TYPHOID EPIDEMIC IN CORK CITY, 1920

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(With Graphs I–III and a Map)

THIS account deals with an outbreak of typhoid fever which occurred in the autumn of 1920 and which has never previously been recorded. As it was the biggest of its kind in the history of the city (and probably of this country also) it seems worth putting on record. The total number of reported cases was 243 but, as will be shown, it is highly probable that this figure represents only a portion of those which actually occurred.

The salient facts came to light shortly after I had taken up office as Medical Officer of Health for the City in 1929 and when I began to compile the *Annual Report* which had been in abeyance since 1919. It will be recalled that the period in which the epidemic occurred was one of great political unrest and this fact must be held accountable for so little being known of it. Fortunately our own records remained intact and were sufficiently interesting to induce me to pursue the matter further. It was obvious that the epidemic was water-borne and due to contamination of the city supply and the problem resolved itself into elucidating the probable manner in which it had been infected—no easy task after a lapse of nine years and rendered still more difficult by the circumstances of the times in which it occurred.

TOPOGRAPHY AND SANITARY CIRCUMSTANCES

Cork is situated on the river Lee, some 40 miles from its source. The central portion is enclosed by two arms of the river which divides about half a mile from its western boundary and re-unites within the city itself. The water is tidal to within about half a mile from the waterworks.

Water supply. This is drawn entirely from the river, which in its course receives many tributaries and passes in close proximity to one small town and numerous villages. The supply is taken from the river a short distance from the western boundary of the city (*vide* Map). Adjacent to the river and 13 ft. beneath its bed a tunnel has been bored for a distance of about quarter-of-a-mile, into which the water filters through the sand and gravel bed of the river. The water from this tunnel is led to a pure water basin from which it is pumped to service reservoirs and delivered directly to the mains without storage. Prior to 1920 this was the only means of purification and in normal times it served the needs of the population, but there is evidence that in times of drought when the supply from the filter tunnel became insufficient it was the custom to admit raw river

water to the pure water basin. This practice was sufficient to explain the endemic nature of typhoid in Cork (see Graph I) but scarcely to account for the explosive outburst of 1920.

Sewerage and sewage disposal. With the exception of some sixty or seventy premises all the houses in Cork are supplied with water-closets and were so in 1920. The great bulk of the privy-served houses are located at the north-eastern portion of the city and actually no cases occurred in them during the epidemic. The sewage is discharged direct into the river without treatment.

Previous incidence of enteric fever

Examination of Graph I shows that since 1880 (the earliest year for which records are available) typhoid was more or less endemic in Cork and that there were major outbreaks in 1880, 1886, 1891 and 1895. After the latter year the trend has been distinctly downwards until the year 1920 when the biggest epidemic occurred. There are numerous references in the reports of my predecessor to this fact, and warnings as to the probable outcome if adequate steps were not taken to improve the system of water purification. Numerous analyses revealed that the quality of the water was unsatisfactory, particularly in the summer months but, apparently, no steps were taken to remedy the state of affairs.

History of the outbreak

Prior to September 1920, 6 cases of typhoid had been reported. In the second week of that month 3 cases occurred and these were the first definite harbingers of the epidemic. In the following week 43 cases were notified and the peak was reached in the third week with 107 cases. In the fourth and fifth weeks 35 and 20 cases respectively occurred and thereafter the incidence dwindled rapidly but the epidemic did not die out until the early weeks of December (see Graph II). This diagram is typical of enteric fever.

The total number of cases recorded in the city area during this period was, as stated, 243 and the number of deaths 13. This yields a fatality rate of 5·3 per cent. In Table I the cases are classified according to age and sex:

Table I. *Age and sex classification of cases with incidence per 1000 of the population in the groups.*

Age groups	Sex		Total	Population of group	Incidence per 1000
	Males	Females			
0–4	—	4	4	8,322	0·48
5–10	4	10	14	8,495	1·64
11–15	18	17	35	5,788	6·04
16–20	19	24	43	7,524	5·71
21–25	13	21	34	7,595	4·47
26–30	16	12	28	6,886	4·06
31–40	23	17	40	10,826	3·69
41–50	5	13	18	9,366	1·92
51–60	3	1	4	6,838	0·63
60 and over	—	3	3	6,850	0·43

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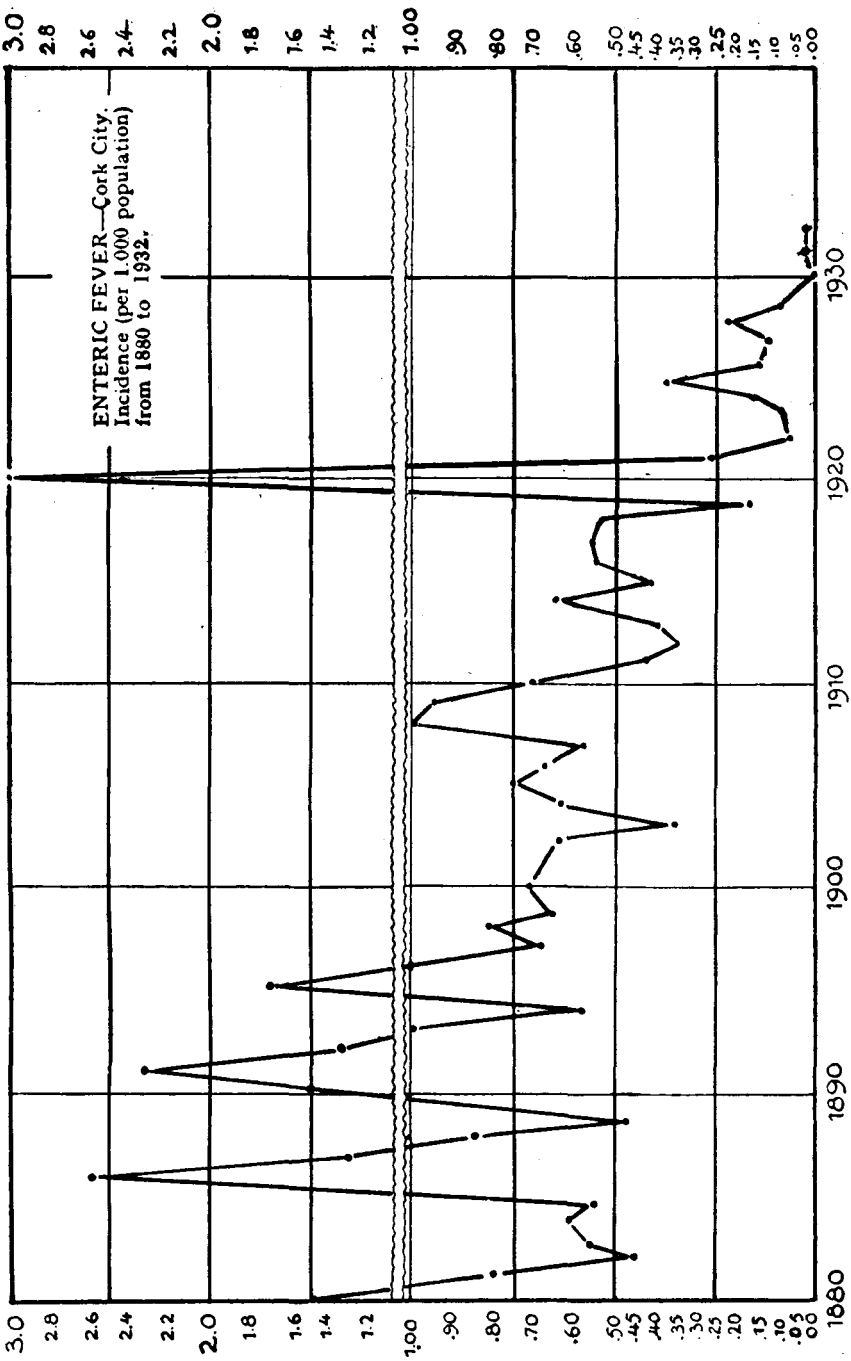

Graph I

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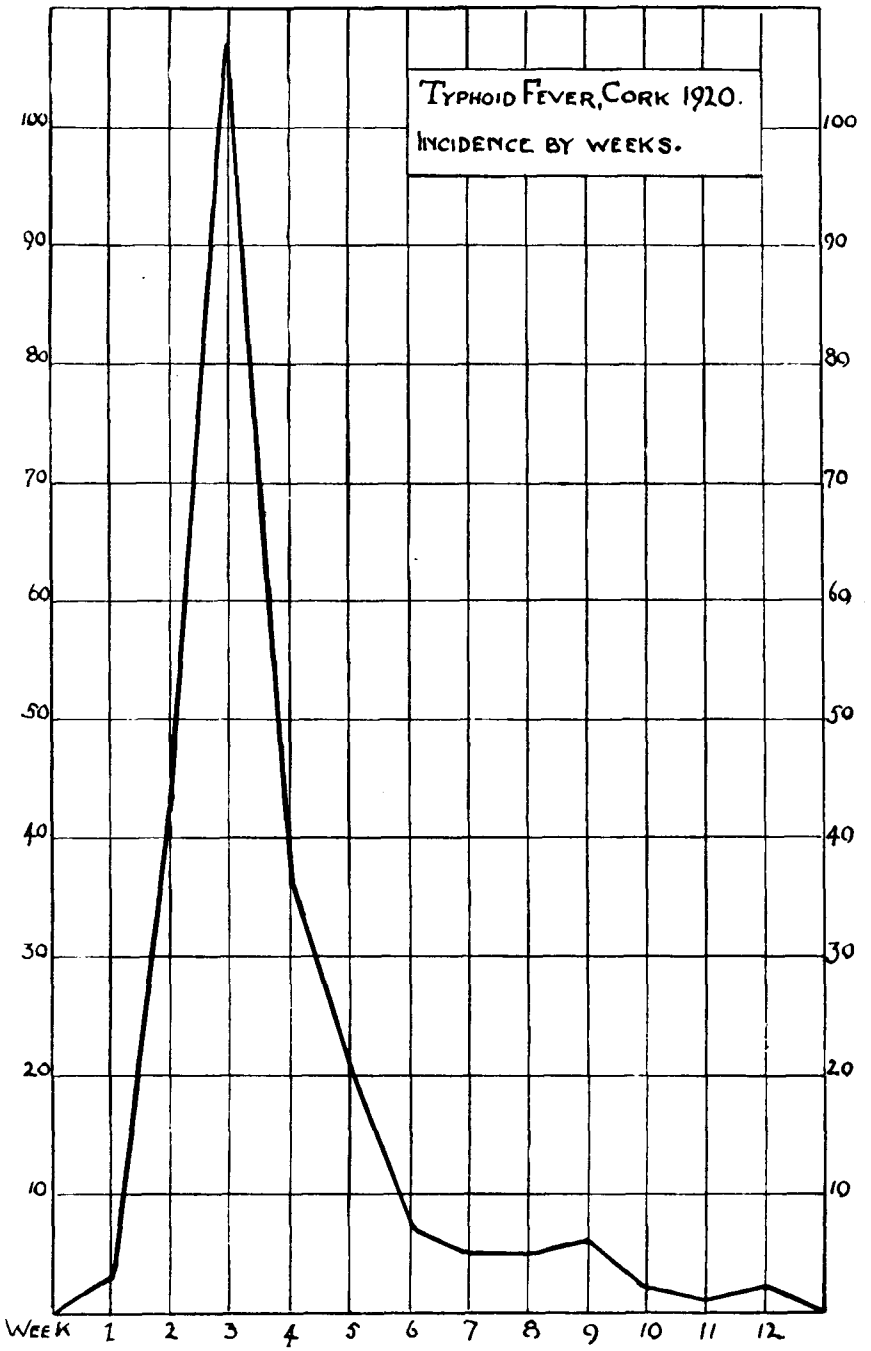

Graph II

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In addition to the above there were 20 cases unclassified as to age (11 males and 9 females) and 12 cases in the military establishment, making a total of 255 cases.

It will be noted that the maximum incidence was in the 11–15 group (6·04 per 1000). The distribution is similar to that of the recent epidemic at Malton[1] in which 99 out of 270 cases occurred in the 11–20 group. 40 occurred in the 31–40 years group in the Cork epidemic in contrast to 23 in the same group in the Malton outbreak. The youngest case was $3\frac{1}{2}$ years and the oldest 72 years.

In addition to the cases enumerated above (which yield an attack rate of 3·1 per 1000 of the population) there were 12 cases among the military establishment, but it is certain that these by no means represent all the cases which occurred in this epidemic. There is a large residential population outside the city boundaries which was (and still is) supplied with city water. An attempt

Table II. *Deaths from typhoid fever in the Cork County Borough and Cork Rural District from* 1916 *to* 1926.

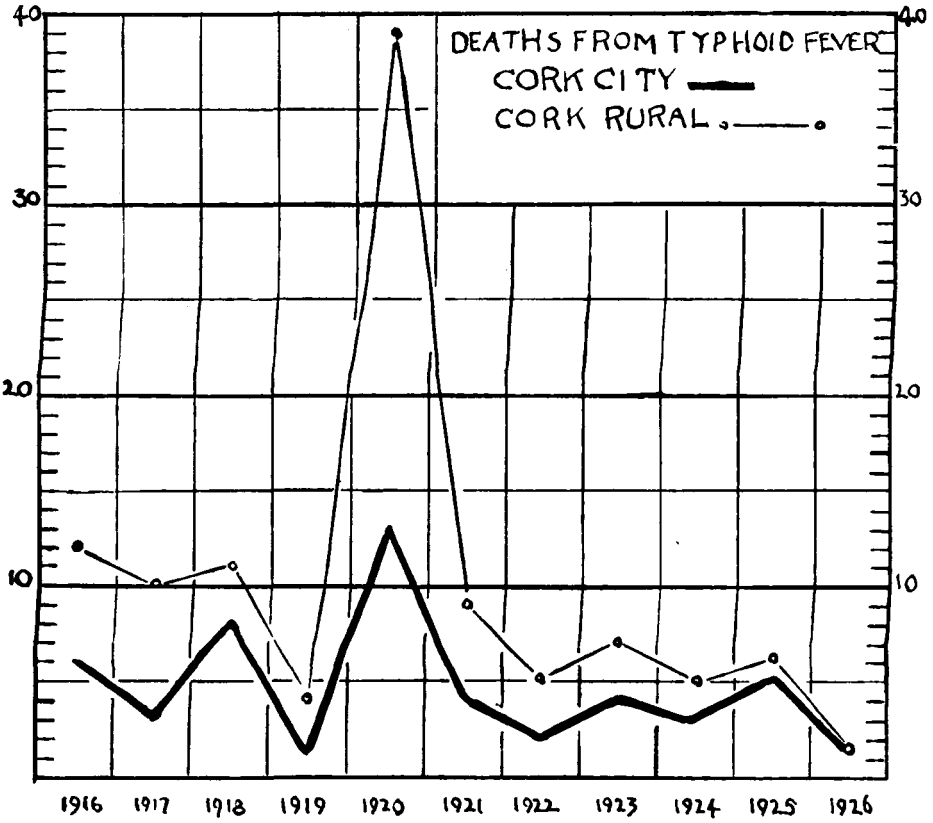
Year	Cork County Borough	Cork Rural District
1916	6	12
1917	3	10
1918	8	11
1919	1	4
1920	**13**	**39**
1921	4	9
1922	2	5
1923	4	7
1924	3	5
1925	5	6
1926	1	1
Average	3·7	7·0

was made to ascertain the number of cases which had occurred in this area in 1920 but, unfortunately, it was unsuccessful as all the records for the period had been destroyed. An enquiry was then directed to the Department of Local Government and Public Health but this also was unfruitful as all records of this Department had also been lost when the headquarters of the Local Government Board were destroyed by fire in 1921. Through the courtesy of the Registrar-General for Ireland, however, it has been possible, to some extent, to reconstruct the picture as it affected the rural area immediately adjacent to the city. This has been done by comparing the deaths from typhoid fever which occurred in that area for a number of years before and after 1920, and by this means to arrive at an approximation of the number of cases. These figures are set out in Table II and compared with similar figures for the city area.

In the rural area the deaths rose from an average 9·25 per annum for the previous four years to 39 in 1932. These figures are represented in Graph III in which the influence of the epidemic becomes at once apparent. Assuming a fatality rate of 5·3 per cent. (as yielded by the city cases) we obtain a figure of

[1] Shaw (1933).

729 cases which presumably occurred in the rural area, making a (presumed) total of nearly 1000 cases. It is not now possible to state definitely whether this number of cases actually occurred nor is it feasible to work out the incidence for the combined populations, as the population at risk in the rural area constitutes but a very small fraction of that of the whole area, only these portions immediately adjacent to the city on its western and southern boundaries being supplied with city water. It is obvious, however, that the incidence of 3·1 per 1000 yielded by the records for the city was greatly exceeded in the combined districts.



Graph III

As compared with water-borne epidemics in other areas the attack rate on the whole may be said to have been low. In Malton the rate was 50 per 1000; in the borough of Worthing (1893), 70 per 1000; Maidstone (1897), 80 per 1000; Lincoln (1904–5), 20 per 1000; Bolton-on-Dearne (1921), 20 per 1000; Bedlington (1918), 4 per 1000[1]. Considerably higher rates have been provided by epidemics in continental countries in past years. In Lansen, Canton Basel (1872) the water was infected by a typhoid patient in a neighbouring valley and

[1] Shaw (1933).

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gave rise to 133 cases or 166 per 1000 of the population[1]. In Plymouth, Penn. (1885) 125 per 1000 of the population were affected when the water supply was also infected by a typhoid patient[1]. In Barcelona (1914) approximately 30 per 1000 and in Hanover (1926) 58 per 1000 were attacked[1]. In Manjato, Minnesota (1908), 403 per 1000 of the population were affected.[2]

The characteristic distribution of the cases in the Cork epidemic is shown in the accompanying Map. It will be seen that they were scattered all over the city and, with the exception of the sparsely populated region in the north-eastern and eastern portions, that practically no part escaped. The incidence was heaviest in the north-west ward where there were a large number of insanitary and over-crowded dwellings and where the general standard of living is lower than that for the city generally, but no rank or age escaped.

ORIGIN OF THE OUTBREAK

This aspect of the epidemic was, perhaps, the most difficult to trace. Apart from the actual entries in the Register of Notifications there was no written evidence to work upon. Fortunately, however, Dr Sterling Berry of the Department of Local Government and Public Health was able to put me in possession of a copy of a report[3] on the epidemic from Lt.-Col. J. T. Johnson, D.D.M.S., to the War Office which was transmitted to Dr Berry by Lt.-Col. W. Brooke Purdon with a covering letter. The letter and report have been invaluable in tracing the origin of the epidemic. The attention of the military authorities was first directed to the matter by the occurrence of two cases of typhoid among the troops, one on September 11th, 1920, and the other three days later. These were followed by others on the 18th and 19th and liaison was made with the city authorities when it was found that numerous cases had been notified.

A joint investigation was then carried on which quickly centred suspicion on the water supply. It was established that a short time previously a large quantity of raw river water had been admitted to the reservoirs and this was verified by bacteriological reports. Samples were taken on September 27th from (*a*) the river water at intake, (*b*) the filter tunnel, (*c*) upper reservoir, and (*d*) lower reservoir. The river water contained *B. coli* in 1 c.c. and was classed as greatly polluted, that from the filter tunnel had no *B. coli* in 30 c.c. but present in 40 c.c. The sample from the upper reservoir had *B. coli* in 10 c.c. and that from the lower in 5 c.c. Both were classified as unfit for drinking. In addition to these samples of tap water taken at the barracks on August 25th and September 24th showed *B. coli* in 1 and 0·5 c.c. respectively. In view of these findings steps were taken at once to render the water more pure and a drip chlorinating plant was installed. At this time there was a large number of troops stationed at Ballincollig, about five miles further up on the river bank, but a careful investigation showed that none of the men were suffering from diarrhoea or enteric and that there were no enteric carriers amongst the numbers. The

[1] Stallybrass (1931). [2] Shaw (1933).
[3] 24/Irish/1006, G.H.Q. I. No. 2/28191 (D.D.M.S.).

sewage of this district received septic tank treatment and land irrigation before discharge into the river.

Rôle of the district mental hospital

The negative findings yielded by the other lines of investigation directed attention to the drainage of this institution, which houses a population of 2000 persons and stands on a marked elevation in immediate proximity to the waterworks, from which it is divided only by the main road. The drainage from the hospital enters the river about 60 yards below the waterworks in the tail-race of the turbines which supply the power for pumping. Normally, when water was drawn only from the filter tunnel there was no possibility of contamination from this source. A small stream which traverses the asylum grounds and formerly discharged above the waterworks had been diverted to discharge below them and, during a search for any possible lead from this stream, the main road was dug up and a square stone drain containing fresh faeces was exposed. This old drain, which was situated about 20 yards from the pure water basin, was believed to have originally served the upper part of the hospital and had apparently been brought into action by the blocking of a manhole and the overflow of the newer drainage system. I was able to obtain interesting confirmation of this from the Clerk of Works of the institution during my personal investigations quite recently.

Before 1895 the sewage of the hospital was disposed through a series of rubble drains, the exact location of which is uncertain, but one of them at least left the curtilage near its eastern boundary and traversing the roadway close to the waterworks discharged into the river about 50 yards below the waterworks. In 1895 this system was replaced by a modern one in which the main outfall followed the general course of the old rubble drain, both drains following the natural contours of the land. A large inspection chamber is interposed on the system just before it leaves, and it was the blockage of this chamber which apparently determined the epidemic in the city of 1920. This manhole is constructed on very unorthodox lines. It is a continuation (in a half channel) of the main drain of the institution, which at this point takes a sharp bend of considerably less than a right angle. In addition it receives three smaller drains, the junction pipes being arranged at different levels. The Clerk of Works informed me that he remembered well one day during the epidemic period observing sewage matter oozing up through the roadway close by the pure water basin. The inspection chamber was immediately examined and found to be full of sewage which was overflowing by a hitherto unsuspected opening. This opening had apparently been made by the contractors to give a temporary connection with the old rubble drain while the new system was under construction, and they had omitted to close it when the work was finished. Owing to the very steep gradient here the sewage did not back up further into the system but discharged itself through the lowest available opening. The

rubble drain evidently accommodated the sewage for a time and then yielded to the pressure and discharged itself on to the roadway as described. The point of breakage coincided with that mentioned in the military report as the site of the stone drain dug up on the main road, 20 yards from the pure water basin. The main drain leading from the manhole was then further explored and it was found to be completely blocked by roots or trees which had worked their way into it.

There seems to be a striking similarity of events between this epidemic and that of Malton. In the latter the determining factor was a broken drain leading from a hospital block in which a typhoid patient was being nursed, whereby the excreta from this patient infected the water supply. But in this case the breakage occurred apparently eighteen months previously, whereas, in the Cork epidemic, the defect had existed for no less than twenty-five years and finally it was only the slow invasion of the drainage system by tree roots which caused the overflow of the sewage and precipitated the outbreak by infecting the water supply.

Having arrived at the probable cause of the epidemic it remained to confirm the findings by establishing a definite focus of infection among the inhabitants of the Mental Hospital, and I am indebted to Dr J. J. FitzGerald, one of the Medical Officers of the institution, for the information which follows. A serious outbreak of typhoid fever occurred in the institution in the winter of 1904–5, commencing in October of 1904 and lasting until the following February: 113 patients, 20 attendants and 1 medical officer were affected. All the attendants were treated in the Cork North Fever Hospital and three of them died. Of the mental patients eighteen died (a fatality rate of 15 per cent.). The origin of this outbreak was traced to milk delivered at the institution. It was discovered that the contractor had had several cases of enteric in his family, and for months the dejecta were thrown into a yard in the centre of which was a pump used to supply water for washing the milk utensils. Ever since this outbreak the Mental Hospital has been a reservoir of infection, practically never being free from cases of the disease. Actually in 1920 several cases occurred in the hospital throughout the year, 12 cases at least were reported of which 7 were affected between the months of July and November, so that it is certain that typhoid-infected faeces were being discharged into the drainage system prior to and after the outbreak in the city and that considerable quantities of this sewage matter must have found its way into the water supply from the rubble drain mentioned above.

STEPS TAKEN TO DEAL WITH THE OUTBREAK

1. Advertisements in the public press advising citizens to boil all water for drinking and domestic purposes.

2. Cleaning out of all reservoirs and lime washing their walls.

3. Enquiry into the state of all water mains. These were found to be satisfactory and contamination from adjacent drains was eliminated.

4. All water supply drawn from filter tunnel, and no unfiltered water allowed into mains.

5. Chlorination. A drip chlorinator was installed at the pure water basin about September 26th and shortly after this the outbreak slowed down. There were no military cases after September 30th and the civilian cases became steadily less. The epidemic may be considered to have come to an end by the middle of October, although cases trickled in until December which may be regarded as secondary.

These measures, though successful in their effect, were obviously only palliative and there remained the larger question of improving the supply in such a way as to preclude the possibility of another such outbreak in the future. This question was not tackled seriously for several years until the City Council had been abolished and replaced by a Commissioner. Plans were then formulated for the erection of a Candy Rapid Gravity Filtration plant to supplement the supply from the filter tunnel. This plant was put into commission in June 1928 and the subsequent history of the city had been characterised by a remarkable improvement in the quality of the water and complete freedom from water-borne typhoid.

The main source of water is still from the filter tunnel and it constitutes about two-thirds of the bulk when the filtration plant is in use. In favourable circumstances the latter is not called upon at all. The maximum demand on the river water is some $1\frac{1}{2}$ million gallons per day, that is after a dry spell when the yield of the tunnel is low. The mixture of waters from the tunnel and filtration plant is chlorinated in the pure water basin before pumping to the reservoirs and, except on a few occasions during warm dry periods, it has not been found necessary to add more than 0·5 parts per million of chlorine.

From 1928 onwards the quality of the water has been carefully controlled by bacteriological examination of samples taken on five days in each week. In that year samples were taken on each occasion from the following points:

(*a*) the river above the intake;
(*b*) output of the filter tunnel;
(*c*) output of the candy filtration plant;
(*d*) laboratory tap.

Each sample was subjected to the following examinations:

(1) Cultivation of 100 c.c. in fractions in McConkey's broth for the quantitive estimation of *B. coli*.

(2) Enumeration of number of organisms per c.c. growing on agar at 37° C. in 24 hours.

(3) Enumeration of number of organisms per c.c. growing on agar at 20° C. in 48 hours.

Table III enumerates the results of this survey:

From 1929 onwards a modified procedure has been adopted. This consists of an examination of tap water from different localities for the presence of the *B. coli* group of organisms by incubation of 10 c.c. in fractions and identifica-

tion of lactose fermenters by incubation on McConkey agar slopes in 6 × 1 in. tubes and testing positive colonies for fermentation characters and indol production. In the event of *B. coli* being present in significant numbers complete examinations have been made of samples from the reservoirs as well as from the taps. Table IV summarises these results:

These results indicate an increasing efficiency in the working of the filtration plant which is also reflected in the figures pertaining to typhoid fever for the city (see Graph I). For the seven years from 1921 to 1927 the average number

Table III

Source	Total no. of samples examined	*B. coli* test. Minimum bulk containing *B. coli* (% of total samples) 100 c.c. −	100 c.c. +	50 c.c. +	10 c.c. +	1 c.c. +	0·1 c.c. +	0·01 c.c. +	Average bacteria per c.c. per sample at 37° C.
River	245	.	.	.	4·5	42·4	42·5	10·6	1039
Tunnel	243	4·5	0·8	23·0	44·0	21·8	4·5	0·8	170
Sand filter	237	3·0	2·1	20·7	40·9	27·4	5·5	.	45
Tap	245	76·3	4·0	13·1	5·7	0·8	.	.	20

Table IV

Figures in parentheses denote percentages.

Year	Total no. of samples examined	*B. coli* test 100 c.c. −	100 c.c. +	50 c.c. +	10 c.c. +	1 c.c. +
1928	245	187 (76·3)	10 (4·0)	32 (13·1)	14 (5·7)	2 (0·8)
1929	251	153 (60·9)	44 (17·5)	40 (15·9)	9 (3·6)	5 (2·0)
1930	268	216 (80·6)	15 (5·8)	14 (5·2)	13 (4·5)	10 (3·7)
1931	260	242 (93·0)	9 (3·5)	9 (3·5)	. .	. .
1932	260	245 (94·6)	3 (1·2)	11 (4·2)	. .	. .
1933	253	244 (96·4)	4 (1·6)	4 (1·6)	1 (0·4)	. .

of cases was 13·1, while for the five years after 1928 the average has fallen to 2·0. In 1928 17 cases occurred but 13 of these arose in a small localised epidemic which was traced to an infected milk supply and which ceased when the source of infection was closed. In the past four years only 4 cases have been reported, in 3 of which infection was definitely traced to sources outside the city and in the fourth (which transpired to be paratyphoid B infection) the source was not traced. In 1930 the city was entirely free from typhoid infection. These facts are of interest as illustrating the value of a properly supervised water supply and the great danger to which a populace is exposed in the absence of such protection.

The bacteriological examinations were carried out by Dr W. J. O'Donovan, Bacteriology Department, University College, Cork.

Summary and conclusions

1. That the epidemic was due to infection of the water supply is borne out by the following points:

(*a*) The explosive character of the outbreak as shown in Graph II which is characterised by a rapid rise to peak at the end of third week followed by a sharp fall and a gradual tailing off to the end of the epidemic.

(*b*) The widespread distribution of cases (see Map), no area supplied by water from the city having escaped.

(*c*) The rapid decline which followed the adoption of appropriate measures to deal with the water supply.

2. 255 persons in the city area (including the 12 military cases) were definitely affected (equivalent to a rate of 3·1 per 1000 of the population). As shown by the rise in the death-rate for the rural area it is apparent that a far greater number of persons were actually attacked.

3. The outbreak had its origin in a defective manhole in the Mental Hospital grounds whereby the sewage overflowed into a rubble drain and infected the water supply. This defect had existed for twenty-five years, and an epidemic in the hospital fifteen years previously established the reservoir from which infection was disseminated through the city.

4. The spread of typhoid was favoured by unsatisfactory arrangements for the filtration of the water supply. This is borne out by the endemic character of the disease prior to the installation of an effective filtration plant.

5. The institution of this plant was followed by an immediate reduction in the incidence of the disease until, as at the present time, water-borne typhoid has been practically eliminated.

6. The value of such a plant combined with chlorination and bacteriological examination has been shown.

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