Winnepesaukee can be approximated artificially and some of the reservoirs recently constructed, like the Wachusett reservoir of the Metropolitan water works in Massachusetts are giving water of most excellent quality, although the water entering them is highly colored and contains large quantities of organic matter.

The best evidence we can have of the safety in the use of such waters is the fact that our large cities, like Boston and New York, which are supplied from storage reservoirs, never have an epidemic of typhoid fever which can be attributed to the water supply, although the feeders of the reservoirs are known to be polluted. The weak points about such supplies are the possibilities of local contamination which may quickly reach the point from which water is drawn and the occasional troubles from tastes and odors due to growths of organisms.

Running streams are the least desirable sources of supply and I do not believe there is any stream, accessible for water supply purposes, which can be considered a safe source from which to take water directly. Although there may be no permanent sources of pollution on the watershed, it is absolutely impossible to prevent access to the stream, and when we consider that any pollution entering the stream at any time is almost immediately taken into the distributing pipes of the water supply system, the danger is obvious. Such supplies, if used at all, should invariably be filtered.

Experience is showing us that the nearer we get to nature, either in disposing of sewage or in obtaining a water supply, the better the results secured. The old-fashioned cesspool which has been so much abused is now considered the best method of disposing of small quantities of sewage. In methods of water purification the most satisfactory are those where nature is assisted as little as possible. The addition of chemicals or the construction of works which require constant personal attention, while frequently necessary, should be adopted only as a last resort.

FILTRATION OF PUBLIC WATER SUPPLIES.*

HARRY W. CLARK.

BOSTON.

The purification of municipal water supplies by filtration has been practiced for over seventy years. Apparently the first filter of considerable size was that constructed by the city of London in 1829, and that city now has about 120 acres of sand filter beds. Berlin, Germany, built water works and sand filters in 1856, fifty years ago, and at the present time practically all the important cities of Great Britain and Germany filter their water supply if this water is taken from a surface source. Filtration of public supplies is widely practiced in other countries, especially Belgium and Holland. Even Russia has several large municipal filters; a recent article in the *Engineering Record* describes large sand filtration plants in Japan, while in India and Egypt a number of large municipal supplies are treated by mechanical filters.

The first large municipal filter in America was constructed at Lawrence, Mass., in 1892-93, although at Poughkeepsie and Hudson, N. Y., St. Johnsbury, Vt., and Nantucket, Mass., small filters had been previously

built, the first one being that at Poughkeepsie, N. Y., constructed in 1872. During the last half of the last century public water supplies in America increased greatly in number, but perhaps the true beginning of the modern desire for pure water in this country, in distinction from the desire for enough water, was given by the State Board of Health of Massachusetts in 1886, when systematic examinations of the water supplies of the state were begun, frequent analyses of these supplies made and the Lawrence Experiment Station established.

Filtration of water is resorted to for various causes: To remove disease germs and render a polluted water safe, to remove undesirable organic or mineral matter present in suspension in water and thus improve its appearance, to remove color and to remove tastes and odors and the organisms causing these tastes and odors.

The first municipal filters were constructed for the purpose of improving the appearance of public supplies, and for many years the removal of organic and mineral matter in suspension in the water was believed to be the chief benefit of filtration. Studies showing the efficiency of sand filters in removing bacteria from water were begun in Berlin in 1884 and since that date the water supply of the city of Berlin has been systematically examined bacterially, and since 1888 constant bacterial examinations of the water supplies of London have been made. In 1887 the Massachusetts State Board of Health began at the Lawrence Experiment Station its investigations on the filtration of water and the purification of sewage, and since then notable studies of the science of water filtration have been made by various municipalities in this country. At Lawrence the studies for many years were directed entirely to what is known as slow sand filtration, but of late years other methods have been studied at Lawrence and mechanical and other forms of water filters have been operated. The improvement of water by double filtration has also been extensively studied there.

The municipal studies in America have been directed almost entirely to determining the comparative efficiency and applicability of sand and mechanical filters in the treatment of the various kinds of water necessary to use in various sections of the country, together with studies of sedimentation, coagulation by different coagulants, etc. In the Lawrence studies more than seventy-five experimental water filters have been kept in operation for periods varying from a few months to fourteen years, and with the laboratory facilities of the station almost every conceivable determination of the efficiency of these filters has been made. Daily determinations of the bacteria in the raw and filtered water and chemical analyses to show the work of the filters in removing color, organic matter, etc., have been made; the effect on filter efficiency of different rates of operation, different depths of filter and filter efficiency when treating different waters have all been exhaustively studied and the results given from year to year in the Lawrence Experiment Station reports.

Since the Lawrence filter was built in 1893 sand filters have been constructed at Mt. Vernon, Albany, Providence, Philadelphia, Washington, Yonkers, New Haven, Springfield, Bar Harbor and other places, and such filters are in process of construction at Pittsburg, Pa., Cincinnati, Ohio, and South Norwalk, Conn. Investigations are also under way looking to the filtration of the old and new water supplies of the city of New York.

Mechanical filters began to be extensively used in America, especially throughout the south and west, in

* Read in the Section on Hygiene and Sanitary Science of the American Medical Association, at the Fifty-eighth Annual Session, held at Atlantic City, June, 1907.

the latter part of the 80's, largely, however, for the purpose of clarifying river water rather than for bacterial purification. In 1904 it was estimated by Hazen that 560,000 people in America were supplied with sand filtered water and 3,000,000 with water treated by mechanical filters. In the past three years, owing to the introduction of sand filters at Washington, Philadelphia, Providence and other places, the number of people supplied with sand filtered water has more than tripled, so that at the present time about 2,000,000 people in this country are so supplied.

The government has recently constructed covered sand filters of twenty-nine acres in area at Washington, these filters having a capacity of 75,000,000 gallons daily. Filter beds twenty-two acres in area supplying 288,000 people, have recently been constructed in Philadelphia and fifty acres are in course of construction, while at Pittsburg forty-six acres of filter beds to supply a population of 400,000 are being constructed and will be completed probably during 1908. The introduction of mechanical filters constructed on a scientific basis has also gone forward with great rapidity during the past few years and probably 1,000,000 more people are supplied with water purified in this way than were supplied in 1904. The filters at Little Falls and Hackensack, N. J., are the largest of this type of filter yet constructed.

A sand filter is a very simply constructed affair. It is in its essential features merely a body of sand of sufficient thickness, underlaid or supported on a few inches of coarse and fine gravel or broken stone, with a proper number of pipe underdrains to collect the water that passes down through the sand, the filtering material enclosed by a suitably constructed concrete masonry basin with tight bottom and sides and in the northern states covered with a roof. These are its essential features of construction, but the details can be varied through wide limits and by the engineering skill of those engaged in planning and building filters; they are being constantly improved, these improvements tending to simplify filter operation, to promote constant efficiency and to reduce the cost of filtration.

Such sand as that in the Lawrence filter will, when first placed in position, allow 50,000,000 gallons of water daily to flow through one acre of surface area; such sand as in the Albany filter will, theoretically, allow under the same conditions about twice as much water to pass through. As the sand remains in position and in constant use, however, it becomes compacted and its maximum rate decreases very materially, so that under the same conditions of head, free underdrains, clean surface, etc., the maximum rate of the filter may be only one-half or one-fourth as great as when first put in use. During the past two or three winters the volume of water that could be made to pass through the Lawrence municipal filter decreased so materially, owing to compactness of the sand due to use and continued water pressure, that it has been a serious problem to filter a volume sufficient for the city's needs. An experimental filter at the experiment station, of the same grade of sand as in the municipal filter and of the same age of operation, has shown similar results as to decreased capacity to flow.

The maximum rate at which a filter may be operated has little connection, however, with the actual rate necessary for bacterial efficiency. In Germany the official rate of filtration recognized by the imperial board of health is 2.57 million gallons per acre daily. The ex-

periments at Lawrence and elsewhere in this country, however, have shown what common sense would tell us, that the rate of filtration may vary very materially with the character and degree of pollution of the raw water. Lawrence experiments make it clear that under careful supervision badly polluted water can be filtered at rates as high as 3,000,000 to 4,000,000 gallons per acre daily with entirely satisfactory results and that with ordinary river and reservoir waters, not grossly polluted, rates of 5,000,000 gallons per acre daily can be safely followed. A sand filter containing from three and one-half to five feet in depth of suitable sand and filtering polluted water at the rates mentioned, is capable, under proper conditions of filtration and skilled operation, of removing 99 per cent. or more of the bacteria present in the applied water and a considerably larger percentage of the bacteria of intestinal origin present in such water.

For nineteen years experimental sand filters have been in operation at the Lawrence Experiment Station. For fourteen years the Lawrence municipal filter has been in use and the Albany filter plant since 1899. Daily records of the bacterial efficiency of the Lawrence filter and the Albany filter show that by proper supervision a thoroughly satisfactory effluent from a bacterial point of view can be obtained at the rates followed at these places. Constant chemical analyses show, moreover, that organic matter can be reduced about 50 per cent. and coloring matter from 20 to 40 per cent. when filtering such river water as passes to these two filters. It has been found that not once has the average yearly efficiency of the Lawrence filter fallen below 98.5 per cent., and that during the past eight years it has been about 99.5 per cent. The Albany figures on the table show a similar result.

In the operation of sand filters a certain amount of sand clogged with organic and mineral matter has to be removed from the surface every little while in order that the filter may be kept in operation and the required rate of filtration and volume of filtered water be obtained. At Albany the period between scrapings averages about twenty-five days and at Lawrence practically the same period elapses. At each scraping about one-half inch of clogged sand is removed, although when the laborers employed in this work are skilful a lesser depth is taken away at each scraping, the depth that must be removed varying, of course, with the character of the matter in and removed from the raw water; for example, the Potomac river water passing to Washington filters contains fine clay particles that penetrate to a considerable depth below the surface and cause deeper sand removal than necessary at Lawrence or at Albany, while a filter receiving lake water free from turbidity would need even less sand removal than the Lawrence and Albany filters. The sand removed is subsequently washed and replaced. Replacement of sand is usually carried out once or twice each year and at this time the filters are filled to grade with new or washed sand. At the present time sand is removed from filter beds by water pressure, that is, a movable hopper connected with pipe or hose is placed on the filter and moved about from place to place and the sand that has been scraped from the filter surface and heaped up is shoveled into it. A stream of water passes through the bottom of this hopper, carries the sand into a pipe and through this to the washing area. According to Lawrence and Albany figures, the cost of filtration exclusive of interest on plant is about \$1.50 per million gallons of water filtered. This includes scrap-

ing, ejection of sand, washing of sand, replacement of sand and general care of the filter beds. At Washington by improved methods and machinery the cost is stated to be only about one-third of this, or 50 cents per million gallons. Including interest on cost of plant and depreciation, the cost of sand filtered water averages about \$10 per million gallons filtered.

The first scientific work in this country on water filtration was that in Massachusetts, where the comparatively clear river water of the eastern states was experimented with. It was found that such waters, polluted by considerable amounts of organic matter and containing the dangerous bacteria from the sewage of cities along their course, could be successfully and comparatively cheaply treated by sand filtration. When the studies were begun at Louisville, Cincinnati and elsewhere on the turbid waters of the central and western states, carrying at times of flood large amounts of clay and silt in suspension, it was found that sand filters were but poorly adapted to the filtration of these turbid waters without extensive preliminary treatments of such waters. Bacterially they could be made about as efficient as in the east, but, owing to the large amount of matter in suspension in these waters and the fineness of many of the particles of this matter, sand filters would quickly clog and the effluents produced were not of a satisfactory quality as regards freedom from matters in suspension. It was also found that it was not economical even with mechanical filters to treat the western river waters directly, but that large sedimentation basins capable of holding from one to many days' supply of water were necessary, and the addition of coagulants in different amounts at different times before filtration, varying with the character of the water treated. It was found, however, that a purification system suitably planned, consisting of sedimentation basins, apparatus for the introduction of coagulants and properly constructed mechanical filters, was capable not only of producing satisfactory effluents from a bacterial point of view but also effluents of a satisfactory clearness and freedom from color.

The simplest form of mechanical filter used in paper mills and elsewhere where a clarified water is desired is a large wooden tub with a couple of feet of sand in its bottom over underdrains and strainers and supplied with mechanical devices by which the sand can be agitated and washed in position by reversing the current of water and passing it up through the sand. In connection with such filters in mills a coagulant, such as sulphate of alumina, is often used, but often also the water is simply strained by the sand at a very high rate without the use of a coagulant. Early forms of mechanical filters employed such filtering materials as charcoal, coke, etc., and water was in some instances passed through under pressure from the city mains. The coagulant, sulphate of alumina, when introduced into an alkaline water decomposes and the gelatinous hydrate of alumina is formed which gathers in aggregates the organic matter, suspended mineral water and bacteria of the raw water, and, by the formation of these aggregates and their subsequent entanglement and collection at the filter surface, forms a most excellent body for the retention of bacteria and organic matter. By the use of a coagulant and this formation, and the use of coarse sand, rates of 75,000,000 to 125,000,000 gallons per acre daily can be maintained.

From the first crude type of mechanical filter, through the experience of those engaged commercially in install-

ing filter plants, and also as a result of the able investigations carried on at Louisville, Pittsburg, Cincinnati and other places by experts in water purification, a new type of filter has been evolved. This new type is a combination of a mechanical and sand filter, although, of course, much nearer the mechanical filter form. The chief change, however, as typified by those recently constructed, is that it is built of practically indestructible materials, concrete or re-enforced concrete, instead of the perishable wooden forms formerly employed. The sand beds are considerably larger than the old wooden tub mechanical filters, but still small compared with the beds of slow sand filters. Improved devices for the even passage and collection of water after passing through the sand have been devised and also better and more efficient methods of washing the sand. Filters of this new and improved type have been installed at Little Falls and Hackensack, N. J., at Ithaca and Watertown, N. Y., Louisville, Ky., Harrisburg, Pa., and are being planned for other places. At Little Falls, N. J., the first large plant of this new and improved type was constructed and put into operation in 1902. This plant is designed to have a capacity of 32,000,000 gallons daily and covers a total area of only about $1\frac{1}{4}$ acres. It has 32 individual filter beds of 360 square feet each, a coagulating and subsiding basin with a capacity of 1,750,000 gallons and a clear water basin of $3\frac{1}{2}$ million gallons capacity. The filters are constructed above the clear water basin. The water filtered is taken from the Passaic River and is a water somewhat dirty in appearance, not highly polluted, but unsatisfactory for domestic use on account of its appearance and the matters in suspension in it.

Sulphate of alumina is used as a coagulant in amounts averaging about 1.3 grains per gallon, and in order to supply sufficient alkalinity to cause good decomposition and coagulation and prevent the passage of undecomposed alum into the effluent, soda ash is used in amounts averaging about $\frac{1}{2}$ grain per gallon. These filters contain $2\frac{1}{2}$ feet in depth of sand of an effective size varying from .35 to .40 mm., placed over fine gravel or broken quartz and this resting on the filter floors in which are inserted the strainers. In washing the sand in these filters, water is passed up from below and the sand agitated by compressed air instead of by the stirring rakes formerly employed. The dirty wash water flows away through the inlet pipe to which a branch is attached leading into the sewer. The rate of filtration employed is 125,000,000 gallons per acre daily. This filter removes more than 98 per cent. of the bacteria in the applied water, about 85 per cent. of the coloring matter, about 40 per cent. of the organic matter determined as albuminoid ammonia, and a much greater percentage of the total organic matter. It lowers the temporary but increases the permanent hardness of this water about 40 per cent.

When a slow sand filter is first put into operation the water comes through almost unchanged, and before good filtration—that is, good bacterial efficiency—can be obtained, the sand grains, especially those near the surface of the filter, must be covered with films of organic matter and this organic matter be filled with the bacterial life which is capable of entangling and destroying the ordinary water bacteria and disease germs present in the raw water. That is, sand filtration is not entirely mechanical straining, but largely a bacterial process of water purification.

With the ordinary New England waters several weeks are necessary for this process of biologic construction to

be established. With a clear water containing little matter in suspension, a longer period even is necessary and finer sand in the filter is of advantage. When the filter has by this biologic construction become a proper medium for the efficient filtration of water, it not only removes bacteria but also improves the appearance of the water. It will also remove from ordinary river and pond waters a large part of the odor and tastes present in these waters. At the low rates at which sand filters are operated, this biologic purification is the efficient agent by which disease germs and organic matter are removed. In mechanical filtration where rates 30 to 50 times as great as ordinary sand filter rates are used, this natural purifying agency is much less efficient and the removal of bacteria depends very largely on the coagulant used, and the flocculent precipitate formed by it, which entangles the bacteria. In sand filters at a 3,000,000 gallon per acre per day rate, the water passes downward through the sand at a rate of about 4.5 inches in depth per hour, but in mechanical filters operated at a rate of 120,000,000 gallons per acre daily the water passes downward at a rate of practically 180 inches per hour.

I have stated that the actual cost of operation at Lawrence and Albany is about \$1.50 per million gallons filtered. I understand that at Little Falls, N. J., it amounts to slightly more than \$3 per million gallons filtered exclusive of cost of filtered water used in washing the filters, and the water used in this way amounts to about 4 per cent. of the total effluent.

In connection with this, however, it must be stated that, while the operation of mechanical filters in which coagulants are used is more expensive per million gallons filtered than sand filtration, yet when the smaller cost of the mechanical filter plant is taken into consideration, the actual cost of each method of filtration, including interest on plant, etc., is ordinarily about the same per million gallons of filtered water obtained.

The efficiency of a mechanical filter depends almost entirely on invariably applying a correct amount of coagulant for the water being treated, however much it may vary from hour to hour and in a suitable period for the decomposition of the chemical coagulant and for sedimentation before the water passes to the filter. In slow sand filtration the changes of the water and the personal equation are not such important factors, as the sand filter operating at a low rate adapts itself more readily to changes in the character of the raw water, receives no coagulant and its efficiency rests on natural rather than chemical means. It is, of course, true that on this account a slow sand filter is more easily worked by unskilled hands and better results obtained than when a mechanical filter is operated by those insufficiently trained to appreciate the necessity of constant care and attention. This gives a certain percentage of safety to the slow sand filter. A decrease of filter efficiency even for a few minutes may, of course, be of serious moment when treating a polluted water, and especially if these few minutes occur several times in the course of a day or of a week. It is the aim at the present time of those planning mechanical filters of the modified type, used for the purification of public supplies, to so construct them that failures are almost impossible. Constant examination of the raw water and effluent is also insisted on. It is undoubtedly true that, with expert supervision, a mechanical filter of the latest design is capable of giving a bacterial efficiency nearly equal to, but probably not quite as great as, that obtained by sand filters. Whether

this very slight difference in efficiency is of any hygienic importance or not yet remains to be demonstrated.

I have collected some data bearing on this phase of the water filtration problem, the results covering thirteen different experimental filters and two large filtration systems. In every case the period that I have selected for comparison of these filters has been such that each, as far as I can determine, was being operated under normal conditions and all analytical results obtained during this period are included in this comparison. From the figures obtained it will readily be seen that the efficiency of all these filters was at times lower than the normal and desired efficiency. Taking the results of the two types of filters collectively, the slow sand filters had an efficiency of over 99 per cent. 42 per cent. of the time, of over 98 per cent. 64 per cent. of the time, and below 95 per cent. 13 per cent. of the time; while the mechanical filters had an efficiency of over 99 per cent. 32 per cent. of the time, of over 98 per cent. 49 per cent. of the time, and less than 95 per cent. 28 per cent. of the time. The filters used in this comparison are the Lawrence city filter, the Little Falls filter and experimental mechanical and sand filters at Lawrence, Washington, Cincinnati, Pittsburg and New Orleans.

Finally, the chief test of the efficiency and value of filtration is the effect that filtered water has on the health of a community using such water compared with the health of the same community when using polluted water before the introduction of filters, or, of course, it can be shown also by comparison between communities using purified water and those still using polluted water. Unfortunately, few results are obtainable showing the direct effect on the health of a city of mechanically or chemically filtered water, while we have, on the other hand, many illustrations, especially abroad, of the hygienic efficiency of slow sand filtration and in this country the results of years of operation of the Lawrence filter and Albany filter. The Lawrence results have been related so frequently that many of you are familiar with them, but, as they are as yet the foremost American exemplification of the value of sand filtered water, they must be repeated here.

The water works of the city of Lawrence were built in 1875, water being taken from the Merrimac River, and soon after their introduction the number of deaths from typhoid fever in the city began to increase. It was finally recognized in the last of the '80s that whenever there was an epidemic of typhoid fever in Lowell, which occurred practically every year, there was also an epidemic of typhoid fever in Lawrence, the city of Lowell, with its present population of 100,000 people, being located about nine miles up the river from the intake of the Lawrence water works and all its sewage passing into the Merrimac. Investigations showed that infection from Lowell reached Lawrence and was distributed throughout the Lawrence water supply system, and this investigation resulted in the construction of the Lawrence filter in 1892 and 1893.

In the tables given showing the growth of the city of Lawrence in population, the total number of deaths in the city, year by year, is also shown and the total number of deaths from typhoid fever before and after the construction of this filter. It will be seen from this table (Table 1) that the greatest number of deaths from typhoid fever in the city, namely, 60, occurred in 1890, when the population of the city was less than 45,000; that in 1892, the year before the construction of the

filter, the total number of typhoid deaths was 50, the city having in that year a population of about 48,000; in 1894, the first year that filtered water was supplied to the city, the number of deaths from typhoid decreased to 24 (more than in any subsequent year to date, as shown by the table), and the total deaths in the city decreased more than 300, or from 1,211 to 901. In 1906 the total number of deaths was 1,330, an increase of 9.8 per cent., and the population of the city was 76,000, an increase of about 75 per cent. The total number of deaths from typhoid fever in 1906 was 15, as against 50 in 1892, making the comparative death rate from typhoid fever as follows: In 1892, 111 per 100,000, and in 1906, 20 per 100,000, or a decrease of 83 per cent. The rates for the intervening years are shown on the table. In Albany the reduction was from an average of 71.5 deaths per year from typhoid for the nine years preceding the building of the filter to an average of 23.8 for the six years following construction. The reduction in the number of cases of typhoid in Albany was from an average of 424.8 cases per year for the nine years preceding the building of the filter to an average of 100.5 for the six years following construction. The total deaths also decreased very remarkably as at Lawrence.

TABLE 1.

VITAL STATISTICS, LAWRENCE, MASS., 1888 TO 1906, INCLUSIVE.

Year.	Total number of deaths from typhoid fever.	Typhoid death rate, 100,000 of population.	Total deaths.	Population.
1888	48	120.0	1122	43,100
1889	55	137.5	1122	43,800
1890	60	133.3	1191	44,700
1891	55	122.0	1136	46,200
1892	50	111.1	1211	47,700
1893	39	86.6	1171	49,200
1894	24	50.0	901	50,700
1895	16	30.7	993	52,200
1896	10	18.6	1017	54,300
1897	9	16.2	1087	56,400
1898	11	18.8	1057	58,500
1899	20	33.1	1234	60,500
1900	11	17.6	1250	62,500
1901	12	18.5	1118	64,700
1902	11	16.5	1163	66,800
1903	22	31.9	1178	68,900
1904	10	14.1	1140	71,000
1905	14	19.0	1372	73,500
1906	15	19.6	1330	76,400

TABLE 2.

NUMBER OF DEATHS FROM TYPHOID FEVER REPORTED IN ALBANY DURING THE NINE YEARS BEFORE AND SIX YEARS SINCE THE STARTING OF THE FILTER PLANT.¹

Deaths from Typhoid Before Filter Plant was Started.	Deaths from Typhoid After Filter Plant was Started.
1890-1	1899-1900
1891-2	1900-1
1892-3	1901-2
1893-4	1902-3
1894-5	1903-4
1895-6	1904-5
1896-7	
1897-8	
1898-9	

While, as I have stated, the actual hygienic efficiency of modern mechanical filters has not been as yet adequately demonstrated, yet such efficiency is, I believe, undoubtedly obtained and will be demonstrated eventually. There is a place for each type of filter. Sand filters are successful with polluted but comparatively clear waters and with the addition of sedimentation basins and the occasional use of coagulants with waters somewhat turbid. At the present time, however, no method of satisfactorily handling the very turbid waters full of clay and other matters in suspension is known other than by the use of coagulants and mechanical filters, although sedimentation and double sand filtration is of much promise. The prejudice in some minds

against the use of aluminum sulphate under proper supervision is, I believe, not justified; the aluminum hydrate formed is invariably removed by the filters if they are successfully operated. We might, perhaps, as well refuse to eat many common foods because in their production chemicals are used as to object to water clarified by coagulants. The public is beginning to demand a clean water of good appearance, as well as safe, and in order to obtain such a water coagulants are sometimes necessary. Before either type of filter is adopted, thorough preliminary studies of all the local conditions as to water supply, etc., should be made and hasty and inexperienced conclusions prevented.

TABLE 3.

NUMBER OF DEATHS FROM TYPHOID FEVER AND RATE PER 100,000 POPULATION IN ALBANY AND NEIGHBORING CITIES.²

	Albany.	Cohoes.	Troy.	Water-vliet.	Schenectady.	Rensselaer.
Population	100,000	24,000	75,000	14,300	56,000	10,000
Number of deaths yearly from typhoid	12	13	32	6	11	5
Rate per 100,000.	12	54	43	42	20	50

THE PELVIC ARTICULATIONS.

A CONSIDERATION OF THEIR ANATOMIC, PHYSIOLOGIC, OBSTETRIC AND GENERAL SURGICAL IMPORTANCE.*

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BOSTON.

The first paper on this subject was published by me in conjunction with Dr. Robert B. Osgood¹ in May, 1905. A second paper now seems justified, since as the result of a larger experience many features of the subject are better understood, and it is possible to write with greater definiteness than was the case two years ago.

In the first place, in the consideration of the subject, it is to be remembered that the pelvic articulations are true joints and that in normal health, entirely irrespective of age or sex, motion is a definite part of their function. In the next place, it should be remembered that because of the character of these articulations, being flat bone surfaces brought together with oblique or vertical axes, their stability is dependent on the tone and character of the muscles and ligaments. This being the case, and it being recognized that all of the strong trunk and abdominal muscles, as well as the muscles involved in the movements of the thighs, are attached to the pelvic girdle, it is evident that anything that interferes with the stability of the pelvis, or that which represents the structural base, must interfere with the normal use and development of the muscles attached to it. The converse of this is equally true, and anything that interferes with the normal use or development of the muscles in this region must result in weakness and lack of stability in these joints, so that after the condition has once started a vicious circle exists, the full significance of which must be recognized if the various features are to be understood and the appropriate treatment given. This, together with the effect which the unstable pelvis, associated with the weakened trunk muscles, must have on the support and function of many of the abdominal organs, is to be recognized, and should, it seems to me, be given special emphasis in a paper presented before this Association.

2. From monthly bulletins of State Department of Health.

* Read in the Section on Surgery and Anatomy of the American Medical Association, at the Fifty-eighth Annual Session, held at Atlantic City, June, 1907.

1. Boston Medical and Surgical Journal, May, 1905.

1. Compiled from records of Bureau of Health and State Board of Health.