THE SEROLOGICAL TYPES OF HAEMOLYTIC STREPTOCOCCI IN EPIDEMIC SCARLATINA

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(With 2 Graphs)

Introduction

Scarlet fever is one of the group of acute infectious diseases which, in distribution, may occur as sporadic cases or as epidemics of varying extent. Edinburgh and its surrounding district was visited in 1933 by an epidemic which rapidly assumed considerable proportions. The onset of the epidemic was presaged by an unusual rise in the number of cases during the month of May. It so happened that during the preceding two months of March and April, a large series of strains of haemolytic streptococci from acute scarlatina had been isolated for the purpose of carrying out an investigation on toxin production. The collection of strains was continued during the epidemic and a unique opportunity was therefore presented of studying the characters of strains isolated during an immediate pre-epidemic period of two months together with those of the epidemic itself.

Of the various methods devised in the attempted classification of haemolytic streptococci, that which has been most extensively used has been the agglutination reaction. Yet the results obtained by different workers have often been at variance. Moser & von Pirquet (1902), utilizing direct agglutination reactions with sera from scarlet-fever patients and also from horses immunized with haemolytic streptococci isolated from the blood of fatal cases of scarlatina, concluded that scarlet-fever strains formed a group serologically distinct from those isolated from other diseases. In this respect he received confirmation by Meyer (1902) and by Rossiwall & Schick (1905). On the other hand, Aronson (1903), using the same technique as that followed by Moser & von Pirquet, was unable to corroborate their findings, while Neufeld (1903), using immune rabbit sera, also failed to define a specific scarlatinal group. For a prolonged period no further results were reported until with the introduction of new methods, an impetus was given to further study of the subject. By the method of agglutinin-absorption Tunnicliff (1920), Bliss (1920) and Gordon (1921) each found that at least 80 per cent of scarlatinal strains were of one serological type, but Williams (1924) was again able to demonstrate multiplicity of types, of which the largest constituted only

15 per cent of all strains examined. Williams showed further that strains identical with those from scarlatina were recoverable from presumably non-scarlatinal sources such as cases of puerperal fever and erysipelas. This, too, has received ample confirmation at the hands of Smith (1926, 1927), James (1926) and MacLachlan & Mackie (1928). An extensive investigation of this nature was reported by Griffith (1927), who found that 60 per cent of strains from acute scarlatina fell into one or other of types 1, 2, 3 and 4 of his classification which now comprises twenty-seven types (Griffith, 1934). Andrewes & Christie (1932) by careful serological analysis were able to identify three of these types, while Allison & Gunn (1932) have confirmed the results in full. No reports have as yet appeared concerning the serological investigation of strains from an epidemic of the magnitude of that experienced in Edinburgh, but Glover and Griffith (1931) and Griffith (1934) have found that in small epidemics there is usually a preponderance of a single type.

Previous reports differ also as to the incidence of carriers of haemolytic streptococci among scarlatinal convalescents. Williams (1924) noted that after 30 days only 20 per cent of convalescents were carriers and in these the numbers of streptococci were few. Kirkbride & Wheeler (1930) found that between 50 and 60 per cent of convalescents were still carriers at the same period. Similarly, Gunn & Griffith (1928) record a carrier rate of 49 per cent, while Brown & Allison (1935) found that 82·8 per cent of patients, irrespective of their length of hospitalization, had haemolytic streptococci in the throat or nose on discharge, and suggest that the true percentage of carriers was probably higher, since return cases followed the discharge of a certain number of those giving a negative cultural result. Of more importance from the point of view of dissemination by carriers is the fact that Kirkbride & Wheeler (1930) could find no fundamental difference as regards pathogenicity or virulence between strains isolated from the acute and convalescent phases, respectively, of illness. Yet only two of thirty-four carriers in their series were reported to have become infecting cases. Not one single return case was ascribed to the 49 per cent of discharge carriers in Gunn and Griffith's series, and this was attributed by the authors to the probably early abolition of the carrier state induced by the altered environment of home conditions. Brown & Allison (1935) made the observation that the degree of infection on discharge as indicated by cultural methods was correlated with the return-case rate, which was 3 per cent in mild and moderate, but 6 per cent in heavy or very heavy infection.

The present study was undertaken in order to re-examine the questions referred to above and also to obtain if possible some information regarding the factors which determine the onset of a widespread epidemic in a community subjected apparently to the same risks as prevail in non-epidemic times.

Methods

Isolation of strains

On admission to hospital a throat swab was taken from each patient and used to inoculate a 5 per cent rabbit-blood agar plate. This plate was then incubated aerobically at 37° C. for 24 hours. A single colony showing β-lysis was emulsified in 0·5 per cent phosphate broth from which were inoculated two tubes, one containing 5 c.c. of 0·5 per cent phosphate broth and the other 5 c.c. of 0·5 per cent glucose broth. The serological examination of the particular strain was initiated by using the growth in phosphate broth after 24 hours incubation at 37° C., while the 24 hours' glucose broth culture was used for inoculating a further 200 c.c. glucose broth if the toxin production of the strain was also to be examined.

On discharge from hospital a second throat swab and, in addition, a nasal swab were again examined in the manner described above. From many of the patients further swabs were examined during the course of their stay in hospital.

Preparation of antisera

Initially four rabbit antisera were prepared by the intravenous injection of heat killed 24-hour broth cultures of types 1, 2, 3 and 4 strains of *Streptococcus haemolyticus* supplied by Dr Griffith. It was soon found that although the sera so prepared agglutinated th homologous strains to high titre, a large proportion of the locally isolated strains were agglutinated, if at all, by only low dilutions of these sera. Accordingly additional sera were prepared against several of these strains and finally eight were utilized, four for Griffith's types 1, 2, 3 and 4 and four for types which were provisionally named A, B, C and D, one of these, A, being serologically identical with type 5.

Direct agglutination reaction

The cultures derived from each case were in the first instance tested for direct agglutination by the eight type specific sera, the method described by Smith (1926) being followed.

Agglutinin absorption

In view of the frequency with which co-agglutination occurred in many strains, the method of agglutinin absorption was used to supplement direct agglutination results. A strain was accepted as belonging to one of the eight types if it absorbed completely from its antiserum the homologous agglutinins.

Experimental observations

Quantitative results of examinations on admission

Single throat swabs from 1875 acute cases were examined for the presence of haemolytic streptococci and of these, 1581 or 84·3 per cent were found positive, while 15·7 per cent were negative or yielded no growth. The detailed quantitative results are given in Table I.

For comparative purposes the results of plating each admission swab were designated +, ++ or +++, according to the number of colonies of haemolytic streptococci obtained. Although it was not assumed that this division of positive results into groups, according to the number of colonies appearing on the plates, afforded an absolute measure of the degree of infection, yet it was taken to give some relative indication of the number of haemolytic streptococci present. Results obtained by this method naturally tended to

err on the side of revealing a lower estimate of the degree of infection than was actually present. Therefore the absence of haemolytic streptococci in 15·7 per cent of the primary plates by no means signified their absence from the throat, but rather failure to isolate on account of technical difficulties such as the overgrowth of haemolytic streptococci by other organisms, variations in the methods of swabbing resulting in differences in the amount of inoculum, and the local use of antiseptics before the taking of a swab.

Table I. *Results of examination of admission throat swabs from acute scarlatina, grouped according to number of haemolytic streptococcal colonies on inoculated plate*

\+ = less than 10 colonies per plate.
\+ + = between 10 and 20 colonies per plate.
\+ + + = more than 20 colonies per plate.
0 = no growth on plate.
\- = no haemolytic streptococci detectable on plate.

	Throat swab plate				
Month of admission	+	+ +	+ + +	-	0
Mar.	12	21	41	8	0
Apr.	18	45	30	24	3
May	24	69	87	18	0
June	28	46	108	22	2
July	29	109	117	21	5
Aug.	32	77	102	16	5
Sept.	40	198	76	107	0
Oct.	45	111	49	41	1
Nov., Dec., Jan.	10	13	44	12	9
Total	238	689	654	269	25
%	12·69	36·74	34·77	14·34	1·32

84·3% positive; 15·7% negative

Quantitative results of examinations on discharge

As the number of swabs dealt with at one time was limited by such conditions as the amount of time and media available it was found impossible to examine on discharge all those cases examined on admission. However, the examination of 1062 of the cases yielding positive swabs on admission was completed, and to these were added 188 cases whose admission swabs were negative and 298 cases which were not examined on admission, the total number of convalescents being 1548. Of these the throat swabs from 978 were found negative while 570 or 36·8 per cent were positive. Table II indicates the numbers of haemolytic streptococci recovered from swabs on discharge and for comparison these are grouped according to the results on admission. It will be seen that although there were 36·8 per cent of carriers on discharge, only 20·1 per cent yielded more than 10 colonies per plate, i.e. + + and + + + groups, as contrasted with the 71·5 per cent of acute cases showing a similar degree of infection. There was no significant difference as to the incidence of carriers among the +, + + and + + + admission groups, the carrier rate on discharge being 32·4, 39·6 and 37·1 per cent respectively (Table II), nor did the proportion of +, + + and + + + results in each of these groups at the time of discharge vary to any marked extent.

Table II. *Results of examination of discharge throat swabs, grouped according to number of haemolytic streptococcal colonies on inoculated plate*

\+ = less than 10 colonies per plate.
\+ + = between 10 and 20 colonies per plate.
\+ + + = more than 20 colonies per plate.
0 = no growth on plate.
\- = no haemolytic streptococci detectable on plate.

Results of admission examination		Discharged without examination	Examined on discharge	Discharge swab results			
				+	+ +	+ + +	-
Positive	+238	90	148	20	19	9	100
			100%	13·5%	12·8%	6·1%	67·6%
„	+ +689	233	456	85	75	21	275
			100%	18·6%	16·4%	4·6%	60·3%
„	+ + +654	196	458	78	68	24	288
			100%	17·0%	14·9%	5·2%	62·8%
Negative	294	106	188	27	27	9	125
No swab on admission	298	0	298	49	38	21	190
		Total	1548	259	227	84	978
		%	100	16·7	14·7	5·4	63·2

Serological examination of strains isolated during the early stage of illness

By the methods described above there were defined eight serological types of which four corresponded to Griffith's types 1, 2, 3 and 4. Representative strains of the remaining four types A, B, C and D have since been submitted to Dr Allison who reported that type A was identical with Griffith's type 5, but that types B, C and D were not represented in this series. In this communication type A will hereafter be referred to as type 5.

It was found possible to place 94·1 per cent of the strains isolated on admission into one or other of these types, leaving a residue of 5·9 per cent which either reacted to none of these type sera or failed to yield suitable suspensions for agglutination. Auto-agglutination is a well recognized technical difficulty encountered in the serological investigation of haemolytic streptococci and, in this inquiry, the special methods used reduced the proportion of strains which had to be discarded as unsuitable to 2·3 per cent.

The number of admission strains of each type isolated during successive months of the year are indicated in Table III. From this table it will be noted that there was, over the whole period, a striking preponderance of type 5 cases. Thus 47·8 per cent of all cases were due to this type whereas Griffith's types 1, 2, 3 and 4 together constituted 29·3 per cent of the total. Reference to Table IV which indicates the proportion of all notified cases of scarlatina subjected to serological examination shows that in any month from April to August the data at hand referred to at least 75 per cent of such notifications, and such data may reasonably be taken to afford information applicable to the epidemic as a whole. During March and September the proportion of cases examined was not so large but was above 50 per cent. With this in mind a study of the proportion of acute cases due to the various types in each particular month reveals several interesting facts (Table V). Thus in March, two months

Table III. *Serological types of haemolytic streptococci from admission throat swabs in acute scarlatina*

Month of admission	Type								Total typed	Total not typed	No. cases
	1	2	3	4	5	B	C	D			
Mar.	7	6	17	7	32	2	0	1	72	2	74
Apr.	10	10	20	6	38	4	1	1	90	3	93
May	10	9	21	11	105	10	4	5	175	5	180
June	11	8	8	0	143	3	1	1	175	7	182
July	12	8	29	12	135	18	15	5	234	21	255
Aug.	11	8	34	8	115	12	4	4	196	15	211
Sept.	19	12	60	10	133	13	31	12	290	24	314
Oct.	30	26	43	29	41	7	21	0	197	8	205
Nov., Dec., Jan.	7	5	16	2	14	3	8	4	59	8	67
Total	117	92	248	85	756	72	85	33	1488	93	1581
%	7·4	5·8	15·7	5·4	47·8	4·6	5·4	2·1	94·1	5·9	100

Table IV. *Number of cases of acute scarlatina bacteriologically examined as compared with the total number of notified cases in Edinburgh during the year* 1933

Month of admission	Number of notifications	Number examined	Percentage of notifications
Jan.	100	0	0
Feb.	79	0	0
Mar.	127	74	58·28
Apr.	124	93	75·00
May	226	180	79·64
June	228	182	79·82
July	308	255	82·79
Aug.	242	211	86·71
Sept.	468	314	67·1
Oct.	924	205	22·18
Nov.	942	53	5·62
Dec.	748	14	1·87
Total	4516	1581	

Table V. *Variation in number of cases of acute scarlatina due to the various serological types of haemolytic streptococci, expressed as percentages of the total number of cases examined during the month.*

Month of admission	Serological type								Un-typed
	1	2	3	4	5	B	C	D	
Mar.	9·4	8·1	22·9	9·4	43·2	2·7	0·0	1·3	2·7
Apr.	10·7	10·7	21·5	6·4	40·8	4·3	1·1	1·1	3·2
May	5·5	4·9	11·6	6·11	58·3	5·5	2·2	2·7	2·7
June	6·0	4·4	4·4	0·0	78·5	1·6	0·5	0·5	3·8
July	4·6	3·1	11·3	4·6	52·9	7·0	5·8	1·9	8·2
Aug.	5·2	3·8	18·8	3·8	54·7	5·7	1·9	1·9	6·6
Sept.	6·0	3·8	19·1	3·1	42·3	4·1	9·8	3·8	7·6
Oct.	14·7	12·8	21·1	14·2	20·9	3·4	10·3	0·0	2·9
Nov., Dec., Jan.	10·4	7·4	12·7	2·9	20·8	4·4	11·9	5·9	11·9

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before the onset of the epidemic, there was already a marked preponderance of type 5 cases in those admitted to hospital. During that month type 5 cases comprised 43·24 per cent of the total, the next largest group of 22·97 per cent being type 3 in origin. During April the proportion of type 5 cases remained approximately the same. In May, with the rise of the epidemic the proportion of type 5 cases mounted to 58·3 per cent and in June had reached 78·5 per cent. From this peak period the proportion of type 5 cases fell during the next three months to 42·3 per cent, but, in the same months, the absolute number of 5 cases remained approximately the same. This fall in the proportion of type 5 cases was largely compensated for by a rise in the number of type 3 strains.

Serological examination of discharge strains

Of the 1581 cases examined on admission, throat and nasal swabs were taken on discharge from 1062 persons and of these 625 or 58·9 per cent yielded no haemolytic streptococci (Table VI). This figure approximated closely to 63·2 per cent of negative swabs noted in the extended survey of discharged cases (Table II). The 41·1 per cent carrier group comprised 31·5 per cent in

Table VI. *Results of examination of discharge throat and nasal swabs grouped according to persistence or otherwise of serological type of haemolytic streptococcus isolated on admission*

Month of admission	Positive admission		Discharge swab results									
			No haemolytic streptococci		Admission type only		Admission type + additional type		Additional type only		No discharge examination	
	Typed	Untyped										
Mar.	72	2	32	1	14	0	3	0	11	1	12	0
Apr.	90	3	35	1	31	0	2	0	13	2	8	0
May	175	5	94	3	40	1	6	1	12	0	23	0
June	175	7	71	2	27	1	4	0	4	2	69	2
July	234	21	117	7	58	3	5	0	11	3	43	8
Aug.	196	15	95	6	53	4	8	0	0	0	40	5
Sept.	290	24	100	8	66	4	6	0	5	0	113	12
Oct.	197	8	46	5	28	0	1	1	4	0	118	2
Nov., Dec., Jan.	59	8	1	1	1	1	0	0	0	0	57	6
	1488	93	591	34	318	16	35	2	60	6	484	35
Total admissions	1581		625		334		37		66		519	
No discharge examination	519											
	1062		58·9%		31·5%		3·4%		6·2%			

whom the type on admission was identical with that isolated on discharge, 3·4 per cent whose discharge swab revealed an additional type together with the admission type, and 6·2 per cent in whom the admission type was absent and replaced by some other type. Thus in 34·9 per cent the admission type was still present in the throat or nose at the time of discharge. Table VII continues this analysis further and shows the combined results on discharge grouped according to the type on admission. The numbers of positive results on discharge in the type 5 and type 3 admission groups were sufficiently large

to yield significant data, and it will be seen that the same types were isolated on discharge, either alone or together with some other type, in 85·1 and 82·9 per cent of these groups respectively. The numbers in the other groups were too small to be expressed as percentages but they all approximated to those in the larger groups. Further, 22·6 per cent of type 5 cases and 28·9 per cent of type 3 cases yielded an additional type on discharge.

Table VII. *Results of examination of discharge throat and nasal swabs, grouped according to type on admission*

Admission examination			Discharge examination									
			(I) No haemolytic streptococci		(II) Admission type only		(III) Admission + different type		(IV) Different type only			
Type	Total	No discharge examination	Total	%	Total	%	Total	%	Total	%	Total	%
A (5)	756	236	317	60·9	157	77·2	16	7·8	30	14·7	203	39·1
B	72	18	30	55·5	22	91·7	1	4·2	1	4·2	24	44·4
C	85	34	30	58·8	15	71·4	2	9·5	4	19·1	21	41·2
D	33	8	20	80·0	5	100·0	0	0	0	0	5	20·0
1	117	33	51	60·7	26	86·5	2	6·6	5	16·6	33	39·3
2	92	32	32	53·3	22	78·5	4	14·2	2	7·1	28	46·6
3	248	85	87	53·3	54	71·1	9	11·8	13	17·1	76	46·6
4	85	38	24	51·1	17	73·9	1	4·3	5	21·7	23	48·9
Untyped	93	35	34	58·9	16	65·2	2	8·7	6	26·1	24	41·1
Total	1581	519	625		334		37		66		437	

In Table VIII are presented the total numbers of the additional types found in throat swabs on discharge in the various admission groups. Of the 103 strains thus isolated, 63 or 61·1 per cent failed to be agglutinated by any of the eight type sera, 17 or 16·5 per cent were type 5 and 15 or 14·5 per cent were type 3, the remaining types constituting only small percentages of the total.

Thus the high carrier rate was, in the main, due to the persistence of the admission types. There was, in addition, a tendency apparently for the predominating types, 5 and 3, to spread to convalescents recovering from infection by other types. This latter finding alone could not be accepted as evidence of

Table VIII. *Numbers of serological types of haemolytic streptococci, other than those present on admission, isolated from discharge throat swabs*

Type on admission	Number of additional discharge types								
	1	2	3	4	5	B	C	D	Untypable
A (5)	1	1	10	—	—	—	—	—	33
B	—	—	—	—	—	—	—	—	2
C	—	—	1	—	1	1	—	—	3
D	—	—	—	—	—	—	—	—	—
1	—	—	—	1	4	—	—	—	2
2	—	—	—	—	2	—	—	—	4
3	1	1	—	1	4	—	—	—	14
4	—	—	1	—	—	—	—	—	5
Untypable	—	—	2	—	6	—	—	—	—
Total	2	2	14	2	17	1	0	0	63

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any enhanced spreading property on the part of these two types since the high concentration of type 5 and type 3 cases in the wards during the epidemic would inevitably result in increased chance of cross infection being due to these types.

Non-agglutinable discharge strains

Among the additional strains isolated on discharge was a large group of 61·1 per cent which apparently did not belong to any of the eight common types. There was the possibility that certain of these may really have represented strains which, owing to continued growth in the secretions of persons undergoing immunization during convalescence, had lost type specificity. An attempt was made, by mouse passage, to raise the virulence of six such strains in the hope that type characters might appear. Each strain was passed, by intraperitoneal injection, through a series of six mice, with intermediate plating on rabbit-blood agar between each passage. The cultures derived from the final passage were then tested against the specific sera but again failed to conform to any of the types.

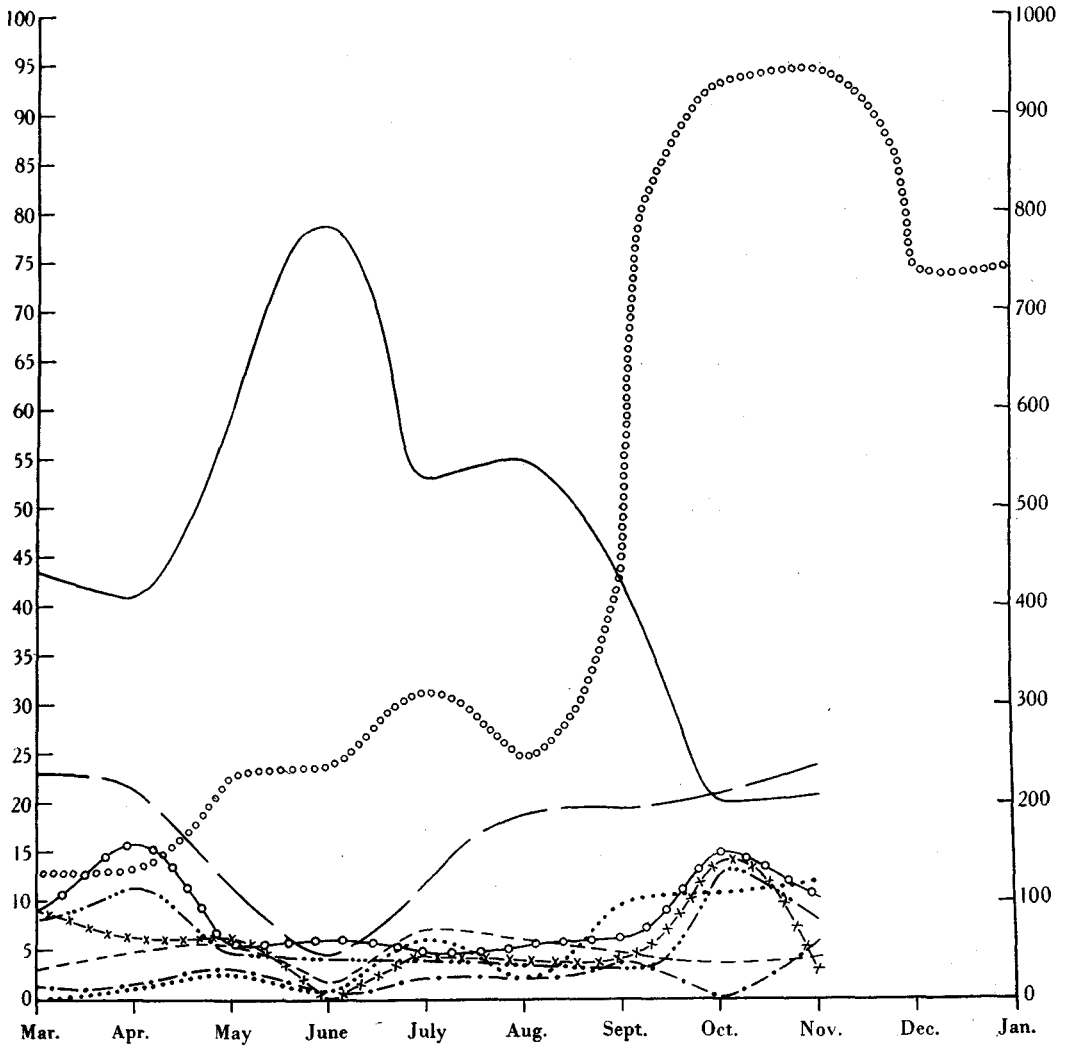
Age incidence

Graph I demonstrates that the majority of cases occurred between the ages of 5 and 15 years. A low incidence at all ages up to 5 years was followed by a very sharp rise in the curve till the peak was reached between 5 and 10. Thereafter the decline in incidence with increase in age was rapid but regular, there being a small rise between 20 and 25. The corresponding data for the years 1931, 1932 and 1934 are included in the graph. There is a striking similarity in the curves for all four years, despite a marked difference in the yearly totals.

During the epidemic year, therefore, the age-group incidence was identical with that of non-epidemic years. The slight secondary rise following the age of 20 years was almost entirely due to cases among young mothers of infant cases.

Discussion

The serological findings are in accord with those investigations which have failed to demonstrate the serological unity of the scarlatinal streptococci. The variation from month to month in the proportion of cases due to the various serological types may serve to explain, in part, the discrepancies noted in previous investigations of this nature. The importance of prolonging the collection of strains from acute cases over a considerable period of time, rather than carrying out an examination of strains gathered during a limited interval, is well illustrated by the variation in the number of type 5 cases. In June, this type was responsible for 78 per cent of all cases, but in September of the same year, for only 42 per cent, i.e. the proportion had fallen by almost half. A limited examination in June only would have led, almost certainly, to the conclusion that the majority of strains from acute scarlatina were of one serological type, whereas a consideration of the September results alone was against such a finding.



Percentage of all cases examined in each month due to:

Type 1 Type 2 Type 3
Type 4 Type 5 Type B
Type C Type D

Number of notifications of Scarlatina in each month:

Graph I. Showing the monthly variation in the percentage number of cases of acute scarlatina due to various serological types of haemolytic streptococci, during the year 1933.

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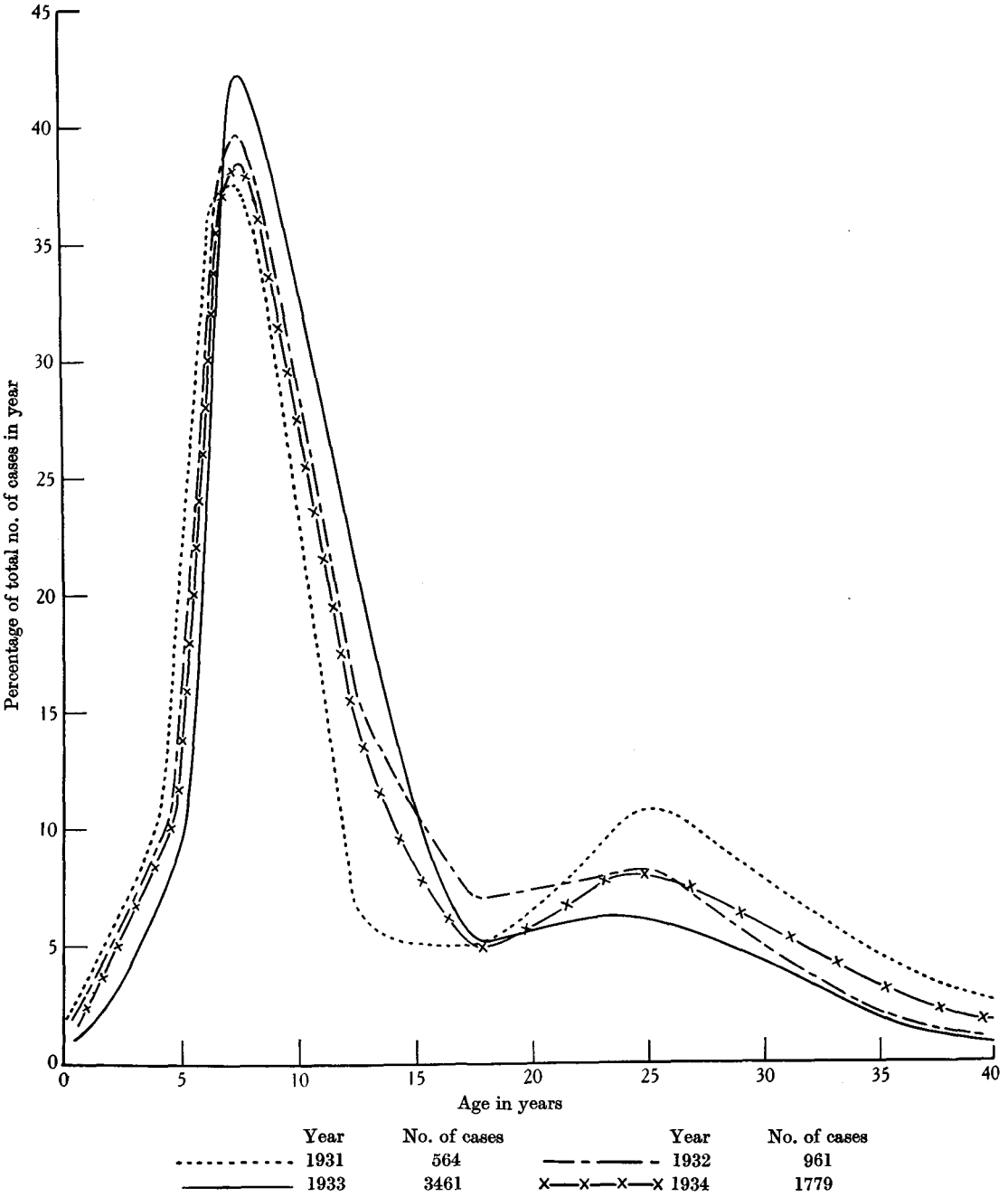

Graph II. Showing the age group incidence, expressed as a percentage of the yearly number of cases of acute scarlatina in Edinburgh during the period 1931–1934.

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Reviewing shortly the age groups in which the cases occurred, there was a remarkable lack of differentiation as between the non-epidemic years 1931, 1932 and 1934 and the epidemic year 1933. Yet during those years there was a very marked difference in the actual number of cases, in 1931 there being a total of 564 and, in 1933, of 3461 or a sixfold increase. Thus during the epidemic year of 1933 all age groups were equally affected by the epidemic since the increase in the number of cases was proportionate in all age groups, the characteristic maximum age-group incidence between the ages of 5 and 9 years being maintained. As far as the exposed population was concerned, there appeared to be two possible explanations for this proportionate increase in case incidence. Firstly, the causal factors of the epidemic were universally at work in all age groups, or alternatively, an increase in the cases at some particular age group was attended by a secondary increase in all other age groups. In the latter event the rise in the primarily affected group would have preceded in time the secondary cases. Instead, the increase was simultaneous in all groups, pointing to the existence of some universal contributory factor.

How far variation in the properties of the causal organism, the haemolytic streptococcus, can be identified with this factor requires further consideration. In this connexion the present investigation revealed several interesting points. Firstly, there was a marked preponderance of one particular type of haemolytic streptococcus, namely 5, during the two-month period preceding the onset of the epidemic. Secondly, the proportion of type 5 cases rose with the early development of the outbreak but had reached a maximum before the epidemic was numerically at its worst. Type 5 at this latter period was still responsible for more cases than any other single type, but the increasing magnitude of the epidemic was maintained by a rise in the proportion of the other types present and, in particular, of type 3. The outbreak of the epidemic was therefore associated with an overwhelming predominance of a single type, but there was a suggestion that it was maintained by a succession of rises in the incidence of all the types present at the outset rather than a continued multiplication of the original predominant type. No evidence was obtained regarding the particular function or property of the organism upon which this rise in the case incidence may depend. Detailed results of an investigation of the toxin production of certain of these strains, isolated at different periods of the epidemic, have been previously reported (Green, 1935). In brief, this study showed that there was no significant variation in the property of toxin production among the strains studied.

There was a distinct tendency for type 5 and type 3 strains to be found with relative frequency in the discharge examination of convalescents, from whom some other type had been isolated in the acute stage. This may have been due to an increased capacity of these particular strains to spread from patient to patient, but a more likely explanation is to be found in the fact that these same strains were in much greater concentration in all wards from the acute stage onwards.

The result of hospitalization was to reduce the number of streptococci in the throat to none or very few in the majority of patients, and in only 5·4 per cent of discharges was there a sufficiently large number present to give rise to any doubt as to the possibility of return cases appearing as a result.

In the greater proportion of those cases in which haemolytic streptococci were recovered on discharge the type present was identical with that isolated on admission. This would appear to indicate that the scarlatinal strains exhibit serological stability to a considerable degree. In a certain number of discharged patients, however, an additional strain was recovered which failed to agglutinate with specific sera against the most frequently encountered types. Continued growth of the original infecting strains in the secretions of persons undergoing active immunization against those strains was thought to be a possible explanation for this inagglutinable type of organism. An attempt to restore the original type characteristics by raising of virulence by animal passage was not successful.

Finally, the results obtained point to the general conclusion that the origin of this epidemic was associated with some still undiscovered property of the infecting organism rather than with any exceptional variation in the affected community.

Summary and conclusions

1. Eight serological types of haemolytic streptococci were recognized in acute scarlatina during the 1933 epidemic in Edinburgh.

2. Five of these types were identical with Griffith's types 1, 2, 3, 4 and 5, while the remainder have been named, provisionally, B, C and D.

3. Type 5 was predominant during the two months preceding the epidemic and throughout the early development of the outbreak.

4. The epidemic was maintained by successive increases in the proportion of cases due to the remaining type, particularly type 3.

5. The age-group incidence in the epidemic year was identical with that of non-epidemic years.

6. 36·8 per cent of patients on discharge were found to have haemolytic streptococci in the throat but in only 5·4 per cent was a large number of organisms isolated.

7. Haemolytic streptococci isolated from discharged convalescents were in the majority of cases of the same type as the admission strain.

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