AN INVESTIGATION INTO THE CONDITIONS AFFECTING THE OCCURRENCE OF TYPHOID FEVER IN BELFAST.

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For a considerable number of years, Belfast has suffered from a high typhoid fever death-rate, and the investigations embodied in the following pages were undertaken at the request of the Corporation, with the purpose of determining the sanitary measures required to prevent, as far as possible, the occurrence of typhoid fever in the city.

Belfast is situated on the banks of the river Lagan, as it falls into the Lough, and alluvial blue clay forms the foundation of the older quarters of the city. The level of this district is very little above that of high water. The more recently built quarters are situated on ground outside this area, where the foundation is composed of heavy red clay, which is very impervious to moisture. The level there gradually rises up to 150—200 feet above high water.

Since 1897, the typhoid problem has been the subject of repeated investigations, and the reports furnished to the Public Health Committee on various aspects of the question have afforded valuable material for the present enquiry.

There are no accurate records of the history of typhoid fever in Belfast until the year 1881. In that year, for the first time, death returns due to this disease were given in a separate group. The following table gives the annual death-rate, per 10,000 of the population, from typhoid fever, during the years 1881—1902.

https://doi.org/10.1017/S0022172400002205 Published online by Cambridge University Press

Year	Annual death-rate	Year	Annual death-rate
1881	3·7	1892	4·1
1882	2·9	1893	4·4
1883	2·8	1894	5·1
1884	2·4	1895	6·2
1885	2·2	1896	4·5
1886	3·9	1897	11·4
1887	3·5	1898	18·8
1888	3·3	1899	7·5
1889	7·9	1900	7·2
1890	7·6	1901	9·7
1891	5·9	1902	4·7

The fact brought out in this table which at once calls for attention is the rise in the year 1889. The table includes 22 years. During the eight years that preceded 1889, the average death return was 3·1 per 10,000 of the population. During the 14 years since that date, the average has been 7·5, and throughout this latter period, it has not once fallen to 3·1. In the course of these 22 years certain essential changes in the sanitary condition of Belfast have been effected. The city as it existed in 1870—1880 had many sanitary defects, which have since been removed, or minimised. At that date, there was no system of sewage disposal. The sewers opened into the Lagan and other available streams. Domestic sanitation was exceedingly defective. The drains of many of the houses were not constructed so as to prevent leakage of the sewage. They were often made of bricks or timber. The houses of the working classes were nearly all provided with privies and ash-pits. The method of cleansing the ash-pits was very defective. Many of these houses were built without back passages, so that when it became necessary to have the ash-pit cleansed the contents had to be carried through the house. To add still further to the sources of filth about these small houses, the practice of keeping pigs was a general one, even in houses which were without back passages. These insanitary conditions were gradually dealt with by the Public Health authorities. In 1888, the main Drainage Scheme was commenced, and this was completed in 1896. In 1889, the registration and regulation of dairies within the city boundaries were introduced. In 1890, the Public Health Officers began to test all drains constructed under their supervision, by the smoke and water test. In 1892, ash-pit cleansing was undertaken free of cost by the Corporation, and regulations regarding the proper construction of the ash-pits were introduced. Prior to this the structure of the ash-pit was very defective. The floor was not concreted, and was therefore pervious. The level was

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below that of the surface of the yard, and consequently the liquid contents could not escape. Further, there was no roof, and the rain washed the contents into the soil. The ash-pit indeed became a small leaking cesspool. The remedying of these structural defects has greatly improved the surroundings of the houses, by diminishing the amount of surface filth. Prior to 1892, also, the Corporation had a rule according to which the householders were compelled to pay 1*s.* for each cart-load of refuse that was removed from the ash-pits. As a result of this rule, the cleansing of the ash-pits was very much neglected, and many of the houses became surrounded by accumulations of filthy refuse. Advantage was taken of any convenient space near, wherein to deposit the refuse that could not be accommodated in the yard. Back passages were often utilised for this purpose. There was, therefore, round the houses of the working classes, a great amount of dangerous surface pollution. The Superintendent of the Cleansing Department informed me that when the cleansing regulations of 1892 came into force, he removed from these houses an average of two loads per house. At present the average cleansing yields one load from every 10 houses. The number of privies has been steadily reduced; especially since 1899, when power was obtained to compel owners of houses to substitute water-closets for them. Since 1894, the drains of all new houses having internal water-closets have been subjected to the water test, and latterly (1898) this test has been applied to new house drains of all kinds. In 1894, regulations regarding the keeping of pigs were introduced, and the new rule that the pigsty must be 15 feet away from the dwelling-house resulted at once in the abolition of nine-tenths of the pig-keeping. In 1894, the Corporation established a disinfecting station. In 1897, the Infectious Diseases Notification Act was adopted.

It is beyond question, therefore, that since 1888 a great advance has been made towards cleanliness in the city. Since the Main Drainage Scheme was commenced, a sanitary reconstruction of the city has been in progress. The question may be asked 'how far the introduction of the regulations just described has succeeded in abolishing the sanitary defects towards the removal of which they were directed.' The data for answering this question have been already partly supplied in the description of the regulations for the cleansing of ash-pits, the regulations regarding pig-keeping, etc.

As regards dwelling-houses, two questions fall to be considered: (1) House accommodation, and (2) Domestic Sanitary arrangements.

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The data regarding house accommodation are furnished by the census of 1901. The city has been increasing rapidly in size. In 1881, there were 208,122 inhabitants, and in 1901 there were 348,705. In spite of this rapid increase in the number of the inhabitants, the house accommodation provided in Belfast is better than that of any other county borough in Ireland. In place, however, of comparing Belfast with other towns in Ireland, it may be more instructive if we put side by side the census returns of Belfast, Liverpool, and Manchester.

House accommodation in Belfast, Liverpool, and Manchester, in 1901.

		Number of Rooms in Tenements	Tenements of less than 5 Rooms	Death-rate from Typhoid per 10,000 of Population	
BELFAST.					
Total tenements	69,981	1	697	1898—18·8	
Tenements of less than 5 rooms	32,008	2	4,874	1899— 7·5	
		3	5,086	1900— 7·2	average 9·5
		4	21,351	1901— 9·7	
				1902— 4·7	
LIVERPOOL.					
Total tenements	138,845	1	8,527	1898— 2·2	
Tenements of less than 5 rooms	46,822	2	11,635	1899— 2·6	
		3	13,010	1900— 1·7	average 2·2
		4	27,433	1901— 2·2	
				1902— 2·2	
MANCHESTER.					
Total tenements	112,854	1	2,140	1898— 2·2	
Tenements of less than 5 rooms	61,572	2	6,869	1899— 1·2	
		3	4,994	1900— 1·2	average 1·4
		4	47,569	1901— 1·3	
				1902— 1·1	

The house accommodation is very similar in Belfast, Manchester, and Liverpool. In Belfast 45 per cent., in Liverpool 34 per cent., and in Manchester 54 per cent. of the tenements have less than 5 rooms. Liverpool, however, had about $\frac{1}{4}$, and Manchester about $\frac{1}{6}$ of the Belfast mortality from typhoid fever in the last five years. It is clear therefore that it is not to defective house accommodation that we have to look for the cause of the excessive typhoid of Belfast.

Domestic sanitation. The data on this subject were obtained in a special investigation of five selected representative areas of the city. I propose to give these results in the tabular form in which they were furnished to me by the Sanitary Inspectors, and then to discuss the conclusions to which they lead.

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General Description of the Selected Areas.

Area A—District[1] No. I.: This district, which covers an area of 10 a. 1 r. 12 p., is built entirely on blue clay, with high sub-soil water. Population, 3,400. The average elevation is 3 feet above high water. The leading streets are of good width (40 to 60 ft.), the smaller streets from 25 to 35 feet; and they are kept clean. The houses are very old, and are occupied chiefly by the artisan and labouring classes. Many of these houses have no back passages.

Area B—District No. III.: This district, which covers an area of 16 a. 3 r. 21 p., is built on the red clay, and has a low sub-soil water. The average elevation above high water is 99 feet. The streets average a width of 35 feet, and are clean, bright, and airy. The houses, which are occupied by the artisan class, are of modern type, and were built about 10 to 14 years ago. They are let at from 3*s.* to 5*s.* per week. The houses have back passages. Population, 4,439.

Area C—District No. IV.: This district covers an area of 14 a. 3 r. 20 p., is built entirely on made-up ground, filled in with road-scrapings, ash-pit and town refuse: sub-soil water high. The average elevation above high water is 10 feet. The streets are wide (35 and 40 feet), and none less than 30 feet. They are clean, bright, and airy. The houses, which are occupied by the artisan class, are of modern type, and with the exceptions of Boyne Square (built about thirty-eight years ago), Roland Street (very old portion), and part of Clementine Street (built about twenty-five years ago), were erected from ten to fourteen years ago. They are let at about 3*s.* 6*d.* per week. City Street is a better class property, and is let at 4*s.* 6*d.* to 5*s.* per week. Population, 4,336. The majority of these houses have back passages.

Area D—District No. VI.: Average elevation, 10 feet. This district, which covers an area of 12 a. 2 r. 3 p., is built the higher portion (next Divis Street) on the red clay, the lower portion (next College Square North) being built on the blue clay, with high sub-soil water. The streets are narrow, being about 25 feet wide, and are hard to keep clean—the residents frequently throwing their slop water on to them. The houses, with the exception of those abutting on College Square North, Durham Street, Divis Street, and King Street, are those of the lower labouring class, and let at about 2*s.* 6*d.* per week. With few exceptions these houses have no back passages. This district is being gradually improved. Population, 2,205.

Area E—District No. X.: This district, which covers an area of 65 a. 1 r. 23 p., is built on the red clay and has a low sub-soil water. The average elevation of the district above high water is 160 feet. The streets are wide, having an average width of 35 feet. They are clean, bright, and airy. The houses are chiefly occupied by the artisan class, are of modern type, and were built about eight years ago. They are let at from 3*s.* 6*d.* to 5*s.* per week. These streets have back passages. Population, 11,270.

A thorough examination of the houses in these areas has been

[1] 'District' refers to Dispensary District, according to which the typhoid returns are classified.

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carried out by the Sanitary Officers in charge of the districts. The results are given in the following table:

Experimental Area	Dispensary District in which situate	Total Number of Houses	Percentage of Houses with Water Closets	Percentage of Houses with Privies	Percentage of Houses with Covered Ash-pits	Percentage of Houses with Uncovered Ash-pits	Percentage of Houses with back passage accommodation	Percentage of Houses without back passage accommodation	Remarks
A	1	694	82 %	18 %	56 %	*38 %	50 %	50 %	*6 % have ash boxes
B	3	906	91 %	8 %	67 %	33 %	99 %	1 %	
C	4	885	93 %	7 %	57 %	*41 %	62·65 %	37·35 %	*2 % have ash boxes
D	6	450	39 %	61 %	26 %	74 %	18 %	82 %	
E	10	2,300	87 %	13 %	96 %	4 %	86 %	14 %	

In the next place the drains were all examined by the smoke-test. The results were somewhat incomplete, but indicated that a proportion of the drains were defective:—

Area A. On applying the smoke-test 33 per cent. of the drains were found defective, but the remainder cannot be guaranteed perfect, as the test may not have been effective owing to the smoke probably escaping into the sewer.

Area B. On applying the smoke-test 73 per cent. of the drains were found defective.

Area C. On applying the smoke-test 32 per cent. of the drains were found defective, but the remainder cannot be guaranteed perfect, as the test may not have been effective in some cases owing to the smoke probably escaping into the sewers.

Area D. On applying the smoke-test 47 per cent. of the drains were found defective, but the remainder cannot be guaranteed perfect, as the test may not have been effective owing to the smoke probably escaping into the sewers.

Area E. On applying the smoke-test 37 per cent. of the drains were found defective.

The sewers were also examined by members of the City Surveyor's Staff. According to the observations, the sewers of each street were classified as in 'good,' 'fair,' or 'bad' state of repair.

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I give in tabular form a summary of the elaborate observations which were made.

Area	District	Number of Sewers examined	State of repair of Sewers			Percentage of good
			Good	Fair	Bad	
A	I	27	12	12	3	44
B	III	14	14	0	0	100
C	IV	17	14	0	3	82
D	VI	26	20	0	6	77
E	X	34	34	0	0	100

The following table gives the number of cases of typhoid fever notified, per 10,000 of the population, in each of the five experimental areas during the 3 years 1900—1902:

	1900	1901	1902	Dispensary District
Experimental Area, A	126·4	64·7	32·3	No. 1
,, ,, B	126·1	153·1	45·0	No. 3
,, ,, C	59·9	57·6	29·9	No. 4
,, ,, D	54·4	99·7	18·1	No. 6
,, ,, E	60·3	139·3	26·6	No. 10

The foregoing table will be more easily understood when it is compared with the next, which gives, in a similar way, the number of cases of typhoid fever, per 10,000, in each Dispensary District, for the same period.

Table showing by Registrar's Districts the number of cases of typhoid fever notified, per 10,000 of the population.

	1900	1901	1902
City	50·9	72·4	29·0
Registrar's District No. 1	56·4	55·1	31·3
,, ,, 2	43·7	63·3	28·3
,, ,, 3	79·1	99·5	34·7
,, ,, 4	42·9	54·8	19·7
,, ,, 5	44·7	92·4	34·1
,, ,, 6	34·7	46·8	17·9
,, ,, 7	—	—	—
,, ,, 8	28·0	66·0	32·0
,, ,, 9	48·2	56·4	21·0
,, ,, 10	104·7	164·3	43·0
,, ,, 11	35·6	42·8	33·6
,, ,, 12	48·0	94·3	40·0
,, ,, 13	34·0	46·0	37·3
,, ,, 14	—	—	—

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The following table shows in the same Districts the annual death-rate per 10,000 of the population from typhoid fever during the years 1900, 1901, and 1902.

District	1900	1901	1902
City	7·2	9·7	4·7
No. 1	8·1	8·8	7·4
2	8·7	8·9	2·7
3	10·0	12·5	4·2
4	7·0	9·5	7·3
5	7·0	12·9	7·0
6	5·4	6·4	2·7
7	—	—	—
8	12·0	2·0	8·0
9	4·1	5·6	4·1
10	14·3	18·2	4·8
11	4·5	8·3	5·7
12	6·2	12·8	5·0
13	4·6	3·3	6·7
14	—	—	—

Unfortunately, the present arrangement of the Dispensary Districts of the city has been in force only since 1900. Hence it is impossible to compare the returns given in the foregoing tables with those obtained in earlier years.

Of the three years included in the table, 1900 and especially 1901 are years in which typhoid fever had assumed the epidemic form. In 1902 it became quiescent, and in this condition it has since remained. It is important to notice that the increase of cases notified in 1901 as compared with 1900 is to be observed in practically all the districts of the city.

District No. 10 which, during the years of the epidemic, gave by far the largest return of cases, has had the same pre-eminence since 1897, when typhoid fever became so firmly established in the city.

Sites.

In the light of these results, we may, in the first place, take up the discussion of the problems connected with the *sites* of the houses.

The chief evil that exists in relation to the sites is that of making the foundations of houses in a layer of recently deposited city refuse. The city refuse, derived as it was from the privies and ash-pits to a considerable extent, contained a large admixture of organic pollution, part of which must undoubtedly have been infected with typhoid bacilli.

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This method of making foundations was most extensively adopted in constructing the streets which now occupy the ground formerly known as Crawford's Brickfields, in No. 4 district. These streets were built in the years 1880—1895. Such ground should not be used as a site for houses till the natural process of purification in the soil has occurred. This precaution was not taken, however. An examination of a group of houses in that district has been carried out by the sanitary officers, and the results are included in the foregoing tables—Experimental Area C, District No. 4.

The houses in this experimental area are fairly well provided with water-closets (93 %). Therefore, while a considerable number have uncovered ash-pits (41 %), and further, 40 % have no back passage; yet the evil of these defects is much lessened by the relative absence of privies. This property is sufficiently good in other respects to permit us to regard the district in which it is situated as a fair test of the evil which arises from building on sites of the imperfect character described. District No. 4 is the part of the city where the largest amount of building on "made soil" has occurred; yet it does not occupy the position of a centre of typhoid infection.

The following is the record of the 3 years 1900—1902:

	1900	1901	1902
Cases notified per 10,000 of the population of the City	50·9	72·4	29·4
District No. 4	42·9	54·8	19·7
Experimental Area C in District No. 4 ...	59·9	57·6	29·9

The district as a whole is distinctly below the average for the city and the experimental area is during 1901 distinctly below, and in 1902 practically the same as, the average. If the originally contaminated condition of the soil, and the soaking of sewage into the sub-soil in this area, were a primary source of typhoid infection, we would have had clear evidence of it in these returns.

Further, in an investigation on the infection of the soil, I have found that the samples of "made soil" from the district just discussed had no special power of sustaining the life of the typhoid bacillus. The bacillus in such soil would rarely survive for more than a few days.

It should be explained at this point that the danger due to contamination of the soil in Belfast has fortunately not been complicated by the use of the sub-soil water for drinking purposes. In former years there were a few wells; but they were never used in large

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numbers, and now they are all closed. On this account the conditions in which soil contamination can become effective are clearly defined. Faecal matter, mixed with a large quantity of soil, is relatively harmless; but the sewage which escapes into the soil from the drains, if it reach the surface, becomes a cause of infection.

As regards the relation of conditions of the soil to the occurrence of typhoid fever, there is further evidence in the fact that in Area E, from District No. 10, we have an example of a virgin soil of red clay as the foundation of the houses; yet the typhoid returns show that this is one of the worst parts of the city.

There is, therefore, no evidence in these returns to show that the character of the soil used as the foundation of the houses has an influence of primary importance on the spread of typhoid fever.

Sanitation of Houses.

The next point which is clear from these tables, is that the Area D, in District 6, is by far the worst of the selected areas as regards the sanitary state of the houses. Only 39 % of the houses have water-closets, only 26 % have covered ash-pits, and only 18 % have back passages. Further, a considerable number (47 %) of the drains were ascertained to be defective. The condition of the sewers is also one of the worst among those examined (23 % defective). The streets are narrow (25 feet wide), and they are difficult to keep clean owing to the careless habits of the occupiers of the houses. In an area containing houses of this insanitary description, as we might well expect, typhoid was plentiful (99·7 cases per 10,000 of the population) in 1901, when it was prevalent in the whole city. It was, however, much more plentiful in the Areas B (153 per 10,000), and E (139 per 10,000), taken from Districts 3 and 10 respectively.

Areas B and E are in many respects similar in character. Both are high lying. The houses are built on the red clay. The sub-soil water is low. The streets are 35 ft. wide, and are clean, bright, and airy in each case. The houses are modern in structure, and they are occupied by the same class of people. The sewers are, without exception, in a good state of repair in each case. In Area E 37 % of the drains were defective, and in Area B 73 % were similarly out of order. The most important defect which was discovered in B was the state of the drains. I made enquiry as to the reason why this area, with houses built within the last 10 years, should compare so

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unfavourably with others in which the houses are much older. The explanation of the leakage from the drains is the fact that the joints of the drain pipes were made with clay. Clay is too readily washed away to form a suitable joint. It is difficult, however, to estimate the relative importance of this defect. In Area E, which had about the average number of defective drains, or about half the number that were found defective in B, the prevalence of typhoid fever is nearly the same as that in B, and both show much higher returns than any of the other areas. The evidence relating to drain defects is incomplete as regards the other three areas. This fact is due to a faulty condition of the drains, generally the absence of inspection chambers. In B and E, however, the test was satisfactorily applied, and the results are sufficient to show that the defects of the drains in B did not greatly add to the liability to typhoid fever of B as compared with E. On the other hand, when we compare E with D, as regards sanitary conditions generally, we observe that E stands far ahead in every respect, and yet it had a much higher return of typhoid cases in the epidemic of 1901.

In order to obtain further evidence on the relation of defective drains to the occurrence of typhoid fever, I asked the sanitary inspectors to furnish me with the results of their experience in this matter. The following table gives the results during three representative periods:

	Total Number of Houses where drains were tested	Houses with defective drains	Percentage of defective drains in the total number	Number of Houses in which Typhoid Fever had occurred	Number of Typhoid Houses with defective drains	Percentage of Typhoid Houses with defective drains
			Per cent.			Per cent.
Northern Division, 1st Feb.—30th March, 1901	85	52	61·2	64	33	51·56
Southern Division, 1st Feb.—30th March, 1901	65	34	52·3	30	12	40
Northern Division, 1st July—31st Dec., 1901	715	363	50·76	625	292	46·72
Southern Division, 1st July—31st Dec., 1901	764	446	58·3	533	309	59·3
Northern Division, 6th Nov., 1902—15th June, 1903	245	138	56·32	142	70	49·29
Southern Division, 6th Nov., 1902—15th June, 1903	248	119	48	137	58	42·4

These returns afford clear evidence that the houses in which typhoid

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cases occur are not specially characterised by the possession of defective drains.

As regards Area A, the results of the investigation are interesting, chiefly in relation to the question of elevation. This it is to be noted is only 3 feet above high water. The houses are old, the foundation is the alluvial blue clay, and the sub-soil water is high. The sewers are distinctly bad. Yet in the epidemic of 1901 the number of typhoid cases was decidedly below the average of the whole city.

The investigation has revealed the presence of sanitary defects in the areas examined, and these areas have been selected as typical of the various districts of the city. These defects all more or less contribute to the conditions which make it easy for typhoid fever to find a footing. There is no evidence, however, from the investigation to show that the peculiar burden of typhoid fever which is laid upon the city is due in the first instance to these defects.

Infection of the Soil.

A further effort was made to define the extent to which defective sanitation in connection with the houses might be regarded as the means of spreading typhoid infection. From leaking house drains, etc., the soil is being more or less constantly inoculated with the typhoid virus. It becomes important therefore to determine how far the soil may be regarded as a medium in which the *Bacillus typhosus* can maintain its life. This problem is a most complicated one, since we are to a large extent without a knowledge of the physical and chemical conditions of soil which are favourable or otherwise to bacterial life. A certain amount of research bearing on the particular question before us has been carried out. It has, however, been limited chiefly to the question of how long the typhoid bacillus will survive in various samples of soil. At the request of the City Council I carried out an investigation upon this subject. The results, the details of which I need not at this time enlarge upon, go to support the conclusion that, as a rule, the typhoid bacillus is unable to survive for more than a short period in natural soils, or even in soils which have been sterilised before the typhoid bacillus has been planted in them.

An examination of the bacteria present in soils which are subject to contamination, showed that not only typhoid bacilli, but also *Bacillus coli communis* are absent, unless the contamination has been very recent.

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On the other hand the durable spores of *Bacillus enteritidis sporogenes* were found widely distributed in such soils.

We cannot, therefore, regard the soil as an enduring source of typhoid infection simply because it has at some time been inoculated with the specific bacillus. The soil acts as a filter, and the sewage which passes through any considerable layer of it loses the typhoid bacillus which it may have originally carried. When the proportion of sewage is very large in relation to the soil in which it is contained, or when it escapes on the surface of the soil, we have to deal with conditions which are, bacteriologically speaking, essentially different from those presented in the problem of infected or inoculated soil. The conditions which arise in these circumstances form part of the general question of surface pollution.

Infective material which finds its way to the surface of the soil by the escape of sewage, or otherwise, is regarded by all investigators as one of the most fertile sources of typhoid disease. Such material may be conveyed to susceptible individuals by various means. It may be carried into the house, as Koch has pointed out, on the feet or hands of children. It may be blown in the form of dust by the wind. It may adhere to the feet of flies and be taken directly to the food. It may be washed into streams and wells from which drinking water is obtained. In these cases the question of the survival of the typhoid bacillus takes a secondary place, while the mode of conveyance of the virus from the surface of the soil to the new patient becomes the primary consideration. In order, however, fully to appreciate the danger which arises from this source of infection, survival of the bacillus must be studied experimentally here also. The problem arises in the investigation of many forms of typhoid epidemic. One illustration of its importance may be quoted. The explanation given of the cause of the typhoid epidemic in Paris in 1894, is that a heavy fall of rain had washed a large amount of contaminated surface matter into the Vanne, from which a section of Paris obtains its water supply. The point of special interest is that although a typhoid epidemic had occurred recently in the Vanne area, a year had elapsed since there had been any cases. The most obvious interpretation of this sequence of events is that the typhoid virus persisted in an effective condition for a year in the surface layers of the soil. That this may have taken place, however, requires further demonstration, especially since other explanations might be offered.

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Direct Infection.

Attention has been directed anew to surface pollution by Koch in his recent enquiry into the continuance of endemic typhoid fever in the villages at Trier[1]. Koch, however, regards the direct transmission of the virus from one individual to another by means of surface pollution as a more important consideration than the survival of it in the surface layers of the soil. According to this hypothesis it is of primary importance to isolate the infected members of the community, and destroy the bacteria in the dejecta, in order to prevent the spread of the disease from one individual to another. Hence, he advocates the necessity for hospital treatment of all cases, and the isolation of those who, though they are not, medically speaking, suffering from typhoid fever, are infected in the sense that an examination of the faeces shows that the typhoid bacillus is present in the intestine.

How far the same explanation would hold for a large city in which, admittedly, surface pollution is abundantly present, has not been determined. Certain data are already in our possession, however, which throw light on the distribution of cases in Belfast. The record of infectious diseases notified to the Medical Officer of Health is so kept that it is possible to classify the houses in which typhoid or other infectious diseases occur, according to the number of cases in them. In the following table I have given the results of a classification of the houses and cases on this basis:

Year	Total number of cases	No. of Houses in which Typhoid cases occurred	Percentage of Houses with one case	Percentage of Houses with two or more cases	Average No. of cases per House, where more than one occurred	Percentage of the cases possibly accounted for as direct infection from the first case in the House	Percentage of the streets in which Typhoid fever occurred, in which there was one case only
1898	5136	4301	86·4	13·6	2·4	16·2	
1899	1598	1403	88·4	11·6	2·2	12·2	
1900	1777	1514	87·6	12·4	2·4	14·9	50·0
1901	2503	2099	86·3	13·7	2·4	16·1	39·3
1902	1044	925	89·2	10·8	2·2	11·4	60·0
1903	842	775	92·9	7·1	2·2	7·9	

From this table it follows, that in fully 85 % of the houses in which typhoid fever occurred there was no second case. It is difficult to

[1] Koch, *Die Bekämpfung des Typhus*, 1903.

https://doi.org/10.1017/S0022172400002205 Published online by Cambridge University Press

reconcile these results with the hypothesis that the primary element of the typhoid problem in the city of Belfast is direct infection. If within the circle of closest personal contact, 70 % of the cases show no evidence of the infection being conveyed from them to others by direct contagion, there seems little ground for trying to link together a chain of cases to explain the spread of infection by direct means outside the household.

I have added the returns per street for three years, and it is found that about 50 per cent. of the streets in which typhoid broke out, have only one case. There is, therefore, nothing in the record of even this wider circle to lead us to believe that direct infection gives rise to more than a minority of the cases.

The conclusions from these tables are subject to various fallacies. In the first place, the table includes cases of simultaneous infection from a common source. Such cases do occur, and if we had the means of separating them from the others, their exclusion would still further lower the number of cases which could be ascribed to direct infection. In the next place, there is no doubt that a large number of typhoid fever cases occur in which the patient never comes under medical treatment. The symptoms are trivial, or they may be in a large measure absent. Such cases, or a large part of them, may, for reasons to be discussed, be regarded as forming examples of that indefinable clinical entity to which the name of "continued fever" has been attached. I have worked out the classification of cases of "continued fever" according to house distribution in 1901. In that year there were 1351 cases of "continued fever" notified. These occurred in 1212 houses, and in 99, or 8·1 %, of these houses there were more than one case. Hence, if we include the whole of the cases of "continued fever" amongst those of typhoid fever, the percentage of houses in which one case occurred would be relatively increased. The classification by houses of other infectious diseases notified to the Medical Officer of Health should be compared with that of typhoid fever. The numbers of these are however so much smaller than that of the typhoid fever cases that the comparison is probably fallacious. The cases of diphtheria in 1900 numbered 321, and these occurred in 265 houses. In 230 houses there was one case, and in the remaining 35 houses (13·2 %) there were two or more cases. In 1900 there were 658 cases of scarlet fever. The number of houses invaded was 604, and of these 99, or 19·6 %, contained more than one case.

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The result is then as follows:

	Percentage of Houses with more than 1 case
Typhoid Fever epidemic	13·6 %
Typhoid Fever moderately quiescent	7·1 ,,
Continued Fever abundant	8·1 ,,
Scarlet Fever moderate	19·9 ,,
Diphtheria quiescent	13·2 ,,

These results are modified to a certain extent by the isolation and treatment of cases in the Fever Hospital. They are of importance from the practical point of view, because of their bearing on that question. In Belfast the treatment of cases of typhoid fever in hospital has not been extensively carried out. Only about 50 % of the cases notified are so treated. It should, however, be pointed out that this estimate of 50 % is probably a very misleading one. As we have suggested, many cases notified as cases of "continued fever" are in all probability cases of typhoid. One of the most valuable portions of Koch's recent treatise is that in which he deals with this subject. He was able to demonstrate, by the Conradi and Drigalski method, the existence of infection in cases which, clinically speaking, would not be notified as "typhoid." That these cases are plentiful has long been suspected, and that many of them find their way into the group of cases of "continued fever" seems certain, if we compare the returns of typhoid fever and "continued fever" year by year.

	1897	1898	1899	1900	1901	1902
Cases of Typhoid Fever	3269	5136	1598	1777	2530	1044
Cases of simple Continued Fever	378	1321	691	813	1351	730

There is a sufficient correspondence in the rise and fall of the numbers of cases of the two diseases to indicate a very close relation between them. If we further computed the numbers by a calculation on the basis of Koch's results at Trier, it would become clear that a relatively small percentage of the cases capable of causing infection find their way into hospital. The hospital treatment which does exist in Belfast, therefore, is not extensive enough to be a source of serious fallacy in the interpretation of this table of the distribution of cases.

We are therefore led to the conclusion that direct conveyance of the virus from one individual to another does not hold the same position as a means of spreading infection in Belfast, as that ascribed to it by Koch in the endemic typhoid at Trier.

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Before leaving this aspect of the subject, reference should be made to the less obvious avenues of infection, some of which, in other places, and in altered conditions, are of much greater importance than they appear to be in Belfast.

Dust.

Admitting as we do that pollution of the surface of the soil is one of the more important sources of typhoid infection, it would seem highly probable that the infective material, when it has dried, may, in the form of dust, be conveyed by currents of air into the houses, and be deposited in the water, or milk, or other nutrient fluids, in which the bacillus is able to grow. Belfast is not specially subject to the dust which is blown from the surface of the soil by the wind. The rain-fall, while not excessively high, is distributed over a large number of days in the year. Hence dusty weather is a comparatively unusual experience. Further, there is no evidence in the record of streets invaded by typhoid to support the hypothesis of the conveyance of infection by dust. The streets which suffer chiefly from dust are those in which there is a large stream of traffic between the city and the surrounding country. The houses in these streets are not specially liable to typhoid.

Flies.

Similarly, the part taken by flies in the spread of typhoid fever is probably a relatively small one in the climate of Belfast. In warmer climates, such as that of South Africa, or Egypt, where flies are extremely plentiful, the dissemination of typhoid bacilli may in some cases be due to their agency. The hypothesis involves conditions the existence of which in our climate has not been demonstrated.

We may here appropriately discuss the conveyance of typhoid infection through two articles of food—shell-fish and milk.

Shell-fish.

The dissemination of typhoid bacilli by shell-fish has special importance in Belfast, from the fact that at present the mode of disposing of the sewage of the city is to discharge it into the ebb-tide, at a point in the Lough about a mile below the mouth of the harbour. The result is that the tidal water at the head of the Lough contains about ·4 % of raw sewage. On either side of the central channel in the Lough there

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is a large area of land, which is covered with water at high tide, and exposed at ebb-tide. From this area, which is known as the "slob land," large quantities of shell-fish are obtained. The returns of the Fisheries Department show the extent to which the industry of gathering shell-fish is pursued. The annual average amount of shell-fish obtained from the Lough during the last seven years has been the following: Periwinkles, 31 tons; Mussels, 413 tons; Cockles, 9200 gallons; Oysters, 241 hundreds; Lobsters, 5190; Crabs, 5000. A large part of the shell-fish is exported from Belfast to be used as bait. On the other hand, there is no doubt that a certain part of it is obtained by the hawkers to be sold in the streets for food. Further, a number of people gather shell-fish on this land for their own use. There is no restriction placed on the gathering of the shell-fish, and people may be frequently seen busy at this work on the area immediately round the place where the sewage is discharged.

In 1902, I made, at the request of the Corporation, an investigation into the kinds of bacteria to be found in shell-fish gathered from the "slob land." The examination of the fluid obtained from the interior of the shell showed the presence of streptococci, amounting in some cases to 1000 per c.c., and of *B. enteritidis sporogenes*, amounting to more than 10 per c.c.; while the cultivation of the bacteria adherent to the gills in phenolated broth, showed the presence of *B. coli communis*, and coli-like forms. Further, 1 c.c. of the fluid injected into a guinea-pig subcutaneously caused death in 48 hours, and from the oedematous fluid which developed, a pure cultivation of typical *B. coli* was obtained. As a control investigation, I examined a second series of cockles procured from an area free from the suspicion of sewage. Eight cockles were examined; but in none of them were any of the three sewage bacteria found to be present.

Cases of typhoid fever have been reported to the sanitary authorities of Belfast, where, upon investigation, it seemed clear that the source of the infection was in all probability the shell-fish from the Lough, which the patients had eaten. The relatively small number of these cases, however, indicates that infection from this source is not more than a subsidiary cause of the spread of typhoid. For many years there has been a constant stream of typhoid-infested sewage discharging into the waters of the Lough, and infection from the shell-fish in these conditions is doubtless continuous, but it is limited in its amount by the fact that the habit of consuming shell-fish bought in the street is confined to a small section of the community.

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Milk.

The other article of food which we must consider is milk. The milk is brought into the city of Belfast from a large number of small dairy farms. The great majority of these are situated outside the municipal boundary, and are therefore not subject to the regulations imposed on dairies by the city council. In a certain number of cases there has been the strongest ground for suspecting that typhoid infection had been conveyed through the milk.

Outside the municipal boundary the Notification of Infectious Diseases Act is not in force. Hence, the occurrence of typhoid in any such district, is unknown to the authorities. It is therefore difficult to make a complete investigation of suspicious cases.

An enquiry regarding the cause of the epidemic in 1901 was carried out by Drs Gardner Robb, Fulton, and Whitaker. They confined their enquiry to the examination of 24 houses in which typhoid fever had occurred, and their conclusion on the subject of milk as the source of infection is the following: "In two houses, we found that none but condensed milk was used. In 4, there was no regular source of milk supply. The remaining 18 drew their milk from 12 different sources. Enquiry at these places failed to elicit any evidence of the possibility of infection by that means."

The outbreaks of typhoid fever which have been justly ascribed to milk infection have been limited to small groups of patients, and since the milk industry in Belfast is in the hands of such a large number of dairymen, it is improbable that a widespread epidemic could arise from this form of infection.

Water.

We have still, in our study of the conditions affecting the occurrence of typhoid fever in Belfast, to consider the subject of the water supply; and the fact that cases of typhoid fever have taken place in the catchment area at once invests it with importance in the discussion.

The water supply of the city is under the direct control of a Corporate Body, established in 1840, and known as the Belfast Water Commissioners. The water is obtained from three sources: the Woodburn, Stoneyford, and Mourne supplies.

The Mourne supply is being gradually introduced at the present time. The water is of the highest quality; but it has not as yet

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been in use to any extent. The health of the city can, therefore, be considered only in relation to the two older sources of supply.

The supply from the Woodburn district was first obtained in 1865; but the scheme was not completed until 1879, or thereabouts. The catchment area is situated 12—15 miles to the North East of the city, in the hilly land behind the town of Carrickfergus. The water collected there is brought to the filtering works in the neighbourhood of the city at Old Park, and from a service reservoir there it is supplied to parts of the city which are at a level of not more than 100 feet above Ordnance datum. This supply has been regarded with suspicion by the Commissioners. They pointed out that in the catchment area there is a considerable number of inhabitants among whom typhoid cases have occurred, and also that top dressing of the land with town manure from Carrickfergus is carried out. The area has deteriorated by the extension of farming of this type since the water was first taken from it in 1866. In 1893 the Commissioners obtained powers to enable them to control the pollution of the streams feeding the reservoirs; but the provisions of the Act were rendered nugatory by a clause which prevented them from interfering with tillage. In consequence of the futility of this Act further steps were taken in 1899, when powers were obtained to purchase large portions of the catchment area, and since then the Commissioners have been making use of the powers granted to them at that date.

The Stoneyford area is situated about 10 miles to the South West of Belfast, on the high lying ground near Lough Neagh, about 5 miles to the North of the town of Lisburn. The scheme for obtaining water from this area was adopted about 1884; but the works were not completed till August 1888. The water from this source was gradually introduced, and by April 1890 it was in general use throughout the city. The water from Stoneyford has been the only supply available for areas which are over 100 feet above Ordnance datum. The water is collected into large reservoirs, and is filtered at Stoneyford, before it is sent to the service reservoir at Lagmore.

The Stoneyford catchment area consists of 5348 acres, 60 % of which is pasture, and 40 % cultivated land. Situated on this area there are 114 dwelling-houses, with a total population of 544. From a sanitary point of view the district is far from satisfactory, and the Commissioners have made a number of attempts to deal with the difficulties arising from the imperfect sanitation of the catchment area. Early in 1903, as the result of an interview which they had with the

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Local Government Board, Dr Clibborn, Local Government Inspector, was directed by the Board to report on the alleged pollution of this source of the water supply. The Public Health Committee of the Corporation put at his disposal the services of two highly trained sanitary sub-officers, and the following table contains the summary of their report:

APRIL, 1903.

SANITARY SURVEY OF CATCHMENT AREA OF THE BELFAST WATER SUPPLY, STONEYFORD.

ABSTRACT OF REPORT.

Number of Dwelling houses 114
„ Schools 2
Total 116
„ Cowsheds 98
„ Houses which have privy accommodation 14

This includes the two schools. These privies, with two exceptions, are improperly constructed, not being bottomed, thus allowing the liquid matter to percolate into the soil. There are no ash-pits at any of these houses. The drainage of the dwelling houses, cowsheds, and liquid matter from manure heaps discharges over the surface of the adjoining ground or field. At one of these houses the drainage discharges direct into the adjoining stream.

Number of Houses which have no privy accommodation of any kind, and where the slops of the dwelling houses and excreta are deposited anywhere around the house 102

Number of Houses where there is no apparent direct pollution of the adjoining watercourses 86

The drainage of these dwelling houses and cowsheds and liquid matter from manure heaps discharges over the surface of the grounds or fields adjoining.

Number of Houses where the drainage of the dwelling houses, cowsheds, and liquid matter of manure heaps discharges into the adjoining watercourses 29

Ballymacward National School. The privy of this school is situated over a small watercourse that discharges into a stream which passes into Stoneyford reservoir.

Number of Houses with liquid manure tank 2
Number of Houses overcrowded 6
Number of Houses, on inspection, which were in a filthy state inside 7

In the great majority of the houses in the catchment area the surroundings were in a filthy state.

(*Signed*) HENRY REYNOLDS.
WILLIAM J. McBRIDE.

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From this report it is clear that there is an almost total lack of ordinary sanitary arrangements in connection with the houses in the Stoneyford catchment area.

Further, on enquiring into the sanitary history of the district as regards typhoid fever, we find a record which corresponds with the defects in general sanitation.

The following table gives the return of typhoid cases in the Stoneyford area since 1897:

Return of Houses in Stoneyford Catchment Area in which Typhoid Fever has occurred.

Name		Date		No. of cases
P.	...	January, 1897	...	4
M'G.	...	August, 1899	...	1
Y.	...	July, 1899	...	1
M'C.	...	March, 1900	...	1
L.	...	February, 1901	...	1
M'M.	...	,,	...	1
M'K.	...	October, 1902	...	1
,,	...	March, 1903	...	1
D.	...	,,	...	7
T.	...	April, 1903	...	1
H.	...	,,	...	2
10 houses		6 years		21 cases

I have not been able to obtain the record of typhoid fever cases for the whole period since water from this supply was used in the city.

The table just given, however, includes the period during which the largest epidemics in the city have occurred, and during this time cases of typhoid fever have taken place in the small catchment area of 5000 acres, each year, except 1898. The relation of the time of occurrence of the cases in Stoneyford to the date of the commencement of the two large epidemics affords important evidence of the direct connection between these cases and the outbreak in Belfast.

The largest epidemic in Belfast, since 1881, occurred in 1897—98. It commenced in the city in March 1897. In January 1897, four cases occurred at P.'s farm in the Stoneyford catchment area.

Another epidemic occurred in 1901. This commenced in the city in the end of March. Two cases of typhoid fever occurred in different houses in the catchment area in February. In both these instances, there is good reason to connect the occurrence of the cases in Stoneyford with the epidemic outbreak in the city.

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To this argument it may be replied, that the cases in 1902 and 1903 have not been followed by typhoid epidemics in the city. We have, however, somewhat different conditions. The filter beds at Stoneyford have been recently increased from four to six, and this makes an enormous difference in the efficiency of the filtration as a means of protecting the consumers. In the next place, the Commissioners have purchased about half of the cultivated land in the catchment area, and in this is included that portion lying nearest the reservoirs, and that which was regarded as the gravest source of pollution. These circumstances, coupled with the fact that the Commissioners have made renewed efforts to deal with each case as it arises, may be justly expected to yield beneficial results. A still further consideration of the greatest importance lies in the fact that typhoid fever has passed into a quiescent phase not only in Belfast, but in the surrounding towns.

A study of the incidence of typhoid fever in the different districts of the city brings out additional evidence regarding the direct effect of the Stoneyford water.

The complete details of the distribution of the water in the city are not easily made out, as there are areas where water from the two sources may be used. Since, however, the water from Stoneyford alone can be supplied to the parts of the city at a level of over 100 feet above Ordnance datum, we can in a measure trace the effect of this water on the typhoid fever rate. District No. X is the clearest example of a district supplied with undiluted Stoneyford water.

This district was the area of the most violent outbreak in the epidemic of 1897—98. Unfortunately, there has been a rearrangement of districts since that date, so that the exact returns are not available for comparison during the whole period since 1897. The returns for 1900—02 are available, and enable us to judge which district bore the brunt of the epidemic of 1901.

The following table answers the question:

No. of Cases of Typhoid Fever notified per 10,000 *of the Population.*

	1900	1901	1902
City	50·9	72·4	29·0
District No. X	104·7	164·3	43·0

Reference to the complete table, already given, will show that this district is by far the most typhoid-stricken area in the city.

The filtered water from the Stoneyford supply has been examined, at the request of the Water Commissioners, by Professor Frankland,

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and his conclusion, in 1899, was the guarded one that it was of good quality "as far as it is possible to render water with this somewhat suspicious history satisfactory."

In 1898, I had the opportunity of making a bacteriological investigation of the water. The investigation was undertaken at the request of the Public Health Committee. I restricted myself practically to the question of determining whether I could detect in the water supplied to the city the typhoid bacillus, or the *Bacillus coli communis.* As regards the typhoid bacillus, the results were negative; but the *Bacillus coli communis* was present in considerable numbers. Some species were of virulent character. The importance of these observations, as far as they go, lies in their agreement with the general facts of the situation. In circumstances of a highly suspicious character, the filtration, and other precautions, were not sufficient to prevent the passage into the water to be supplied to the consumers, of bacteria of intestinal derivation. This bacteriological evidence proved the existence of a certain degree of pollution, and therefore of potential mischief, but did not prove specific pollution. Systematic bacteriological observation of the Stoneyford water has never been carried out, and hence, the case from this point of view, and independently of other facts, has never been completely investigated.

The evidence which I have summarised shows that the citizens of Belfast have been provided with surface and sub-soil water from a typhoid-infected area. The sanitary reform in the city has led to the closing of surface wells situated inside the municipal boundaries, in order to avoid the risk of typhoid infection from the water of the contaminated sub-soil. The contaminated sub-soil water in Stoneyford gives rise to the same risk; but the corresponding sanitary reform has not been carried out.

To protect the consumers however from the danger the Water Commissioners have adopted various expedients. In the first place, they have filtered the water through sand filters, and these filters have been recently increased from four to six in number. The construction of the filters and the rules applied in their use are similar to those adopted by the London Water Companies. The old established doctrine that filtration of water through sand filters is a relative, and not an absolute, safeguard has never been departed from. The security of the consumer, even apart from actual breakdown in the filtering arrangements, is a relative one, and the facts taken as a whole indicate that the security is proportional to the efficiency of the

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filtration, on the one hand, and to the infective power of the virus, on the other. When the virus is powerful in virtue of its quantity or quality it will be conveyed through channels which are closed to a virus of less active character. Again, it cannot be inferred from the success of filtration in the treatment of Thames water by the London Companies that a similar degree of security will be gained from the application of the same process in circumstances such as those of Stoneyford.

The Water Commissioners have recognised that in times of danger extra precautions are necessary, and they have adopted the rule of turning off a stream, and allowing the water to run to waste, as soon as they know that a case of typhoid fever has occurred in any house on its banks. The application of this rule, however, is involved in very great difficulty. The Water Commissioners are not the Sanitary Authority of the area. Their attempt to obtain this power from Parliament was unsuccessful. The rural Sanitary Authority under whose charge the area remains has not adopted the Notification of Infectious Diseases Act. Hence, for lack of the necessary information regarding cases of typhoid fever, the Commissioners are unable to apply their rule with the promptitude required. It is also to be noted that Koch has shown recently that, along with cases of typhoid fever acute enough to require medical treatment, there is a large amount of latent typhoid fever. Hence, even the most complete system of notification would afford a protection of an insecure description. Nor, finally, do we yet know how long a stream from an infected surface, or sub-soil, should be prohibited as a water supply.

Comparison of Death-rates.

In conclusion, if we review the sanitary history of Belfast we find that further light is thrown on the typhoid problem by contrasting the record of the general death-rate and the zymotic death-rate with that of deaths due to typhoid fever.

In 1889, Belfast, in common with other places, suffered from an outbreak of typhoid fever, and, though the outbreak subsided in a measure, there was still in subsequent years an excessive amount of typhoid. This condition of things remained until 1897, when a violent epidemic occurred, the causation of which I have discussed in detail. It is, therefore, clear that typhoid cases have been in excess in Belfast since water was supplied from the typhoid-infected district of Stoneyford. Whatever deficiencies have been shown to exist in the sanitation of the

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city, it has also been made clear that a great degree of reform has been carried out. Not only have important regulations been enforced but a great amount of insanitary property has been swept away. Nor has this sanitary reform been without a very distinct effect on the death-rate of the city. The following tables show this clearly:

Return, showing annual death-rate from Typhoid Fever, Zymotic Diseases, and total from all causes, during the years 1881—1902.

Year	Typhoid Fever, per 10,000	Zymotic Diseases, per 1,000	All Causes, per 1,000	Remarks
1881	3·7	2·4	23·6	
1882	2·9	4·0	25·8	
1883	2·8	4·3	26·2	
1884	2·4	2·9	23·4	
1885	2·2	5·3	27·9	
1886	3·9	2·4	23·7	
1887	3·5	4·0	25·9	
1888	3·3	3·4	25·3	Main Drainage Works commenced, and Stoneyford Water introduced.
1889	7·9	3·9	25·8	Dairy Regulations came into force.
1890	7·6	5·2	29·5	Bye-Laws as to New Buildings came into force, and Smoke and Water test commenced by Public Health Department.
1891	5·9	2·6	25·5	
1892	4·1	3·8	26·5	Systematic removal of refuse introduced.
1893	4·4	4·7	25·8	
1894	5·1	4·1	23·2	Bye-Laws for the Regulation of Piggeries came into force. Commenced testing drainage of all new houses having internal water-closets. Disinfecting Station established.
1895	6·2	3·3	24·3	
1896	4·5	3·3	23·1	Main Drainage Works completed.
1897	11·4	3·6	23·0	Infectious Disease (Notification) Act adopted. Typhoid Fever at Stoneyford Catchment Area.
1898	18·8	3·8	22·8	Commenced testing new house drains of every description.
1899	7·5	2·9	22·7	Parliamentary powers obtained to substitute water-closets for privies. Typhoid Fever at Stoneyford Catchment Area.
1900	7·2	2·1	21·3	Typhoid Fever at Stoneyford Catchment Area.
1901	9·7	3·3	22·4	Do.
1902	4·7	2·8	20·8	Do.

The general death-rate has fallen continuously since 1890. If we compare the death returns for the eight years between 1881—1888 with those of the eight years 1895—1902, we will be able to observe at

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a glance the effect on the health of the city due to improved sanitation. The returns are in each case per 1000 of the population.

Years	Total death-rate	Zymotic death-rate	Typhoid death-rate	Zymotic death-rate apart from typhoid
1881—1888	25·2	3·59	·31	3·27
1895—1902	22·5	3·14	·87	2·27

From this it is clear that the sanitary rearrangement of the city has not resulted in failure, and, while the general death-rate has decreased, the zymotic death-rate, apart from typhoid, has decreased to a much greater extent. There has, however, been conspicuous failure in relation to typhoid fever, the death-rate from which has risen to an extraordinary degree.

Conclusions.

To sum up, the facts demonstrate the existence of a special source of typhoid infection which has not been removed by the sanitary reforms that have lowered the general death-rate and the zymotic death-rate. The investigation has failed to discover this source of infection in the city. On the other hand the Stoneyford catchment area has contained a focus of typhoid infection, which has there remained unaltered during the period of sanitary reform in the city, and we are compelled to hold it to be the primary cause of the excessive amount of typhoid fever which has existed in Belfast since water from this source was supplied to the citizens.

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