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## AN EXPERIMENTAL TEST OF THE RELATION OF SEWAGE DISPOSAL TO THE SPREAD OF PELLAGRA \*

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### INTRODUCTION

In September, 1913, we<sup>1</sup> called attention to the apparent relation between the origin of new cases of pellagra and the employment of insanitary methods of sewage disposal. This relationship has been discussed in several subsequent publications of this commission, and we have offered the hypothesis that the methods of disposal of human wastes might prove to be a determining factor in the spread of pellagra in certain communities. A practical experiment was announced and described in our second progress report.<sup>2</sup> Since that time our epidemiologic observations on this particular point have been supported by other independent observers in Charleston, S. C.,<sup>3</sup> and in Nashville, Tenn.<sup>4</sup>

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\* From the Robert M. Thompson Pellagra Commission of the New York Post-Graduate Medical School and Hospital.

\* Read in part before the Society for Experimental Biology and Medicine, Nov. 15, 1916.

\* The epidemiologic surveys in 1915 and 1916, utilized in this paper, have been made since Dr. Garrison and Dr. Siler were recalled to active duty in the Medical Corps, U. S. Navy and U. S. Army, respectively. The paper itself has been written since that time. They are, therefore, not personally responsible for the observations of the last two years, for the compilation of the data, or for the deductions drawn from them.

1. Siler, J. F., Garrison, P. E., and MacNeal, W. J.: A Summary of the First Progress Report of the Thompson-McFadden Pellagra Commission. Read at the Special Pellagra Conference at Spartanburg, S. C., Sept. 3, 1913; Jour. Am. Med. Assn., Jan. 3, 1914, **62**, 8.

2. Siler, J. F., Garrison, P. E., and MacNeal, W. J.: The Relation of Methods of Disposal of Sewage to the Spread of Pellagra. *THE ARCHIVES INT. MED.*, 1914, **14**, 453; Second Progress Report, New York, 1915, p. 96.

3. Smith, W. A.: Epidemiology of Pellagra in Charleston, S. C. Read at the Third Triennial Pellagra Conference, Columbia, S. C., October, 1915.

4. Jobling, J. W., and Peterson, W.: A Preliminary Report on the Epidemiology of Pellagra in Nashville, Tenn., Jour. Infect. Dis., 1916, **18**, 501.

## THE EXPERIMENT

In the present communication we wish to present the results of the experiment begun in the community of Spartan Mills, Spartanburg, South Carolina, in 1913. This particular community had been a conspicuous endemic center of pellagra as long as the disease had been recognized in this region. Our records show that five new cases of pellagra were known to have appeared in this mill village previous to 1909, five in 1909, thirteen in 1910, twenty-three in 1911, eight in 1912 and thirty in 1913. In the fall of 1913 the installation of a water-carriage system of sewerage was begun, and the actual house connections were made as rapidly as the progress of the work would permit. One house was equipped in August, 1913; five houses in September, 1913; five blocks of houses in December, 1913; three blocks in January, 1914; three blocks in March; five blocks in April and seven blocks in May, 1914. A small group of houses, six in number, situated on very uneven ground at one corner of the mill property, was left without sewer connection. These houses were equipped with fly-proof pail closets. All the old, open, unscreened surface privies were demolished and removed. We had made a complete house-to-house survey of this community and of some of the adjoining groups of houses in 1913, and had accumulated rather extensive but, of course, much less complete records of the pellagrins there in previous years. The house-to-house survey was again made in 1914, in 1915 and in 1916, and in these years the survey was also extended to some of the neighboring districts.

In 1914 considerable attention was given by the Spartanburg Health Department to the privies everywhere in the city, and the owners of the houses adjacent to Spartan Mill, which is within the city limits, were compelled to make all privies fly-tight and leak-proof in that year. Subsequently, many of these privies have been maintained in a fairly sanitary condition, but others have fallen into a state of dilapidation, such that they are, from the point of view of disease dissemination, not at all different from the old surface privies. On the other hand, the sewered closets of the mill houses, which were occasionally stopped up or out of use because of ignorance of the population during the first year, have become more and more efficient as the people have become accustomed to their use and have recognized the ease with which they can be kept clean. It should also be mentioned that the houses on the mill property all belong to the mill company and are rented to their employees, who, as a rule, are not property owners. The houses on the neighboring property are privately owned and frequently occupied by the owners, and, if rented, are generally rented to people in better financial circumstances than the mill population.

## THE RESULTS

From 1908 to and including 1913, eight<sup>5</sup> new cases of pellagra appeared in the houses immediately adjacent to the mill property, which have been included in this survey. During the same time there arose eighty-three<sup>6</sup> new cases within the mill property. Table 1 shows the number of new pellagrins that appeared in each of these two sections in each year since 1908. The population living on the mill property was approximately 2,000 people, and that in the adjacent houses included in this survey approximately 300.

TABLE 1.—PELLAGRINS INCIDENT IN SPARTAN MILLS AND IN THE ADJACENT SURVEYED DISTRICT IN EACH YEAR

	1908	1909	1910	1911	1912	1913	1914	1915	1916
In Spartan Mills.....	4	5	13	23	8	30	18	8	2
In adjacent district.....	0	2	0	1	3	2	3	2	4

During the year 1914, in which the sewer connections were completed, eighteen persons developed initial symptoms on the mill property. One arose in a house which was sewered in December, 1913, but just across the street from a house in which pellagrins were living, and which was not connected to the sewer until May, 1914. One arose in a house well within the district sewered in December, 1913. This patient was a married woman, whose mother, Pellagrin 237, had suffered from pellagra for many years. The mother lived in the neighboring unsewered district and was frequently visited by her daughter. Three cases appeared in a section which was sewered in January, 1914, eight arose in a section which was connected with the sewer in March, 1914, one in a section connected with sewer in April, and the remaining four in a section which was connected with the sewer in May, 1914. The installation of the sewers was probably too late to influence very much the pellagra incidence in 1914.

In the year 1915 there were eight new cases of pellagra found on the mill property. Two of these were children who had been living for at least two years in a district sewered in March, 1914. The father of one and the mother of the other were old pellagrins. In both these

5. This number does not include Pellagrins 91 and 991 with origin in 1911 and 1913, respectively. Both of these patients apparently contracted the disease while residing in this district, but moved away before the erythema appeared.

6. This number does not include Pellagrin 868, who had resided in Spartan Mills for about twelve years, but first developed the pellagrous erythema in 1913 while away on a visit.

children the diagnosis is somewhat doubtful, for they showed an eruption on the feet only, and this eruption has never recurred. Another case was in a woman who had lived in the sewered district since November, 1914. She gave birth to a child in June, 1915, and broke out with pellagra in July, 1915. Previous to November, 1914, she had lived in an unsewered mill in next-door relationship to a pellagrin. Another patient, Pellagrin 1282, was a feeble-minded woman, who denied all symptoms of pellagra, but showed a typical eruption in August, 1915. She may have had the disease previously, but has been recorded as a 1915 case. She lived with her mother, Pellagrin 940, in the sewered house since October, 1914, having previously lived in the unsewered section, where her mother contracted the disease in the summer of 1914. Another woman, Pellagrin 1336, had lived in the mill village since May, 1913, and suffered her first attack of pellagra in April, 1915. In February, 1915, she spent a week at her father's house in the country, her mother being severely ill with some gastrointestinal disorder at that time. Her father had been a pellagrin for several years and a sister, living at home, had her first attack in the previous summer. Pellagrin 1336, herself, developed pellagrous erythema of the hands about six weeks after her return to Spartan Mills. Another case was in a baby who came to this village in the latter part of January, 1915, and broke out with pellagra May 28, 1915. Her mother was an old pellagrin and was severely ill with a recurrent attack of the disease in April, 1915, and was committed to the State Hospital for the Insane about May 20. The house was in a filthy condition during the mother's illness. In an unscreened house next door to this one, Pellagrin 1279 had her initial attack June 15, 1915. She had lived there only since March. Before that she had lived for eighteen months in an unsewered section. Her daughter, aged 7, living with her, had been a pellagrin since 1913. The eighth patient, Pellagrin 1303, had lived in a neighboring unsewered mill village from November, 1914, to April, 1915, and she had shown indefinite symptoms of pellagra there in March, 1915. Her first erythema appeared early in June, 1915, about two months after coming to Spartan Mills.

In 1916 only two cases of pellagra are known to have appeared in the mill village. One woman, Pellagrin 1377, had her initial attack in June, 1916. She was an old resident and lived in a house at the edge of the sewered district just across the street from an unsewered house in which an old pellagrin resided. Pellagrin 1377 had borne a child in the latter part of April, 1916. The other patient, Pellagrin 1356, came to Spartan Mills in April, 1916, and developed her first erythema in that month. Previously she had been living with her daughter, Pellagrin 1167, in an unsewered house.

In this sewered district the number of new cases each year has shown a progressive diminution since 1913, being eighteen in 1914, eight in 1915 and two in 1916. The installation of the sewers could have had only a partial effect in 1914, because the connections were not completed until May of that year. In 1915 the incidence diminished very appreciably, but a number of new cases appeared among people who had moved into the mill village within a year. This influx was due to the very serious financial depression, and especially to the general depression in the cotton market from August, 1914, through 1915. Except for the two children in whom the diagnosis was doubtful, and the one woman, Pellagrin 1336, who had nursed her mother on her father's farm for a week in February, 1915, all the new pellagrins had moved within a year. In 1916 the result of the experiment is even more clearly evident. In this year only one new case appeared among the older residents on the mill property, and that was in a house at the extreme edge of the sewered district.

During the same years nine new cases of pellagra appeared in the small group of the more well-to-do population living in the adjacent partly sewered district which has been included in the survey. Three of these appeared in 1914. Pellagrin 1389, a contracting carpenter in very comfortable financial circumstances, suffered his first attack in 1914 in a house next door to pellagrins living on either side in unsewered houses. He had been living in the same house for several years. Pellagrin 940, an old woman, suffered her first attack in 1914 in a house next door to an unsewered house in which two pellagrins were living. Pellagrin 1289, a young girl, had her first attack while living with her pellagrous mother in an unsewered house. In 1915, after the general enforcement of the sanitary ordinance in regard to privies in Spartanburg City, only two new cases of pellagra appeared in this district. One was a man, Pellagrin 1314, living in an unsewered house with his wife, an old pellagrin. The other patient was a woman, Pellagrin 1285, who had moved about a good deal. She lived with her mother, Pellagrin 912, until the summer of 1914, in a sewered house just across the street from an unsewered house in which an active pellagrin resided until October, 1914. This patient, Pellagrin 1285, moved to the unsewered district outside the mill property Jan. 1, 1915, and into a house just vacated by a pellagrin. She gave birth to a child Feb. 14, 1915, and had her initial erythema in May, 1915.

In 1916 there were four new cases of pellagra in this district, three of them in one little focus in two houses immediately adjacent to a dilapidated and very dirty surface privy, which was used daily by old pellagrins, and one of them in a sewered house in which an old pellagrin resided at the time.

TABLE 2.—PELLAGRINS RESIDING IN SPARTAN MILLS IN EACH YEAR CLASSIFIED ACCORDING TO MANIFESTATIONS OF THE DISEASE AND LENGTH OF RESIDENCE

Year	With Indefinite Record		Without Recurrence		With Recurrent Attack		With Initial Attack	
	Old Residents	Recent Arrivals	Old Residents	Recent Arrivals	Old Residents	Recent Arrivals	Old Residents	Recent Arrivals
1908	0	0	0	1	1	0	3	1
1909	1	1	1	0	3	1	2	3
1910	0	0	1	1	3	0	9	4
1911	2	0	2	1	8	3	13	10
1912	1	1	9	0	17	3	4	4
1913	1	1	13	1	21	5	16	14
1914	1	1	18	7	27	13	7	11
1915	1	0	32	10	26	14	3	5
1916	3	0	49	6	15	6	1	1

Table 2 shows the number of cases of pellagra known to have resided in Spartan Mills in each year from 1908 to 1916, inclusive, classified according to initial attack, recurrent attack, absence of recurrence and lack of definite record. Each of these classes has been subdivided into two groups; one group, designated as old residents, being made up of those who had been living in the village for at least a year, and a second group comprising those who had moved into the village within the year.

Table 3 shows in a similar way the pellagrins known to have resided in the surveyed adjacent district. The data of these tables are pre-

TABLE 3.—PELLAGRINS RESIDING IN HOUSES ADJACENT TO SPARTAN MILLS IN EACH YEAR CLASSIFIED ACCORDING TO MANIFESTATIONS OF THE DISEASE AND LENGTH OF RESIDENCE

Year	With Indefinite Record		Without Recurrence		With Recurrent Attack		With Initial Attack	
	Old Residents	Recent Arrivals	Old Residents	Recent Arrivals	Old Residents	Recent Arrivals	Old Residents	Recent Arrivals
1908	0	0	0	0	1	0	0	0
1909	0	0	0	0	0	1	2	0
1910	0	0	0	0	3	0	0	0
1911	0	0	0	0	3	2	0	1
1912	0	0	0	0	4	3	1	2
1913	1	0	2	4	6	2	2	0
1914	1	0	2	1	2	1	2	1
1915	0	0	1	0	6	0	1	1
1916	0	0	6	2	1	4	2	2

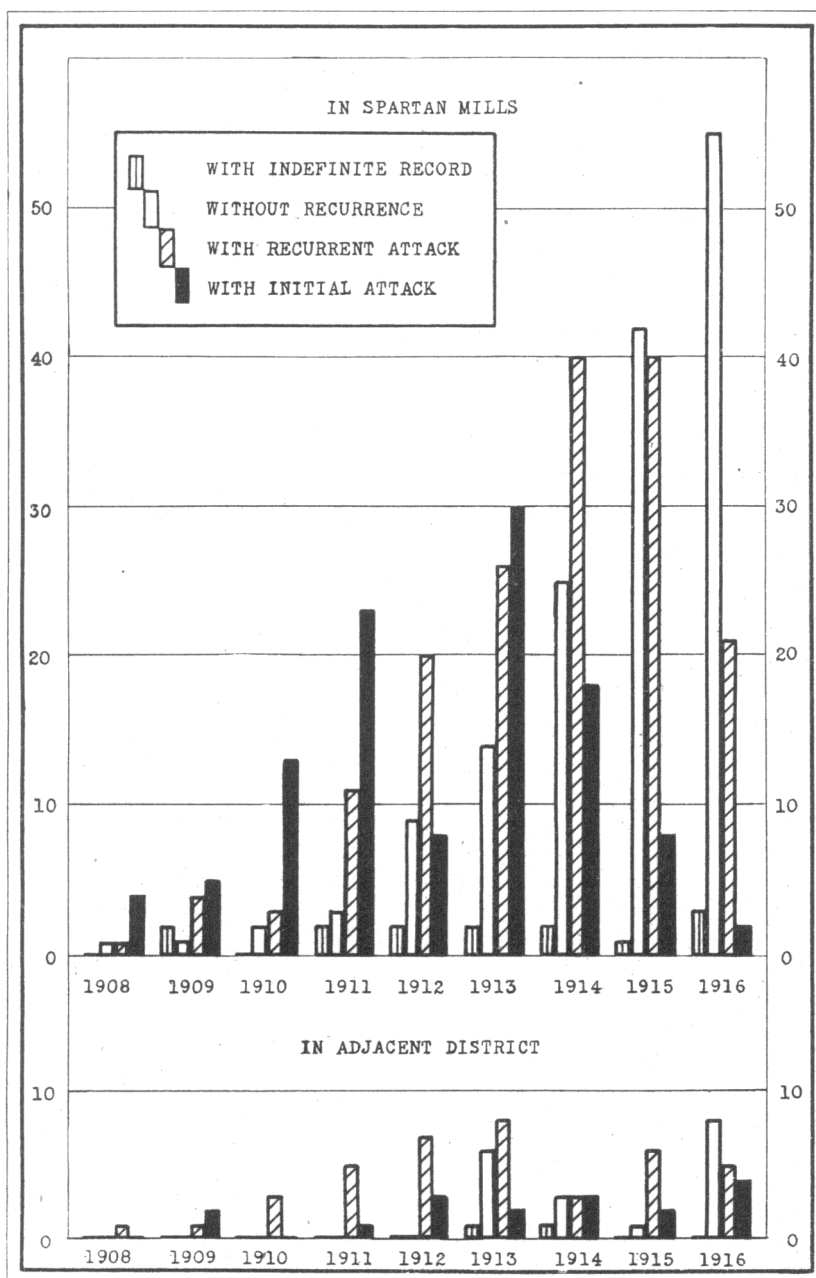


Fig. 1.—The total number of pellagrins residing in Spartan Mills and in the adjacent surveyed district in each year.

sented in graphic form in Figures 1 and 2. The former shows the total pellagrins of each class present in each year in the mill village and in the adjacent district, and Figure 2 shows in a similar way the old residents, excluding all who had moved in within the year.

In the charts one can see that the number of newly incident cases of pellagra reached the maximum in 1913, after which the number diminished rapidly. We believe that this reduction may be reasonably ascribed to the improved sanitation instituted in 1913 and 1914. The number of pellagrins who suffered recurrent attacks increased each year, to reach its maximum in 1914, in which year forty of the residents within the mill village suffered from recurrent pellagra. In 1915 the number with recurrent attacks of the disease was the same, but in 1916 there was a marked diminution in the number of recurrent cases. The amount of recurrent pellagra seems not to have been influenced directly by the change in sanitation. The diminution in this group would appear to be due in part to the falling off in the number of newly incident cases in the years immediately preceding. As we have shown in an earlier paper<sup>7</sup> in this series, the proportion of old pellagrins who suffer recurrence of the disease tends to diminish progressively with the lapse of time, and inasmuch as only eight new cases appeared in 1915, the recurrences in 1916 could not be very numerous unless cases dating from 1914 or before furnished the bulk of such recurrences. The diminished number of recurrences in 1916 has probably been due in part also to the increased prosperity of the population and to a considerable degree to the free dinners provided for these old pellagrins by the United States Public Health Hospital. The number of pellagrins without recurrent attack has increased progressively to the maximum of fifty-five in 1916. This shows that the pellagrous population has not been decreased especially by emigration, but that the patients have remained in the village for the most part and have outlived the active stage of the disease.

The situation brought about by the installation of the sewer system appears to be closely analogous to the condition previously observed by us<sup>2</sup> in the Newry Mill Village, a situation such that pellagra may continue to recur in those patients who have previously contracted the disease, but in which new cases of pellagra do not arise in any appreciable number.

The data for pellagra in the immediately adjacent district are of interest as a control study. The population of this district was about one-sixth as large as that of the mill village. From 1908 to 1913, inclusive, there had been eight instances of initial attack of pellagra

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7. Siler, J. F., Garrison, P. E., and MacNeal, W. J.: The Subsequent History of Pellagrins in Spartanburg County, S. C., Who Survived the Initial Attack, *THE ARCHIVES INT. MED.*, 1916, **18**, 340.



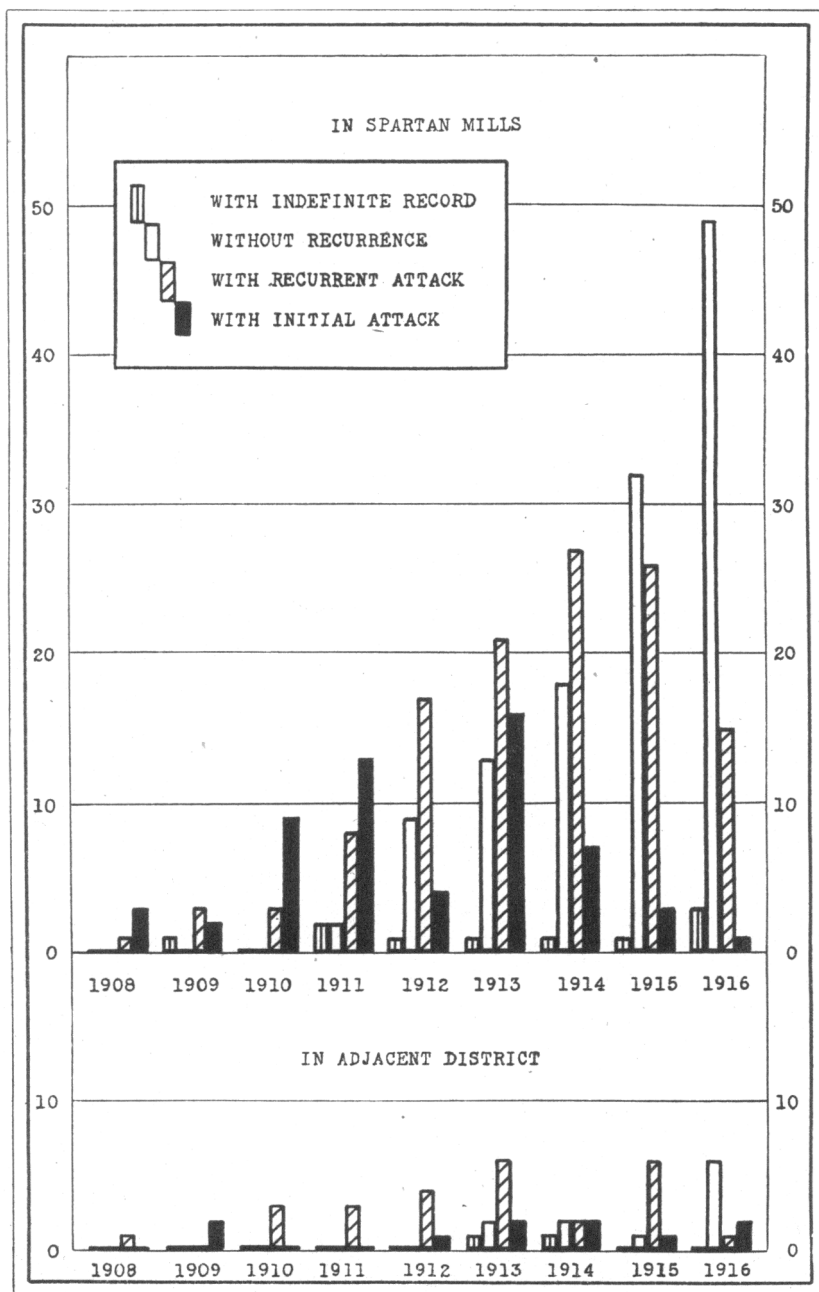


Fig. 2.—The number of pellagrins among old residents in Spartan Mills and in the adjacent surveyed district in each year.

here, while eighty-three cases had arisen in the mill village itself. In 1914 there were three new cases in this control district and eighteen in the mill village; in 1915 two here and eight in the mill village, and in 1916 four here as against only two in the mill village. It will be noted that pellagra has continued to spread in this district adjacent to the mill village since 1913 at about the same rate as it did before.

#### COMMENT

The diminution in new cases of pellagra in this community from thirty in 1913 to eighteen in 1914, eight in 1915 and two in 1916, has been very remarkable, and the obvious cause of this improvement would appear to be the intentional experimental factor, namely, the installation of the sewerage system. It is necessary, however, to examine critically the experiment and to give full consideration to other possible factors which may have entered into and influenced the result. Especially important in this respect would seem to be the condition of general prosperity and the possible changes in food habits of the population, for it is well known that both incident and recurrent attacks of pellagra tend to be more prevalent among the poor and ill-nourished.

The general prosperity may first be considered. In 1913 and 1914 these people were in better financial circumstances than in 1911 and 1912. In 1915 they were suffering from the general business depression, which became serious about Aug. 1, 1914, too late, however, to be effective in the pellagra season of 1914. This depression caused an influx of the poorer farming population to the mill, where work could be obtained although wages were low. The general financial condition of the population in 1915 was much worse than in 1914 and probably worse than in 1911 or 1912. In 1916 this situation had been relieved and the demand for labor elsewhere had brought about a slight increase in wages in the mill in order to retain the workers. Financial conditions in 1916 were much better than in 1915 and probably better than in 1913 and 1914. The influence of this factor is apparently manifested by the smaller number of recurrences in 1916 as compared with 1915. It is necessary, however, to keep in mind that a reduction in the number of newly incident cases in one year necessarily tends to bring about a reduction in the number of recurrent cases in the next subsequent year or two, so that the small number of recurrences in 1916 may be partly due to smaller crops of new cases in 1914 and 1915. Granting, for the moment, that increased prosperity has caused a reduction in recurrent cases from forty in 1914 and forty in 1915 to twenty-one in 1916, it is evidently quite impossible to ascribe to it the decrease in newly incident cases from thirty in 1913 to eighteen in 1914, when the recurrent cases increased from twenty-six to forty, or

the further decrease to eight incident cases in 1915 while the recurrences still remained at forty. Furthermore, in 1916 the newly incident cases were reduced almost to the vanishing point while the recurrent cases were only about 50 per cent. less than the largest number ever observed. The reduction in the incident cases cannot, therefore, be satisfactorily ascribed to the improved financial conditions.

Another factor which requires consideration is the possible change in diet of the population, dependent on educational propaganda resulting from the investigations of pellagra, and on the presence of the pellagra hospital located within this mill village. This hospital was conducted by our commission in 1913 and was taken over by the United States Public Health Service in 1914. The value of improved nutrition in the prevention and treatment of pellagra has been preached to this population by us since 1912, and since the fall of 1914 the Public Health Service has provided a free dinner for all known pellagrins who would come regularly to partake of it. This food was provided only for pellagrous individuals and not for the general population. The educational campaign has also reached especially the pellagrins, but of course to a less degree the general population. It is perhaps justifiable to credit, in part, to this campaign of dietary improvement the progressive increase since 1912 in the number of old pellagrins without recurrence present in this community and the actual reduction in recurrent attacks observed in 1916, especially the latter, because of the improved diet actually given to many of the old pellagrins. An attempt to ascribe the diminution in newly incident cases to improved dietary meets at once with difficulties of the same nature as those mentioned in the preceding paragraph. The diet has been applied directly and definitely to the old cases of the disease with the result that the recurrences have been reduced from twenty-six in 1913 to twenty-one in 1916, while among the general population, on whose diet the effect of this factor was only indirect and probably very slight, the number of incident cases of pellagra has diminished from thirty in 1913 to two in 1916.

When, therefore, the influence of these general factors is examined and measured by the behavior of the old cases of pellagra, it is found quite inadequate to explain the diminution in the number of newly incident cases of pellagra, and, therefore, quite inadequate to have influenced materially the result of the main experiment. A further light is thrown on the matter by the control group of population in the adjacent surveyed district.

The people in this district adjacent to Spartan Mills were influenced also by the general prosperity, by the educational propaganda and by the free dinners. The eight pellagrins in this district who escaped recurrence in 1916 may perhaps be reasonably credited in part to these

factors. It is, however, very significant that in spite of these general influences new cases of pellagra were as numerous as ever in 1916 in this district. In fact, more new cases occurred here in 1916 than in the enormously greater population of the mill village itself.

This experiment at Spartan Mills is, of course, only one experiment, and we realize that sweeping conclusions cannot justly be drawn from any single experiment in which various uncontrolled and unknown factors may have entered. Nevertheless, we feel justified in pointing out that the result of the experiment is fully in accord with the hypothesis announced at its inception, as a test of which it was undertaken. Furthermore, the outcome of this experiment considered together with the large mass of epidemiologic evidence, previously presented by us and confirmed by other independent observers, seems very convincing. We feel warranted in continuing to recommend most heartily the installation of sanitary systems of sewage disposal as an important means of restricting the spread of pellagra.

#### SUMMARY

1. Subsequent to the installation of a water carriage system of sewage disposal at Spartan Mills, the community has been transformed from a pellagra focus to a community in which pellagra no longer spreads.
2. Old cases of pellagra have continued to recur in this community, although a distinct decrease in them has occurred in the third year after the installation of the sewers.
3. The installation of sanitary systems of sewage disposal is recommended as a measure for the restriction of the spread of pellagra in the general population.