

Phage types of *Staphylococcus aureus* in one hospital 1961–72

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SUMMARY

Between 1961 and 1972, 4547 independent strains of *Staphylococcus aureus* isolated from one hospital were examined for phage type. After 1967 there was a decline in the number of strains received, which we consider reflects a decline in the number of infections in the hospital, and which was largely accounted for by a great reduction in the number of strains in four 'epidemic' types. Overall, the number of multiple-resistant staphylococci received also declined; this was in part due to the decline in the epidemic types and in part to a reduction in the proportion of multiple-resistant strains of all types.

INTRODUCTION

From 1961 to 1972 strains of *Staphylococcus aureus* isolated from in-patients at St Mary's Hospital, London, were routinely tested for phage-type. This paper summarizes the change in phage-type frequencies over the years and reports, in addition, the antibiotic sensitivities for strains examined between 1964 and 1972.

MATERIAL

We made it a rule that all strains of *Staphylococcus aureus* isolated in our diagnostic laboratory from in-patients were to be tested for phage type and we believe that cultures were taken from practically all lesions in which any infection was suspected. Doubtless some strains were missed and others failed to survive, but we know of no systematic changes occurring over the 12 years that would affect the selection of strains for testing. The number of staphylococcal cultures is therefore an index of the number of cases of staphylococcal infection. We have not been able to distinguish infections acquired in hospital from those already present when the patient was admitted. This analysis is based on strains from blood cultures, wounds, minor septic lesions and urines; it includes only one strain of any one phage type from any one patient.

Phage typing was performed by methods, and with phages, provided by the PHLs Staphylococcus Reference Laboratory, Colindale. All the strains were tested at R.T.D. and untypable strains were retested at 1000 × R.T.D. (from 1961

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Table 1. *Phage types of strains 1961-72*

Phage group	Phage pattern	Number of strains
I	80/81	123
	80; 80/+; 81; 81/+	326
	52/52A/80/81; 52/52A/80/+;	
	52/52A/81/+; 52A/80/81/+	173
	29/52/80; 29/52/+; 29/80/+	286
	29	144
	52A/79; 52A/+; 79/+	164
	Other patterns	318
II	55; 55/+	53
	3C/55/71; 55/71 (+)	75
	Other patterns	223
III	6/7/47/54/75, incl. strains with 3 or more of these reactions	206
	83A; 83A/+	82
	84/85; 84; 85; 84/85/88	269
	77; 77/+	99
	Other patterns	643
Mixed group patterns		416
Untypable		947
Total		4547

Note. No other phage pattern or group of closely related patterns was represented by 50 or more strains.

to 1970) or at $100 \times$ R.T.D. (1971-2); phages 83A, 84 and 85 were not included in the 'concentrated-phage' set. Phages 84 and 85 were not in use during 1961 and 1962, but we have some evidence that strains that would have been lysed by these phages were not then present in more than very small numbers.

The phage types were classified as shown in Table 1. Our definition of type 80/81 is narrower than that used by Parker *et al.* (1974) because preliminary studies showed a striking variation in the prevalence of the type as narrowly defined. Some of the strains classified by Parker *et al.* in the 52, 52A, 80, 81 complex are here included under 'other patterns' in Group I. We have also separated some other types in Group I that we encountered frequently.

Antibiotic sensitivity was determined by the diagnostic bacteriology laboratory using Oxoid 'Multodisks'. Penicillin, tetracycline, chloramphenicol, neomycin, erythromycin and cloxacillin were used throughout; streptomycin was included until 1967; fucidin and cephaloridine were introduced in 1968.

RESULTS

We had available for analysis the phage-typing results of 4547 'independent' strains of *Staphylococcus aureus*. The number received each year fluctuated between about 375 and 500 from 1961 to 1967 and subsequently declined (Fig. 1). As

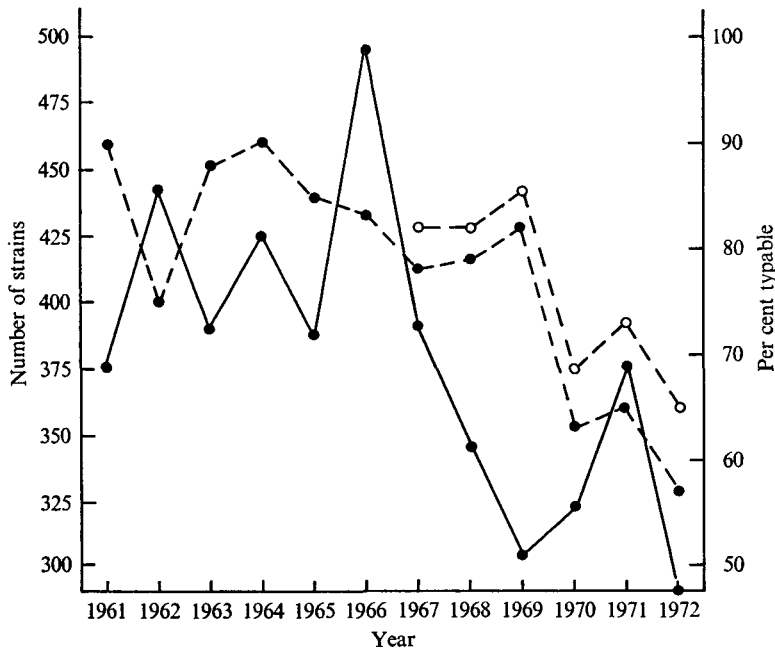


Fig. 1. Number of strains received 1961-72. ●—●, total; ●---●, per cent typable; ○---○, per cent found typable at Colindale.

already noted we believe that this decline reflects a decline in the number of staphylococcal infections recognized in the hospital.

From 1961 to 1969 the proportion of strains that were typable remained at about 80% or more, but in 1970-2 the percentage typable was much lower (Fig. 1). From 1967 to 1972 we contributed a random sample of 100 strains per year to Dr M. T. Parker's survey (Parker *et al.* 1974) and the results of retesting these strains at Colindale show that the decline was not due simply to technical difficulties in our laboratory; at Colindale only 65% of the 100 strains examined in 1972 proved typable, compared with our figure of 57% for the 290 strains typed at St Mary's.

A total of 12 different phage 'types' were each represented by 50 or more strains (Table 1) and 2000 (44.0%) of the total 4547 strains fell into one or other of these, which may be called 'endemic' types; 1600 strains fell into types each represented by only a small number of strains.

The 12 endemic phage types seemed to fall into two groups. Four types (80/81, 83A, 6/7/47/54/75 and 84/85) were very prevalent during the early years (constituting 23% of all strains tested in 1961-4) and then declined (Fig. 2). These are all types that have been widely recognized elsewhere as responsible for 'epidemics' of hospital infection, and may for convenience be termed 'epidemic' types.

The remaining 8 endemic types showed substantial variations in number from year to year but secular trends were not obvious (Fig. 3).

The changes in the distribution over the three groups, epidemic, other endemic

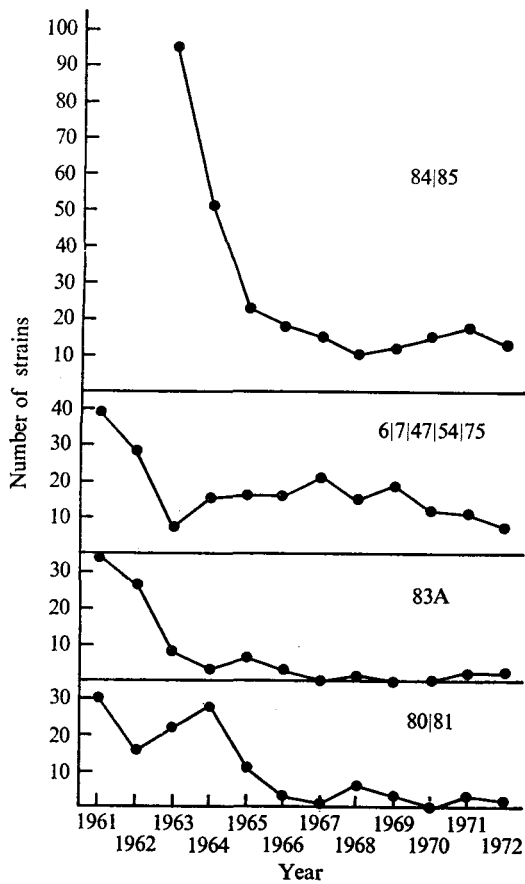


Fig. 2

Fig. 2. Changes in prevalence of epidemic types.

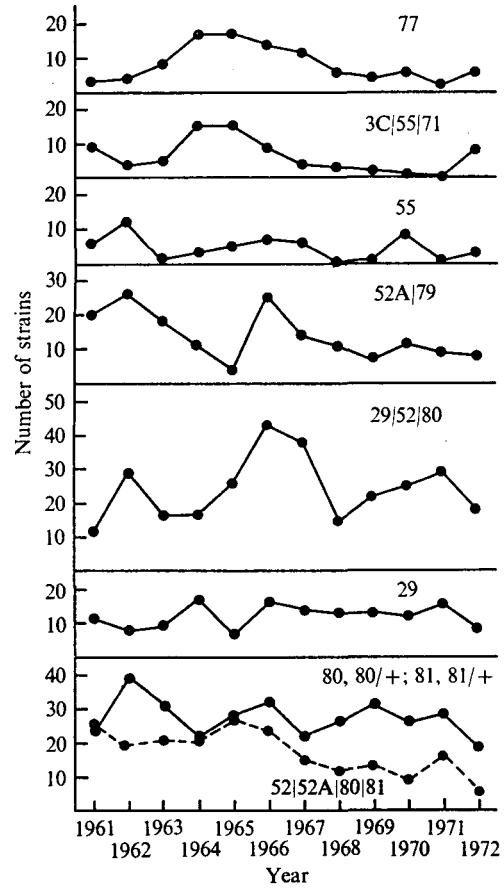


Fig. 3

Fig. 3. Changes in prevalence of non-epidemic endemic types.

and sporadic are illustrated by smoothed curves drawn from 3-year moving averages in Fig. 4. There was a steep decline in the prevalence of the epidemic types between 1964 and 1967, from about 100 per year to about 30 per year. The number of strains of the other endemic types showed, over the whole period, a slight decline, but the numbers of 'other types' and untypable strains showed, if anything, a slight increase from just under to rather over 200 per year. The decline in the total number of strains received is, therefore, accounted for very largely by the decline in frequency of strains in the epidemic and other endemic phage types. In so far as 'strains received' may be equated to 'infections' this appears to indicate a decline in the incidence of infections due to the types that have commonly been associated with epidemics of hospital infection, but little change in the infections due to the great number of sporadic types. Many of these doubtless represent self-infection with staphylococci carried before admission to hospital, or sporadic cross-infections from staff.

Records of antibiotic sensitivity tests were available for almost all the strains

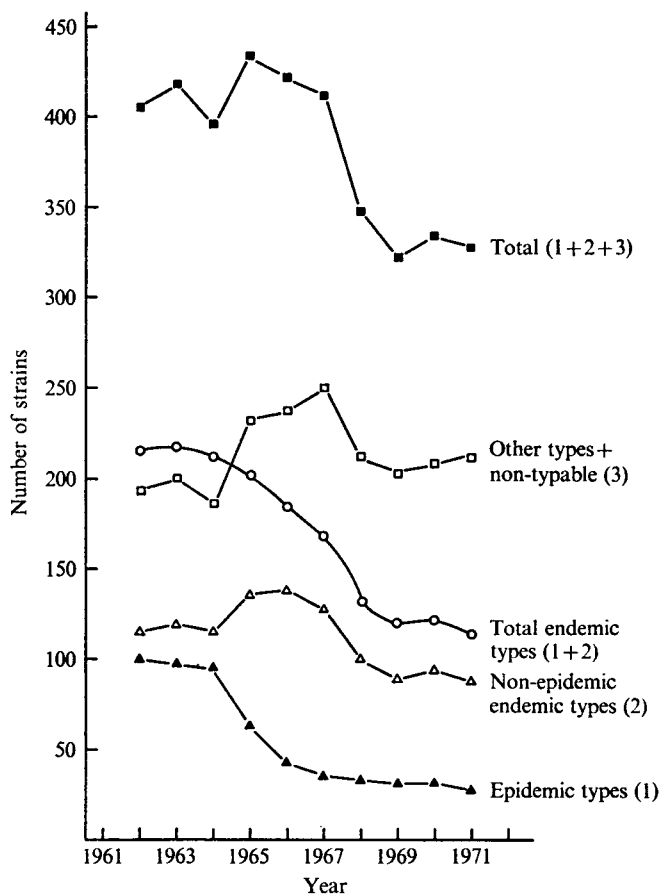


Fig. 4. Prevalence of staphylococci in epidemic, endemic and other types: 3-year moving average, 1962-71.

received from 1964 to 1972. Strains were classed as (S) sensitive to all antibiotics tested, (P) resistant to penicillin but to no other drug, or (M) resistant to penicillin and others, or resistant to other drugs while sensitive to penicillin (multiple-resistant). The year-by-year trend for all strains tested is shown in Fig. 5. There was no consistent variation for the number of sensitive strains received but there was a clear decrease in the number of multiple-resistant strains. After 1965 penicillin-resistant strains were commoner than in 1964 and 1965. The decrease in the number of multiple-resistant strains is clearly associated with, although not fully explained by, the decrease in the number of strains of the endemic types, especially the epidemic types (Fig. 6). Over the 9 years as a whole, 67% of the strains in the epidemic types were multiple-resistant, while 25% were penicillin-resistant and only 8% sensitive. There was a slight decline in the number of multiple-resistant strains and a rise in the number of penicillin-resistant strains in the sporadic types (including untypable strains) (Fig. 7).

The number of strains of individual phage types tested in each year was naturally small, but, as seen in Table 2, the proportion of multiple-resistant strains in

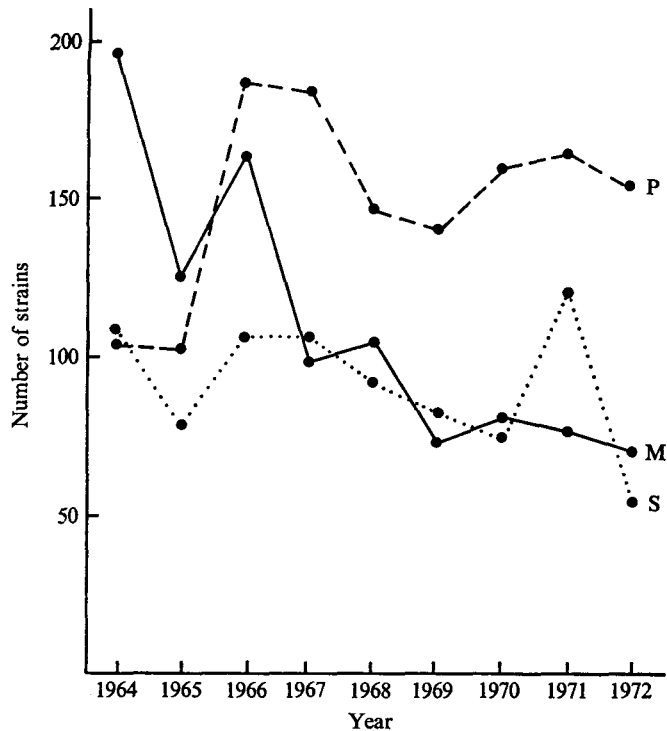


Fig. 5. Prevalence of antibiotic-sensitive (S), penicillin-resistant (P) and multiple-resistant (M) staphylococci, 1964–72.

three of the four epidemic types was lower in 1968–72 than in 1964–7, as was the proportion in other groups of types. The overall decline in the number of resistant strains was therefore only in part due to the disappearance of those types characteristically having a very high proportion of multiple-resistant strains.

DISCUSSION

This report supplements the larger survey reported by Parker *et al.* (1974) within which some of our results were included. Our survey began in 1961 when staphylococcal infection in hospital was a topic of much concern and when 'epidemics' of such infection seemed to be common; by the end of the period, in 1972, epidemics were generally considered to be rare and staphylococcal infections were no longer regarded as so serious a problem.

To the extent that the numbers of staphylococci isolated in our diagnostic laboratory reflect the incidence of infection in the hospital – and we think that they are probably a reasonable indication – St Mary's Hospital has experienced a decline in staphylococcal infection, mostly in the period from 1968 to 1972, and for this reason we have presented the numbers of strains received, rather than the proportion, in various phage-types or resistance categories.

Examination of the trends for a number of phage-types showed immediately that the decline was associated with a striking drop in the numbers of strains in

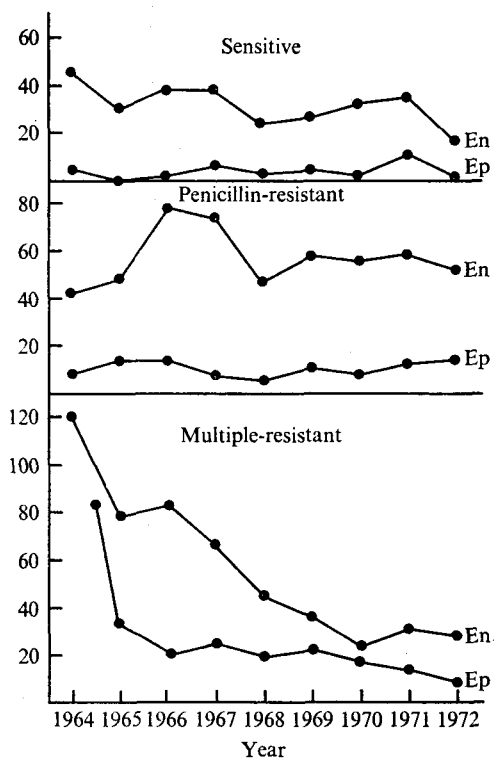


Fig. 6

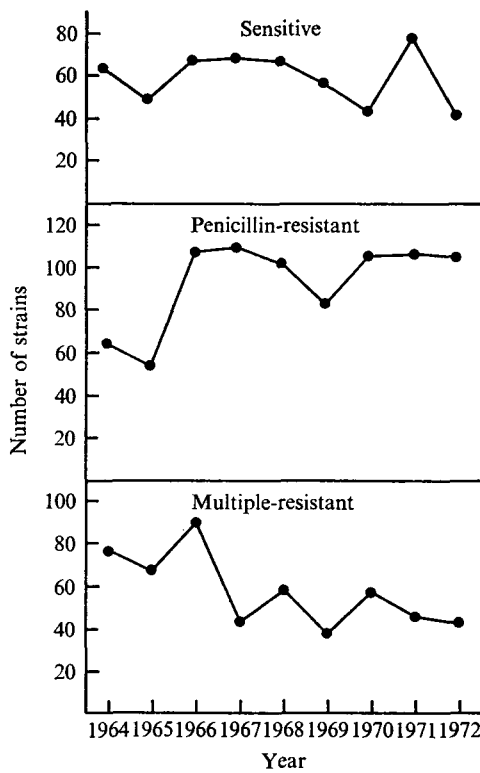


Fig. 7

Fig. 6. Antibiotic sensitivity of strains in epidemic (Ep) and other endemic (En) types.

Fig. 7. Antibiotic sensitivity of strains in sporadic types and of untypable strains.

Table 2. Proportion of multiple-resistant staphylococci in various groups of phage-types, 1964-7 and 1968-72

	Percentage multiple-resistant	
	1964-7	1968-72
Epidemic types 80/81	90 (41)	79 (14)
83A	80 (10)	20 (5)
6/7/47/54/75	34 (61)	46 (59)
84/85	94 (100)	58 (66)
Total endemic types	45 (715)	29 (565)
Other types and untypable	31 (264)	24 (1015)

Figures in parentheses = number of strains.

four types, 80/81, 6/7/47/54/75, 83A and 84/85. These are all types that have been recognized as causing 'epidemics' in hospitals in many parts of the world. In other analyses there have been indications that particular epidemic types were 'replaced': 80/81 by 52/52A/80/81 and similar strains, and 83A by 84/85 and so on. There is no clear evidence of such replacement in our data for numbers, as opposed to proportions, in particular types. There was a smaller drop in infections due to three of the other seven 'endemic' types, namely 77, 3C/55/71 and 52A/79. About half (46 %) of the strains tested in 1961 fell into one or other of a very large number of phage types, each represented by very few strains, or were untypable; there was no significant decline in infections due to these strains over the 12 years, which therefore increased in relative prevalence and constituted 66 % of the total received in 1972.

The decline in infections may therefore be accounted for by the great decline in the frequency of strains in a few 'epidemic' types.

We have no records of antibiotic sensitivity during the first three years of the survey, but from 1964 onwards there was a decline in the number of infections due to multiple-resistant staphylococci and little change in the frequency of infections due to sensitive strains or strains resistant only to penicillin. In part the decline in multiple-resistant strains is attributable to the decrease in the number of strains in the generally resistant epidemic types, but there was also a decrease in the proportion of multiple-resistant strains in all the groups of strains.

One can only speculate on the cause of these changes. An isolation ward was opened in the hospital in 1961 and was replaced by a larger isolation ward in 1966; these wards were used to segregate patients with overt staphylococcal infections. There was over the years a steady increase in the general 'hygienic' facilities in the hospital and latterly the use of pre-sterilized and disposable materials. We have not had an explicit antibiotic policy. It may be that a progressive increase in the efficiency of our hygienic precautions has hindered the transmission of the multiple-resistant staphylococci and that perhaps, as Parker *et al.* (1974) have suggested, an increase in the range of antibiotics available has altered the selection pressures that formerly operated in favour of the epidemic strains. Or it may be that we are going through a fortunate period when there happen to be no very communicable staphylococci in circulation.

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REFERENCE

- PARKER, M. T., ASHESHOV, ELIZABETH H., HEWITT, J. H., NAKLA, L. S. & BLOCK, BRENDA M. (1974). Endemic Staphylococcal Infections in Hospitals. *Annals of the New York Academy of Sciences* (in press).