factors, the importance of which has been underestimated. Engineers know without question how to eliminate the typhoid that is carried through water supplies; and there the function of the engineer ceases, or rather merges in with that of the municipal official upon whom falls the burden of dealing with that part of the typhoid which has been called "residual." The indications seem to be that in some communities this "residual" typhoid may be a large part of the whole, and the need of greater knowledge in regard to it is evident. In connection with some problems it has been thoroughly studied with promising results in some directions, though less so in others, but it should be persisted in without discouragement.

The importance of education in this subject of typhoid has been mentioned. An epidemic is a good means to that end, but it is an expensive and heart-rending, as well as an impressive ex-

perience. Education through the medical fraternity seems logical for this subject, but it has been found unsatisfactory and ineffective. The same is true of bulletins, circulars, and newspaper publicity. But could any means be found more satisfactory than through the public schools? For the subjects of study of the school children, if of human interest, very quickly become the subjects of discussion and perhaps of further study in the home. They need not be technical; the less technical, in fact, the better. There are a few admirable books that would answer the purpose, and the writing of others awaits only the creation of the proper demand.

The writer is inclined to offer an apology for dwelling upon topics that lie more strictly within the realm of education and of medicine, but while they are of little value to a superintendent in checking waste, or to an engineer in the selection of pumps, they are pertinent in the discussion of a subject which concerns us all, as this does.

One other point the writer wishes to refer to is a case of gross carelessness in the pumping station at Watertown. The regular intake extends, as Dr. Soper has stated, to a settling basin. During the construction of the filters and the extension of the intake to the new plant and coagulating basin the city supply was drawn partly through an emergency supply pipe directly from the flume along the east side of the building. About 50 or 60 feet above this emergency intake, and situated within the pump-house, was the toilet-room jutting out over the flume, a splendid opportunity for another spectacular outbreak of typhoid by a very direct transmission of infectious material, only wanting the proper individual, and disgusting from its evident proximity. Inquiry failed to reveal any one who had suffered from the fever, and who had worked in, or frequented the pump-house. The danger from this source was eliminated, of course, when the proper intake to the new filters was put in service, and later the toilet-room itself was removed. But it is an example of the dangers that may lurk right under the official eye and escape detection in the general search that is made for sources of pollution.

Dr. Leonard P. Kinnicutt * (*by letter*). No one can read Dr. Soper's most interesting and instructive paper on the 1904 typhoid

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epidemic at Watertown, N. Y., without feeling how great are the strides made by epidemiology during the past two years, and how differently a typhoid fever epidemic is handled to-day than it would have been yesterday.

Yesterday we sought for the primary cause and, finding it, we contented ourselves with an attempt to prevent further spread of the disease from the original source, leaving almost untouched all secondary causes. To-day it is considered that unless all possible means are used to prevent the indirect spread of the disease, comparatively little has been done.

Koch's investigations at Triers showed that for the prevention of the spread of typhoid fever almost as great precaution must be taken as is the case with scarlet fever or diphtheria; and possibly the most interesting part of Dr. Soper's paper is the description of what might almost be called the extreme measures that were used at Watertown to prevent all possible sources of danger of the infection being carried from person to person; and to those familiar with city governments it shows what " courage of conviction " is able to accomplish; and there is no question that the work of Dr. Soper will be of great use and make the work of the epidemiologist in the future much easier in persuading city officials that only by the most thorough measures can an epidemic of typhoid fever be stamped out.

Possibly one point in Dr. Soper's paper that is not sufficiently dwelt upon is regarding the closing of all suspicious wells. This, of course, may have been done at Watertown, though the statement that the result of the examinations of the wells showed that the water of most of them was of an unsatisfactory quality, yet only in a few cases were the wells ordered closed, leaves the question somewhat in doubt. In times of epidemics it would certainly be best to close all wells which gave any indication of pollution.

Dr. Soper, in speaking of the mechanical filtration plant which was in course of construction at the time of the epidemic, gives the typhoid fever rate since it was put in operation, in 1905, 24 per 100 000; in 1906, 50; and in 1907, 37; but makes no comment on these figures. Professor Sedgwick, in referring to them and to the continued typhoid at Washington since the slow sand filters were put in commission, states that in his belief it is due to residual

typhoid or to typhoid due to other causes than the public water supply. Not questioning at all the fact that typhoid is due to other causes than polluted water, is it not possible that the prejudice of the French sanitarians against filtered water and the present tend in Germany to the development of ground waters as a source of supply is not without justification?

DR. M. J. ROSENAU * (*by letter*). In addition to the many excellent features of Mr. Soper's report, one is especially impressed with the fact that Watertown got off very cheaply. The efficient and energetic measures adopted to suppress the epidemic were put into effect at a small cost, compared with the price of life and health. Watertown owes to the sanitarian a debt of gratitude. Ordinarily it takes a catastrophe to stimulate a community to adopt vigorous sanitary measures. It is a matter of much regret that cities suffering with residual typhoid, or with typhoid in what might be called the *status epidemicus* cannot be stimulated to adopt vigorous suppressive measures.

DR. SOPER. Among the many interesting questions raised in the discussion of this paper, there is one upon which there is substantial agreement. All agree that typhoid must be regarded as not merely an infectious disease, but as one that is contagious as well. The fact that a public water supply must not be alone held responsible for cases of sickness in an epidemic like that at Watertown is recognized by all. The general acceptance of this view is peculiarly agreeable to me since, as Professor Sedgwick says, my convictions with respect to this point have strongly influenced my work for the last five years. That the plan for the Watertown campaign has met with approval at the hands of the very experts whose opinions I most value is very gratifying.

There never was any doubt in my mind as to the effectiveness of the work. To stop the epidemic a sum approximating $25 000 was spent in two months. The epidemic had been running without abatement for two months. Within two weeks after the measures of suppression were put in force, the number of new cases each day diminished to about one half, and although the epidemic continued for nearly two months longer, its intensity never again increased, but diminished steadily to the end. If the table given in the body

* Public Health and Marine-Hospital Service, Washington, D. C.

of the paper showing the number of cases reported daily does not indicate the effectiveness of the suppressive measures, I am at a loss to comprehend to what cause the diminution is to be attributed.

The only regret is, as Mr. Baker has pointed out, that the work of stamping out this epidemic was not begun earlier; that it was not, in fact, made unnecessary by preventive and remedial sanitary measures applied to the water supply years before. Health Officer Willard in his discussion has explained why some valuable time was lost. Acting on advice which I myself had given in a paper read before the assembled health officers of New York state some months previously, the city of Watertown applied to the New York State Department of Health before seeking help from outside sources. Had the state responded to the call with the promptness and thoroughness which the situation demanded there is no reason why the city should not have had relief three weeks earlier. The delay in calling upon the State Department and the indifference with which the citizens had continued to drink polluted water from the Black River for so many years prior to the epidemic can only be attributed to apathy, an apathy which, as has been pointed out by Mr. Whipple, is not peculiar to Watertown. Apathy toward typhoid exists everywhere in the United States.

The personal element enters into the cause of typhoid fever to a far greater extent than is commonly understood, for typhoid is transmitted from one person to another not only in epidemics, but at all times. The cause of this personal transmission is due, in the last analysis, to individual ignorance and indifference.

The time has passed when a single channel of transmission like a public water supply should be held accountable for all the cases of typhoid which occur in an outbreak. The possibilities of transmission from persons who are sick and from healthy bacillus producers are sufficient to account for many cases in every epidemic. I believe that practically all sporadic or prosodemic typhoid is produced in this way. Only by preventing typhoid from spreading in this way can we hope to eliminate it utterly. As Professor Sedgwick says, typhoid is commonly looked upon as infectious and not contagious. It is too often regarded as transmissible in only one way in an epidemic, as by water, for example. This is a mistake.

A point to which Professor Kinnicutt has alluded, and which

was apparently not made sufficiently clear in my paper, is the danger which is to be apprehended from local foci other than strictly personal ones. Wells belong to this class. There is no doubt in my mind that in typhoid epidemics, wells which are ordinarily only polluted sometimes become infected with typhoid germs and give rise to cases of typhoid which are attributed to the main source of infection. I found in the epidemic at Ithaca a well of this kind. The well had long been regarded as pure, and when the public learned that the city water supply was dangerous, as many people as possible turned with confidence to the well for their drinking water. So great was this confidence, and so large the demand on the well, that the water was piped from the private property upon which the well was located to another house in the vicinity. At first no trouble resulted. But toward the end of the epidemic a case of typhoid occurred in the house where the well was located. The attending physician did not recognize the sickness as typhoid, and the dejections were allowed to pass without disinfection through the sewer. The sewer was defective and the bacilli entered the well, producing fifty cases of typhoid with five deaths.*

The danger from wells was constantly guarded against at Watertown. Wells located on private property and in mills were examined with much care by means of analyses and inspections. One of the objects of the laboratory was to examine the waters of the wells. At Ithaca 946 private wells had been examined under my direction, and at Watertown, although there were fewer wells, the work was no less thorough. The people were warned against the use of wells whose purity rested merely on common repute. It was generally necessary to present convincing evidence of danger in order to prove that the well was polluted, for people in small cities are as loyal to their wells and privies as though they were members of the family. But once the danger was made plain, a family would willingly abandon its well. Few wells were formally ordered closed for this reason. The object of the spring water supply distributed by the Board of Health was to cut off the need of using the public water and the private wells as far as practicable.

* "The Epidemic of Typhoid Fever at Ithaca, N. Y.," by George A. Soper, Ph.D., JOURNAL of NEW ENGLAND WATER WORKS ASSOCIATION, Vol. XVIII, No. 4, pp. 445–446.

I feared contamination of the milk supplies, for it is not uncommon in an epidemic like that at Watertown for country people who are attacked during temporary residence in the city to go back home to be nursed through typhoid. One case of typhoid in a dairy might very possibly cause many others. Here was a danger which it is extremely difficult for a city like Watertown, when afflicted by epidemic, to guard against. The farms which supply the milk are likely to be miserably dirty. To at once raise them from their filthy state to such a condition of sanitary excellence as to exclude the danger that the milk may become infested with typhoid germs is impossible. I am confident that in some of the long and intense typhoid epidemics which have afflicted American cities, milk supplies have become foci of typhoid germs long after the original cause of the epidemic has ceased to act. At Watertown the Board of Health sought to combat this danger by warning the public against drinking raw milk and by exercising such supervision as was practicable over the sources of the milk. It is proper to say that these precautions were not as thorough as was desirable, but no milk supply was found to be contaminated.

Along with such foci as water and milk belong dangers incident to the consumption of fruit and other food which are handled and exposed for sale within an infected city. At Watertown an Italian fruit dealer who was found to be harboring a case of typhoid in his establishment was given the choice of closing his shop or having the patient removed to hospital.

Mr. Whipple has said that the original source of the infectious matter seemed to be less effectively guarded against than the local sources. This criticism is, in a measure, just. The public water supply was, in my judgment, so heavily polluted that no measures intended to exclude or remove the polluting matters would be at all likely to prove successful. It seemed to be a sheer waste of time and money to attempt to " clean up " the drainage area, as is so often attempted in epidemics. Two months of spring weather probably had done much more than human effort could do to remove all the defilement which it was practicable to remove.

On this point there was, as pointed out in the paper, a clear division of opinion between the state department of health on the one hand and the city department of health on the other. It

was not doubted by either that the typhoid epidemic had been brought upon the city by the water and that permanent sources of pollution still existed upon the river. But it seemed to me impracticable to do away with these sources. Because of the great expense involved it had been impossible for the water board to avoid them by enforcing the state law. The drainage area was extensive and at several places villages and mills crowded the river banks, and even islands in the river were built upon. Several sewerage systems were discharging into the stream when the epidemic broke out. These sewerage systems could not be eliminated. So far as typhoid was concerned, it was necessary first to find the infectious matter before it could be removed. The investigators available for this undertaking were such young men as happened to be out of employment and could be induced to take up this work. They knew nothing of sanitation. The inhabitants of the drainage area were by no means all on friendly terms with the city and it seemed undesirable to earn their hostility by a clumsy interference with what they had long considered were their rights. The details of the procedures which should be followed in the event of a case of typhoid being discovered were by no means well defined. Obviously they should vary with circumstances. The best that could be done would be to trust to the judgment of the inspectors. In view of the fact that the city had its hands full in guarding against local sources of infection, it seemed far better to leave the cleaning of the drainage area to the state department of health, place emphasis upon the fact that the river water was dangerous and must remain so, and at the same time place within the reach of all an abundant source of water of unquestioned purity.

At the same time, by special arrangement with the authorities at Deferiets, a number of cases of typhoid in that village were taken off the sewerage system and provision was made for disinfecting and disposing of the excreta in a sanitary manner. The hospital facilities at Watertown were extended, as always, to the country people. The laboratory facilities of the Watertown Board of Health were placed at the disposal of all physicians on the drainage area for the discovery of typhoid cases and of people who were not sick but who were unconsciously producing typhoid

bacilli. In this way a little boy was discovered who had recovered from typhoid and who was being sent to school in one of the villages on the river above Watertown with urine literally clouded with typhoid bacilli.

With so many possible sources of typhoid within and near the city, it is not strange that the epidemic, once started, should have been of long duration. In fact, it is not clear why typhoid should ever be completely stamped out without careful, skillful, and long-continued effort. In some epidemics it seems not to stop until every susceptible person is attacked.

The danger of an indefinite continuance of typhoid seems the greater when we consider the part played by healthy bacillus carriers in the dissemination of the disease. In the case of a chronic bacillus carrier whom I happened to discover in 1906, seven separate household epidemics were produced over a period of five years, a record which probably would be increasing to-day were it not that the unfortunate person who was producing the germs was taken into custody by the New York City Department of Health and detained as a menace to the public health.* In numerous occurrences of typhoid in Germany, and in a notable outbreak just reported by Dr. R. M. Buchanan, of Glasgow, the danger of unsuspected typhoid bacillus carriers in dairies, and wherever food is handled, has abundantly been set forth.

The bearing of all these facts upon typhoid is evident. Residual typhoid no longer necessarily means, as we all understood the term to mean when Professors Sedgwick and Winslow originally proposed it, the typhoid which remains in a city after the public water supply has been perfected. It may mean the typhoid which remains when the sources which lie within the city have been satisfactorily eradicated and only the water supply remains open to suspicion. In many instances these proximate sources may alone be to blame. The experience of Washington, and the thoughtful remarks of Mr. Longley in connection with this subject, well illustrate the necessity of taking advanced ground in accounting for the presence of typhoid fever everywhere.

As Professor Kinnicutt has said, great progress has recently

* "The Work of a Chronic Typhoid Germ Distributer," by George A. Soper, Ph.D., *Journal of the American Medical Association*, June 15, 1907.

been made in our understanding of the cause of typhoid, and the opinions of yesterday are no longer those of to-day. But there still remain some obscure problems connected with this subject. I agree with Professor Winslow in believing that we are only at the beginning of our knowledge of typhoid, and I cannot share Mr. Whipple's view that the ways in which the typhoid germ is transmitted and the ways of preventing this transmission are all well understood. I hope the knowledge of to-morrow will be considerably in advance of the knowledge of to-day.

Mr. Allen has raised an interesting question. He has called attention to the fact that typhoid epidemics are sometimes highly educational, and he and Mr. Longley have remarked that the sanitary instruction, coupled with the alarm which people experience at such times, apparently cause them to exercise precautions that, for a few years at least, after the epidemic, protect them to a considerable extent against typhoid. With this view I am in general agreement. But I cannot think that greater precautions alone account for the fact that in the year or two following an epidemic there is likely to be much less typhoid than previously existed. I think other forces are at work also.

Why Watertown has had so much typhoid since its epidemic of 1904, I am unable to explain. Mr. Jennings suggests that it is because the country people in the vicinity use the city hospitals, and Mr. Whipple gives a number of reasons for thinking that the filter plant is not to blame. On the other hand, Professor Kinnicutt plainly intimates that he is not perfectly assured of the infallibility of filters. Mr. Longley apparently thinks the disease is being spread through lax sanitary precautions. This point is an extremely interesting and important one, but I confess I know nothing whatever about the persistence of typhoid in Watertown since the epidemic. I agree in thinking this question should be cleared up.

An obscure point in the epidemiology of typhoid is the fact that strangers are more likely to be attacked on visiting a typhoid city than are the customary residents. At Ithaca typhoid was prevalent for years among new students at Cornell University. So disproportionately large was the number of freshmen attacked that the disease which filled the infirmary every fall was called

" freshman fever." Troops sent to a distance are said to be much more liable to typhoid soon after reaching their destination than subsequently. Similarly, typhoid epidemics appear to be most intense in places where the people have previously suffered least from that disease. It is possible that the epidemic at Watertown would have claimed more victims at the outset had the water supply not been so contaminated and typhoid so common in other years. Does continued exposure to the germs always either produce typhoid fever or confer immunity? There is here a most interesting field for research.

It is difficult to account for the obscure question of the seasonal distribution of typhoid to which Professor Winslow refers. Excluding epidemics due to surface water supplies, typhoid is, in northern countries, chiefly a disease of autumn. I believe that people are more exposed to typhoid germs at this season than at any other. At this time people are moving about the country more freely than at other seasons, exposing themselves and others to an unusual extent. Probably people are more susceptible to typhoid in the autumn. This may be because of changes in diet, or it may be because of certain unusual metabolic conditions due to changes in temperature. Certainly personal susceptibility changes from day to day and it probably varies from season to season.

Is it not possible that the difference in seasonal incidence of typhoid among Indian and British troops mentioned by Professor Winslow may be due to some difference in personal habits? I cannot think that the temperature of the summer or early autumn has any material effect upon the vitality or virulence of the typhoid organism outside of the body, or that the weather directly affects one class of men in one way and another in an opposite way. I am inclined to believe that the causes which lead to the prevalence of typhoid in the autumn are due to (1) greater personal susceptibility; (2) greater exposure to the germs.

Before attempting to explain what appears to be the excessive prevalence of typhoid in some American states as compared with others, I should like better assurance of the correctness of the statistics. It is a cause of just reproach that vital statistics are so inaccurate in America. Even the statistics of deaths are unreliable in our most enlightened states, and this being so, what

reliance can we place upon the reports for the whole country? In the masterly investigations made into the causes of typhoid fever among the American troops in the Spanish War, Drs. Reed, Vaughan, and Shakespeare considered that not over 50 per cent. of the typhoid cases were discovered by the average civilian physician. This is not denying, however, that typhoid is more prevalent in warm countries than in northern ones. There is much evidence to support the interesting point raised by Professor Winslow.

Mr. Allen and Mr. Longley, Mr. Whipple and Mr. Baker, have urged the necessity of official action in respect to the control of typhoid fever, and the suggestions which these gentlemen make are worthy of most careful consideration. There is need of defining city and state limits of supervision over the pollution of streams; there is need of really useful state rules for the protection of surface water supplies; water boards should insist that boards of health trace typhoid cases to their sources. Physicians should report their cases of typhoid. It is high time that the principles of sanitary science applicable to the prevention of typhoid were recognized by educational authorities and taught more rationally and effectively in the schools.

As Professor Sedgwick has eloquently and forcibly pointed out, the keynote to better work in the prevention of typhoid lies in adopting higher standards of living. Higher standards should be established in every branch and department of public health work, including the conduct of public water supplies. The adoption of higher standards can alone eliminate typhoid.

Typhoid will continue to be prevalent so long as indifference toward it continues. The tribute which the American people are paying for this indifference is the loss of not less than 20 000 lives, $150 000 000, and the heart-rending miseries which are entailed by over 300 000 cases of typhoid annually.