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# A STUDY IN EPIDEMIOLOGY

ILLUSTRATED BY A

# DIPHTHERIA EPIDEMIC.



BY

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## INTRODUCTION.

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The consideration of Epidemic disease here set out, while illustrated by the study of a Diphtheria Epidemic, represents rather the conclusions arrived at after some twenty years experience of disease in general gained in the practice of Medicine and Surgery, amplified by two years recently devoted to the study of Preventive Medicine and Bacteriology in particular. Little of originality is claimed ; but the exceptional advantage of being able to discuss an epidemic from personal investigation thereof, from the clinical and epidemiological at the same time as from the Bacteriological standpoint is undoubted.

Personal experience would stand for little, unless it had been aided by the study of the recent and current literature on the subject of Diphtheria and Epidemics in general. Contributions to the various Medical Journals, 'Public Health,' Journal of Hygiene, and different publications and text books have all been taken advantage of ; and amongst others contributing to these may be mentioned the names of Loeffler, Newsholme, Newman, Theobald Smith, Cobbett, Graham Smith, Delépine, Woodhead. I may add that I owe much to Professor Delépine of Manchester, under whom I spent various periods of study from 1908 to 1910 ; for no one can come in contact with him without being infected with his enthusiasm in the cause of Preventive Medicine and trying to emulate in some degree his extraordinary precision and thoroughness and attempting to adopt his breadth of outlook. The personal friendship as well as continuous help and suggestion of Dr. Buckley, Medical Officer of Health for Crewe, greatly assisted my work at Crewe.

A. G. M.

Kingston, Jamaica,

March, 1910.

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## I.—ENVIRONMENTAL CONSIDERATIONS.

(1) *Topographical.* The Borough of Crewe is situated on the Valley Brook, a tributary of the river Weaver, at a mean elevation of about 170 feet above sea level. The soil is of drift deposit, boulder clay with intersections and pockets of sand and gravel. The highest temperature and also the greatest range occur in August; and the lowest temperature and least range in December and January. The mean annual rainfall is about 22 inches; July, October and December being on the average the months of greatest rainfall. The Borough is subject most times of the year to a steamy and foggy atmosphere owing to the nature of soil and sub-soil. Open air life and recreation out of doors may be indulged in most part of the year; but during the short dull days of the winter months indoor life with closed doors and windows comes naturally to the people. The result of this is evident in the expectation and occurrence of outbreaks of infectious disease with the onset of winter. The same result has been obvious in the summer months, when the season has been cold and wet and less out of doors life was readily obtainable. In reviewing the zymotic history of the Borough this has been the only evidence of effect traceable to the seasons and meteorological conditions in general viz: increased opportunity for spread of disease by increased personal contact. The Borough has a population (1901) of 42,074; an area of 2,185 acres and a density of 22·2 persons to the acre.

(2) *Sanitary Conditions.* There is a wholesome water supply laid on to every house in the Borough; the total number of occupied houses is 10,143 (1909); over 7,000 houses have Water Closets either in the house or in the yard; and over 3,000 have Privy Pails, while a few have Midden Closets. The statistical record of the Closet accommodation gave no indication of greater incidence of disease under one system than under another; the Diphtheria incidence affected all indifferently in direct relation to the proportions existing be-

tween the different modes. The sewerage system is good and the bulk of the sewerage is treated on the Corporation Farm. The dwellings of the people are of a good character, and there is little or no actual slum property. The scavenging, night soil removal and general sanitation are well managed.

(3) *Economic and Social Conditions.* The big bulk of the population is composed of the artisan class; the main employment is in connection with railway stock construction of the London and North Western Railway; there is little employment for women; what there is being tailoring of 'ready made' clothes, laundry work and domestic service. Work for a few years has been bad: many men have been out of employment for varying periods, and of those in work many have been on short time. This has resulted in fewer holidays and outings for families, perhaps poorer feeding and more staying indoors; all which mean increased opportunity for the personal transmission of infective disease.

The different classes of property are more or less isolated in groups within areas, but there is no large grouping of different social grades in isolated districts. The children of different social status mix at the public schools, but one or two schools where selected children attended did remain more or less free from infection, and when infection did occur it was more promptly identified and kept from spreading. The situation of the schools was the main factor in determining the limitation of the Epidemic, but the fact of the children from the same homes in many cases attending different schools and more particularly different Sunday schools led to variety of cross infection. Especially was the cross infection evident in the case of the many Sunday schools over which the Health Authorities were able to obtain no efficient control. Contact at work was not found to have any influence in affecting spread of infection. Contact of children at play in the yards and street and at the schools was found most important. And the reaction of climatic conditions independent of season, had a distinct influence on raising the case rate; obviously by throwing individuals into closer contact indoors and multiplying the chances of infection.

## II.—CLINICAL HISTORY OF THE EPIDEMIC.

(1) *Endemicity.* Diphtheria may be said to be endemic in the Borough; which simply means that over a course of years (over 30 years) there had each year been cases notified.

(2) *Epidemicity.* The transition from 'Endemic' to 'Epidemic' is merely a matter of volume. In the light of modern knowledge of the 'carrier' in infective diseases, the increase in volume that determines the 'Epidemic' is to be attributed wholly to the 'carrier'. The nature of the 'carrier' and the opportunity of contact with a sufficiency of susceptibles are the prime factors in spreading disease. The chance of contamination of milk, food, water and other vehicular means of infection are part of the 'opportunity'; and as has been admitted above the meteorological factor is of real existence only so far as it affects the social conditions of the people and enhances the opportunity. This statement is emphasised in order to discount the unreasoned theorem of our profession no less than of the laity that 'the weather', 'the time of year', 'a special virulence', are the cause of causes ordaining Epidemicity.

For the ten years previous to 1909 the cases and deaths were as follows :

	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908
Cases	46	36	112	136	150	53	47	32	37	39
Deaths	14	4	16	28	18	3	4	4	6	8
Fatality %	30·4	11·1	14·2	20·5	12·0	5·6	8·5	12·5	16·2	20·5

It will be seen that there was an endemic constant of nearly 40 cases a year, and that in the three years 1901, 1902, 1903 the volume increased to Epidemic recognition. No meteorological or other constant has been ascertained varying with this change of volume, and in the light of 'carrier' knowledge obtained in the 1909-1910 Epidemic, the 'carrier opportunity' is assumed.

(3) *Origin of the 1909-10 Epidemic.* The monthly notifications in 1909 were :

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
4	6	2	1	6	5	1	6	16	20	24	21

For the same period the Scarlatina notifications were :

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
7	1	13	10	10	16	21	26	18	8	10	9

10 YEARS AVERAGE.

22	16	11	10	14	12	9	12	15	25	24	22
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1908.

95	53	21	22	24	20	18	15	7	7	10	4
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The Scarlatina notifications for the year 1909 will be seen to be below the average for the previous ten years ; the susceptible population having been exhausted by Epidemic in 1907-1908, of which the finish is seen in the early months of 1908. In June, July and August there is a Scarlatina rise ; in July there was 1 Diphtheria notification, in August 6, and in September 16. Coincident with the Diphtheria rise, the Scarlatina rate recedes to about the mean that might be expected from the exhaustion of 1907-1908.

From this it might be inferred that the Diphtheria rise may have really begun in July when only 1 case was notified, and that the Scarlatina rise of that month was really a Diphtheria rise. On tracing later the cases of this period, the presumptive evidence of this supposition was strong ; and as regards the months of August and September real evidence in support of it was furnished by Bacteriological examination. In the month of September it became evident that Diphtheria was more prevalent, and the Scarlatina notifications decline. Evidence also was obtained in September that cases of sore throat and undefined and undiagnosed illness had existed during July and August in families amongst whom in September undoubted Diphtheria was reported. These facts and the opportunity afforded by the social, school and Sunday school environment of the several discovered omitted cases justify the assumption that the headway—the volume necessary to establish an Epidemic was obtained at this time by the free intercourse of a body of scattered 'Carriers'.

(4) *Course of the Epidemic from August 1909 to March 1910.* The notifications from August 1909 to February 1910, were :

August	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
6	16	29	24	21	41	41

Most of the cases were isolated in Hospital ; the children of affected families were kept from school for three weeks, but it was impossible to ensure that they did not attend Sunday school ; Bacteriological reports were obtained of the notified cases, and a negative report was required before removal from Hospital was granted ; some suspected cases and 'contacts' were Bacteriologically reported on, but the staff at this time had not the necessary time available to make wholesale examination of 'contacts'. It is evident from the returns for October, November and December that the efforts of the Health Department decidedly checked the spread of the disease. The autumn and early winter months were clear and frosty, and probably there was more open air life and less crowding together indoors than is usual in the average foggy damp autumn and winter months. With the coming of Christmas and New Year the condition of affairs altered ; the ordinary seasonal festivities led to increased opportunity for contact, and along with this a change to moist foggy weather increased the indoor life and gave 'enhanced opportunity' to the 'carrier'. The notified cases rose to 41 in January and 41 in February, and a local Bacteriological investigation was determined on.

*(5) Course of the Epidemic from March to September, 1910.*

The notifications received were :

March	April	May	June	July	Aug.	Sept.
49	31	25	27	15	10	5

As was to be expected from the increased interest and vigilance resultant on the establishment of a Bacteriological centre on the spot, the first result was an increase in the number of recognised cases of Diphtheria. No doubt by this time the volume had so increased that more cases were to be expected. Many mild cases were discovered in infected families and were notified. These would help to swell the list ; but at the same time the isolation of 'carriers' (20 in March) would greatly lessen the 'opportunity', and the March return might even have been greater in absence of local investigation, considering the volume that had been attained in the two preceding months.



The history of 90 Diphtheria 'carriers' found during the six months, March—August, 1910 will best describe the course and nature of the Clinical and Bacteriological work carried out in that period.

*(6) History of 90 'Carriers' isolated in association with 157 cases notified.*

The term "carrier" or "positive contact" here used applies to persons who on examination were found to harbour the Bacillus of Diphtheria. The situations usually examined for the Bacillus were the throat and nose and the only other situation where the Bacillus was found in this investigation is the ear. By examination of the throat is meant careful swabbing of the tonsils and pharynx; of the nose, the passage of a swab slowly and carefully in and out through one or other nostril, separate swabs being used for each nostril.

Examination was undertaken on account of contact with a notified case of Diphtheria, and the "Contacts" were roughly divided into "home contacts" and "school contacts."

"Home contacts" include the members of the family of the notified person, and also of the neighbours and friends with whom contact at home was suspected or suggested; "School contacts" include all those examined at school or rarely at workplace on account of their contact with a notified person. The scheme of "swabbing" had to be modified at various times to suit circumstances and with a view to getting the best results, and in the end the attempt was always made to make the "swabbing" as wholesale as possible. The people have aided the efforts of the Health Authorities with wonderful readiness, but in various quarters opposition naturally was met with which tended to lessen the satisfactory nature of the results and probably retarded the stamping out of the disease.

In a further paper I hope to discuss the epidemic in all its bearings, but meanwhile shall limit criticism to the "Carrier" problem.

For the sake of comparison and of giving an idea of the relative proportion of things, I give in tabular form the number of notifications received during the six months under consideration, and also various figures representing the amount of "contact" work done. The tables speak for themselves and I have drawn out no percentage estimates or averages for any of the figures, having poor opinion of the utility of doing so, as the amount of work done—the estimation of the number and nature of the "contacts" to be examined and the persistency with which the examination is followed out—is so much a personal and also local matter that no comparison could well be instituted with the work of others.

In the table of "contacts" again the approximate duration of known infectivity is given, and no average is struck. It is evident that the known period of infectiveness gives little idea of the whole period of infectiveness, and that even the "known period" would vary in different hands according to the local conditions—the facility afforded by the people for re-examination and the strength of the Public Health Staff. It is evident also that to strike an average of known duration of infectiveness between cases that are found infective for some few days and others whose infectiveness continues over a period of months would be of no practical utility.

TABLE I.

Shows the number of cases bacteriologically examined during the months March—August, 1910.

1910.	Notified & Suspected cases.	Contact Cases.			For release from quarantine. Hospital & home cases & contacts.	Total cases examined.
		Home	School	Total.		
March	43	65	49	114	56	213
April	70	117	99	216	140	426
May	95	95	101	196	141	432
June	63	106	171	277	148	488
July	61	83	31	114	159	334
August	42	68	193	261	130	433
Totals	374	534	644	1178	774	2326

The above table shows the relative proportion of cases actually examined and does not include subcultures or duplicates, except of examination for release from quarantine.

It will be seen that the number of "notified and suspected" cases in March is fewer than the number of "notified" cases as shown in Table 2; while in the other months that number is considerably higher than the "notified" number. The reason is that at first all the "notified" cases were not bacteriologically examined as they were afterwards, nor until the work was in full swing was there the same assistance from the medical practitioners, teachers and others in bringing to notice "suspected" cases. In the schools the teachers took up the work of observation with enthusiasm, and all the children brought under observation were "swabbed" and referred at once to their medical attendant for treatment, whatever the condition might be.

TABLE II.

Shows the number of cases of Diphtheria notified in each of the six months, March—August; the number of "Contacts" examined and those found "positive."

It may be observed in connection with this table that the cases of Diphtheria found as the result of Bacteriological examination of notified cases is fewer than the notified cases by a small and varying percentage—being smaller when there is much Diphtheria and greater when there is little.

1910.	Number of Notifica-tions.	Number of Contacts Examined.			Number of Contacts found Positive.		
		Home	School	Total.	Home	School	Total.
March	49	65	49	114	13	7	20
April	31	117	99	216	15	3	18
May	25	95	101	196	10	3	13
June	27	106	171	277	11	10	21
July	15	83	31	114	10	5	15
August	10	68	193	261	3	0	3
Totals	157	534	644	1178	62	28	90

The chief point brought out in Table 2, is the proportion of Contacts found positive to Contacts examined, and the relative proportion of "positive" "home contacts" to "school contacts." The number of school "carriers" is also unduly inflated by the inclusion of 12 cases who were included on suspicion and whose after examination led to the belief that the bacilli which were the cause of suspicion were after all not *B. Diphtheriæ*. They had characters sufficient to justify

temporary observation in the presence of an outbreak of Diphtheria, and the temporary quarantine and suspension from school was little hardship and a measure of safety. All school carriers were found to be intimately associated at play with other "cases" and "carriers" and mere classroom proximity was found to be of little importance as a factor in spreading the disease. The evidence all goes to indicate the very intimate means necessary for the transmission of diphtheria from one individual to another. In the home the "positive" cases have been found in most number amongst those who are naturally in closest communication, and the same holds for playmates in the same street and at school. This fact is of great importance and indicates how readily by prompt bacteriological examination and detection of "positive" cases the dissemination of the disease may be prevented.

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# TABLE III.

## DETAILS OF 90 "CARRIERS."

No.	Sex	Age	Known duration "Carrier," Period.	REMARKS.
1	M	12	6 weeks.	School "suspect"—Bacilli in throat four weeks—in nose six weeks. Cases of Diphtheria in his class.
2	M	16	5 days.	Home "contact" of notified case—no history of illness.
3	F	6	3 weeks.	School "contact" of notified case—no history of illness.
4	M	3	5 weeks.	} Brother and sister home "contacts"—family of seven—"case" at school where were other cases—no discoverable previous or current illness of "carriers".
5	F	1	3 weeks.	
6	F	6	3 weeks.	School contact—no evidence of illness.
7	M	6	Not ascertained.	School contact—notified two days later—treated at home—no other swabs obtainable.
8	M	6	Not ascertained.	School contact—left the district before another swab was obtained.
9	M	9	2 weeks.	Home contact—brother of 20—no illness.
10	M	7	1 week.	School contact of 20—no illness admitted.
11	F	7	2 weeks.	School contact of 20—no illness admitted.
12	M	7	2 weeks.	Home contact—no illness.
13	M	7	2 weeks.	Home contact—no illness.
14	F	8	2 weeks.	Home contact—no illness.
15	F	7	2 weeks.	School contact—no illness.
16	M	11	4 weeks.	Home contact—brother of 17—got no antitoxin—notified two days later.
17	F	7	4 weeks.	Home contact—sister of 16—got antitoxin—no evidence of illness.
18	F	7	4 weeks.	School contact—no illness.
19	M	25	Not ascertained.	Home contact—"out of work"—nursed notified sister on his knee—went off to work 10 days later without having been re-examined.
20	M	7	15 weeks	Brother of 9—Bacilli remained in nose and throat—allowed to leave Hospital under his Doctor's supervision—successive negative swabs obtained 10 days later.
21	M	10	8 days.	Home contact—no illness.
22	F	15	2 weeks.	Home contact of 23—not examined when 23 went to Hospital—no sign of illness.
23	M	6	2 weeks.	Discharged from Hospital—found "positive" in nose a week after discharge.

### TABLE III.--CONTINUED.

No.	Sex	Age	Known duration "Carrier" Period.	REMARKS.
24	M	27	3 days,	} Father of notified case—no illness—got antitoxin.
25	F	26	3 days.	
26	M	1	3 days.	
27	M	13	'Not ascertained.'	} Home contacts—four cases notified simultaneously—these then found "negative"—baby of 8 months notified a month later when these were found "positive"—further examination obstructed.
28	F	6	'Not ascertained.'	
29	F	35	2 weeks.	
30	F	13	3 weeks.	} Home contact—mother of notified case—no illness.
31	F	12	3 weeks.	
32	F	10	4 weeks.	
33	F	6	3 weeks.	} School contact—no illness.
34	M	27	12 days.	
35	F	45	8 months and still 'positive'.	
36	F	43	3 months.	} Home contact—no illness.
37	F	10	2 weeks.	
38	M	7	'Not ascertained.'	
39	F	10	6 weeks.	} Home contact—no illness—had antitoxin, } sisters.
40	F	16	6 weeks.	
41	F	31	5 weeks.	} Home contact of baby 1 year old—atrophic condition of nasal and pharyngeal mucosa—a laundry worker—probably introduced the disease to home.
42	M	1	3 weeks.	
43	F	5	'Not ascertained.'	} Home contact—brother of 39 and 40—had no antitoxin—notified 2 days later.
44	M	5	'Not ascertained.'	
45	M	5	'Not ascertained.'	} School contact—no illness—not re-examined.
46	M	10	4 weeks.	
47	F	11	3 weeks.	
48	F	14	3 weeks.	} —"bacilli found in nose with membranous rhinitis. Lost sight of. Notified as Scarlet Fever—found also to carry B. Diphtheria in throat. Home contact—no illness—antitoxin given } sisters. } two others in hospital.

TABLE III.—CONTINUED.

No.	Sex	Age	Known duration "Carrier" Period.	REMARKS.
49	M	3	3 weeks.	Home contact—no illness—got antitoxin—one of family discharged from Hospital 2 weeks before—found "negative"—other infection probable.
50	M	9	4 weeks.	Home contact—no illness.
51	M	14	4 weeks.	Home contact—no illness—at date of last examination found delivering bread from handcart.
52	F	41	6 weeks.	Home contact—mother of 39, 40 and 42.
53	F	6	Not ascertained.	Discharged from Hospital 10 days before brother notified—found "positive" in nose—mother No. 36 still "positive."
54	M	10	Not ascertained.	Home contact—no illness—no antitoxin—pretence of isolation—3 others in family notified during next fortnight.
55	M	5	13 weeks.	Home contact—examination not obtained until after fresh case in own and next door family.
56	M	5	12 weeks.	Home contact—two days before found getting "sweets" straight from mouth of 55.
57	F	19	2 days.	Home contact—no illness.
58	M	7	Not ascertained.	School contact—lost sight of.
59	M	7	3 weeks.	School contact—no illness in self or family.
60	M	7	2 days.	" " " " " "
61	M	7	3 weeks.	" " " " " "
62	M	7	4 weeks.	School contact—found 67 "positive" had sore throat 10 days before—also 66 notified a day later.
63	M	7	3 weeks.	School contact—no complaint—found 68 at home "positive".
64	M	7	Not ascertained.	School contact—no complaint—lost sight of.
65	F	6	Not ascertained.	Home contact—no illness—re-swabbing not obtainable.
66	F	6	3 weeks.	Sister of 62—found at home "positive"—notified two days later before antitoxin given.
67	M	9	3 weeks.	Brother of 62—glands enlarged—had "Mumps" ten days before
68	M	2	3 weeks.	Brother of 63—had antitoxin at once—no symptoms of illness.
69	F	7	2 weeks.	Scarlet Fever case in Hospital—possible "school contact"—bacilli proved "Virulent"
70	F	5	1 week.	School contact—} for various reasons on suspicion included as "carriers"—but as
71	F	5	Not ascertained.	School contact—} repeated examination of cultures failed to yield isolated colonies of
72	M	5	Not ascertained.	School contact—} B. Diphtheria the cases were not followed.



TABLE III.—CONTINUED.

No.	Sex	Age	Known duration "Carrier" Period.	REMARKS.
73	M	6	2 weeks.	School contact—frequent sore throats—no notice taken of recent illness.
74	M	6	'Not ascertained.'	School contact—
75	F	6	'Not ascertained.'	School contact—} No. 73 alone of this group gave a pure culture—and as holidays
76	M	6	'Not ascertained.'	School contact—} supervened the cases could not easily be found for further swabbing.
77	F	6	'Not ascertained.'	School contact—
78	M	7	3 weeks.	Scarlet Fever case—probable school contact.
79	F	7	'Not ascertained.'	Home contact—had 'rheumatic fever' shortly before—further swabbing refused.
80	F	21	4 weeks.	Home contact—no symptoms of illness—got antitoxin.
81	F	2	4 weeks.	Home contact—''''''''''
82	M	11	4 weeks.	Home contact—no illness—got antitoxin.
83	M	7	7 weeks.	Home contact—chronic membranous rhinitis—bacilli proved 'virulent',
84	F	4	4 weeks.	Home contact—no illness—had antitoxin.
85	M	16	2 weeks.	Home contact—no illness—had antitoxin.
86	M	3	3 weeks.	Home contact—no illness—had antitoxin.
87	F	9	3 weeks.	Home contact—notified a day later before having antitoxin.
88	F	41	1 week.	Home contact—no illness.
89	M	13	1 week.	Home contact—son of 88.
90	F	8	6 weeks.	Scarlet Fever case—acute and lingering rhinitis—bacilli proved 'Virulent.' Antitoxin was recommended in all cases of immediate contacts 'positive' or 'negative', and administered in most—although it has not been possible to ascertain the number of cases who had antitoxin privately administered.

In criticising the series of "carriers" set out in Table 3, it will be seen that they may be divided into four definite groups. First, there are those who show no clinical evidence of Diphtheria in whom the bacillus diphtheriæ is found for a short time—These persons probably possess some immunity or have a bacterial flora in mouth or nose inimical to the bacillus diphtheriæ. Secondly, we find cases in whom a history of 'cold,' 'sore throat,' 'mumps,' &c., some time previously may be elicited. They may also have some form of paralysis, and are obviously neglected cases of Diphtheria. Thirdly, there are cases without clinical history of Diphtheria with some local lesion in throat, nose, skin, ear, &c., where the bacillus diphtheriæ finds continued lodgment—Membranous rhinitis is the most common lesion found—and Fourthly, akin to the third group are those who have passed through a definite attack of Diphtheria, and in whom usually associated with some pathological lesion the bacillus diphtheriæ remains for lengthy periods after convalescence.

The diagnosis of these carriers was in the largest proportion made from microscopical demonstration of the bacillus diphtheriæ obtained from isolated colonies. The exceptions mentioned in considering Table 2, were temporarily diagnosed from bacilli observed in mixed preparations—The microscopic preparations are extant. "Virulence" is probably legitimately assumed where morphologically typical diphtheria bacilli are found in individuals intimately associated with clinically and bacteriologically typical cases of diphtheria. In a few cases where doubts as to virulence might be raised—the scarlet fever cases and the prolonged cases—"Virulence" was established by the physiological test at the Public Health Laboratory, Manchester, under the supervision of Professor Delèpine to whose courtesy and kindness the permission to use the report is due.

As a rule, when a carrier is found in association with a case, there is nothing, except history of previous "contact" to indicate which carried the bacilli to the other—although in some cases a pathological lesion or the bacterial flora may suggest a long-time carrier.

The fate of the bacillus diphtheriæ when it disappears from an infected person is not obvious. There is no evidence of phagocytosis in the affected regions ; and the most probable explanation is that it disappears before the growth of some organism for which the environment for the time being is more favourable. The total disappearance of the bacillus diphtheriæ is very surprising in those cases where it is found for only a short time. In the chronic cases it seems usually to beat a slow retreat before a staphylococcus and "ghost" forms of bacillus diphtheriæ are commonly to be found amongst the staphylococci for some time after the bacilli have ceased to be successfully isolated.

In some of the chronic carriers attempts have been made to implant on the pharynx and nasal passages flora which observation suggested might be inimical to the growth of the Bacillus Diphtheriæ ; but although some of these implanted organisms were recovered on subsequent swabs the Bacillus Diphtheriæ continued to grow. It seems probable, nevertheless, that further prosecution of work on these lines may result in finding harmless organisms whose implantation and growth on Diphtheria-infected persons may result in ousting the Bacillus Diphtheriæ from its usual haunts.

The administration of antitoxin has no apparent effect on the persistence of the Bacillus Diphtheriæ in "carrier" any more than in "case".

In addition to the foregoing observations the lesson of these carriers may be briefly summed up as follows :—

1. Carriers are found at all ages and of either sex.
2. The previous "carrier" period can not be ascertained but may in some cases be inferred.
3. Nor can it be said in many cases that one case was derived from another—that is, the "carrier" found may have given the disease to those around or may only have just received it.
4. The presence or absence of obvious pathological condition is no criterion of the fact of a carrier ; of the length of "carrier" life, or of "virulence".

5. The length of "carrier" life seems to have no effect on virulence: Bacilli have been demonstrated to be "virulent" after 4 and 8 months in ear and nose of different individuals.
6. "Carriers" are found amongst those most intimately associated with other "carriers" or "cases"; at home between mother (nurse) and child, and child and child that play together; at school the "carriers" found are few and always closely associated (in play and not necessarily in schoolroom proximity) with some other "carriers" or "cases".
7. The control of Diphtheria depends (assuming control of the "case") on the control of the "carrier".
8. The "carrier" should be notified as a case of Diphtheria, no matter of what age or sex—and due quarantine and observation should be maintained until satisfactory demonstration of the disappearance of the *Bacillus Diphtheriæ*.
9. As everything points to the conclusion that the *Bacillus Diphtheriæ* is essentially a human parasite (a saphrophytic existence is not evident; the transference from animal to human is at any rate rare, and many cases of apparent transport by milk and other agencies are manifestly from human contact) a determined attack on the lines of thorough Bacteriological investigation should have no difficulty in stamping out Diphtheria altogether from the land.
10. Evidence points also to the slow inevitable mechanical distribution of the disease which persists endemic in the undiscovered carriers. Epidemicity depends entirely upon the number and nature of the "carriers"; the headway that has been attained before preventive measures have been effectively used; and upon various sociological factors more or less under the control of the authorities. The invocation of miracle; of meteorological factors local and universal; of special intensity of the virus; et omne ignotum, which is the commonplace of authority to-day, might surely give way to the recognition of simple natural open-eye causation.

(7) *Analysis of 157 cases notified.*

a. *Age.* The ages of the notified cases were as follows :

Under	Years	Years	Years	Years	Years
1 year	1-5	5-10	10-15	15-20	20-45
4	63	52	19	5	14

The youngest case was an infant of four months old and the oldest a woman forty-five years of age. The incidence as regards age is manifestly in favour of childhood and early school age. The observation of children at play gives plain indication of why this should be—the means of direct transmission from mouth to mouth are manifestly frequent. Though the adult is less prone to give evidence of having the disease, the proportion of adults found to be “carriers” amongst the small number examined, shows them to be a frequent vehicle of transmission from child to child.

b. *Sex.* The incidence as to sex was—

Males	Females	Total
71	86	157

This gives a slight preponderance of females, which is no doubt due to the sex distinction in the nature of play and general sociability. Several fathers and several mothers and nurses from families with infected children are included in the list. There were also several male and female adults in whose case the source of infection was not traced; and several also whose diagnosis was in error.

c. *Cases Bacteriologically Negative.* Twenty-five cases were found to be negative on first examination—of these 4 were found ‘positive’ on subsequent examination—One of these 4 was treated at home where there was no other case so that for some reason, possibly faulty swab taking, the ‘negative’ result was an error. The other three cases were re-examined after four days in hospital, which makes infection in hospital a possibility. The 21 cases, however, that remained continuously ‘negative’ stayed in hospital and received no Diphtheria infection though most of them were part time in the general Diphtheria Ward. It was not possible in all cases to accommodate them in an isolation Ward until Bacteriological verification was obtained; although all cases of evidently doubtful diagnosis were thus isolated.

There were also eight cases early in March that were not Bacteriologically examined, but their Clinical history was sufficiently definite to have them unhesitatingly diagnosed as suffering from Diphtheria. Brief Clinical and Bacteriological notes of these 21 cases are given.

*Twenty-one cases found "Negative" with brief  
Bacteriological and Clinical Notes.*

BACTERIOLOGICAL REPORT.	CLINICAL NOTES.
1 "Yeast"	"White patch on throat" Temp. 103°f. Lysis.
2 "Streptococci & Staphylococco bacteria"	Follicular tonsillitis. Temp. 104°f. Lysis.
3 "Diplococci and moulds"	Follicular tonsillitis. Temp. 103°f. Lysis.
4 "Diplococci and Staphylococci"	Membranous tonsillitis. Temp. 103°f. Lysis.
5 "Diplo and Strepto cocci"	"Quinsey" Temp. 103°f. Lysis.
6 "Diplo and cocco-bacteria"	Membranous tonsillitis. Temp. 105°f. Crisis.
7 "Diplo. Staphylo and strepto- cocci"	Scarlatina Temp. 103°f. Lysis.
8 "Strepto-cocci and moulds"	Membranous tonsillitis. Temp. 103°f. Lysis.
9 "Yeast and Strepto-cocci"	Follic. tonsillitis, Temp. 101°f. Lysis.
10 "Strepto and Diplo-cocci"	Follic. tonsillitis. Temp. 102°f. Lysis.
11 "Moulds"	Membranous tonsillitis Temp. 101°f. Crisis.
12 "Streptococci"	"Quinsey" Lysis.
13 "Moulds"	Membranous tonsillitis. Temp. 101°f. Lysis
14 "Strepto and Diplo-cocci"	Scarlatina. Temp. 103°f. Lysis.
15 "Strepto and Diplo-cocci"	Scarlatina. Temp. 104°f. Lysis.
16 } "Staphylo-diplo and Strepto-	Follicular tonsillitis.
17 }       cocci"	Temp. 103°f. Lysis.
18 }	
19 "Yeast and Staphylo-cocci"	Soft white membrane Temp. normal. Membranous tonsillitis. 101°f. and 100°f. Lysis.
20 } "Massed ovoid bacilli"	Probably a Milk Infection, the
21 } Showing Metachromatism.	same bacillus was isolated from milk and from the throats of 4 other members of the same family who had no clinical symptoms.

*d. Individual Clinical History.*

The clinical history of a case of Diphtheria reacting in a benign way after the hypodermic injection of a dose of antitoxin is typically simple. The temperature of a benign case is seldom higher than 100°f. to 102°f. The chart opposite gives the typical hourly reading of the thermometer, which indicates a rapid drop in temperature followed by a temperature remaining about a normal level.

This crisis is definitely marked off from the lysis that is almost invariably the rule in suspected cases where the Diphtheria bacillus is not found e.g. in Scarlatina, follicular Tonsillitis and varieties of membranous Tonsillitis.

In malignant cases of Diphtheria where death more or less rapidly follows Antitoxin administration the nature of the temperature varies. In these cases the temperature is often sub-normal from start to finish and is rarely at any time much above normal. Where Suppurations occur in tonsils, neck, ears, etc., the temperature may be high from Staphylococcal and Streptococcal infection.

*e. Fatal cases.* Deaths occurred as follows :—

March	April	May	June	July	August
6	0	3	0	3	1

Of these 13 deaths (about 8% of notified cases) no record is available of the history of 5, while of 8 cases the clinical history is briefly as below.

All received 4000 units of Antitoxin on admission : in 5 cases the temperature was sub-normal throughout till death variously from 4 to 24 hours : In one case the temperature was 101°f. without change till death in 3 days : Two cases had a temperature of 100°f. which came down to 97°f. by crisis in 4 hours and remained so till death, in one case in 24 hours, in the other not till 7 days. All these were of the 'malignant type' with severe prostration from toxin poisoning and death resulted in all from Syncope.

*f. Treatment.* Rest in bed, milk diet, occasional doses of castor oil, and frequent use of soap and water enemata comprise the general treatment. Cases undergoing normal recovery were allowed out of bed and out of doors in three weeks ; complicated cases had to be specially studied. Medi-

cinal treatment was limited mainly to a routine of Liquor Ferri in varying doses, and cases showing heart failure were treated with Liquor Strychnine and Strophanthus Tincture in addition. No special effect can be ascribed to medicinal treatment.

Local applications to the tonsils, pharynx, and douching of the nares were variously composed of Chlorine Water, Boric Acid Solutions, Common Salt Solutions, Sodium Carbonate and Bicarbonate Solutions, and Aqua destillata, but no special therapeutic result or diminution in the stay of the Bacillus in the passages can be ascribed to one more than another. Iodine Water and Tincture of Iodine were used in obstinate nasal conditions without obvious benefit.

White Precipitate Ointment and the Nitrate of Mercury Ointment were useful in healing up obstinate nasal ulcerations. The implantation of various Flora never found along with Bacillus Diphtheriæ was tried without success, so far as concerned the removal of the Bacillus Diphtheriæ.

Antitoxin Diphtheriæ was the sheet anchor in treatment, and the satisfactory result of immediate infection of from 2000 to 4000 units was continuously manifest. The fatal cases were all practically moribund on reaching Hospital. Several cases that might almost have been called moribund, and some with laryngeal symptoms suggesting immediate tracheotomy revived miraculously after antitoxin administration. To one who had seen much Diphtheria in pre-antitoxin days, there is no hesitation in lauding the virtues of antitoxin. Antitoxin was tried in doses of from 2000 to 10000 units as gravity of the case suggested; but a routine dose of 4000 units was ultimately resolved on, and rarely had this routine to be departed from.

*g. Sequelæ.* Urticaria was frequent from the seventh to the tenth days. It never was distressing to any extent. Paralysees were rare, though one or two cases of throat trouble and of eye trouble were heard of after leaving hospital. The after history when the patient had left hospital, it was not possible to study. Cardiac paralysis was obvious in only one of the deaths, and it as well as the other fatal cases, was of the severe "malignant type".



*h. Environmental Factors of Notified Cases.**(1) Sanitary Arrangements.*

Pail Closets (emptied weekly)	-	50
Water Closets (12 indoors, 72 in yard)	-	84
Water Closet (tippers waste water)	-	12
Mixens (midden ashpit, emptied from 2 to 3 months)		11
		157
	Total cases	157

The total in the Borough :

Pail Closets	-	-	2973
Water Closets (in and out)	-	-	7265
Tipper Closets	-	-	1077
Mixens	-	-	519

The proportion roughly gives—

Pail Closets,	1 case in 60.
Water Closets,	1 ,, ,, 90.
Tipper ,,	1 ,, ,, 90.
Mixens	1 ,, ,, 50.

This calculation suggests the superiority of the water carriage sewerage system over middens and pails, and as the different methods of disposal are more or less impartially distributed over the whole Borough, the inference may be justified.

House rent, school attendance, social status and habits, and other factors combine to determine the class of tenant occupying houses of one or other sort in any area.

Too much stress should therefore not be placed on this one factor, without due consideration being given to other influences.

*(2) Milk Supply.* Frequent analyses of samples of milk showed the milk to be fairly satisfactory, and in no case was the *Bacillus diphtheriæ* found.

The total number of sources of milk supply within and from without the Borough was 163.

Over a period embracing 303 notifications of Diphtheria, the supply analysis is as follows :

Sources of Supply.	Cases.
63 were associated with	0
28 " " "	1
22 " " "	2
13 " " "	3
17 " " "	4
8 " " "	5
4 " " "	6
1 " " "	7
2 " " "	8
2 " " "	10
1 " " "	11
1 " " "	14
1 " " "	20

This records a period of 19 months and the cases were scattered at intervals over the whole period ; no group of cases at any time was associated with milk supply, except on occasions when more than one member of a family were attacked at the same time, and then obvious other source of infection was found.

At the commencement of the Epidemic the 22 cases notified in August and September 1909, were associated with 15 sources of milk supply, and the duplicated associations were divided in time though not families.

There was nothing found therefore at any time to cast suspicion on the milk supply as a source of infection.

(3) *Residential effect.* Contact was clearly established between house and house in the same street, always by children mixing at play in street and yard. Otherwise there was no obvious residential factor other than as suggested, when considering the Sanitary arrangements.

(4) *Work-place.* Several adults were notified, but in all the infection was got at home and no cases were traced from them to other workers. In one case a woman laundry worker was found to be a 'carrier' and was kept from work until declared 'negative' to satisfaction. An infant of hers died of Diphtheria and no source of contact was found. It is possible the mother may have been infected from articles at the laundry, but no evidence to incriminate the laundry was forthcoming.

(5) *School and Sunday School.* School, Residence and Playground are all intimately associated as factors affording the favorable opportunity for contact spread of the Infection of Diphtheria which has been the sole discoverable means of spread in this Epidemic.

The rough sketch opposite gives diagrammatically the means of infection that were repeatedly demonstrated.

As before admitted the sequence of infection was impossible to be established, but the association was undoubted. The ready infection from house to house by children at play; the less frequent infection by contact at school; the complicated infection due to the double mixing of children from different areas at Sunday school; and the more tardy spread from one area of the Borough to another, owing to the natural barriers opposing free intercourse amongst the people—the railways divide the town into several clearly defined areas, between which the means of communication are limited—these are all schematically indicated on the sketch.

As regards the relative incidence of 'cases' and 'carriers' occurring in schools that might be classed as Sanitary and Insanitary, the evidence inculcated to a definite extent the Insanitary schools—But the complication arising from members of one family attending as many as four different Day schools, and several different Sunday schools makes it impossible to lay too much stress on the incidence as regards the condition of the school buildings. So many other factors also influence the spread, and the factor of outstanding importance that stood out above all others in every trail pursued was that of direct contact.

(6) *Seasonal Influences.* No seasonal factor was directly demonstrable, but indirectly in so far as the seasons reacted on the social behaviour of the people, the seasonal effect was recognisable as introducing the factor of 'increased opportunity' from proximity.

(7) *Urban and Rural Influences.*

From collateral knowledge of several slight outbreaks in the Rural District which were usually confined to one family which had got infected from contact with Urban cases the same fact of opportunity from proximity was manifested.

(8) *Water, Food, Fruit and fomites in general.*

As in the case of milk repeated Bacteriological examination failed to attribute any certain infection to these factors; although it is no doubt certain, considering the ways of children that some of these elements are likely to act at times as the vehicles of transmission.

(9) *Disinfection Procedure.* When a case was removed to Hospital immediate disinfection of all clothing, bed-clothing and suspected articles was undertaken by the Authorities at the Steam Disinfection Station. The articles were carefully removed in a special Van and duly returned after certain disinfection. A routine disinfection of the house was carried out, the value of which was perhaps more demonstrative than necessary or effective.

Before release from Hospital patients had to satisfy a Bacteriological record of three negative swabs on successive days, had a bath and donned freshly disinfected clothing on the eve of departure. Open air regime had previously been maintained from the earliest possible period of convalescence.

### III. BACTERIOLOGICAL HISTORY.

(1) *Material.* Work was assisted by the possession of a well arranged and well equipped Laboratory: a long north window with strong bench, abundant water supply and sinks; gas with sufficiency of Bunsen jets: electric light: Incubator: Steriliser: Hot air ovens: still: retorts, etc.: a substantial microscope by Leitz with an admirable one-twelfth inch oil immersion objective: in fact an admirably supplied chemical and Bacteriological Laboratory with a fairly free hand to obtain fresh material.

*Culture Media.* The culture medium employed was Loeffler's Blood serum made at the Laboratory to Loeffler's formula. Afterwards the attention necessary during inspissation of the serum took up so much time that the making of serum was abandoned and fresh supplies of capital serum were regularly obtained from the Public Health Laboratory, Manchester.

*Gelatine and Agar Media* were made in the Laboratory, and also Bouillon was prepared for use in Typhoid and other operations that were carried on *pari passu* with the Diphtheria work.

*Swabs.* With assistance swab making was kept up

throughout; the material used being narrow glass tubes drawn out in the Laboratory, bird-cage wire fixed in the narrow cork and bearing a swab of cotton wool round the curved end: the whole was sterilised by dry heat for two hours at a temperature just short of singeing the cotton wool; occasionally the cotton wool was browned by heat which for practical purposes was a negligible matter. At first the tubes were sterilised, boiled again in alkali, washed in acid, dried and used over again; but it was found later to be as easy and no more costly to prepare fresh tubes as well as swabs for each supply.

*Microscope.* The microscope was a Leitz A1, with a steady base, a centering table, and a perfect achromatic one-twelfth inch oil immersion objective; a No. 4 eye-piece was used and a tube length of 170 m.m. was usually employed for Diagnosis. Natural daylight was practically always the test, as it was found best to have the microscopic work done by daylight and I have a personal aversion to electric or other artificial light when working with stained bodies under the one-twelfth inch oil immersion objective.

*Staining.* All known methods of staining were employed and also many experimental methods, but the stain found most satisfactory and of certain diagnostic value along with other determined factors was a half-strength Ziehl Neelsen Stain poured over the slide and immediately washed off under the running tap.

*Culture Tubes.* Three-fourth inch test tubes without rims were mostly in use for cultures: fresh tubes being always used for filling with serum.

*Slides and cover glasses.* The usual Bacteriological slides were in use and no slide or cover glass on which were found Diphtheria bacilli was used over again: some of the other slides after being boiled in Hudson's Extract of Soap, digested in Bichromate of Potash and Sulphuric Acid, and washed in Ammonia, and stored in alcohol, were used over again. Cover glasses were little used.

*Needles, Spatulæ and Loops* made of *platinum* acted as the culture and demonstration utensils. A *Metal rest* held these while not in use, and a *Bunsen Flame* served for their *Sterilisation*,

*Antiseptics.* The use of Antiseptics was restricted to

washing of the hands after work in 1-2000 Corrosive Sublimate solution, and of the face when rarely considered necessary: the bench around the working place and the floor were freely washed with 1-2000 Corrosive Sublimate lotion at the end of each working period.

*Sterilisation* of used material was effected in a Kochs steriliser at 100° C. for three hours, and most material destroyed thereafter in an open fire-place.

*Perforated wooden blocks* were used for the safe carriage of the swab tubes: and occasionally in large swabbings the swabs were carried loose in card board boxes. *Linen Overalls* were regularly worn and frequently sterilised and washed.

## (2) *Methods.*

*a. Swabbing.* The sterilised swab was applied to the tonsils, pharynx, gums, eyes, internal ear, nostrils, to eczematous patches, sores on various parts, to the moistened surface of fruits, vegetables, sweets, pencils, pens, slates, dolls, toys, etc., to anything on which suspicion was cast or where one desired to decide yea or nay: it was immediately replaced in the tube and not removed again except for culture preparation. A gummed label attached to each tube was at once filled in ink with all detail of the person, site, date, etc., of the taking of the swab.

*b. Innoculation of Media.* At the bench the swab tube is taken in the left hand, a few drops (sufficient to make a visible amount of emulsion in the bottom of the tube) of distilled water are added from a Pasteur pipette, the cork is slightly withdrawn, the tube held horizontally with the cork on the palm of the opposite hand, and by a rapid motion back and fore rubbing the cork on the palm of the hand the wire is made to revolve in the bottle, and the material on the cotton wool swab makes with the few drops of water a small amount of turbid emulsion. The wire is withdrawn and stood in a tin which with the accumulated wires is afterwards destroyed in the fire. A stout platinum spatula is now taken from the rest and sterilised in the Bunsen flame: the swab tube and one or more plugged tubes of sterile Loeffler's Serum are held in the other hand; the plugs are sterilised with the necks of the serum tubes in the Bunsen flame, extinguished by insertion then withdrawn by forceps and held between the fingers in orthodox manner: the spatula is inserted to the

bottom of the swab tube and with long firm strokes is next drawn over the serum in the tube or tubes of "Lœffler", three strokes as a rule in each tube being a convenient number to make for purposes of observation. The spatula is again sterilised in the flame and laid on the rest. With forceps the plugs of cotton wool are taken and ignited in the flame and inserted in the serum tubes. The swab tube is set aside with the wire in a vessel with or without some antiseptic, and later destroyed by fire, or first sterilised in the Koch. The gummed labels on the serum tubes are now marked in ink with a number and date and all detail requisite for absolute identification. The serum tubes are stood in cups usually of tinware, capable of holding six to eight tubes and placed in the Incubator at a temperature of from 36° to 37° C. for a period of from 16 to 24 hours. Placing in the Incubator from 3 to 5 o'clock in the afternoon allows of satisfactory microscopic examination being carried out from 9 to 1 next forenoon.

*c. Microscopic observation.* The small circular colonies visible on the serum after sixteen hours growth are not absolutely characteristic, but it is wonderful how the trained eye comes in time to be able to pick out in more cases than not the actual colonies of *Bacillus Diphtheriæ*.

The colonies that most nearly resemble them under all the same conditions are those of *Staphylococcus pyogenes* of any of the sub-varieties and *Bacillus of Hoffmann*.

The somewhat denser centre of the *Bacillus diphtheriæ* colony, the rather pearly distinctness of Hoffmann's bacillus in colony, and the uniformity of dull whiteness or yellowness of the *Staphylococcus*, serve to distinguish each; but there is a combination of appearances to suggest to the trained eye which is difficult of description.

*d. Preparation of specimen for microscopic examination.*

For ease in observation and accuracy it is essential to persist in the removal of only one colony or part of a colony at a time. The use of coverglass was soon given up for slides; the advantage in time saving when much work had to be done is enormous; the slides can be handled more freely and without risk of breakage and many more colonies can be examined on a slide. The routine adopted has been to spread six separate likely colonies on a slide and to make a

seventh smear from a brush of the needle over the surface of the serum growth. This method is sufficient to ensure almost certain capture of a Diphtheria colony if present and though the mixed smear was persisted in, the Bacillus Diphtheria was rarely found in it without being at the same time isolated in individual colonies. A loopful of distilled water was dropped on the slide for each colony detached with the needle and the material was spread in the drop of water by the needle. The slides were laid out to dry, and by the time a dozen or twenty were prepared they were passed in succession through the Bunsen flame to 'fix', the judgment necessary to determine the heat required being soon attained. The half strength Ziehl solution was prepared in a cylinder or measure glass: the slide taken up by forceps and the stain poured over it and immediately washed off under the running tap: the slide was then blotted and allowed to dry, and before placing under the microscope was passed rapidly over the flame to ensure perfect dryness. No mounting was adopted, and the ordinary thickened cedarwood oil was dropped directly on the smear which was then ready for examination. The individual colonies were then serially examined and a positive result recorded the moment the Bacillus Diphtheria was detected. With the individual colonies the microscopic examination can be made with rapidity as with the one-twelfth inch oil immersion lens, the organism in each colony is immediately diagnosed; and in the case of any doubtful Bacilli, the slide is not recorded until after further examination, and in some cases of fresh smears or sub-cultures.

### (3) *Diagnosis.*

The appearance of the Bacillus after 16 to 24 hours growth on Loeffler's Blood Serum and stained rapidly with half strength Ziehl-Neelsen solution, examined under the one-twelfth inch oil immersion lens is absolutely characteristic. In most colonies a variety of forms of the Bacillus Diphtheriæ is found, and in most colonies one form may predominate. A series of throats from one family taken at the same time may give the same variety of form of the Bacillus; while again different forms may predominate in colonies from a series of throats taken together and evidently due to the same infection. No special variety of form was observed to coincide with special benignity or malignity clinically; and throughout the Examination of the Epidemic the Bacteriological worker had the advantage of being conversant with the clinical appearances and history.



Stained with Ziehl as postulated the typical form of the Bacillus is a club shaped rod of about 3 u in length by 1 u broad at the thicker blunt end and  $\frac{1}{2}$  u to  $\frac{3}{4}$  u thick at the narrower blunt end with one more or less centrally situated dark red stained oval nucleus or septum reaching to the lateral borders of the body but not to the ends, the rest of the rod being of a misty filmy appearance and faintly stained of a pale pinky bluish color; the first impression often received by the eye being of a field full of large almost round cocci because the faint stained body of the cell is not so quickly observed as the dark stained nucleus or Septum.

These rods lie in typical parallel groups and clusters leaning to or away from each other in V. and N. formations. But it is typical besides to have all manner of variations from this the simple type occurring in the same colony with all conditions of origin, growth, preparation and staining identical. Instead of one band there may be two, three or more and the length of the rod may extend to as much as 10 u: the clubbed end is general but the big bulk of some colonies may even in the first culture be of a streptococcal form without either end being appreciably thicker than the other. These forms of course are common in sub-cultures, or cultures of more than 24 hours growth. No stain tried has given such absolute satisfactory typical uniform results as this.

The postulates for Diagnosis then I may repeat are—

(a) Growth of freshly acquired swab material on Loeffler's Blood Serum.

(b) 16 to 24 hours growth at a temperature of 36° to 37° C.

(c) Examination with one-twelfth inch oil immersion lens after 16 and under 24 hours.

(d) Of individual colonies stained by a half strength Ziehl-Neelsen Carboll-Fuchsin stain.

Other staining re-agents give satisfactory enough demonstration of the Bacillus, but none gives such Diagnostic certainty under these other conditions. There is no Diagnostic importance in the Neisser demonstration of Polar Bodies; like many other methods it is a lovely microscopic picture and may point the way to further discovery. The staining in blue by Loeffler's method fails to give the definite satisfaction of Ziehl: and the application of Gram's method is of no diagnostic utility whatever for the Diphtheria bacillus.

If the above detailed postulates are adhered to there is only the *Bacillus of Hoffmann* to give occasionally any trouble in Diagnosis. Under the same conditions of growth, age, and staining, the *Bacillus Hoffmanni* typically is a diplobacillus uniformly stained about 3 u in length, by  $\frac{3}{4}$  u in breadth, blunt ended, with one end definitely but very little thicker than the other, with a central division due seemingly to envelope division and without a central nuclear or septal staining as in *Bacillus diphtheriæ*. On rare occasions there were found forms that took on stain less deeply and showed a nuclear or septal stain in each division of the rod. Sub-culture always revealed the typical short form of Hoffmann's bacillus. Also rarely a *Bacillus diphtheriæ* appeared to resemble Hoffmann's by taking on stain more uniformly. Sub-culture again cleared up this resemblance by producing varied and clubbed diphtheria forms. The site from which the swab was taken is of some assistance in diagnosing between Hoffmanni and *Diphtheriæ*, for Hoffmann's bacillus was found in over 80% of 200 nostrils examined in a mixed series of infected and non-infected cases.

*Hyphæ* and *Mycelia* of various moulds sometimes gave a momentary suggestion of diphtheria bacilli.

The *Bacillus Xerosis* was obtained in 9 out of 11 eyes incidentally swabbed. This *Bacillus* under the postulates can cause no error in diagnosis: under 24 hours its growth is very scanty and resembles the *Bacillus diphtheriæ* only after 48 hours growth; its naked eye appearance on serum is typical, and microscopically it has a hard stick-like bend and angular look that the trained eye observes at once.

Various *Diplobacilli* and *Staphylobacilli* are found in the normal flora of the nose and mouth that may occasionally give pause in diagnosis; but sub-culture definitely clears away doubt; and with them all the ultimate resort to the physiological test on guinea pigs removes all possibility of error.

The *Flora of Nose and Throat* otherwise is enormous and varied, but the only possibly mistakable organisms have been referred to.

(4) *Persistence of the Bacillus diphtheriæ under culture.*

(a) *In Pure Culture* the *Bacillus diphtheriæ* continues to grow vigorously from sub-culture to sub-culture, indefinitely

in varied clubbed and streptococcal forms. When grown for some time on the same tube without sub-culturing, it develops a thick mould-like pellicle, and the appearance under the microscope is of long branching hyphæ like rods, vacuolated often and staining irregularly. But on sub-culture of 24 hours growth the typical forms re-appear.

(b) *With other Organisms* in culture and sub-culture, the *Bacillus diphtheriæ* continues to grow typically.

Sub-cultures of the *Bacillus diphtheriæ* have been extended for some time with—

B. Hoffmanni  
Staphylococci varii  
Streptococci     ,,  
Diplobacilli     ,,  
Diplococci       ,,  
Fusiform bacilli  
and Moulds,

and though in many cases the macroscopic appearance of the growth masked the *Bacillus diphtheriæ*, yet in every instance of 30 sub-cultures it was possible to isolate typical *Bacillus diphtheria*. The *Staphylococcus pyogenes aureus* seemed to outgrow the *Bacillus* in vitro, but after the sixth sub-culture the *Bacillus* could be isolated. From the combined growth of Hoffmann and *Diphtheria*, each could be distinctly isolated.

(5) *Persistence of the Bacillus diphtheriæ in Throat, Nose, and Ear.* These are the only sites where persistence was observed and studied, and the *Bacillus* was found in Throat (fauces and tonsils) 3 months, in Nose 6 months, and in Ear 12 months after discovery in typical form and virulent.

In the nose the *Bacillus* was in most cases associated with *Staphylococci* and as the *Bacilli* gradually disappeared, only a pure culture of *Staphylococci* remained. In one instance some time after the *B. diphtheriæ* disappeared, the *Staphylococci* were replaced entirely by *B. Hoffmanni*, presumably on the healing up of some ulceration and re-invasion from the throat or from an outside source by Hoffmann, whose normal habitat seems to be the nasal passages.

Presuming on the possibility of antagonism in growth in nature to account for the sudden predominance at one time, and the sudden disappearance at another of *B. diphtheriæ*, attempts were made by swabbing throat and nose with other

organisms in protracted cases of persistent *Bacillus diphtheriæ*.

- Three separate swabbings were made in three cases with  
 in (a) Fusiform bacilli  
 (b) Staphylococci  
 (c) Moulds,

and though in each case the inoculated organism was recovered on examination, the *B. diphtheriæ* still persisted.

(6) *Fate of the Bacillus Diphtheriæ in the human being.*

Usually in Diphtheria the *Bacillus* suddenly disappears leaving the parts affected in their normal condition as to Flora. Whether Phagocytosis or antagonism of other organisms in the mucosa is the cause of the disappearance there was found no direct evidence to tell. The gradual disappearance in chronic ulcerated cases in the presence of Staphylococci may indicate a squeezing out by survival of the fittest, but the few attempts made to bring this about artificially failed.

(7) *Cases clinically resembling Diphtheria not proved so bacteriologically* form a definite percentage of notified cases. These were variously

- (a) Scarlatina  
 (b) Follicular Tonsillitis of Streptococcal association.  
 (c) *Quinsies*—staphylococcal and streptococcal.  
 (d) *Membranous tonsillitis* associated with a definite meta-chromatic staphylo-diplo bacillus.  
 (e) *Membranous tonsillitis* associated with various moulds.

Although the mistake in Diagnosis is in most cases justifiable enough, yet clinically there are points sufficient to distinguish these cases from Diphtheria—chief of which are

- (1) Colour of patch or patches  
 (2) Distribution of patches  
 (3) Tenacity of patches  
 (4) Nature of origin  
 (5) Temperature  
 and (6) Course of the affection.

No harm is done provided the patients are quarantined in an isolation ward or isolated in the general ward while

there remains any doubt, and it is always safer that the Medical Officer of Health should have charge of doubtful cases than that actual cases should be missed through a fear of wrong diagnosis and so become carriers in the community.

#### IV. CONCLUSIONS.

##### *Co-operation of Bacteriologist and Epidemiologist.*

The problem of how to deal satisfactorily with Diphtheria in the community is bound up with the intelligent co-operation of Clinical and Bacteriological observation. To base a scheme of prevention on clinical evidence alone is possible; but, in the light of Bacteriological knowledge it would be fraught with extreme inconvenience to the community, and the system would bring discredit and animosity upon the supervising authority.

For instance on the notification of a case of Diphtheria in a family, the person affected might be isolated at home or in hospital; the whole family being 'contacts' might be quarantined, and workers kept from work for an indefinite number of days or weeks; all neighbour contacts, and contacts at school and elsewhere might be sought out and similarly isolated. In so doing it is possible that the whole source of infection might be kept in hand, and fresh cases of the disease confined to this somewhat large group. The administration at the same time of antitoxin, wholesale or to those in the group considered most susceptible to the disease might be had resort to, and the quarantine relaxed after a suitable interval. It is evident, however, that if other cases developed within this group, the period of quarantine, at any rate of sections of the group, might have to be indefinitely extended, and from what we know of the length of time, infection may sometimes persist in 'carriers', the arbitrary interval of quarantine might after all prove of no avail.

##### *Wide examination of Contacts.*

On the other hand, however, if Bacteriological investigation follows immediately on the notification of the disease; if a systematic search is made amongst all possible contacts, and secondary trails are laid when 'positive' cases are discovered amongst these; then the necessity for isolation would lie only against those carrying the Diphtheria Bacillus, whether suffering from the disease or not; and the interference with

wage-earning, school attendance, and social duties would be reduced to a minimum.

*Consideration of the facts observed.*

*Direct Contact.* From first to last the evidence has pointed to Direct Contact being the usual means by which the disease was spread.

It is obvious to any one observing the ways of children, alone or at play with others, that the channels and vehicles of transference of Diphtheria bacilli from one throat to another are very numerous. Considering then the possibilities of spreading from child to child at play, when hands pass from nose, throat, ear, eye, and elsewhere to the same parts of the bodies of the playmates; when mouth to mouth, tongue to tongue, nose to nose, and so on, are regular items in childhood's game; when pencils, toffees, coins, fruit, etc., are exchanged with regularity; when the same drinking utensils are used; when mothers lip-kiss their children, pass sucking bottles, teats, sweets, etc., from mouth to mouth; it seems strange rather than otherwise that Diphtheria does not spread with more rapidity at any time.

*Evidence of Direct Contact.*

It is only rarely and that usually in isolated cases or in small epidemics that direct evidence of the actual source of infection is obtainable. When a case occurs in a family and positive contacts are found amongst others of the family and amongst playmates, it is impossible where the disease is widely prevalent, to say that such a case came from such a 'carrier', or that the 'carrier' got the infection from the case. If the disease manifested itself clinically after a definite period of incubation, the chances of pointing out the source of each case would be favorable; but, recognising the indefinite period of time that Diphtheria bacilli may remain in the throat and still be virulent, the assertion of prior or ulterior infection is, except in rare cases, manifestly an impossibility.

A few cases presumably demonstrate the direct infectivity of a carrier. A case was notified in the family of 55, who refused to be 'swabbed' at the time. A week afterwards another case was notified in the family of 55, and one next door in the family of 56. Two days before (according to the mother) 55 had been found passing sweets directly from his mouth to the mouth of 56 and his 'notified' brother.

In another instance a woman (35) was discharged from hospital on the strength of one negative swab from her ear, which had profuse purulent discharge, and which had for weeks given a positive and virulent result. Eight days after her return home a son was sent to hospital suffering from Diphtheria. The ear discharge was found on re-examination to be positive, and proved also to be virulent for months afterwards. Another possible return case came from a family where a mother and daughter were found to be 'carriers' when one other child was sent to hospital suffering from Diphtheria. A son was sent to hospital soon after the child's return home. The child had given two negative results from the throat before discharge, and on re-examination at home was still negative in the throat, although a positive result was obtained from one nostril. The mother was still positive and remained so for some weeks longer, so it is not possible to attribute the infection to the child returned from Hospital, when the condition of the mother might throw suspicion on her. Similar occurrences could no doubt be multiplied if there were an efficient staff to thoroughly investigate every case of disease; but the actual demonstration of virulence and of the exact channel of infection is in ordinary circumstances difficult.

*Home Life and Neighbouring.* The assumption of direct spread from case to case and from carriers in the home and amongst intimate neighbours is justified from the frequent occurrence of cases associated in this way, together with the absence of any other cause of spread in the environment.

*School Life.* The influence of school life as influencing the spread of Diphtheria is difficult to settle. The children undoubtedly are brought into close contact at school, both within the school buildings and on the playground. The interchange of books, toys, etc., at school is a source of danger; especially considering the fondness younger children have of putting articles of all sorts in the mouth and elsewhere. A common drinking cup must be a dangerous utensil, even when cared for and washed by the teacher. The nature of play in the playground must give opportunities of transferring infection over considerable areas of the population. It might be presumed that the hygienic condition of the schoolrooms would influence the spread of infection; and this would seem to be borne out by experience. The classrooms where most cases came from were on the whole

the most ill-lighted, defectively ventilated, and over-crowded. A good many cases later came from classrooms that could not be so stigmatised.

In examining for 'carriers' at school, a selection was made at first of the more immediate contacts in the school-room. Eight children were swabbed surrounding the affected case—three behind, three in front, and one on each side. But though this plan in one or two cases yielded 'carriers', it was soon evident that it was faulty, and afterwards the whole class was swabbed whence a case had been reported. The result of this wholesale swabbing was rather to incriminate playtime and play conditions, and showed no evidence of spreading by contact relations through classroom proximity. In the later stages of the epidemic the swabbing of whole classes yielded no 'carriers', whereas in the earlier swabbings quite ten per cent. of various classes were found to be infected. The improvement gradually attained in the control of the cases by all the authorities concerned no doubt accounted for this. The closing of the Day Schools was not deemed expedient, nor were the Sunday Schools closed; and in these latter, one would not expect the same control as in the Day Schools, so that if any value were attached to school closure, the attempt should be made to close the Sunday Schools as well. The evidence of the result of school closure in other centres of population where it had been adopted, gave no favorable indication of good therefrom. At home the children, if Schools are closed, are left to free mixing at play and in the home, and possibly more opportunity of spread of infection is thus afforded. The opportunity of seeking out 'carriers' is diminished when the Schools are closed; for great difficulties are found in attempting to obtain satisfactory house to house swabbing.

A different state of affairs obtains when the Schools are closed naturally for the Holiday seasons. Then domestic arrangements ordain the breaking up of most families; the children are scattered in the country or by the seaside; and while a local diminution of infection may be thus brought about, it is unfortunately only too likely that the seeds of disease are carried far and wide over the country.

In the present instance the closing of the schools for the short periods at Christmas and Easter had no effect on the progress of the Epidemic. But when the Schools were closed in the month of July for the longer summer holidays, a con-



siderable diminution in the cases notified and carriers found, quickly took place. By this time however the Epidemic had been got well under control, and there are many other social factors to be taken into account that would affect the opportunity of infection besides the mere closing of the Schools.

*Effect of Nurture.* It is questionable if nurture has any influence per se in limiting the spread of Diphtheria. There is no evidence to prove any special incidence on the less well nourished. The evidence points to equal incidence, but the hygienic environment of certain social grades aids the 'carrier', and the better nourished no doubt have more power of recovery, and make a more complete and speedy convalescence. The more careful observance of general hygienic measures and more effective control over the habits of children are certain to have a limiting effect on disease in general independent of nurture.

*Virulence.* The virulence has been tested and satisfactorily established, of Baccilli from the throats of patients suffering from Diphtheria, from throat and nose of 'carriers' not having the disease, and from ear and throat of 'carriers' some length of time after having suffered from Diphtheria.

In no case in this investigation did an actual 'carrier' manifest the disease later than two days from the date of discovery. Those who developed Diphtheria did not have antitoxin before the disease was declared. Of the others, some from their history presumably had suffered from Diphtheria, and most were treated with antitoxin, which no doubt prevented Diphtheria without affecting the length of 'carrier' life. Two adult cases however of more recent date under private observation, and outside the scope of this investigation were known to be carriers for at least three weeks. After that time from discovery a definite clinical and bacteriological attack of Diphtheria occurred, preceded by three days definite slight malaise. Neither had received antitoxin.

There was no evidence of special virulence at different stages of the disease, or at different periods of carrier life; nor was any seasonal virulence manifested. So far as any case could be directly traced to another, the infecting case was found at any period of illness or carrier life.

*Age and Sex.* The analysis of the age and sex incidence indicates that neither factor in itself predisposes to the disease; but each factor is reacted upon by the various socio-

logical conditions that determine the operation of 'carrier' opportunity. A preponderance of females were affected which a moment's consideration of the social habits of young and old of both sexes will suggest reasons for.

The same may be said with regard to the preponderant incidence on childhood and early school life.

At the same time the adult is not to be neglected in the search for 'carriers'. Diphtheria is generally looked upon as a disease especially of childhood, and the adult is apt to be ignored in the investigation of infection. It has been shown however that the adults in the family frequently have Diphtheria, and not uncommonly also are found to harbour the Bacilli in the throat without having shown clinical symptoms of the disease. The mothers of several families where children had the disease, proved to be 'carriers' for considerable periods while kept under observation. Adult male 'carriers' were also found. In one case an adult male was 'out of work' at the time and spent his time nursing an affected child on his knee. He was found to be a 'carrier'. The fathers were rarely at home when swabbing was carried out, but in several cases the father suffered from the disease both when 'carriers' were found amongst others of the family, and in one case at least where no other case or 'carrier' was recorded in the family. These facts tend to emphasise the prime importance of direct contact; the fathers who are away all day at work and rarely nurse the children, being seldom affected; while the mothers from nursing the children, and occasionally the more domesticated fathers were more prone to infection.

*Importance of the 'Carrier'.* There can be no hesitation in asserting the paramount importance of the 'carrier' in determining the course of a Diphtheria epidemic.

The 'diphtheria carrier' may be defined as one harbouring Diphtheria bacillus usually in throat or nose for an indefinite period of time. For preventive purposes the 'carrier' must be considered to be a source of infection and a danger to the community. The 'carrier' may have had Diphtheria in mild unrecognised form or with the usual clinical symptoms; may be going to have the disease if not treated; or may not have the disease at all. In any case he or she may continue for an indefinite time to be a vehicle of infection, and must be reckoned with as an important factor in the spreading of Diphtheria, and should be

treated in every way as an actual sufferer from infectious disease. Due quarantine regulations should be enforced without seclusion indoors. Continuous open air life is in our experience of more value in shortening the 'carrier' period than any persistence in medicinal and antiseptic treatment, general and local. These may of course be part of the routine treatment in the hope of good result and on account of the psychic effect. Regular Bacteriological examination should be made and a decided sequence of negative results ascertained before the carrier is declared free from infection.

*Errors in Diagnosis.* A definite proportion of cases notified as Diphtheria during the prevalence of an epidemic turn out to be something else. This is unavoidable, and the Health Authorities must support the position of the Practitioner in dealing with all such cases. If sent to Hospital they should be treated in all respects as Diphtheria patients: due isolation must be maintained to prevent their getting Diphtheria in Hospital, and likewise to prevent their communicating other infectious disease to patients in Hospital: and when other obvious infectious disease develops in any such case, it should be immediately relegated to the special block or sideward set aside for such cases. When such cases are nursed at home the co-operation of the Health Authorities is likewise of value to the Practitioner in helping to clear up a doubtful diagnosis, and there should never be any difficulty in satisfying the patient or the patient's guardians that the best had been done for all.

It is better for the Health Authorities and for the community at large that there should be cases notified in excess of the actual occurrence of Diphtheria, than that a single mild case should, through doubt of its real nature be allowed to go at large.

The conclusions to be drawn from the analysis of the epidemic may thus be briefly summarised:—

(1) The Bacteriologist should be an essential member of the Public Health Staff.

(2) Wide examination of contacts is necessary in order to obtain the maximum of control, while causing a minimum of social interference.

(3) The ways of children and social habits generally, readily account for the spread of infection.

(4) Direct contact while being the primary factor in the spread of Diphtheria, is aided by various sociological and seasonal factors.

(5) Nurture has no evident effect on the incidence of infection.

(6) Age and sex have no effect, except in so far as each influences 'carrier opportunity'.

(7) The effect of social status depends on increased or diminished 'carrier opportunity'.

(8) The Carrier is a vital source of infection; and may

(a) have had the Disease

(b) be going to have it

or (c) may remain immune

(9) The virulence of a carrier at any period is as certain as the virulence of an acute case of Diphtheria; so far as infection of others is concerned.

(10) Special virulence of a Carrier at one time more than at another is not found.

(11) There is no evidence of seasonal virulence.

## V. SCHEME OF PREVENTION.

There is here detailed an elaboration of the methods adopted during the epidemic under consideration. Experience as time went on added to the importance of some measures; revealed the need of new measures, and established the inutility of certain others.

In the face of disease spreading in epidemic form in a community, no measures are to be neglected that in any way are calculated to reach the intelligence of the people. The clergy, school teachers, the medical profession, sick nursing and philanthropic organisations, and voluntary aid of all sorts, should be sympathetically enlisted in the campaign on a practical educational basis. Through these means and directly through the Health Department, Health Leaflets, general and special, may be distributed and discussed amongst the people.

*SAMPLE OF HEALTH LEAFLET (GENERAL.)*

## HEALTH DEPARTMENT.

## ADVICE TO PARENTS

Parents can do a great deal to aid the Health Authorities in their efforts to combat Epidemics and to maintain a high level of the public health.

In the care of their children parents have in their hands the main conduct (1) of their feeding, (2) of their clothing, (3) of cleanliness, (4) of regularity of habit, and (5) of supplying them with abundance of fresh air.

(1) The food of the child should be plain, well cooked, varied and abundant. Milk should take a prominent part in the feeding of the child, and in the presence of Epidemic disease it is advisable that all milk should be cooked, either by being boiled for use by itself or in the form of milk puddings.

(2) The clothing should be light and warm, and in changeable weather an overcoat should be worn out of doors. Woollen clothing has decided advantages over flannelettes and other materials.

(3) Too much attention cannot be paid to the personal cleanliness of the child. A daily bath at bed-time, and the washing of the hands and face before each meal is not too much to be expected in every family. Special attention should be paid to cleansing of the teeth, nostrils, ears and finger nails.

(4) Regularity in rising, in meal times, in play, in school hours, in bedtime, and in attending to the bowels is of very great importance—an early attention to regularity begets a habit in the growing child.

(5) Fresh air is cheap and abundant even in towns. It should not merely be sought out of doors but should be freely admitted into the house by doors and windows both by day and by night. It matters little how far the bedroom window is open at night if the child is well covered up in plenty of warm blankets and warm woollen nightdress. Fresh air and abundant water are the cheapest and best antiseptics for general use. Children should be kept in the fields and playgrounds as much of the day as possible. Dwelling in close, overheated rooms powerfully aids the spreading of disease.

Parents should draw the attention of their medical adviser at once to the presence of the slightest ailment in a child. It is a rare thing for a child to omit play or complain without being really ill; and the giving of home remedies or the latest quack medicine is usually but a dangerous waste of time.

It is not necessary that a child should complain of the throat in Scarlet Fever or Diphtheria when either disease may be present. A slight sickness may be the first sign of the Fever, and a mere tired feeling and desire for rest may indicate Diphtheria.

These few suggestions apply to the preservation of health in general; in the presence of actual disease further instructions will naturally be given by the medical adviser or nurse in charge, and by the Health Authorities if called to investigate infectious disease.

(Signed) Medical Officer of Health.

*SAMPLE OF HEALTH LEAFLET (SPECIAL.)*

HEALTH DEPARTMENT.

### **DIPHTHERIA.**

Diphtheria is an infectious Disease, but due precaution may decidedly limit its spread.

It chiefly affects the Throat, and the passage of the germs of the disease from one throat to another, directly or indirectly is the usual means of infection.

Adults and children may have the germs of the disease in their throat or nose for long periods—

- (1) after having had Diphtheria
- (2) before having Diphtheria
- or (3) without showing signs of Diphtheria.

In this condition they are known as Diphtheria 'carriers' and are as dangerous to others as if they were seriously ill with the disease.

Avoid all direct contact.

Destroy by fire all material coughed or spit up.

Let each individual in a household use separate cups,

spoons, towels, etc. Those of the infected person should be disinfected and washed separately.

Be absolutely cleanly in all your habits.

Avoid lip kissing.

Parents should consider it an indecency to pass food or comfits from their mouths to the mouths of their children; and should early inculcate the same belief in their children.

Mothers especially should be careful not to pass the teats of feeding bottles or anything else from mouth to mouth.

Obey strictly all the instructions as to isolation and disinfection given you by your medical attendant.

In the absence of special chemical disinfectants, remember always that boiling water and fire are convenient and trustworthy disinfectants,

The disinfection of all clothing, bed linen, etc., will be undertaken by the authorities of the Health Department.

(Signed) Medical Officer of Health.

Special instructions should always be amplified orally and repeatedly by the Health Authorities, the Medical Attendant and Nurses.

Instructions to School Teachers should be issued as they have abundant opportunity of emphasising health matters to the children under their charge.

Example—

HEALTH DEPARTMENT.

### SUGGESTIONS TO TEACHERS.

Teachers have it in their power greatly to aid the preservation of the Public Health, both by example at school and by suggestion to their pupils in various matters affecting the well-being of the children.

Much may be done without interfering in the least with prescribed work.

Fresh air should be freely admitted to the school rooms as well when the children are in them as when they are outside. Teachers should see that the schoolroom floors are fre-

quently washed; dust is a special carrier of disease. Cloak-rooms should be well aired and an attempt made to have accommodation sufficient to prevent mixing and overhanging of the garments of different children.

All slates and slate pencils should be abolished. Paper which can be burned should be used, and each child should have its own pen or lead pencil with name marked on the cut end. All the books, etc., belonging to any one child should be kept in a case specially reserved for that child's use.

Sickly children should be referred through their parents for medical advice.

A few minutes interval should be found between each lesson for a run in the playground; a longer interval in the middle of each school meeting. Exercise is a much more efficient and wholesome means of giving warmth to the child than sitting over a fire or staying in a close heated room.

Cleanliness in the children is of prime importance—children with foul nostrils, dirty mouths, dirt-laden finger nails, and any other sign of uncleanness should be sent home to have the condition corrected—or where persistent uncleanness indicates impossible home conditions, the child's care should be undertaken by the Nurse or in the best means possible at school.

Most teachers will find it possible, without undue interference with the regular work, to impress their pupils with the paramount importance for the sake of health, of

- (1) Good food
  - (2) Fresh air
  - (3) Absolute cleanliness
  - (4) Regular habits
- and (5) Warm clothing

The few suggestions addressed to parents on another leaflet may be an aid to the younger teachers in their consideration of these points.

(Signed) Medical Officer of Health.



## DEPARTMENTAL ROUTINE.

*Isolation of Notified case and Disinfection of Premises and Clothing*

The Isolation of the case should be secured as early as possibly after receipt of notification. If an Isolation Hospital is available removal thither is the best course to adopt. All clothing and articles deemed necessary to be disinfected should be at once removed in the Municipal Van to the Steam Disinfecting Station; an inventory given the householder, and a receipt obtained by the Inspector on the return of the articles. The house at the same time should undergo what disinfection the Medical Officer of Health may deem advisable. If the patient is treated at home strict instructions as to isolation and regular disinfection of sickroom articles should be given; and at the end of the illness the routine steam disinfection of the necessary articles and due disinfection of the premises will be undertaken. After the house is disinfected the owner should be notified of what renewal or rehabilitation is deemed necessary by the Medical Officer of Health. (See Schedule.)

*Investigation of Infection; and 'Carrier' Procedure.*

The investigation should embrace a thorough enquiry into the history of the patient, the environmental surroundings in general, and specially the food, bread, milk, and water supplies; and should cover a full knowledge of the contacts at home and neighbouring; at school and at work. A swab for bacteriological examination should be taken from the patient with the consent of the Medical Attendant, and swabs should be taken of all the home contacts.

As wide a circle as possible of outside contacts should be swabbed. Until the Bacteriological report is available, which should be in 24 to 48 hours depending on whether the examination is made locally or away, all contacts should be isolated and kept from work and from school. Providing proper isolation of the case is effected all contacts reported 'negative' may be allowed to pursue their vocation. All contacts found 'positive' should be treated as cases of Diphtheria: they should be isolated at home or in hospital as appears safest in the individual instance, and the administration of antitoxin by their Medical Attendant should be advised. In the poorer classes the administration of antitoxin as a preventive and curative measure may be undertaken by the Corporation or the Poor Law Authorities.

Each case of Diphtheria, and each Diphtheria carrier should now be kept in such a state of isolation as suggests to the Medical Officer of Health the greatest degree of safety to the community with whose interests he is entrusted.

Where any persons are kept at home from work or from school due notice should be sent to employers and teachers with instructions to refuse their re-admission unless they bring a written permit from the Medical Officer of Health. If any Library books are in the infected house, the Librarian should be notified of the occurrence and of the intention of the authorities to have them disinfected or destroyed as may seem satisfactory to the Medical Officer of Health.

Various schedules containing these several instructions are here inserted as illustrating the procedure suggested.

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**FORM A1.            MEDICAL ATTENDANT.**

**HEALTH DEPARTMENT,**

**19**

DEAR DR.

I shall be glad to receive from you at your convenience and on the accompanying form the information desired thereon.

Yours faithfully,

Medical Officer of Health.

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**FORM A1.**

Address

Date

I am of opinion that  
is now sufficiently recovered to permit of the Health Authorities taking whatever steps they deem necessary in respect to patient and premises for the prevention of further infection.

Signature

FORM A2. **PARENT OR GUARDIAN.**  
HEALTH DEPARTMENT,

19

This is to inform the Parent or Guardian of  
residing at \_\_\_\_\_ that  
residing at \_\_\_\_\_ is suffering from ( \_\_\_\_\_ )  
an Infections disease ; and that all due precautions must be  
taken to prevent the spread of the disease. Your Medical at-  
tendant will no doubt instruct you as to what measures to  
adopt, and the Officials of this Department are at all times  
prepared to give any information and assistance you may  
desire. You are requested to have the goodness to inform  
the Health Authorities of the expiration of the illness, so  
that due Disinfection methods may be adopted without delay.

Medical Officer of Health.

FORM A3. **EMPLOYER.**  
HEALTH DEPARTMENT,

19

SIR,

I have to inform you that there is Infectious Disease at  
the residence of \_\_\_\_\_  
your employee ; and request you not to employ  
until a permit is brought signed by the Medical Officer of  
Health.

Yours faithfully,

Medical Officer of Health.

FORM A3½ **EMPLOYER.**  
HEALTH DEPARTMENT,

19

DEAR SIR OR MADAM,

In my opinion  
may return to work without risk of Infection.

Yours faithfully,

Medical Officer of Health.

FORM A4.

**HEAD TEACHER.**

HEALTH DEPARTMENT,

19

DEAR SIR OR MADAM,

I have to inform you that there is Infectious Disease at \_\_\_\_\_ whence you have a scholar; and to request that you will not admit to School any member of that household unless provided with a permit signed by the Medical Officer of Health.

Yours faithfully,  
Medical Officer of Health.

FORM A4½

**HEAD TEACHER.**

HEALTH DEPARTMENT,

19

DEAR SIR OR MADAM,

In my opinion  
may now be admitted to School without risk of Infection.

Yours faithfully,  
Medical Officer of Health.

FORM A5.

**DISINFECTION.**

HEALTH DEPARTMENT,

19

DEAR M

I shall be glad to learn what day and hour will be most convenient for you to have the Disinfecting Inspector call to Disinfect your premises and clothing. Please give 24 hours notice, and unless you are otherwise informed the Inspector will call at the time you suggest.

Yours faithfully,  
Medical Officer of Health.



FORM A5.

**DISINFECTION.**

Date

Please send the Disinfecting Inspector to attend to my premises and clothing at \_\_\_\_\_ o'clock on \_\_\_\_\_ the \_\_\_\_\_ inst.

FORM A6.

**HEALTH DEPARTMENT,**

19

To the Librarian of

I beg to inform you that there is Infectious disease at \_\_\_\_\_ where there is reason to suspect the presence of Library Books. These will be disinfected in the Municipal Steam Disinfector at your risk or destroyed as urgency may demand.

Yours faithfully,

Medical Officer of Health.

FORM A7.

**CLEANSING.****HEALTH DEPARTMENT,**

19

DEAR SIR OR MADAM,

On account of Infectious Disease I have had your house at \_\_\_\_\_ Disinfected ; but warn you that the Official Disinfection is not to be regarded as relieving you from obligations of cleanliness. It will be necessary for you now to see that the interior of the house is thoroughly cleansed.

The walls and ceiling must be painted, papered, varnished or whitewashed ; and in every case where walls have been papered, the old paper must be removed from the walls, before a new finish is placed thereon.

Yours faithfully,

Medical Officer of Health.

FORM A8.

NOTICE TO SANITARY INSPECTOR.  
DISINFECTION.

TO MR.

Sanitary Inspector.

You will proceed at \_\_\_\_\_ a.m. on \_\_\_\_\_  
to \_\_\_\_\_ where there  
has lately been a case of \_\_\_\_\_

You will remove the usual clothing and necessary objects for disinfection at the Steam Disinfection Station and in addition remove \_\_\_\_\_

You will hand to the Occupier an Inventory of all you remove and obtain a receipt for the objects on their return. While the material is at the Disinfecting Station you will proceed to disinfect the house in the usual manner.

Medical Officer of Health.

Special Instructions :—

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No 'case' or 'carrier' should be released from the observation of the Health Authorities until at least three swabs taken on three successive days have been declared negative by the Bacteriologist.

The period of retention in Hospital and detention from employment of a chronic 'carrier' is a question that must be left for the Medical Officer of Health to decide in the light of his knowledge of the special surroundings. Undoubtedly however, the radical treatment of the Diphtheria carrier should be aimed at, if the disease is to be absolutely controlled and banished.

The matter of expense is the limitation of the power to eradicate Diphtheria from a community.

Given a sufficient staff, a local Bacteriological equipment, and power of control over the carrier as over the case, then the extinction of Diphtheria at any rate in epidemic form is merely a matter of time.

## VI. EPIDEMIOLOGY.

The study of this Epidemic and collateral enquiry into epidemic factors in other diseases lead to definite views on general epidemiology which it seems not inconsistent to advance in this connection.

Throughout history the occurrence of disease in epidemic form has been a noted fact; and there seems up to the present time to have been a recognition of a 'slumbering' of the disease in certain localities during the intervals. Men regarded the slumbering of the disease and its persistence in endemic form as an understandable state of affairs, requiring no special explanation. Its sudden outburst as an Epidemic spreading far and wide, apparently leaping over one area and playing havoc in one more remote; its seeming excessive virulence over what it had been whilst only endemic or slumbering, and over what it had been in a previous epidemic; its selection of special classes of the community, or mayhap its indifference to class, sex, or age, these happenings have seemed to demand explanation, and have received and still receive explanation in all the mythical, meteorological, 'special virulence', and other creeds that the enlightenment of each age could suggest.

As in the study of Geology, perhaps the greatest stride has been made since the recognition of the slow continuous action of natural causes replaced cataclysmic fancies: so it would appear that modern enlightenment demands the recognition of similar causes working towards the manufacture of an Epidemic.

To the popular mind an Epidemic is an entity in itself: to the physician or the preventive officer it merely means so many more cases of a certain disease to cope with. And while labour and ingenuity have been expended in explaining and combating the great and miraculous in the shape of the epidemic, all too little work and study have been devoted to understanding the small and 'understood' in the disease slumbering or endemic.

The simplicity of an affair once understood makes most men confident they have always recognised it. There is no need to deplore this phase of mentality; it can be taken advantage of in the furtherance of effort.

With present day knowledge and careful study of sufficiently extensive collateral data it may be asserted that the time of rise and area of spread of any disease in epidemic form, urban, parochial or earthwide, could be calculated with fair accuracy. And if but a single one of such epidemics need not have arisen, preventive medicine fails to reap the fruits of its knowledge.

The discoveries of recent years that have led to the great reduction of many Tropical Scourges and held out the Tropics as a healthy home to the white man, are certainly a panoramic demonstration of the possibilities of Preventive Medicine. But in the Temperate Zone, the white man's home, many scourges yet run rampant, that modern knowledge would not for a moment allow if financial and popular prejudice had not the hold on public affairs they have.

*The Endemic Factor.* In the study of an Epidemic disease the chief factor to be seriously considered is the Endemic Factor, a full understanding of which is the foundation of the Scheme of Prevention.

Endemicity is a complex of the 'Evident' and the 'Concealed'. The 'Evident' consists in the occasional occurrence of cases of the disease, mild or severe, over periods of time when no epidemic breaks out. The 'Concealed' is a further complex of mild unrecognised cases occurring in the community; and of the continuance of the disease in the persons of 'Carriers'.

The failure of Endemicity to lead to Epidemicity more frequently than occurs, depends on various factors, social and general; and the key of the Epidemic question lies in a full appreciation of these.

*Individual Endemic Factor.* It is obvious that the result of an Epidemic must be to leave a minimum of susceptible persons in the community. The cessation of an Epidemic on the other hand does not imply a cessation of the disease in that community. The embers are still smouldering; the disease slumbers on; sporadic cases occur; and many 'carriers' are left who have had the disease; and there are many 'carriers' who have shown no symptom of disease. The existence of this Individual Endemic Factor is now proved for many diseases; and may be presumed, though absolute proof is yet lacking, for many others.



The Individual Endemic Factor is not necessarily limited to one genus either in epizootic or in epidemic disease; nor is the potency in this factor alone unaided. The existence of a vehicle of transmission or Intermediary Carrier is in many cases essential to reproduce the disease in endemic or epidemic form, e g., tick, flea, anopheline and culicine mosquitoes, in piroplasmosis, plague, malaria and yellow fever.

*Post Epidemic State.* The state of affairs quâ a certain disease in a community after the cessation of an Epidemic, will then be somewhat as follows—There will be certain potential nuclei of disease scattered throughout the population, composed of 'carriers'; and these will be surrounded by a body of immunes, more or less completely. Sex, age, social status, employment, and various other subsidiary agencies will affect their power of doing harm. Time also will lessen the number of these carriers, and many will disappear before handing on their fatal legacy.

Suppose that as a result of sex, age, or any combination of factors, the immediate environment of a certain 'carrier' is so limited that contact is possible with none but immunes, and vehicular transmission is obviated; then so long as that state of affairs continues, the spreading power of that 'carrier' is null. The result may be that in course of time the virus ceases to exist, and the carrier again becomes a sane member of the community. Another carrier may be less completely barred by immunes; a 'susceptible' may take the disease from contact and there is a sporadic case in the community. This may take place at different foci and any of such sporadic cases may have a history which is a repetition of the history of the 'carrier'.

It will be evident that as time goes on the immunes in the community will die out. Death and emigration will remove some; the acquired or even the natural immunity may cease; a new population is springing up by birth and immigration; and there comes a time when the immune barrier of the 'carriers' still existing becomes a fragile affair and susceptibles crowd round on every hand ready to receive the disease. The community is ripe for epidemic.

Besides the personal contact possibility, there is the secondary contact of infected media—a potent source of origin for many Epidemics, to site only the chance contamination of milk as a means of spreading Scarlatina and Diphthe-

ria, and the pollution of water to originate an epidemic of Cholera or of Typhoid.

The subsidiary factors differ according to the disease ; but the main factor, the Individual Endemic Factor, is the same for all.

This operation then—the slow sporadic manufacture of cases may go on indefinitely over a period of time, evidencing Endemicity; until such time as Immunity reaches a minimum of resistance power and the carriers become surrounded by susceptibles. The added source just mentioned of secondary vehicular means of infection may come into play, and the combined personal and secondary infections have full Epidemic swing.

*Sporadic and Mild Cases explained, and also why any susceptibles are left.*

Analysis of this idea will explain clearly the sporadic rise and the sporadic decline of Epidemics—as the bonfire flickers at the start and dies slowly with occasional showers of sparks amongst its embers. Once a little headway is made the volume of infection increases rapidly till the susceptibles become fewer and the carrier opportunity lessens, and the Epidemic gradually subsides leaving a residue of carriers to keep up a succession of sporadic cases amongst the scattered susceptibles left.

The observed fact that mild cases characterise the beginning and end of many epidemics is perhaps more apparent than real. The mortality case rate of an epidemic is never an ascertainable item with accuracy: many mild cases are never heard of, and the mortality case rate is only the mortality known-case rate. An individual death at the beginning and at the end of an Epidemic, and while the disease remains Endemic or Sporadic for a period of time, may be found to bear the same relation to the case rate as during a full-blaze Epidemic if carefully investigated ; though to ordinary observation the accentuated death rate and the many severe cases during the epidemic exaggerate the proportions of severity and mortality.

The same reasoning serves to explain why in an epidemic every susceptible member of a community is not attacked by the disease. There must be a natural limit to the spreading power of the disease. As time goes on they get

hedged round more and more by individuals possessing immunity, natural or acquired, and their susceptible contact diminishes.

*Subsidiary Factors.* These are many; and all at one time or other play their small part in weakening the barrier that shuts off the smouldering ember and allows entrance for combustible material necessary for the Epidemic flame. All however are negligible if the carrier is under full control.

*Sex.* Few if any Epidemic diseases show partiality for either sex; and what partiality there may seem to be is the result of the social influence of sex permitting either less or more intimate contact of susceptibles with the carrier.

*Age.* Again the social factor is the chief element in considering age; though certain diseases are more prone to epidemic form in children for special reasons. Acquired immunity in the adult affects this factor; and school life and play affect the problem of the carrier in childhood's diseases.

*Employment.* The danger of infection in special forms of employment is important; and the control of carriers in general in the daily meetings with their fellow men demands attention.

*Meteorological Factors.* That certain diseases are more given to Epidemicity at certain seasons of the year is common knowledge; but that the social habits of the people are the most important cause of this, is not so clearly recognised. The oncoming of winter in temperate latitudes; short days; cold wet weather; the consequent staying indoors for many hours longer than in summer; overheated rooms; increased opportunity for the barrier around the carrier to be broken down; the rainy season in tropical countries with the teeming increase in numbers of the vehicular carrier—these and other changes in the social life of the people are the cause of the seasonal variation in disease, and not some vague meteorological influence not named but mystically suggested.

*Rainfall, Soil, Sub-soil, Winds, Drought, Damp Dwellings,* and many recondite possible factors have been laboriously investigated in their relation to disease without due recognition being given to the slumbering ember itself. For instance to discuss in weighty volumes the effect of rainfall

and sub-soil on the urban epidemicity of Diphtheria, when the true relation of the carrier to immunes and susceptibles is neglected, seems at the least a piece of misdirected energy. The social results of all these various factors no doubt exist; but their reaction on the foci of disease should be negligible if these same foci were determined and controlled.

*Vehicular Factor.* The vehicle of transmission may be animate or inanimate and the importance of this factor is great. It is a cause of many epidemics, e.g., milk in Diphtheria, Scarlatina and Typhoid; water in cholera and Typhoid; the rat flea in Plague; and in some cases it is essentially bound up in the Individual Endemic Factor, e.g., the Stegomyia in yellow fever, Anopheles in Malaria, Glossina in Trypanosomiasis.

*The Future of Control.* At the present day the leaders in Preventive Medicine and men of Science generally are apt to resent what they deem the frequent display of administrative impecuniosity, and regret the pandering often to popular prejudice that baulks them of fruitful result from the execution of their ideas. But at the same time these may be salutary restraining influences; and with the accumulation of facts instead of studied fancies it is more than likely that the time will come and the intelligent government and people with it, when the fetish of false enomy will give place to vigorous expenditure of co-operative energy on the part of all for the common weal.

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