BACTERIOLOGICAL INVESTIGATION

OF A SCHOOL OUTBREAK OF DIPHTHERIA

IN THE BLACKWELL RURAL DISTRICT

WITH AN INQUIRY INTO THE ROLE OF THE

BACILLUS OF HOFFMANN.

Being a THESIS for the Degree of M.D.

Glasgow, October, 1904.

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PREFACE.

Owing to the continued prevalence of Diphtheria in the Blackwell Rural District, Derbyshire, and to the fact that the disease seemed to have its main focus in the Blackwell Church School, I was appointed by the County Council to report on the bacteriological condition of the throats of the children attending that school.

The notes which I made them have been embodied in the following thesis. As it is mainly a record of my own work, the references are few, and are from the literature I consulted while engaged on the investigation.

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PART. I

SOME GENERAL CONSIDERATIONS

In all individuals suffering from true Diphtheria the Bacillus Diphtheriae is always present. This bacillus was first discovered and isolated by Löffler in 1884, although Klebs pointed out the presence of bacilli before that, and for the last twelve years or so this organism has been recognised as the essential factor in the causation of Diphtheria. When it gains access to the throat, it rapidly multiplies, forms the characteristic membrane, and produces poisonous compounds, which after absorption into the blood produce the symptoms of the disease. By examining the membrane bacteriologically the bacilli are found in nearly all cases recognised clinically as true Diphtheria.

It is, however, now recognised that Klebs-Löffler bacilli may not only be found in the throats of clinically diphtheritic patients, but also in those of perfectly healthy individuals who have been exposed to infection, and who, although not suffering in any way themselves, may be the means of causing a virulent form of the disease in others. Many instances have lately been cited in medical literature which illustrates this point. The reason why such individuals do not/

not suffer themselves is either because the mucous membrane of their throats is healthy enough to resist the invasion of the microbe, or because they have suffered from a previous recognised or mild unrecognised attack, which is known to confer a more or less permanent degree of immunity. The bacilli can seemingly only obtain foothold, multiply rapidly, and cause the disease, when the mucous membrane is in an unhealthy condition, or when the normal resistance of the person is run down from some cause or other.

Diphtheria is a highly contagious disease, and so far as we know, spreads mostly by direct personal infection. The bacilli are given off by the breath in speaking, by coughing, by sneezing, and by kissing. They may be conveyed also in schools, especially, by the transference of articles, such as pens, pencils and sweets from mouth to mouth, by towels, by rags used for cleaning slates, and by the use of such school apparatus as is used by the children in common.

Insanitary surroundings, foul privies and ashpits, badly constructed and ventilated drains and sewers, damp soil and accumulation of filth of all kinds, tend to produce a susceptible condition of the throat, and to lower the general health, which/

which predisposes to any disease that may be prevalent. Experiments (1) have shewn that the Bacillus Diphtheriae may live for ten months in moist soil at 14°C, and about a week in dry soil at 30°C. At 26°C in moist soil it dies out in two months. It is thus seen to be quite possible for the bacilli to live for an indefinite time in soil, ready to emerge when circumstances are favourable.

Captain Fred Smith (2) found the bacilli in the urine of guinea-pigs after experimental inoculation, and that it is possible for human urine also to become infected by Klebs-Löffler Bacilli was seen in a case under my charge in the Middle Ward Hospital, Motherwell. This was a girl, aged 9, who for five consecutive days at the beginning of convalescence from diphtheria shewed a bacteriuria. On the fifth day the urine was examined more particularly, was found to be acid, and on direct examination to contain, besides abundance of cocci, a few bacilli which stained by Neisser's method and were microscopically indistinguishable from Klebs-Löffler bacilli. A smear was made on serum, but after culture no bacilli could be obtained. Bacilluria did not occur again, and no external local condition could be found to account for it/

it. As in the case of Enteric Fever, infected urine may thus be one of the methods by which soil is contaminated with the specific bacilli. Bad sanitation, however, cannot have any very great influence on the spread of diphtheria, because in recent years, although there has been great improvement in sanitation, the diphtheria death-rate has increased, in spite of improved methods of treatment.

Newsholme (3) states that years of deficient rainfall shew an increase in the epidemicity of diphtheria, or at any rate a rise in the annual death-rate, and that there is a diminished prevalence in years of excessive rainfall. Where it prevails in wet years, he supposes that it has obtained firm hold of the community in the preceding dry years, and continues to spread, presumably by personal infection. In the epidemic at Blackwell, which I investigated, during its prevalence in 1902 - 1903, there was an increased rainfall (4) which would tend to support the personal element of spread.

Klein has shewn experimentally that cows may suffer from lesions, due to the Bacillus Diphtheriae, and that the bacilli may be found in the milk as well as in vesicles, which/

which develop on the teats. In two outbreaks at Croydon and Bishop's Stortford where lesions of the udder were found, he did not claim however to have isolated the Bacillus Diphtheriae either from the lesions or from the milk, still, milk from a diseased cow may be the means of disseminating the disease apart from contamination of the milk from a human source. In support of this, Dean and Todd (5), found in a limited outbreak of Diphtheria, that two cows shewed lesions in the udder, and obtained the bacilli both there and in the milk.

Water and Air (6) have also been suspected by some of being capable of conveying the infection, but there is no authentic record of any epidemic having been caused by these means.

Dr. Littlewood (7) the Medical Officer of Health for the Blackwell Rural District was able to shew that the drainage, water supply, and milk supply of the district had nothing whatever to do with the spread of the epidemic of which I am about to chronicle the investigation, so I need not dwell upon these points.

The incidence of the disease is greatest among children between/

between the ages of three and twelve, that is at the school age, but apart from that, the mere aggregation of children in schools has a great influence (8) not only in the dissemination of this disease, but also in the fostering and spreading of sore throats, cases of which are known as a rule to prevail before and during outbreaks of diphtheria (9). That school closure has an important controlling effect was well brought out during an epidemic at Pirbright in Surrey, investigated by Mr. W. H. Power (10). Among children at school the incidence was 16.6 %, and among those not at school 3.8 %. Shirley Murphy (11) has also brought forward similar evidence drawn from the London schools.

Although school influence may be said therefore to have great effect on the spread of diphtheria, it need not necessarily, because in Hamburg and Berlin where there has been steady enforcement of school attendance for many years, Newsholme (12) has shewn that there is no corresponding increased incidence of diphtheria.

The relationship between the Klebs-Löffler, and the Hoffmann Bacilli.

The Klebs-Löffler bacillus is very seldom obtained in pure/

pure culture from the throats of diphtheritic patients, and much more seldom from those of contacts; its differentiation and recognition is often a matter of the greatest difficulty. The chief micro-organism with which it may be confounded is the bacillus of Hoffmann, some strains of which are almost indistinguishable from it both morphologically and culturally. This bacillus was described by Löffler in 1887, and by Hoffmann in the following year, but with care they could distinguish the one from the other, even though the two organisms were often found associated. Various other bacilli, which resemble the Klebs-Löffler bacillus in one or more respects, have also been described, particularly by Gordon (15).

There is much controversy going on at present as to the significance of the Hoffmann Bacillus, and many observers (Roux, Yersin, Abbott, &c.) look upon it as an extremely attenuated form of the Klebs-Löffler bacillus, as undoubted diphtheria bacilli are known to vary widely as regards pathogenicity. If this were so, then the necessity for making an accurate diagnosis between them would not exist, and it would simplify matters exceedingly if we called them all Bacillus Diphtheriae. The same precautions that are taken in/

in the one case, would have to be taken in the other, because we could not tell at what instant the attenuated form would take on a virulent character. Such throats would be potentially dangerous.

Many arguments have been advanced to shew that there is some connection between the two. The fact that the Hoffmann bacillus is very often found in the earliest stages of diphtheria and during convalescence is no proof of significance as it is not obtained in a larger proportion in diphtheritic cases and diphtheritic contacts than in healthy non-contact cases. It is an exceedingly common inhabitant of the throats and noses of all individuals. Graham Smith (14) in the Colchester outbreak found that of 576 cultures from a non-infected district, the Hoffmann bacillus was present in 54.8 %, but the percentage varied according to the class of school, from 64.5 % in the poorer schools to 22.7 % in the well-to-do class schools. As shewing the infectivity of the organism, out of 66 Hoffmann infected families, it was found in 73.6 % of members. Cobbett (15) found that of 1,495 non-infected contacts, 36 % shewed its presence. At Duffield I examined cultures from 27 non-contact children, and found

that/

that it was present in 40.7 %. The presence of the bacillus therefore is easily accounted for in the early stages of and during convalescence from diphtheria. Its growth may be inhibited for the time being, and its presence masked, by the growth of the Klebs-Löffler bacilli, but it would come into view again on the dying out of the latter during treatment.

It has been stated by various observers that the Hoffmann bacillus is capable of causing a disease similar to Diphtheria. Priestly (16) described an infectious school outbreak in which there were clinical symptoms of diphtheria associated with the presence of the Hoffmann bacillus. In a few cases, (3%) however, it is significant that the Klebs-Löffler bacillus was found. Again, so far as the clinical throat and heart symptoms are concerned, I have seen them in practice, in many cases during scarlet fever and measles outbreaks, where repeated examinations of swabs from throat and nose failed to demonstrate Klebs-Löffler bacilli. Simularity of symptoms by no means indicates the same etiological factor.

Cases have been reported of notified patients, shewing only the Hoffmann bacillus, being treated in ordinary diphtheria wards without contracting the disease. This may also mean that/

that the Klebs-Löffler bacilli were overlooked, or that the children were not susceptible . All contacts do not necessarily contract the disease or harbour the bacilli. There is even a less chance of doing so in a well regulated hospital than in private houses or crowded schools.

Where Hoffmann cases apparently give rise (17) in contacts to genuine diphtheria shewing the Klebs-Löffler bacillus, the probability is that the former had also the Klebs-Löffler bacillus in their throats, but masked by a superabundant growth of the Hoffmann bacillus, or that the latter were in contact with other unknown cases, which harboured the Klebs-Löffler bacillus. The possibility of the tonsillar crypts harbouring the Klebs-Löffler bacillus was demonstrated forcibly to me by a notified case in the Middle Ward of Lanark Fever Hospital. The case, a boy of 5, had patchy membrane all over the tonsils, soft palate and pharyngeal wall. Repeated swabbings, however, only shewed cocci, both on culture and direct examination. On removing the membrane from one tonsil, and then taking a swab from an enlarged tonsillar crypt, an almost pure culture of Klebs-Löffler bacilli was obtained.

When/

When so many of the ordinary population shew the presence of Hoffmann bacilli in their throats and noses, it is curious that so few ever shew the presence of Kleb-Löffler bacilli. G. S. Graham-Smith (18) has compiled tables from various sources, which shew that out of 1,149 persons who had not recently been exposed to infection, 32 or 2.8 % shewed diphtheria bacilli, but only 3 or .26 % were virulent, and that out of 3,374 persons, in whom no inquiries as to exposure seem to have been made, 105 or 3.2 % shewed organisms morphologically resembling diphtheria bacilli. 35 of these were tested, but only 9 or .26 % of the total were proved to be virulent. This emphasises the fact that the large majority of diphtheria bacilli found in persons who have not, so far as can be ascertained, been in contact with clinical cases, are non-virulent, and that virulent bacilli very seldom occur in the throats of healthy persons who have not been exposed to infection.

The claim that the Bacillus Diphtheriae has been converted into the Hoffmann bacillus and <u>vice versa</u> does not carry much weight as the published cases are too few, and other observers have met with failure in trying to repeat them. Hewlett and Knight (19) claimed to have done the former/

former, and Salter and Richmond (20) the latter. In Salter's and Richmond's experiments, however, the Hoffmann bacillus was not above suspicion. At one time the Bacillus typhosus and Bacillus Coli communis were believed by some observers to be identical.

The two bacilli, when typical, are absolutely distinct in morphology and staining. The appearance of the cultures cannot be relied upon (21). The chief points of difference are, that the Hoffmann bacillus is shorter and thicker, with little tendency to clubs and segments, but with marked parallel grouping, and that it makes broth rapidly turbid with an increased alkalinity during the first two or three days (22). It also stains more evenly, shews no polar staining, does not shew granules by Neisser's method, and is non-pathogenic for guinea-pigs (23)-(24). Many of the bacilli are plump with pointed ends and with a central unstained septum. These differences would seem to make a diagnosis comparatively easy, but in reality it is not so, as intermediate forms may be met with. I met with two instances of this during my investigation. Bacilli were obtained which presented a beaded appearance with Löffler's Blue, but gave a negative result with Neisser's stain. On making a more careful ex-

amination/

amination however, and finding in a few days that the broth culture remained alkaline, they were found to be Hoffmann bacilli with two and three unstained septa. Hewlett and Knight state that while"pseudo"forms occur very rarely in cultures of Klebs-Löffler bacilli, the latter occur almost always at some time or other in cultures of the "pseudo" bacillus, and that a series of organisms forming a connecting chain between the two can be obtained. I have examined many cultures for this, both while engaged with the Blackwell investigation of contacts, and at the Middle Ward of Lanark Fever Hospital, Motherwell, but so far, beginning with a pure culture, have never been able to find it. I have often obtained involution forms in Klebs-Löffler cultures, although none could be mistaken for Hoffmann bacilli. Hewlett and Knight conclude "that the pseudo is sometimes a modified Klebs-Löffler, though perhaps not always," which leaves us much in the same position as before.

In examining the Blackwell swabs, I had to rely mainly on two points, viz.- Neisser's stain and the broth reaction. This latter requires a few days for its production, so that when an immediate diagnosis was wanted, Neisser's stain had alone/

alone to be relied upon. I tried it in many instances, also for the direct examination of the swabs, but obtained such variable results that I abandoned it and concluded that the direct method was of little service in the examination of the throats of contacts. I found Neisser's stain to be of great value in excluding the Hoffmann bacillus, and the Bacillus Coryzae Segmentosus which with ordinary stains resembles the Klebs-Löffler bacillus.

Certain continental observers however, as mentioned in Gordon's paper, appear to doubt the absoluteness of Neisser's stain. Certainly the Bacillus Mallei stains well with it. The test of pathogenicity is of the greatest importance, but in only one case (at the British Institute of Preventive Medicine) was it employed, as the requisite power was awanting.

Attempts have been made lately (Gordon) to find a method of diagnosis, on the same lines as Widal's Reaction in Enteric Fever, but so far without success.

PART. II

THE BLACKWELL CHURCH SCHOOL EPIDEMIC.

HISTORY OF THE OUTBREAK.

Diphtheria was present in the Blackwell Rural District from March, 1902, and attained epidemic form in the last Quarter of the year. In a population of over 33,000, 105 cases were notified, the parish of Blackwell containing only one-eight of the entire population, contributing 55. The mortality per cent was 16.3. In 1903 the disease still continued and 177 cases were notified, Blackwell parish contributing 66 %. It was found that 80 % of the cases were in children of school age, and that 47 % shewed connection with the Blackwell Church School. The school was closed for the Christmas holidays on December 19th, 1902, and reopened on January 5th. 1903. No case was notified from this school till the week ending February 5th; from that date however the number gradually rose till February 27th. when the school was ordered to be closed. Closure was immediately followed by a diminution, but in the first week after reopening on April 22nd. two fresh cases occurred/

ed. The school was closed for the summer holidays from June 19th. to July 13th. and during that time no case was notified among the children. After that, cases again began to crop up, and the disease assumed serious proportions in August. For the whole year the mortality per cent was 4.2, a remarkable difference from the previous year, and attributed to the increased use of anti-diphtheritic serum.

Previous bacteriological examinations.

On March 3rd. during the school closure, the children were asked to come to school in order that swabs from their throats might be taken. 132 swabs were then taken and sent to the University of Birmingham for examination. 54 or 40.9 % were certified as shewing "diphtheria bacilli of the Löffler type" or "Hoffmann type". The following table gives a summary of the results obtained, as shewn by the certificates:-

Klebs-Löffler bacillus alone	7	18.1 %
" " " and Hoffmann bacillus	14	
Hoffmann B. and doubtful Klebs-Löffler B.	3	35.6 %
Hoffmann bacillus alone	30	
Doubtful Hoffmann B.	1	
" specimens.	6.	
Other micro-organisms (cocci mostly)	71	
Total.	132	

If we regard the Hoffmann bacillus as well as the Klebs-Löffler bacillus as the cause of Diphtheria we had to deal with 40.9 % of diphtheritic children; on the other hand if we accept the Klebs-Löffler bacillus alone, the proportion of children requiring special treatment was 18.1 %.

Again, in the beginning of May, from the children and staff then attending school, 229 swabs were taken and forwarded to Birmingham. The following table gives the results:-

Klebs-Löffler bacillus alone.....	3	10.9 %
" " " and Hoffmann bacillus..	22	12.6 %
Hoffmann bacillus alone.....	7	
Doubtful.....	1	
Other micro-organisms.....	196	
Total	229	

These figures are remarkable, first because they shew such a small proportion (12.6 %) of total Hoffmann cases, as compared with what is usually met with, and what was met with in March, and because three-fourths of them were accompanied by Klebs-Löffler bacilli. The cases shewing the latter were also reduced from 18.1 % to 10.9 %, and the total number of infected children from 41 % to 14 %. In

March/

March, if the school had not been already closed, the exclusion of 41 % of the children would have made it necessary. When the result of the May examination was known, the 14 % were excluded.

Prophylactic use of Anti-diphtheritic Serum.

Owing to the serious nature of the epidemic, arrangements were made in March to supply anti-diphtheritic serum free of charge to all those that wished to have it, and on April 7th. and 8th. so far as I can ascertain from the figures at my disposal, 57 of the Blackwell Church School children availed themselves of the opportunity. A dose of 400 c.c. was employed on the recommendation of Dr. McFadyean of the Jenner Institute. I have summarised from the Birmingham certificates the bacteriological throat conditions of these 57 children in the following table. As the swabs were taken on March 3rd. and May 7th. practically a month before and a month after, the prophylactic injections, we can assume that the conclusions are fairly accurate:-

One month before prophylactic injection.	One month after prophylactic injection.				
	Löffler B	Hoffmann B	Both B	Cocci	Unknow
2 shewed Löffler B.	1	-	-	1	-
10 " Hoffmann B.	-	1	1	6	2
6 " Löffler and Hoffmann B.	-	-	1	4	1
26 " Cocci only	-	1	2	19	4
13 were unknown	-	1	-	12	-

From the above it will be seen that of 36 cases which shewed no Klebs-Löffler bacilli one month previous to the injection, 3 or 8.3 % shewed them one month afterwards, and of 8 positive cases 2 or 25 % still shewed the bacilli afterwards. If we assume that Hoffmann bacilli can also cause diphtheria, then of the 16 cases prior to injection, 3 or 19 % were still uninfluenced by the injections.

These figures point to the fact that, so far as the mere presence of the bacilli is concerned, prophylactic injections have very little, if any, effect. In other epidemics it has been claimed that they prevent the development of/

of the disease. In America they have been found to be of the greatest service; whereas 10 - 30 % of the contacts would have taken the disease, after their use, only ¼ - ½ % contracted it. In Cambridge (Cobbett) out of 290 persons known to harbour the bacilli, all were injected and only one slight case occurred. Here, in Blackwell, two cases which had received prophylactic injections in April were notified as suffering from the disease, one in June and the other in September. In these cases, of course, the inhibitory effect may have worn off, as it is not claimed to last indefinitely. The maximum period is probably a month.

The present investigation.

At various dates in September and October, I visited the school, and took some 20 swabs each time. By taking notes of each child, I was able to correlate the clinical appearance of the throat with the bacteriological examination of the swabs. So far as possible the children were taken class by class.

No time was lost in cultivating the swabs. Cultures were made on blood serum on the same day that the swabs

were/

were taken, and were ready for examination the next morning. Some cover-glass preparations were made direct from swabs from suspicious looking throats, and stained by Neisser's method, but, as before mentioned, this was given up, as the results were diverse. The serum was incubated at 37° C.- From the appearance of the colonies, in very few instances was it possible to tell whether we had to deal with the Klebs-Löffler bacillus or not. In only 9 did the appearance of the growth justify a diagnosis of this bacillus. The colonies were small and of a yellowish-white appearance. When subcultures of suspected colonies were made, it was usually possible at the end of 24 hours to tell to which category they belonged.

Subcultures were also made in slightly alkaline glucose litmus broth and incubated for two days to see whether a production of acid was obtained or not. An attempt was made to use this reaction as a means of differentiation from the Hoffmann bacilli by making broth cultures directly from the swabs. It was thought that if this were successful it could be carried out at the school, and would effect a great saving both in time and manipulation, but it/

it was found not to be reliable as few of the organisms were met with in pure culture, besides many of the varieties of the cocci met with also produced acid. When pure, or when subcultures from serum were made the reaction was obtained in every case. 127 broths were inoculated directly from swabs. 93 of them gave an acid reaction in two days, and 47 shewed the presence of Klebs-Löffler bacilli. Only 9 of the 47 were in practically pure culture, the others being mixed with Hoffmann bacilli and various forms of cocci. One broth which contained very few Klebs-Löffler bacilli gave an alkaline reaction. 28 of the 93 acid broths were found to contain Hoffmann bacilli, but not in pure culture. If pure, the broth was invariably alkaline.

In the doubtful cases, peptone water cultures were made. After a week's incubation the indol reaction was tested for, with sulphuric acid alone. Klebs-Löffler cultures give it after one week's growth, but Hoffmann cultures take a longer time - about three weeks.

Löffler's Methylene-blue and Neisser's stains were used in all instances. The latter was indispensable in the diagnosis of cases which were doubtful with Löffler's

Blue/

Blue; out of 25 such cases it shewed the presence of Klebs-Löffler bacilli in 7, Hoffmann bacill in 15, and what was believed to be the B. Coryzae Segmentosus (Gordon) in 3 (2 obtained from nose swabs).

As an immediate diagnosis of any individual swab was not required at any time, considerable care was given to each case, so as to obtain a diagnosis as accurate as possible. Two and even three swabs were taken from several of the children, and nose swabs were obtained in many instances as well. Given a throat containing few Klebs-Löffler bacilli, failure to find them may be due to several causes.- 1. They may not be transferred from the throat to the swab. 2. They may not be transferred from the swab to the blood serum. 3. An antiseptic gargle may have been used which would inhibit the growth of the bacilli (two instances of this were met with). 4. The colonies on the serum may be so crowded out by the growth of other organisms that they are overlooked, and not transferred to the cover-glass.

Results obtained.

Altogether I took swabs from 174 children, who were in attendance at school at the time of my visits. Their examination/

examination revealed the following state of affairs:-

Organisms.		
Klebs-Löffler bacilli (in almost pure culture)..	9	20.1%
" " " and various forms of Cocci	18	
" " and Hoffmann bacilli.....	8	
Hoffmann bacilli.....	11	27.5%
" " and various Cocci.....	29	
Cocci (strepto-, staphylo-, and diplo- cocci)...	78	
Other Bacilli (mostly Bacillus Subtilis).....	18	
Saccharomyces Albicans.....	2	
Doubtful.	1	
Total	174	

Klebs-Löffler bacilli are thus seen to have been present in 35 or 20.1 % of the throats examined, and Hoffmann bacilli in 48 or 27.5 %, both of which numbers somewhat differ from the previous figures obtained at Birmingham. Notes were kept of the varieties of bacilli found. Of the 35 Klebs-Löffler cultures, 9 shewed the long irregularly stained form, 8 of them in almost pure culture; 24 were of the short variety, oval, and shewing bipolar staining, while 2 were of a short oval form, staining uniformly with Löffler's Blue, but shewing the Neisser granules. One culture presented both long and short forms/

forms. As regards the Hoffmann bacilli, 31 were short with tapering ends and unstained septum, 2 were longer with two and three unstained septa, 9 were very long and tapering, and 6 were irregularly shaped, staining solidly.

46 cultures of streptococci were met with, 18 of staphylococci, 4 of diplococci, and 10 were not placed. By the intensity of the staining, large size of the individual cocci, and the formation of long chains, 11 of the cultures of streptococci gave me the impression of being very virulent. Most of them indeed, were obtained from throats which were clinically dirty and congested. In 2 oval and spindle-shaped cocci were seen, both in the serum growth, and in the broth and serum condensation liquid. There was a tendency to conglomeration, and the broth culture was fairly clear with a deposit on the sides and bottom of the tube. The appearance was strongly suspicious of Streptococcus Scarlatinae (25). No attempt was made to diagnose any of the Cocci.

The Vincent bacillus and spirillum were never found.

The two children in whom Thrush was found sat side by side on the same form.

Bacteriological examination and clinical diagnosis.

When examining the children, I was very much struck with/

with the large number of abnormal throats. I have tabulated the throat conditions as under, according to standards:-

Clinical Condition	Standards							Number shewing Klebs-Löffler bacilli	Number shewing Hoffmann bacilli
	Infants	I	II	III	IV	V & VI	Total.		
Normal or practically normal	20	4	6	8	-	21	59	4	12
Enlarged tonsils, some very slightly	10	9	21	16	17	-	73	16	19
Congested fauces & tonsils	12	4	2	4	-	7	29	9	14
Markedly enlarged tonsils	2	2	5	1	-	-	10	4	3
Rhinitis and enlarged tonsils	1	-	1	-	-	1	3	2	-
Number shewing Klebs-Löffler bacilli - per standard	11	2	11	6	4	1	35		
Percentage	24.4	10.5	31.4	20.7	23.5	3.4	20.1		

Speaking generally, the children of the first four standards, all taught in one common room, shewed much worse throats than those of the upper standards or of the infants. It was noted too in many cases that the children with the worst throats, either sat next to each other in school, or belonged to the same family. Less than a third of the children/

children possessed normal throats. The ten with "markedly enlarged tonsils" required operative interference; three of them had adenoids as well, and all shewed large follicular crypts.

From the clinical appearance of any given throat, it was practically impossible to tell what form of organism would be met with. In only two cases, sisters, was the appearance strongly suspicious of diphtheria. Klebs-Löffler bacilli were certainly found in both, but neither of them was subsequently notified. Of the 59 practically normal throats 4 or 6.8 % shewed Klebs-Löffler bacilli, and 31 or 27 % of the 115 abnormal throats. This emphasises the fact therefore, that although the percentage of infected normal throats was small, in an investigation of this sort they cannot be passed over without examination. The figures, however, given in the last table shew that there was a strong tendency for abnormal throats and Klebs-Löffler infected throats to go together. The two upper standards, for instance, presented not only the smallest number of abnormal throats, but also the smallest number of Klebs-Löffler cases, while the reverse held good as regards Standard II. Although apparently an exception, the same

was/

was true of the Infants; only one case was met with among those shewing normal throats. Altogether 89 % of the total Klebs-Löffler cases were from abnormal throats, and from an analysis of these cases it was found that 75 % were associated with the presence of other microbes, including Hoffmann bacilli. This seemed to point to the conclusion that these other microbes produced the condition of abnormality noticed, and so gave opportunity for the entrance and growth of Klebs-Löffler bacilli. The same thing might be argued from an analysis of the Hoffmann infected cases, 75 % of which came from abnormal throats, and 67 % of them associated with other organisms. This bacillus, however, has been shewn to occur in a large proportion of the normal population with presumably normal throats, so that the conditions are not analogous.

Persistence of the Bacilli.

Among the 174 children examined in September, 18 had been notified at various dates between February and June, and 5 of these still shewed the Klebs-Löffler bacilli. 3 out of the five gave negative results in May, and in I only was a positive result obtained in October. In that case

between/

between notification on February 7th. and the finding of the bacilli on September 11th. & October 13th, the bacilli must have been present for 248 days, unless we presume that a fresh infection had taken place previous to the September examination.

13 of the children had suffered from diphtheria at various dates in the latter months of 1902. In this examination all gave negative results except one, who shewed the long variety of Klebs-Löffler bacilli in October, on two separate occasions, a week apart. In May the result was negative. This would seem to point more definitely to a fresh infection than the last case, and perhaps all the more so, owing to the long variety being found, as this is stated by many observers to be the more virulent form. Of the above 31 notified cases, 26 in September shewed an abnormal condition of the throat, including all those that gave positive results.

Apart from the above 2 cases, a remarkable persistence of bacilli was noticed in six instances, 4 shewed the presence of Klebs-Löffler bacilli for 159 days, examinations yielding positive results on four separate occasions, 1 for 127 days, and 1 for 65 days. The latter was the only one that was confirmed by inoculation of a guinea-pig/

guinea-pig.

A similar persistence has been reported by other observers. Sims Woodhead (26) found in the Metropolitan Asylums Board Hospitals that 79 patients shewed bacilli for 100 days and 2 for 200 days. He also stated at the Sanitary Congress at Birmingham in 1898 that he had seen a persistence up to 8 months. Hewlett (also) describes one case where they were found for 22 weeks, and another for 15 months. Prip (27) in examining cases admitted to the Blegdams Hospital, Copenhagen, found that convalescents harboured the bacilli for periods up to 22 months, and that nothing seemed to have any effect on them except an attack of intercurrent disease. Maether (28) suggests that persistence may be due to the bacilli existing in enlarged follicles, protected by a covering of mucus. Whatever the real reason may be, persistence here was certainly associated with an abnormal condition of the throat.

After my investigations were finished, 5 notifications were received. 4 of these I had previously found to be negative, including 2 shewing Hoffmann bacilli, and 1 positive. The latter was notified only a few days after I had taken the swab.

Total/

Total number of children examined.....	174
Number from infected families.....	42
Number of the latter shewing Klebs-Löffler bacilli.....	11
Number of previously notified children.....	31
Number of the latter shewing Klebs-Löffler bacilli.....	6

Thus the number of children who had either had the disease, or who belonged to families where the disease had previously existed, comprised 42 % of the whole, and about 10 % harboured the specific micro-organism. This points to the inevitable conclusion that most of these children, doubtless returned to school before their throats were free from the bacilli, and acted as disseminators of the disease to other children. The second standard contained the heaviest proportion, viz.- 15 out of 35.

Result of Second Swabs.

Second swabs were taken at intervals of two to five weeks after the first swabbing, from 25 of the 35 children who had given positive results in September, and who had been excluded from school; the other 10 were not at home when the visits were made. Only one child was confined to the house, and with a sore throat. 14 of the 25 still shewed the presence of Klebs-Löffler bacilli, but they were

all/

all uniform in this, that no pure culture was obtained, there was a distinct diminution of the relative numbers of Klebs-Löffler bacilli to other organisms, there was less virulence of these other organisms judging by size and intensity of staining, and in all but 3 was there a distinct alteration for the better in the clinical appearance of the throats. Hoffmann bacilli were present in 8 of the cases, a percentage of 32, practically double what was found in these cases in September and shewing an approach to a more normal condition of things. Exclusion from school had evidently been to the advantage of these children, but as shewing a method of possible personal infection one of the children was found to be nursing a neighbour's baby at the time the visit was made.

The Duffield Control.

As a control, 27 swabs were taken from Duffield school children, none of whom had been in contact with diphtheria for at least a year. No Klebs-Löffler bacilli were found in any of them, although a bacillus was obtained which stained with Neisser but did not produce acid in glucose broth. Hoffmann bacilli were obtained in 11 or 40.7 %, a much higher figure than was obtained among the Blackwell children. A marked difference was seen in the condition of the throats. All except 3 were normal, and these/

these only shewed a slight congestion of the fauces and slight tonsillar enlargement. No such septic throats, or virulent looking cocci were met with as were so often seen at Blackwell.

Sanitary Condition of the School.

It was no part of my duties to report on the sanitary condition of the school, but various structural defects were seen and noted. The privies, situated about 20 yards from the school buildings, were badly constructed and badly ventilated, and they opened into common exposed receptacles. They lay at a higher level than the school itself, and leakage from them as well as surface water would naturally gravitate from the unpaved playground to the school buildings. The school-house yard and gully, and the lavatory gully were also badly constructed. The disconnecting chamber was inefficient and the system of sewers was not ventilated at its highest point, namely at the boys' urinal. There were two basins in the lavatory, supplied with rain-water from the roof, and only one towel, which was not changed sufficiently often. A dozen swabs were taken from the slimy material on the lavatory waste pipe, and lavatory gully, from one towel and from the liquid in the boys' urinal and the girls' /

girls' privy. All gave negative results, so far as Klebs-Löffler and Hoffmann bacilli were concerned. In a school outbreak at Lambeth, Priestly (29) discovered both in the waste pipes of lavatory basins.

Conclusions.

After taking into consideration the available literature on the subject, the investigations made, the results obtained, and all the circumstances of this outbreak, I am of opinion that Klebs-Löffler bacilli and Hoffmann bacilli are totally distinct organisms, and that the latter have got little, if any, influence in the causation of diphtheria. They can be absolutely distinguished from Klebs-Löffler bacilli culturally, by the microscope and by inoculation experiments, they occur to a large extent in ordinary healthy throats, and satisfactory proof is awanting that they can be converted into Klebs-Löffler bacilli and vice versa.

Children shewing Hoffmann bacilli need not be excluded from school, unless they shew clinical evidence of diphtheria.

All children shewing the presence of Klebs-Löffler bacilli should be excluded from school till a negative bacteriological examination has been obtained. It is

recommended/

recommended by some authorities that they should not be allowed to return to school till three consecutive negative bacteriological examinations have been obtained, but in rural districts such as Blackwell, situated far from a laboratory and where the expense would be prohibitive, this is a counsel of perfection.

It is good to exclude an infected child from school, but is it good to allow it to mix with other children outside, even although a prophylactic injection has been given? I think not. To treat such children scientifically, they would require to be sent to a reception house. A home of this sort has been established at Colchester, but children with persistent bacilli cannot be kept in indefinitely. The question of expense has also to be considered, but apart from that, a reception house would have been of little benefit here, as no Isolation Hospital was available for acute cases. As before mentioned, and as seen in the Reports of the Medical Officer of the Local Government Board, (by Power, Buchanan, Bruce Low, Thorne Thorne &c) and as was experienced here, total school closure was followed by a diminution in the number of cases notified. This however is a drastic measure, seriously interfering with education, and there is no necessity for it. The exclusion

from/

from school of infected children has exactly the same effect, a result which was well brought out in the present instance. The local Medical Officer of Health was kept informed of the results obtained, and the children harbouring Klebs-Löffler bacilli were at once excluded from school, with the result that the school cases quickly diminished.

Doubtless, children with abnormal throats , which are recognised as predisposing to the disease, ought also to have been excluded, but to have done so would have meant a serious interference with education.

Antiseptic gargles have not been found to be of much service in other epidemics, but I believe they would have been of service here, as such a large number of children were met with presenting very septic and inflamed throats. Long persistence of the bacilli is usually associated with such throats, and they are probably more dangerous under these conditions.

The general prophylactic use of anti-diphtheritic serum was of no very apparent service in this epidemic. Its use is probably indicated therefore for contacts in

infected/

infected houses only.

It was suggested by the County Medical Officer, that (a) the use of slates should be discouraged, but if still used the slates should be periodically disinfected, (b) that the danger of the transference of sweets, pencils &c. from mouth to mouth should be pointed out, and (c) that an efficient supply of lavatory towels should be provided.

The insanitary state of the privies, &c. was also seen to be a danger, although no direct causal relationship could be shewn. Still, it is a well known fact, that, in infectious diseases generally, to determine an attack, two factors are necessary, viz:- the presence of the specific microbe, and a predisposition. This latter can be brought about by various adverse influences, of which insanitary surroundings are the chief.

Frequent disinfection of the whole school was advocated, and also the daily wiping over of the school furniture with dusters wrung out with some antiseptic. It has been found by experiments in the Pavillon Bretonneau of the Hopital Trousseau (30) that Diphtheria bacilli were present in the air of the wards, but that they disappeared after/

after disinfection.

Many of the foregoing figures are very remarkable, especially those that relate to the length of time which some of the bacilli persisted. The exclusion from school of infected cases was certainly followed by an immediate diminution and finally stoppage of the notifications. Only one case was notified in November in the Blackwell parish, and none in December.

This epidemic seemed to spread almost entirely by direct personal contact, but only under certain conditions of close aggregation, and perhaps bad sanitary surroundings, both of which reached their maximum in the Blackwell Church School.

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REFERENCES.

1. Notter and Firth, Hygiene, 1900, p.485

2. Lancet, Nov.19th. 1898.

3. Notter and Firth, Hygiene, 485.

4. Annual Reports for 1902 and 1903, of County and District Medical Officers of Health.

5. Journal of Hygiene, Vol. II - 2.

6. Parker, Nature and Treatment of Diphtheria, pp.13, 14.

7. Annual Report, 1902.

8. Parker, pp.15,16.

9. Trans. Epidem. Society, 1878. Paper by Thorne Thorne; also Thorne Thorne, Diphtheria; its natural history &c. pp.107 et seq.

10. Cited in Allbutts System of Medicine - Vol. I - 706.

11. Annual Reports.

12. Epidemic Diphtheria, Newsholme.

13. Supplement to 31st. Annual Report of the Local Government Board.

14. Journal of Hygiene, April 1903.

15. Journal of Hygiene, Vol. I - 2, and in a paper read before the Liverpool Congress of the Roy. Inst. Pub. Health 1903.

16/

16. Paper read before Metropolitan Branch, Society Medical Officers of Health. Public Health, July, 1903.

17. Dr. Heaven, Deputy M. O. H. of Bristol and Dr. Tanner, Bacteriologist to the County Borough of Bournemouth, in papers read at the Liverpool Congress, 1903.

18. Journal of Hygiene, April, 1903.

19. Trans. Brit. Inst. Prev. Med. 1897. First series.

20. Guy's Hospital Reports. 1898.

21. Pakes, Application of Bacteriology to Public Health.

22. Escherich. M. Public Health, July, 1903.

23. Gordon. Supplement to 31st. Annual Report of the L.G.B.

24. Scientific Bulletin No.1 Health Department, City of New York, pp.31 et seq.

25. Supplement to 30th. Annual Report of the L. G. B. Plate X, Fig. 12.

26. Report on Bacteriological Diagnosis &c. of cases admitted to the M. A. B. Hospitals 1895-1896.

27. Reported in Public Health, July, 1901.

28. La Presse Medicale, Fév. 1901.

29. Public Health, July, 1903. Outbreak of Pseudo-diphtheria.

30. Gazette des Maladies Infantiles.

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