

DIPHTHERIA IN GLASGOW 1934-42

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(With 1 Figure in the Text)

This paper is a continuation of previous studies (Carter, 1933, 1936) and aims at recording broadly the aspects of diphtheria as it has occurred in Glasgow in the past nine years.

During that time the city has had a large number of cases of diphtheria and 1210 persons have died of the disease, 632 in the last four years. The case mortality has fortunately been relatively low and on the whole has not shown great fluctuation. In 1934 the case fatality rate was 6.1%; in 1936, 2.7; for the rest of the time it has averaged a little over 4%. There was a large increase in the number of cases in the years 1939-41 with a maximum in 1940, when the death-rate per 100,000 of the population was 20.6, but the case fatality rate 4.3%. Although this mortality is the highest in any year under review, it does not approach the height reached in other places in epidemic times when the *gravis* type of *C. diphtheriae* was predominant. The death-rates per 100,000 of the population in Glasgow from 1934 to 1942 were as below:

1934	14.4	1939	14.4
1935	10.2	1940	20.6
1936	4.8	1941	13.1
1937	10.4	1942	8.6
1938	11.7		

In 1938 a fairly sudden change in the predominant type of *C. diphtheriae* took place.

As before, the basis of this work has been the swabs sent for routine diagnosis by city practitioners to the bacteriological laboratory of the Glasgow Public Health Authority. Even the large numbers passing through the laboratory are only a large sample, but the results derived from the examination of the strains of *C. diphtheriae* isolated from these swabs, together with such clinical correlations as have been possible, present, it is hoped, a not inaccurate picture of the disease in the Glasgow area. Over eleven thousand strains of *C. diphtheriae* have been typed and are consecutive and unselected in that, although in some years, when diphtheria was not attracting much attention, typing was omitted for a month or two in the summer, the series always ran in monthly periods, and mostly for the whole or greater part of each year. This sampling was designed to give a fair yearly picture, within the laboratory opportunity for observation. It is not forgotten that by no means all cases of diphtheria are swabbed before admission to hospital, nor that it is often more expedient to swab older children and adults, whilst younger children with suspicious throats are sent into hospital unswabbed. All strains have been identified and typed by the use of McLeod's original heated blood tellurite

medium, or, later on, an unheated blood tellurite medium, with the help of the usual biochemical criteria in doubtful cases. Virulence tests have been done as occasion demanded, by intracutaneous or subcutaneous inoculation.

The incidence of types during the years is given in Table 1. These figures show the almost mirror-like reversal of *intermedius* and *gravis* types in predominance, with the curves of percentage incidence crossing at about 40% in 1938, and the gradual decrease in the percentage of *mitis* strains. These features are displayed graphically in the diagram. The rise in the *gravis* curve is sudden and steep; the *intermedius* curve falls more gradually and irregularly. The *gravis* plateau now reached is a little below that of *intermedius* up to 1936, and the *intermedius* curve has not reached the low level of that of *gravis* before 1937.

Also recorded in the table are numbers of atypical strains occurring chiefly in the earlier years, increasing near the transition period of type predominance, and then gradually disappearing. A similar change in type incidence reported by Robinson & Marshall (1935) was not accompanied by the appearance of atypical forms. Although these anomalous variants have practically disappeared in Glasgow, Murray (1942) describes them in the Witwatersrand, and they are known to occur in the east of Scotland. Apparently they are uncommon in England.

Type IV, whether it be classified as an aberrant *gravis* strain or as a rough *mitis* strain, is certainly capable of causing fatal disease (Bloch, 1938). Bloch's strains were typed in this laboratory and none of them could be persuaded to ferment starch, though they were fairly good pellicle formers.

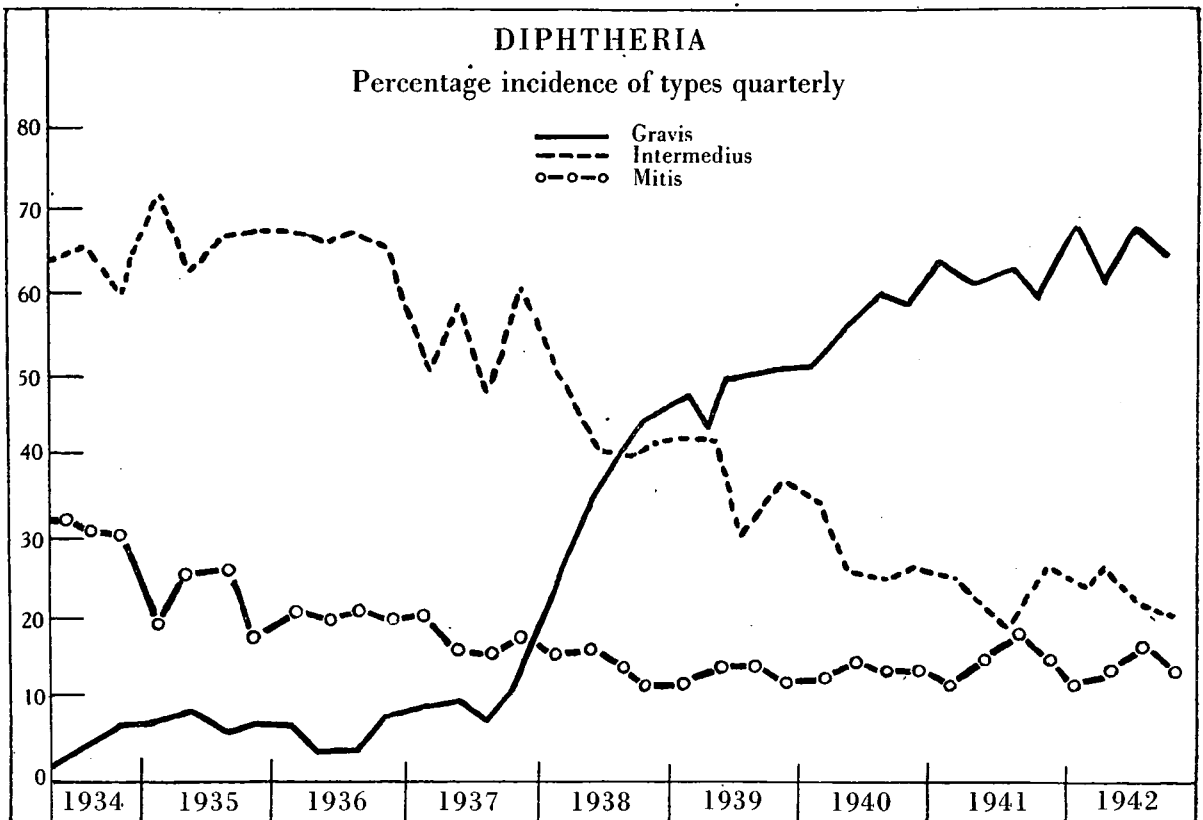
Type VI, if a true diphtheria bacillus, is practically non-virulent, and has for the present disappeared from Glasgow.

Type VII (Wright, 1937) is a form previously noted, but not numbered, in this laboratory.

Type V (Wright & Christison, 1935) we have never isolated. A fuller description of these atypical strains was given in an earlier paper (Carter, 1936). The significance of the increase in numbers of these atypical strains in 1937 and in the earlier part of 1938 just before the change in the prevailing type took place is not clear. No 'dissociating' strains similar to those described by Frobisher (1940), regarded by him as an indication of impending change of type, were encountered. At most they might be looked upon as evidence of some instability in type characteristics, not unusual where diphtheria is mild and endemic, which disappears more or less when one type is about to assume epidemic distribution. All of them bred true and showed no

Table 1. Incidence of infections with various types

Year	<i>Gravis</i>		<i>Intermedius</i>		<i>Mitis</i>		Atypical strains			Total
	No.	%	No.	%	No.	%	Type IV No.	Type VI No.	Type VII No.	
1934	33	5.2	385	61.1	198	31.4	3	8	3	630
1935	56	6.1	617	68	176	19.4	6	51	1	907
1936	35	6.3	363	65.8	114	20.7	3	29	7	551
1937	95	10.8	470	53.7	158	18	42	108	1	874
1938	497	37	585	43.6	202	15	19	34	5	1342
1939	708	46.6	586	38.5	208	13.7	13	4	—	1519
1940	1367	57.6	651	27.4	348	14.2	6	—	—	2372
1941	895	60	367	24.6	223	14.9	6	—	—	1491
1942	1111	68.2	303	18.6	213	13	—	—	—	1627
1934-42	4797	42.4	4327	38.2	1840	16.2	98	234	17	11313



tendency to exhibit several different colony forms as did Frobisher's strains.

CASE MORTALITY

On the whole during the period under survey diphtheria has been mild. *Gravis* and *intermedius* types though showing capacity for spread among the community, especially the former, have not displayed such lethal power as has been noted in other places. The following table sets out the case fatality rates, as far as can be

ascertained, for the years before the change in type incidence; for the year of change, 1938; and for the last three years. The number of *gravis* strains, particularly, in the earlier years is so small that the percentage rates may be a trifle high. The *gravis* type gives the highest rate, but this has diminished considerably with the greatly increased dissemination of this variant during the later years. The case mortality for the *intermedius* type has also fallen and reaches a low level in 1942. The rate for *mitis* infections since 1934 is unremarkable and

falls into line with most other observations elsewhere. Before 1934 it was unusually high and in 1932-3 reached 7.2% in a series of 125 cases. A similar high rate for *mitis* infections has been recorded in Australia (Anderson, Goldsworthy & Ward, 1936), and by Murray (1942) in Africa.

The year of change of incidence of the predominant type, 1938, produced a higher rate in *intermedius* infections than in *gravis* by about 1%, but all rates are

Case fatality rates at different age periods for 2483 cases in 1942, which form a straight run of discharges from the City hospitals, are given in Table 3, and are highest in the 0-4 age period as expected, with the exception of a rate of 3.4 for the *intermedius* infections in the 5-15 age group. But for all cases the 0-4 group shows the highest mortality, with almost 50% of the total deaths. In the years when the *intermedius* strain was predominant the percentage case fatality due to it

Table 2. Case fatality rates in infections with different types

Year	<i>Gravis</i>			<i>Intermedius</i>			<i>Mitis</i>		
	Cases	Deaths	Case fatality rate %	Cases	Deaths	Case fatality rate %	Cases	Deaths	Case fatality rate %
1934	33	3	9.09	385	28	7.27	198	6	3.03
1935	56	5	8.93	617	33	5.34	176	3	1.70
1936	35	2	5.71	363	11	3.03	114	2	1.76
1934-6	124	10	8.06	1365	72	5.27	488	11	2.25
1938	497	23	4.62	585	32	5.47	202	5	2.47
1940	1367	71	5.19	651	29	4.45	348	5	1.43
1941	895	41	4.57	367	16	4.36	223	3	1.35
1942	1111	52	4.68	303	6	1.94	213	3	1.40
1940-2	3373	164	4.86	1321	51	3.86	784	11	1.40

Table 3. Case fatality in different age periods. 2483 cases

Type	Age groups								
	0-4			5-15			15+		
	Cases	Deaths	Case fatality rate	Cases	Deaths	Case fatality rate	Cases	Deaths	Case fatality rate
<i>Gravis</i>	301	25	8.3	520	24	4.6	290	3	1
Percentage incidence	18.5	41	—	31.9	39.3	—	17.8	4.9	—
<i>Intermedius</i>	73	1	1.3	148	5	3.4	82	0	—
Percentage incidence	4.4	1.6	—	9	8.2	—	5	—	—
<i>Mitis</i>	55	3	5.4	92	0	—	66	0	—
Percentage incidence	3.3	4.9	—	5.6	—	—	4	—	—
All types	429	29	6.7	760	29	3.8	438	3	0.6
Percentage incidence	26.9	47.5	—	46.7	47.5	—	26.9	4.9	—
Not typed	243	10	4.1	407	6	1.4	206	2	0.9
	9.8	12.6	—	16.3	7.6	—	8.2	2.5	—
Totals	672	39	5.8	1167	35	3	644	5	0.7
Percentage incidence	27	49.3	—	47	44.3	—	26	6.3	—

fairly low and indicate the moderate severity of the disease.

In 1940-2 there occurs a further declension in rates, despite the large increase in the number of infected persons.

The crude case fatality rates for the city in these and other years were:

1934	6.1	1940	4.3
1935	4.7	1941	3.8
1936	2.7	1942	2.6
1938	4.6		

rose to over 7%, but it did not show a capacity for communicability equal to that of *gravis* recently. This table does not distinguish between immunized and non-immunized persons. Excluding the immunized the case fatality rate in the 0-4 age group for *gravis* infections is increased to 9.9% and in the 5-15 age group to 6.4%. But considering persons of all ages the rate, 4.6, for those infected with the *gravis* type is not exceptionally high. The arresting feature of the *gravis* strain in Glasgow, considering its depredations in quality and quantity, has not been lethality but communicability, and because of this there has been some increase in

total mortality. There were three deaths among the immunized in the 5-15 age group from *gravis* infections, giving a rate of 1.5%. Among eight immunized children in the 0-4 age group infected with the *mitis* type, one death occurred. These were the only fatal cases among the immunized during the year.

SEVERITY OF CASES

Before 1934 the *intermedius* type was responsible for the severer cases in Glasgow; the *mitis* type ran closely with the *intermedius*, whilst the *gravis* type, which was then rarely found, gave rise to mild infections (Carter, 1933). By the beginning of 1936 *mitis* infections had become mild with a case fatality rate of 1.7%, below the average of 2.3 given by Cooper, Happold, McLeod & Woodcock (1936) in their analysis of 1488 infections with this type, but, with a case mortality of 9% in a series of eighty-nine cases of *gravis* infections (Carter, 1936), this type was displaying increased lethal power. In the present series about 25% of *gravis* cases are classed as severe, and the *intermedius* type gave rise to

deaths from *intermedius* infection among the immunes. The *gravis* type appears to have maintained a good deal of the enhanced virulence which it acquired between 1933 and 1935, before it became predominant. In both groups *mitis* infections provide the largest percentage of mild cases. Considering all cases and types there are 21.3% of severe cases among the non-immunized against 13.2% among the immunized.

At the same time the incidence of complication in the typed cases of the series is lower than the average that has been reported in the past from many places, and is no greater than it has been in Glasgow since 1935. It has been noticed, however, that since the rise in the number of *gravis* infections many more diphtheria cases have required longer hospitalization, but the average stay in hospital has not been unduly lengthy. The average time of retention in hospital of

840 *gravis* infections was 47.8 days,
235 *intermedius* infections was 45 days,
180 *mitis* infections was 40.3 days.

Table 4. Relative severity of infections due to different types

Type	Mild		Moderate		Severe		Fatal		Total
	No.	%	No.	%	No.	%	No.	%	
Not immunized									
<i>Gravis</i>	193	22.4	428	49.7	190	22.1	49	5.7	860
<i>Intermedius</i>	72	30.5	130	55.0	28	11.8	6	2.5	236
<i>Mitis</i>	73	41.9	88	50.5	11	6.3	2	1.1	174
Not typed	190	28.4	351	52.3	110	16.4	18	2.7	669
All types	528	27.2	997	51.4	339	17.5	75	3.8	1939
Immunized									
<i>Gravis</i>	80	31.8	130	51.7	38	15.1	3	1.1	251
<i>Intermedius</i>	21	31.3	36	53.7	10	14.9	—	—	67
<i>Mitis</i>	21	54.0	16	41	1	2.5	1	2.5	39
Not typed	71	37.9	97	51.8	19	10.1	—	—	187
All types	193	35.4	279	50.3	68	12.5	4	0.7	544
Grand total	721	28.6	1276	51.3	407	16.4	79	3.1	2483

much the same proportion of severe cases. Table 4 gives an analysis of over 2000 cases in 1942, with regard to their relative severity according to the infecting types of *C. diphtheriae*. Cases of 'bacteriological diphtheria' are excluded, and the immunized separated from the non-immunized. Only fully immunized cases are included where, as far as could be ascertained, at least three months had elapsed from the last inoculation to the time of sickening. In most of these cases the period was more than three months. Estimation of the immunity level by Schick testing has not been found practicable on any large scale in Glasgow. Here it is seen that in each type infection about half the cases were of moderate severity, 27.8% of *gravis* infections are classed as severe among the non-immunized, but only 16.2% among the immunized, while for *mitis* infections the figures are 7.4 and 5% respectively. The *intermedius* type is responsible for fewer severe cases than formerly, percentages being between 14 and 15 in both non-immunized and immunized; but there were no

These were all in non-immunized persons. The figures for the immunized do not differ materially. Clinical diphtheria alone is considered in these estimates.

Table 5 shows the incidence of complications in the series. Haemorrhagic diphtheria, five cases only, is limited to infections with *gravis* and *intermedius* strains and in approximately the same percentage incidence. The addition of cases in which the infecting organism was not typed, 669 non-immunized persons and 187 immunized, reduces the percentage death-rates to 3.8 and 0.73 respectively, and does not appreciably alter the picture as regards complications. Actually the four deaths among immunes occurred (in this series) in 620 infected persons ('bacteriological diphtheria' cases included).

NOTE ON IMMUNIZATION

The relative incidence of the three types among immunized and non-immunized is as follows: the figures are percentages:

<i>Gravis Intermedius Mitis</i>			
Not immunized			
67.7	18.5	13.7	Carriers excluded
67.2	18.9	13.8	Carriers included
Immunized			
70.3	18.7	10.9	Carriers excluded
70.5	17.4	12	Carriers included

As far as the figures go it would seem that non-immunized and immunized display practically the same relative susceptibility to the three types. The proportion of cases in the immunized to the total number of cases is high, but not higher than has on occasion been reported elsewhere, and *gravis* and *intermedius* strains show approximately equal powers in breaking immunity.

Immunization on a large scale was commenced in Glasgow late in 1940, and by the end of 1942 about 27.6% of children under 5 years of age, 61.3% of children of school age, and 1.4% of persons over 15 years of age had been protected. This wholesale immunization though as yet insufficient according to the all or nothing

group. The shift is obviously chiefly from the school-age period, which contains the largest percentage of immunes, to the later age periods. The change in type predominance has apparently had no effect on the age group incidence, except that noticeable in 1935 after the only considerable drop in *mitis* infections. The various factors responsible for the incidence of diphtheria among pre-school children appear to be in balanced equilibrium, for there is no notable change throughout the years after the initial fall in 1935. This despite the fact that wholesale immunization gives rise to healthy temporary carriers who may be supposed to be potential infectors of the younger susceptible. Considering the attack rate in Glasgow the non-immunized child is at present about 4½ times more liable to contract diphtheria than the immunized, and the risk of a fatal issue among the immunized is slight.

BACTERIOLOGICAL DIPHTHERIA

The number of cases of 'bacteriological diphtheria' associated with this run of clinical cases was 314; 238 in

Table 5. Incidence of complications

Type	Cases	Paralysis		Cardiac complications		Albuminuria		Haemorrhagic cases		Deaths	
		No.	%	No.	%	No.	%	No.	%	No.	%
Not immunized											
<i>Gravis</i>	860	74	8.6	108	12.5	16	1.8	4	0.46	49	5.7
<i>Intermedius</i>	236	9	3.8	15	6.3	3	1.2	1	0.4	6	2.5
<i>Mitis</i>	174	2	1.1	10	5.7	1	0.5	—	—	2	1.1
All types	1270	85	6.7	133	10.4	20	1.5	5	0.4	57	4.5
Immunized											
<i>Gravis</i>	251	7	2.7	24	9.5	3	1.2	—	—	3	1.19
<i>Intermedius</i>	67	1	1.5	7	10.4	2	3	—	—	—	—
<i>Mitis</i>	39	—	—	1	2.5	—	—	—	—	1	2.5
All types	357	8	2.2	32	9.0	5	1.4	—	—	4	1.1

school, whose ideals are difficult to compass in a great industrial city, may be the cause of some deflexion of the incidence of diphtheria from the lower age groups to the higher as the following table of incidence shows.

Table 6. Percentage age incidence of diphtheria

Year	Age groups		
	0-4	5-15	Over 15
1934	32.3	49.9	17.8
1935	26.5	56.3	17.2
1936	25.6	53.5	20.9
1938	28.5	54.5	17.
1940	28.9	51.1	20
1941	28.5	46	25.5
1942	27.3	46.9	25.8

One remembers however that change in the age incidence of diphtheria has occurred before as a phenomenon of epidemic years, independently of immunization, particularly from the 0-4 age group to the 5-15

the non-immunized and 76 among the immunized, or 12.2 and 10.9% respectively of the totals in the two groups. These of course were simply those who for some reason found their way to hospital. The proportion appears large, and is a reminder that it is possibly easier to obtain immunity to clinical diphtheria than immunity to carrier infections. Of the strains isolated from these carriers which were typed, 63.6 were *gravis* in type. The rate of *gravis* infections to *intermedius* infections among non-immunized carriers was 3 to 1; among immunized 7 to 1; the ratios of *gravis* carriers to *mitis* carriers were 4 to 1 and 3 to 1 respectively. This might suggest that the present prophylactic used in immunization gives better protection against *intermedius* strains than against *gravis* strains, although it is to be noted that the community was well salted against *intermedius* diphtheria before the change of type occurred. Any anti-bacterial immunity would also be chiefly type specific for the *intermedius* variant, which differs antigenically from the *gravis* type of organism. Doubt as to the complete efficacy of the toxoids used in modern immunization and produced from the toxigenic Park 8

(now not definitely classified, but which resembles an atypical, Type IV) strain would raise the question whether, in face of a *gravis* epidemic, it might be useful to include the toxic products of the local *gravis* strain in the immunizing elements, notwithstanding the belief that the toxins of the various types do not differ appreciably.

FURTHER CONSIDERATIONS

Wright (1939) investigated the severity of diphtheria since 1911 in six large towns of which Glasgow was one. It is of interest to add to his analysis the figures for the

Table 7. *Diphtheria in Glasgow, 1911-40*

All ages					
1911	1916	1921	1926	1931	1936
-15	-20	-25	-30	-35	-40
Case rate per 10,000					
19	14	17	23	21.2	27.6
Death-rate per 100,000					
19	14	12	12	11	12
Case fatality rate %					
10.3	10.0	7.5	5.2	5.1	4.4

1936-40 (Table 8), but it is still smaller than occurred in other large towns in the previous five years.

Shift in the incidence of the death-rate to higher age periods has been noted by several authors, and Picken (1937) pointed out that it was associated with a higher relative case fatality rate. This shift has been going on for some years, and has recently been shown, Cheeseman, Martin & Russell (1939), to be connected with change in the size of the family and to a lesser extent with environmental improvements. It has been noted that shifts have taken place where no epidemics have occurred. This shift has been delayed in Glasgow, but a table of proportional rates shows that some movement occurred in Glasgow in the 1931-5 period, but that there has been little shift in the proportional case fatality rates between 1911 and 1935. These movements are seen (Table 9) to have become more marked in the 1936-40 quinquennium, the higher proportional death-rates in the 5-9 age group being associated with a higher proportional case fatality rate. Epidemics in Liverpool, Leeds and Hull were characterized by a high proportional case rate for the second age group—much greater than the impression made in the 1936-40 quinquennium by

Table 8. *Diphtheria rates for age periods in different quinquennia*

Year	Case rate per 10,000			Death-rate per 100,000			Case fatality rate %		
	0-4	5-9	10-14	0-4	5-9	10-14	0-4	5-9	10-14
1911-15	80	67	24	136	42	9	16.5	6.3	3.6
1916-20	57	51	18	100	39	3	17.9	7.6	1.7
1921-25	66	54	23	94	32	3	14.1	5.9	1.4
1926-30	83	90	33	92	30	4	11.1	3.3	1.2
1931-35	65	87	40	65	36	7	10.0	4.1	1.8
1936-40	85	106	51	72	48	8	8.5	4.5	1.6

Table 9. *Proportional diphtheria rates for different age groups in quinquennia*

	Case rates			Death-rates			Case fatality rates		
	0-4	5-9	10-14	0-4	5-9	10-14	0-4	5-9	10-14
1911-15	100	84	30	100	31	6	100	38	22
1916-20	100	90	32	100	39	3	100	42	9
1921-25	100	82	34	100	34	3	100	42	10
1926-30	100	108	40	100	32	4	100	30	16
1931-35	100	133	61	100	54	11	100	41	18
1936-40	100	125	60	100	66	11	100	51	17

quinquennium 1936-40, during which period there was a change of type in the predominating strain of *C. diphtheriae*, and in the last year of which diphtheria was epidemic in Glasgow. Tables 7 and 8 show these additions in the proper places. Table 7 shows the increased case rate in the last quinquennium, with a death-rate little changed and a case fatality rate slightly smaller than in the previous five year period.

Wright remarked upon the general decline in the case fatality rates in both the 0-4 and 5-9 age groups, greater in some towns than in Glasgow. There was little change in the 1931-35 periods, but the over 5 age group rates are up a little. There is a further slight rise in the 5-9 age group noticeable in the latest quinquennium

the Glasgow epidemic of 1940. But the relative death-rates and case fatality rates are seen to show increases. 1941 and 1942 brought a decrease in incidence and mortality; particularly 1942, in which there was considerable reduction. Proportional figures for these two years on the lines of Table 9, though not strictly comparable, because of the differing time lapse, show interesting changes (Table 10). Marked diminutions in the 5-9 case rate and death-rate are shown. A smaller proportional case fatality rate in the same group is plain, with the increase in the 10-14 group. As the influence of immunization, which began late in 1940, would hardly be felt during 1941, a good deal of the decline must be post-epidemic, but the sudden descent

during 1942 with only 90 deaths during the year, as against 216 in 1940 and 148 in 1941, makes it reasonable to hazard the conjecture that some of the amelioration may be due to immunization. The average general case rate for 1941 and 1942 is well below the rate for 1940, but is not comparable with the preceding quinquennial rates. Further time must elapse before accurate comparisons can be made.

BACTERIOLOGICAL TYPES FOR *C. DIPHTHERIAE*

Over 12,000 strains of *C. diphtheriae* have been typed by the writer during the past eleven years. A certain facility has thus been acquired and the difficulties encountered by earlier workers in allocating them to the three primary groups, described by Anderson *et al.* (1931), have not been experienced. The broad distinguishing features between the three types are constant, though minor colony variations within the groups are common enough. Murray (1942) describes umbonate colonies of the *mitis* type. These certainly occur and can sometimes be seen at the edges of the medium when the centre contains more closely packed entire smooth dome-shaped colonies. Drying of the medium has some effect in altering the architecture of colonies. They have not been seen in young cultures. *Mitis* strains seen recently do not develop as readily on

No avirulent *gravis* strains such as apparently exist in numbers in some of the American States (Frobisher, 1940) have been found.

The *gravis* strains prevalent in Glasgow at present belong serologically to Robinson and Peeney's Sub-type I. Agglutination tests recently made upon over two hundred cultures have failed to reveal any other type. An antiserum made as far back as 1935, which has agglutinated many samples of cultures in the intervening years, has also been identified as originating from a Sub-type I strain. Nevertheless Robinson & Peeney (1936) found two of their Sub-type II and five of Sub-type IV among nine Glasgow strains tested by them. Sub-type II certainly does not exist in any number to-day. Sub-type IV, according to these authors, produces colonies approaching the *mitis* type, and their strains may have been specimens of Group VII (Wright, 1937), some of which have been found in Glasgow.

Robinson and Peeney's Sub-type III, which was responsible for severe diphtheria in Hull, has not been found.

All the experience in Glasgow supports the essential scientific soundness of the broad division of the diphtheria species into the three types, notwithstanding the amount of variation within the types that can arise spontaneously or be produced by art. Also epidemio-

Table 10. Proportional diphtheria rates for different age groups, 1941-2

Year	Case rate			Death-rate			Case fatality rate		
	0-4	5-9	10-14	0-4	5-9	10-14	0-4	5-9	10-14
1941-2	100	98	49	100	42	13	100	42	25

the standard medium as did the more virulent strains of 1932-4. Frequently they are not as glossy and translucent in appearance, nor as soft in consistency. Some reduce tellurite more, and the classical dome shape takes on a suggestion of the conical. The virulent *mitis* colonies seen in the early days had something of the mucoid quality of the M type described by Hobby (1935) and Morton (1940*b*). A few *intermedius* strains have been seen to produce dwarf colonies, even after 48 hr. growth. These seem to be similar to the D form of Morton (1940*a, b*) produced by an ageing Park 8 strain. The bacilli in the dwarf colonies have the morphological barred appearance of the *intermedius* type. In subculture upon the heated blood tellurite medium they throw up typical *intermedius* colonies as well as more pin-point dwarf colonies, but when they are transferred to Loeffler's medium their growth is normal. These anomalous *intermedius* strains, which are very few, seem only to be an instance of inhibition of growth. Many *mitis* and *gravis* strains grow badly on the standard medium, and all these do better on an unheated medium. Morton's G or gonidial colony containing organisms coccoid or filamentous in form has not been seen. Occasionally one has seen a rather finer growing rough colony somewhat between the forms of *gravis* and *intermedius*, which grows like normal *intermedius* in broth but ferments starch. These strains have always produced late pellicles on broth, in about six to eight days. Otherwise they are reminiscent of Stuart's single strain described by Cooper *et al.* in their review.

logically and pathologically the division is useful in considering the behaviour of diphtheria, with its vagaries of virulence and transmissibility, at large among the community.

SUMMARY

1. A general survey of diphtheria in Glasgow during 1934-42 has been made. Over 11,000 strains of *C. diphtheriae* have been typed and the incidence of the types is recorded.
2. The period has been marked by a change in the predominant type of organism from *intermedius* to *gravis*, and *gravis* infections are now responsible for most of the mortality, though the average case fatality rate due to them is not high.
3. Diphtheria on the whole has been mild and complications relatively few, but some shift in the death-rate incidence to the higher age periods with increase in the corresponding case fatality rate has taken place. A small shift in the age incidence of diphtheria is noted.
4. Some account of the effect of immunization is given.
5. Comment is made upon colony variation among the types of *C. diphtheriae*.

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Addendum, 1944. As some time has elapsed since this paper was submitted, it can be added that the relative incidence of types did not change

materially in 1943. An examination of 1900 strains gave 62% *gravis*, 24.8% *intermedius* and 13.2% *mitis*.

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