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REPORT OF AN EPIDEMIC OF TYPHOID FEVER IN NORTH CAROLINA, AND ITS INVESTIGATION.

BY SENECA EGBERT, M.D.,
Philadelphia.

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DURING the month of November last the writer was called upon to investigate the nature and cause of a peculiar epidemic that was at that time occurring in a small manufacturing village in the southern portion of North Carolina, and, if possible, to suggest measures for its suppression and for the prevention of future outbreaks.

Inasmuch as some of the characteristics of the epidemic are worthy of note, and as the results of my inquiry have seemed to furnish additional evidence to that already collated as to the possibility of direct infection by means of the drinking-water, I have taken the liberty to make the following report:

Situated on one of the sand-hills common to that locality, some forty or fifty feet above the cotton factory where most of the inhabitants find employment, and surrounded by a semi-forest of pine and scrub-oak, the village in question covers about nine acres, and consists of sixty-six frame dwellings and one store. Everything is owned by and under the control of the company that operates the mill, and the people are simply tenants of the houses which they occupy.

The dwellings are in pairs, and with one exception are but a single story in height, and for the most part have but two rooms each. In some, where a family is large, doors have been cut through the dividing partition, and the family occupies both houses. Each pair of houses stands in a lot sixty feet wide by one hundred and fifty feet long.

A common pump, not more than ten feet from the back doors, furnished the water supply to each pair, and a double privy, or outhouse, was located at the extreme end of the lot and at least eighty feet from the pump. The wells were driven pipes, having a pointed, perforated "shoe" at the bottom and an ordinary iron pump above. The average depth of the wells was about twenty feet, with a variation not exceeding three feet, showing that the level of the ground water followed closely that of the surface above.

Over the whole area of the village the soil is but a layer of sand, ten feet deep. Beneath this is a stratum of so-called clay and then another of sand. That the clay stratum is freely permeable was shown by the fact that all the wells had to pierce it to obtain water.

On the surface there was a slight but comparatively uniform slope from the northwest to the southeast corner of the settlement, with an especially marked hollow, to which I shall again refer, running through the northern part. The natural drainage was thus almost directly toward the stream that supplied power to the mill, as will be seen by referring to the map.

There was nothing resembling a cesspool in the village. The outhouses were located on the sandy surface, without any preliminary excavation. Up to the time when the epidemic became serious, the solid excreta was removed at monthly intervals, the liquids, of course, sinking directly into the sand. However, as soon as it was observed that the sickness was of an infectious character, tight boxes were placed under the outhouses, by the advice of the attending physicians, these being removed and emptied twice each week, and chlorinated lime and dry earth freely used, daily, by persons appointed for that purpose.

Water-power to the mill or factory was furnished by a large stream, across which a dam had been constructed, the resulting pond overflooding a considerable area south of the village and killing a large amount of pine timber. Part of this was still standing, and part had fallen and was submerged in three or four feet of water. The nearest houses to this pond were from fifty to seventy-five yards distant and at least forty feet above it.

These preliminary details, together with the map, are given, that by means of them the discussion of the epidemic may be more readily understood.

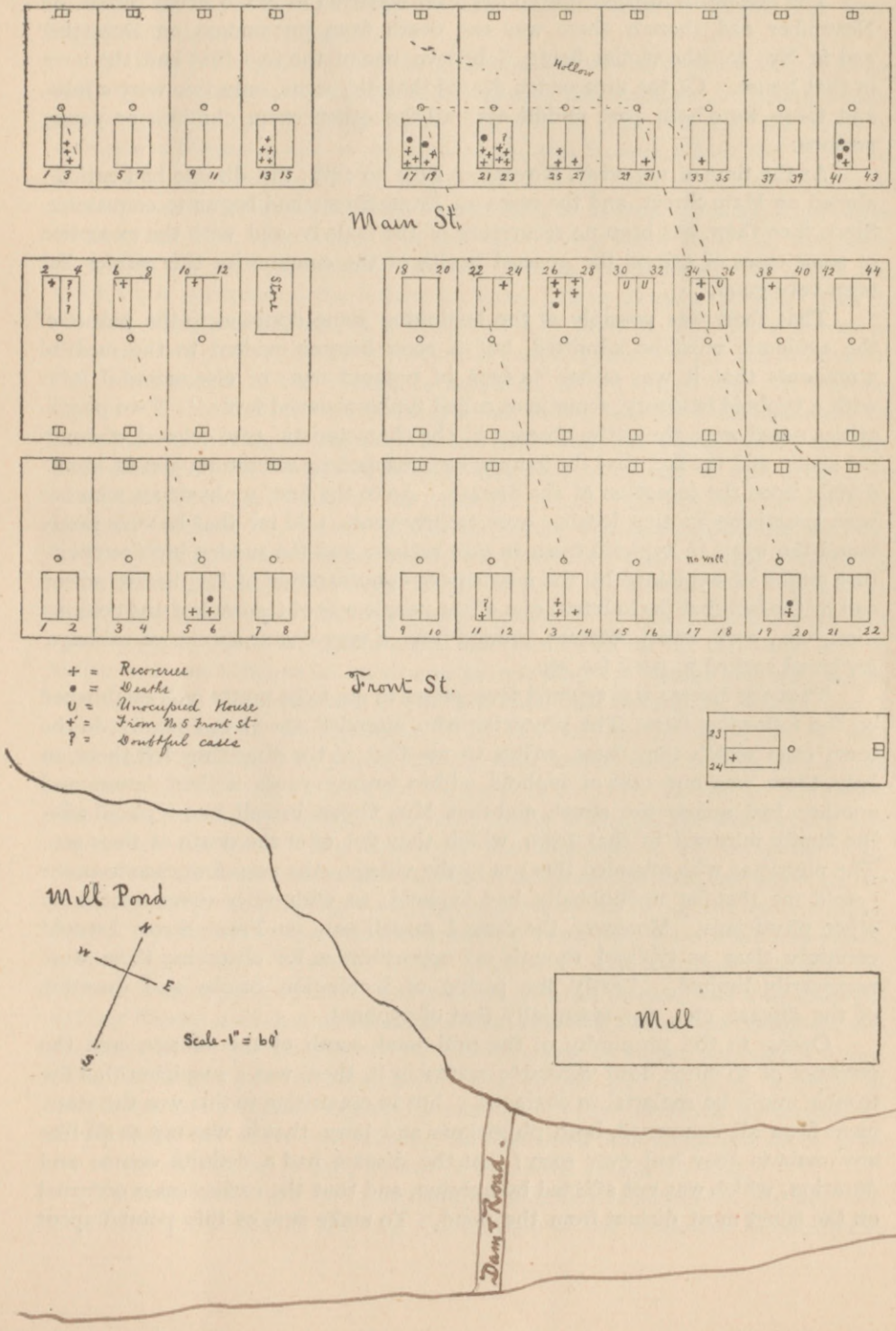
Though the summer and autumn were remarkably dry, following a wet spring, until August there was no special sickness in the village, nor had there ever been a case of typhoid or like fever from the time the mill and village were established, two or more years before.

About the twenty-first of July a family named Green came to the village from a neighboring town, some of the members expecting to find employment in the mill.

They brought with them a sick boy, and went to live in house No. 3 Main Street. (See plan.) After living there a short time, two other members of the family were taken ill, and the family moved into No. 19 on the same street, but lower down in the village. After they moved out of No. 3, another family moved in, and of this second family two, and possibly three, members were affected with the same malady.

Other cases then began to appear on both sides of Main Street, though I am not sure any special alarm was felt by the people until the death of the boy Green,—the one that was sick when he came to the village. This death occurred on the twenty-seventh of August.

From that time on the epidemic increased in gravity, until the earlier part of October, when there began to be "a marked decrease in the severity of the initiatory symptoms," and on the fifteenth of that month there were only ten cases of the disease in bed, and those in charge felt sure that the epidemic was


Hollow
Main St.
Store
Front St.
+ = Recoveries
• = Deaths
U = Unoccupied House
↑ = From No 5 Front St
? = Doubtful cases
no well
Mill Pond
N
E
S
Scale-1" = 60'
Mill
Dam Road.

under control. But it is to be noted that up to this time all the cases had been confined to one or the other side of Main Street. After a short respite the disease reappeared, but this time among those living on Front Street, and by the middle of November there were ten well-established cases on that street.

The last death directly due to the fever occurred in No. 6 Front Street, on November 22d, though there was one death from pneumonia on December 22d in No. 20—the victim being, I believe, one of the two that had the fever in that house. Of the nine or ten deaths that did occur, only two were adults, and these were both past middle age; all the others were children or young persons.

At the time of my visit, November 24th to 28th, the disease had entirely abated on Main Street, and the cases on Front Street had begun to convalesce. Since then there has been no recurrence of the malady, and with the exception of some cases of grippe the general health of the community this winter has been very good.

That there was possibly at the beginning some doubt as to the nature of the epidemic must be admitted, but it soon became evident to the medical attendants that it was either "a type of typhoid fever or else malarial fever with a typhoid tendency, sometimes called typho-malarial fever." Two peculiarities noted were the entire absence of the characteristic rose-colored, abdominal spots, and the fact that the temperature reached its maximum almost immediately upon the inception of the disease. As to the first, a physician, who has been practising in that locality over twenty years, told me that he very rarely found the spots in typhoid cases in that region; and the sudden high temperature might be explained by the intensity or concentration of the disease poison and by the fact that the habitual diet of the people was of the crudest and coarsest kind, viz., pork, sweet potatoes, ground peas, a very coarse species of cabbage, *hot* bread soaked in pork fat, etc.

That the disease was typhoid fever seems to me to be pretty well established by the following facts: The physician who attended the Green family, in the town from which they came, writes to me that at the time they left there, in July, there was one case of typhoid within twenty yards of their house and another just across the street, and that Mrs. Green herself had typhoid after the family returned to that town, which they did after the death of their son. The physician who attended this son in the village—the very first case to occur—told me that he undoubtedly had typhoid; so with other cases treated by other physicians. Moreover, the cases I myself saw on Front Street I would certainly class as typhoid, though my opportunities for observing them were necessarily limited. Lastly, the period of incubation, course and duration of the disease, etc., was essentially that of typhoid.

Owing to the proximity of the mill-pond, south of the village, and the presence of so much dead vegetable matter in it, there was a suspicion that the trouble might be malarial in character; but in opposition to this was the statement from all concerned, both physicians and laity, that it was not at all like any malaria they had ever seen; that the disease had a definite course and duration, which was not affected by quinine, and that the earlier cases occurred on the street most distant from the pond. To make sure of this point I spent

a whole morning searching for the *plasmodium malariæ* in the blood of those who were still sick at the time of my visit, but without the least success. That malaria complicated many cases, however, is more than probable, for a number of those I interviewed told me that they had been subject to it for a long time, though they were freer from it there than at the places in which they lived before coming to the village.

Taking it for granted that the epidemic was one of typhoid fever, I think a study of the map will show that for most of the cases the infectious matter was carried by the drinking-water. It will be observed that the lines of infection all begin at one or the other of the two houses which the family of Greens occupied while in the village, that these lines of infection coincide almost exactly with what should be the lines of natural drainage from these houses, and that the sequence of the cases along these lines was unbroken from first to last. Beginning back of No. 19 Main Street, the house the Greens last occupied, is the hollow of which I have already spoken. This is marked, though not deep; it continues back of three or four other houses in the row, then crosses the street abruptly, passes under No. 34 and on toward the lower corner of the village, as indicated by the dotted line. It is along the line of this hollow, or else along a line drawn directly from the house to the creek—according to the slope of the land—that one would expect the surface drainage from the lot of Nos. 17 and 19 to flow, and it was along just these two lines that many of the cases did occur. Almost all the rest were along a line from No. 3 Main Street, the house first occupied by the Greens, to No. 6 Front Street—almost exactly the line of the surface slope. The only other cases that occurred in the village were in the houses Nos. 13 and 41 Main Street, and these require special mention. In No. 13 there were five cases reported, with no deaths; the family was said to be very lazy and to rather welcome sickness as an excuse for not working, though this may not be so. I did not learn that any of the five cases had been at all serious, and I am not sure that all were genuine. The fact that the family in No. 15, who used water from the same pump, had no cases, would seem to indicate that the water-supply was not to blame for the cases in No. 13. In No. 41 there were four cases with three deaths—the only family in the village where there was more than one death. But here again the neighbors in 43, using the same pump, had no cases, and, moreover, this house is on a hillock and much higher than any of the neighboring ones, thus apparently absolving the water-supply. As an explanation of the extreme mortality I can only give what was practically the unanimous report of all the neighbors. One daughter, who had not been well during the summer, was stricken with the disease, and then throughout her illness and that of the others that followed there were continued disobedience to the physician's orders, unwillingness to accept neighborly assistance, inordinate use of stimulants, and, above all, an utter neglect of cleanliness and ordinary sanitary precautions. The physician in attendance corroborated the above and assured me that there was no excuse for at least two of the deaths, or, in fact, for any of the cases except the first.

To understand how the water-supply became contaminated, one has only to consider the nature of the soil, the location of the outhouses in relation to

the wells and the depth of the latter, and to remember that in the early days of the epidemic, at least, the excreta was received directly upon the soil. If wells in ordinary soils drain an area whose radius is equal to four times their depth—the exact ratio in this case—how quickly would the liquid portions of the excreta deposited in the outhouses reach the wells and be drawn up into the pumps of every house in the village? But worse than that, according to common report, the Greens and their neighbors in No. 17, and possibly others, made a practice of throwing their liquid and night-slops out on the lot instead of carrying them back thirty yards or so to the privy. The poisoning of the water could scarcely have been more direct had they poured their filth down the pump itself. The unfortunate part of it all is that others than themselves had to suffer so grievously.

The company is to be commended for the promptness and energy with which they acted when once the gravity of the situation became apparent. Orders were issued to boil all drinking-water; chlorinated lime and other disinfectants were freely used about the outhouses and infected houses, the changes already noted as to the disposal of excreta were made, and there was a thorough sanitary policing of the whole village. The people were too slow to heed, however, and the soil had become too saturated with the poison to prevent the cases that occurred on Front Street. I have no doubt that if they had simply boiled their drinking-water as directed they would have escaped, but when they saw the trouble abating and disappearing in the rest of the village, they doubtless became negligent and returned to their old habits.

Having made the investigation, with the results as detailed above, it remained for the writer to suggest how the sanitary condition of the community might be improved and the occurrence of any such epidemic prevented in the future.

Undoubtedly, with such a soil and such a population the water from any shallow wells in the village could not be considered pure or safe. People will be careless or unwilling to exert themselves, and filth and house refuse of all kinds will be thrown upon the soil without. Consequently, a new water-supply, free from a reasonable possibility of contamination, must be sought for.

The stream that furnishes power to the mill is of considerable size, comes through an almost uninhabited country for sixty miles, is said to be always cool and clear, and is apparently free from any possible danger of contamination for years to come. I advised, therefore, that the water-supply should be pumped from the running stream to a stand-pipe or elevated tank, located in the woods west of the village, to be conveyed thence by a system of pipes to a hydrant just outside of each house; provided, of course, that the chemical analysis of the water proved it to be as pure as it seemed to be physically. This analysis, which was made by an eminent chemist of this city, together with others of samples of water from various wells in the village, is given below, and justifies, at least, the condemnation of the wells in the village.

The chemist's report is practically as follows:

"The samples of water submitted for examination consisted of

"(1) From the mill-pond, lying about fifty feet below the average level of the houses of the village.

"(2) From a spring on a hillside, divided from the village by the outlet from the pond.

"(3) From a sample obtained by taking a sample of water from each of the wells in the village and mixing these samples together.

"(4) From well at 41 Main Street.

"(5) From well at 34 Main Street.

"(6) From well at 19 Main Street (Green's).

"(7) From well at 6 Front Street.

"(8) From well at 5 Main Street.

"The following gives the results of the analysis in parts per million:

	1	2	3	4	5	6	7	8
Chlorine	5.32	5 33	16.96	14.20	14 20	7.10	6.21	10 64
Nitrogen as nitrates	0.252	None.	1.40	1.29	0.91	2.24	0.35	0.56
Free ammonia	0.02	0 01	Trace.	0.01	0.005	None.	Trace.	
Albuminoid ammonia	0.14	0.07	0.025	0.018	0.025	0.175	0.045	
Hardness	4.			10.	5.	25.	5.	None.
Acidity or alkalinity	Neutral			Neutral.	Slightly alkaline.	Neutral	Neutral.	Neutral.
Total solids Dissolved and suspended — Volatile	110	50						
Total solids Dissolved and suspended — Non-volatile	110	60						

"The water of the pond has a distinct yellowish-green color and an odor of pine. The amount of total solids in this pond water is unduly increased from the fact that not only the dissolved but also the suspended matter was reckoned; and the amount of the latter was disproportionately large, from the fact that the sample was collected close to the bank and to submerged logs over which the water was flowing.

"The amount of chloride in all the samples is small, and sufficiently indicates that the contamination by sewage or urine is so small that it may be neglected. On the other hand, the percentage of albuminoid ammonia in the pond water would seem to be very much larger than it ought to be. In every other respect it appears to be a soft and excellent potable water. A sample should be taken in the middle of the pond, away from the banks, and where the water has been afforded an opportunity for subsidence.

"The spring water is unexceptionable.

"As to the mixed sample of all wells (No. 3) and the samples from the separate wells, it may be said that while none of them but No. 6 are absolutely inadmissible as potable waters, on account of their analyses, yet they show such variations in their contained matter in solution, that it is evident that they are largely affected by superficial drainage, and it is not safe to depend upon them to supply drinking-water to the families of the mill."

In accordance with the suggestion in the above report, a second sample of the pond water was obtained, this time at a distance from the shore, and analyzed by the same chemist. He reports: "The agreement between the determination of chloride (5.32) in the first and second samples is exact and proves there is no contamination from cesspool drainage in the pond.

"As I predicted, the percentage of nitrogen as nitrates (0.13), of free ammonia (0.01), and of total solids (30), in the second sample, is much less than in the first, being one-half in the first two constituents named, to less than one-third in the last. But, to my surprise, the albuminoid ammonia (0.178) in the second sample is greater than the first, in the proportion of 9 to 7."

That such an excess of the single constituent, albuminoid ammonia, even though it approach what is commonly considered the danger line, is not sufficient to condemn a water in a case like the present, is evidenced by the following quotation from "Parke's Hygiene":[1]

"The presence of a considerable amount of albuminoid ammonia, with little free ammonia and chlorides, is generally indicative of vegetable organic matter, often peaty. This is the character of the greater part of the water-supply of Ireland. The real significance of the albuminoid ammonia has been much discussed, but the results obtained are sufficiently uniform to give us a convenient measure of purity, provided we are careful not to draw the line too close."

The above is exactly the condition that obtains in this case. The creek comes down from over sixty miles, through pine forests and sandy soil, with absolutely no possibility of animal contamination to any appreciable degree, and the albuminoid ammonia present must be of vegetable origin. Consequently, the writer can see no reason to change his opinion that the stream furnishes an abundant, pure and absolutely safe source for a water-supply to the village. I might add that the company is now supplying the people with water from the spring across the creek, hauling a sufficient supply each day, and that the use of all the wells for drinking or cooking purposes has been forbidden and discontinued. This, however, is only a temporary expedient, until proper arrangements for obtaining a more abundant supply can be effected.

It is to be regretted that no bacteriological examination of the water, especially of the wells, could be made, though it is doubtful whether the typhoid organism could have been thus positively demonstrated, as so long a time had elapsed between the inception of even the last cases and that of my visit. I had provided myself with a number of gelatine tubes for this purpose, but at almost the moment of my departure from the city was informed that the person who prepared them had failed to neutralize the gelatine, and that it would doubtless be too acid for satisfactory results. This I tried to remedy on arriving at my destination, but my facilities were there so limited that it could only be done imperfectly and inaccurately, and the results were correspondingly unsatisfactory. The impossibility of procuring any ice in that locality also precluded the idea of bringing samples of the water to Philadelphia and making cultures from them here, as to transport them so far at the ordinary temperature would have but favored the growth of certain saprophytic bacteria and the destruction by them of all others, including the pathogenic ones we were seeking.

That the water might be freer from danger, well ærated and cool in summer, I also advised that the supply be taken from the running stream rather

[1] Eighth edition, page 709.

than from the pond, and that the stand-pipe or tank be furnished with an automatic siphon, whereby it would be emptied periodically, say at night, when there is least demand for water, and refilled daily with a fresh supply.

As to the present method of disposing of the sewage (the dry-earth system, coupled with frequent removal), under the circumstances, probably no better could be devised. In the long run, however, it will probably be more expensive than a simple system of sewers, but space does not permit such a discussion in the present paper. Some system of soil drainage may have to be provided, if the sewers are not, to carry off the excess of waste water following the introduction of the hydrants, but I am inclined to think that this will not be necessary, owing to the extreme porosity of the soil, the active oxidizing power of that atmosphere and the fact that all refuse is either disposed of in the manner described or fed to swine outside of the village limits. The company, however, will have to take care to prevent excessive waste of water and to provide for the proper sanitary policing of the village.

In conclusion, I regret that certain necessary conditions forbid my being more definite as to the exact locality of the village in question, as I am prevented not only from acknowledging the courtesies and assistance which were so freely extended to me in my work, both by the officials of the company and the physicians attending the sick, but also from publicly recording the self-sacrificing devotion and faithfulness of the latter, which I am confident kept the mortality lower than it otherwise would have been. As it was, of the three hundred inhabitants—the approximate population September 1st—fifty-three were undoubtedly sick with the fever and ten died, practically all of which sickness and death might have been prevented, in so far as we can now see, had the well-established laws of sanitation and disinfection been properly observed and enforced in the very first case.

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