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Surveys of hospital infection in the Birmingham region

I. Effect of age, sex, length of stay and antibiotic use on nasal carriage of tetracycline-resistant *Staphyloccus aureus* and on post-operative wound infection

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SUMMARY

Cross-sectional surveys of infection in relation to ward structure and practice were made in 38 hospitals between 1967 and 1973, including repeat surveys in 12 hospitals. The survey team (a research nurse and a senior microbiologist or technician) visited one ward a day and entered data on patients, including appearance of wounds seen at change of dressings, on the structure of the ward, and on ward practices; bacteriological swabs were taken from noses of all patients and staff of wards visited and from infected or open wounds, also from some environmental sites. Effect of age, sex, length of hospital stay and antibiotic use on carriage of tetracycline-resistant *Staphylococcus aureus* and on post-operative sepsis are considered here.

Clinical infection (sepsis), further classified as 'severe', 'moderate' or 'mild' in accordance with a code of physical signs, including inflammation and suppuration, was found in 6·1% of clean undrained operation wounds. Drained wounds and those through hollow, heavily colonized viscera ('contaminated' wounds) had higher sepsis rates than undrained and 'clean' wounds; there was less sepsis with closed drainage and with small drains. *Staph. aureus* (24%) was the commonest single bacterial species, but gram-negative bacilli (50%) were found in a much larger proportion of septic wounds. The results showed that the infection rate was lowest among patients between 20 and 40 years old. Infection was significantly more common in male than in female patients.

Nasal carriage of tetracycline-resistant *Staph. aureus*, used as an index of hospital-acquired infection, was commonest in geriatric patients and least common in gynaecological patients. There was correlation between nasal carriage of tetracycline-resistant staphylococci and age of the patient, length of hospital stay, sex, (male greater than female), operative treatment, and treatment with tetracycline, ampicillin and nitrofurantoin, but not with penicillin.

INTRODUCTION

Rates of hospital infection are commonly assessed by continuous surveillance which gives useful evidence of fluctuations in endemic infection and of the development of outbreaks in individual hospitals. For comparison of infection rates in different hospitals, cross-sectional (or prevalence) surveys carried out by a team which visits each hospital for a period of days or weeks is an appropriate method (Eikhoff, Brackman, Bennett & Brown, 1969).

To assess current rates of infection and their relation to hospital structure and practices, a series of cross-sectional surveys has been made in the Birmingham region. Between 1967 and 1973, 38 hospitals were visited and repeat surveys were made in 12 hospitals. Most of those visited were general hospitals, both large and small, including hospitals in the teaching group; a number of small specialized units were also visited, including neurosurgical, thoracic, ophthalmic, orthopaedic, accident, skin, and ear, nose and throat hospitals. Preliminary reports have been published on aseptic practices (Ayliffe, Brightwell, Collins & Lowbury 1969), on the incidence of infection (Ayliffe, 1971), and on the use of antibiotics (Ayliffe, 1973).

In this paper we describe the techniques of the survey and the influence of age and sex of the patient on the incidence of wound infection, also the influence of length of stay in hospital, of surgery and of the use of antibiotics on the nasal carriage of tetracycline-resistant *Staph. aureus*. Tetracycline-resistant strains were rarely isolated from the noses of the general population outside the hospital at the time of the survey; it was, therefore, assumed in this study that resistant strains were acquired in hospital, and carriage of such strains was used as an index of cross-infection. A nasal swab is also a convenient method for sampling all patients, irrespective of age, disease or general condition. The relation of the age and size of hospital, ward structure and practices to wound infection and nasal carriage will be reported in a further paper.

TECHNIQUE OF SURVEY

Before the first survey of a hospital, a preliminary visit was made to discuss details of the study with senior members of the medical, nursing and administrative staff. Agreement for the survey was obtained from the Medical Staff Committee. In the survey, a team consisting of the Research Nurse and a Consultant Microbiologist or a Technician visited the wards, one ward per morning, and collected data which were entered on specially designed forms. Information about a patient's age, sex, date of admission, diagnosis, date of operation, wound sepsis or other infection and antibiotic treatment at time of visit, were recorded on one form, and details of ward structure and aseptic and domestic practices were recorded on other forms. The nurse or microbiologist attended the routine dressing of wounds and recorded the presence or absence of sepsis by criteria described below. Information on all acquired infections and on antibiotic treatment was obtained from case-notes, ward records and temperature charts and from discussion with the ward sisters. Criteria for infections other than those of wounds were similar to those used in a study by the Centre for Disease Control, Atlanta (Garner *et al.* 1971). Nose swabs were taken from all patients and staff in the ward at the time of the visit and from all infected operation wounds or other open lesions. Many samples were taken from environmental sites, especially 'wet' areas or equipment.

The information on the forms was transferred initially to punch cards by the Regional Health Authority and later to computer tape for analysis. The data were analysed by the Bio Medical Section of the Department of Production Engineering, Aston University, using their ICL 1904S computer. Statistical significance tests (chi squared) and computer assisted regression analysis and curve fitting techniques were used in the analysis.

BACTERIOLOGICAL METHODS

Wound and lesion swabs were cultured aerobically on blood agar and MacConkey plates. Nose swabs were cultured on nutrient agar containing 1% horse serum, diphenolpthalein diphosphate for recognition of presumptive *Staph. aureus* (Barber & Kuper, 1951) and tetracycline (10 μg/ml). Tetracycline was not included in plates used for culturing nose swabs from maternity units, where cross-infection commonly occurs with antibiotic sensitive strains, or strains resistant to penicillin only, probably because the adult patients were young females staying in hospital for a short time only. Swabs taken from a number of environmental sites were cultured on blood agar, MacConkey's medium, improved cetrimide agar (Brown & Lowbury, 1965) and in nutrient broth. Some sterile fluids and disinfectants were also examined for possible contamination. Antibiotic sensitivity tests were made by a ditch-plate, or disk diffusion method, on strains of *Staph. aureus* isolated from noses and lesions, and on gram-negative bacilli isolated from lesions. Most strains of *Staph. aureus* isolated from wounds or lesions were phage typed (Blair & Williams, 1961).

DEFINITIONS

Wound infection

Operation wounds were divided into three categories modified from those described in a survey made in the USA (National Research Council, 1964) as follows.

Clean wounds

An operation not transecting gastro-intestinal, genito-urinary or tracheobronchial systems and not performed in the vicinity of any apparent inflammatory reaction.

Clean-contaminated

An operation transecting one of the above systems, where bacterial contamination could occur but evidence of contamination was uncertain, e.g. operations on the stomach, gall-bladder and bladder.

Contaminated

An operation transecting systems where bacteria are known to be present (and usually abundant), or in the vicinity of apparent inflammatory reactions, e.g. operations on colon, perforated appendix, mouth.

Table 1. *Type of wound and infection rate*

	Types of wound							
	Clean		Contaminated		Clean contaminated		Not known	Total
	ND	D	ND	D	ND	D		
No. in group	1553	560	134	232	393	476	6	3354
Percentage infected (all infections)	6·1	15·5	30·6	47·4	16·0	25·2	0	15·4
Percentage infected (purulent wounds)	3·4	6·3	18·7	31·9	9·2	10·3	0	6·9

ND, not drained; D, drained.

Wounds were described as having (1) no infection; (2) redness of edges and serious discharge; (3) pus; or (4) cellulitis. The presence of haematoma, sinuses or fistulae, wound breakdown, slough, or deep abscess was recorded. The presence or absence of a drain was also recorded.

Wounds described as clinically infected were graded as mild, moderate or severe. Doubtful infections, mild infection of drainage wounds and wounds previously infected but healed at the time of the survey were also recorded.

Severity of infection was defined as follows.

Mild. A small or superficial area of inflammation with minimal discharge.

Moderate. Superficial inflammation of whole wound (or over one third) with a serous exudate or small amount of purulent discharge; or a deeper infection involving a small area (one third or less) usually with a purulent discharge.

Severe. A deep purulent infection with or without sinuses or fistulae, or widespread cellulitis, or wound breakdown with an obvious inflammatory reaction and pus.

The appearance of wounds was very variable and the grade of severity, although based on the above definitions, was a personal opinion of the observer. However, some consistency was ensured, because all wounds were examined and assessed by one or the other of two observers.

RESULTS

Wound infection rate

The incidence of post-operative clinical infection of wounds is shown in Table 1. Doubtful infections and certain categories of operation, e.g. vaginal, rectal, traumatic and drainage of abscesses have been excluded; the infection rate in each class is the percentage of clinically infected wounds except those in the categories excluded. As expected, drained wounds showed a higher infection rate than those which were not drained, and contaminated wounds showed a higher infection rate than clean-contaminated or clean wounds. If pus is considered to be the only criterion of infection, the infection rate is halved.

Table 2 shows infection rates in wounds with different types of drain. Lower rates were found in wounds with smaller drains or closed drainage systems, e.g. 'Redivac'.

Table 2. *Type of drain and wound infection rate*

Type of drain	Number of Patients	Percentage infected
Redivac	497	17·1
Corrugated	223	37·7
Large tube	273	28·9
Wick	19	26·3
Small tube	155	20·6
More than one drain	69	40·6
Total	1236	25·3

Table 3. *Percentage of wounds which yielded bacteria*

	Percentage
Staph. albus	13
Staph. aureus	24
E. coli	17
Proteus sp.	15
Klebsiella-enterobacter sp.	11
Ps. aeruginosa	7

Table 4. *Wound infection rate and age of patients*

Age group	No. in group	Percentage infected
1–9	177	13·6
10–19	234	12·0
20–29	310	11·3
30–39	316	11·4
40–49	458	13·1
50–59	551	16·2
60–69	614	21·2
Total	2660	15·1

Bacteria of infected wounds

Swabs were taken from 906 wounds, including mild infections of drained sites and doubtful infections which were excluded from the analysis. The bacteria which were isolated are shown in Table 3. More than one organism was often isolated from a wound. Most of the swabs which did not yield one or more of these organisms showed no bacterial growth.

Age and wound infection rate

Patient ages were classified in seven groups for convenience and, to provide an adequate number in each group, 10 years was taken as the interval. Wounds in the first year of age were excluded for the purpose of this analysis, since most of these patients were neonates. The results are shown in Table 4 and Fig. 1. Although a high correlation coefficient was found between wound infection rate and age, a linear regression equation does not represent the relation satisfactorily. This can, however, be well represented by a simple quadratic, $Y = A - BX + CX^2$, where Y is the infection rate, X the age and A, B and C are constants. For the data on

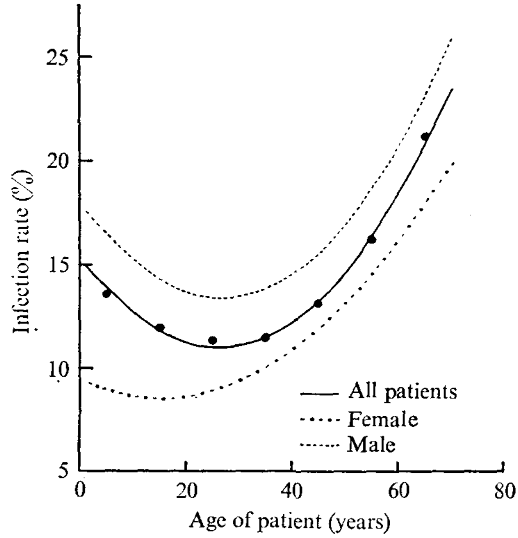

Fig. 1. The relation between age and wound infection rate.

infection in relation to age of patient the following equation gives the best fit, with a sum of squared deviation (SSD) of 0·5 which absorbs more than 99 % of the variance about the mean; $Y = 15{\cdot}35 - 0{\cdot}34X + 0{\cdot}0065X^2$; differentiating to obtain the minimum value for Y,

$$\frac{dy}{dx} = 0,\ x = 26.$$

These data therefore suggest a minimum infection rate about the age of 26, with the infection rate increasing for younger or older ages.

Sex and age of patients and wound infection rate

The patients in the same age-groups were further classified according to sex. The total infection rate was significantly higher in male patients (17·7 %) than in female patients (12·5 %) ($\chi^2 = 18{\cdot}8$, 1 D.F., $P < 0{\cdot}005$).

Since the type of surgery is often different in male and female patients, a comparison was made of infection rates in operations common to both sexes. The operations were mainly gastrectomy and related operations, cholecystectomy, appendicectomy, hernia repair, varicose-vein stripping, colectomy and nephrectomy.

Table 5 shows that there is still a significant difference ($\chi^2 = 4{\cdot}7$, 1 D.F., $P < 0{\cdot}05$) in infection rates of male and female patients when only operations common to male and female patients are included in the analysis; infection rates were lower in female patients in all age groups except in those of 60–69 years.

As in the analysis for all groups of patients, there is a high correlation coefficient between age and wound infection rate for both male and female groups when analysed separately, and the data can be well represented by simple quadratics. The equation for the male patient group is

$$Y = 18{\cdot}18 - 0{\cdot}359X + 0\ 0067X^2,\ \text{SSD} = 5{\cdot}4.$$

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Table 5. *Age of patient and wound infection rate following operations common to males and females*

Age group	Males: No. in group	Males: Percentage infected	Females: No. in group	Females: Percentage infected
1–9	39	25·5	17	11·8
10–19	37	21·6	45	8·9
20–29	43	27·9	58	12·1
30–39	37	21·6	47	12·8
40–49	98	16·3	65	13·9
50–59	125	20·0	76	10·5
60–69	107	23·4	89	28·1
⩾ 70	64	20·3	68	19·1
Total	550	21·3	465	15·9

Table 6. *Type of patient and nasal carriage rate*

	Number of patients	Carriage rate (%)
General surgery	2785	9·6
General medicine	2172	10·5
Gynaecology	575	2·4
Obstetrics	1363	4·0
Paediatrics	659	4·0
Orthopaedic	835	8·5
Geriatric	494	23·5

which absorbs 93 % of the variance about the mean and has a minimum at 27 years. For female patients

$$Y = 9{\cdot}49 - 0{\cdot}118X + 0{\cdot}0038X^2,\ \mathrm{SSD} = 6{\cdot}5,$$

which absorbs nearly 98 % of the variance about the mean and has a minimum at 15 years. The two curves are shown in Fig. 1. The difference in infection rate due to the sexes was greater in the younger age groups.

Nasal carriage of tetracycline-resistant Staph. aureus

The incidence of nasal carriage in the main groups of patients is shown in Table 6. Carriage is defined as the presence in the nose of a strain of *Staph. aureus* resistant to tetracycline. The carriage rate is the percentage of patients carrying these strains. There was little difference in the carriage rate of general medical and surgical patients, but the rate for geriatric patients was much higher, and rates for gynaecological, obstetric and paediatric patients were much lower.

Age of patient and carriage rate

Since neonates rarely acquire multiple-resistant strains, but many acquire strains which are antibiotic-sensitive or penicillin-resistant only, data on patients of 1–70 years were used in the analysis, divided into age groups as before. The incidence of nasal carriage in these is shown in Table 7 and Fig. 2.

Table 7. *Nasal carriage rate and age of patient*

Age group	No. in group	Carriage rate (%)
1–9	766	6·1
10–19	717	4·5
20–29	1340	5·2
30–39	991	4·6
40–49	1200	6·3
50–59	1622	9·6
60–69	1890	10·9
Total	8526	7·4

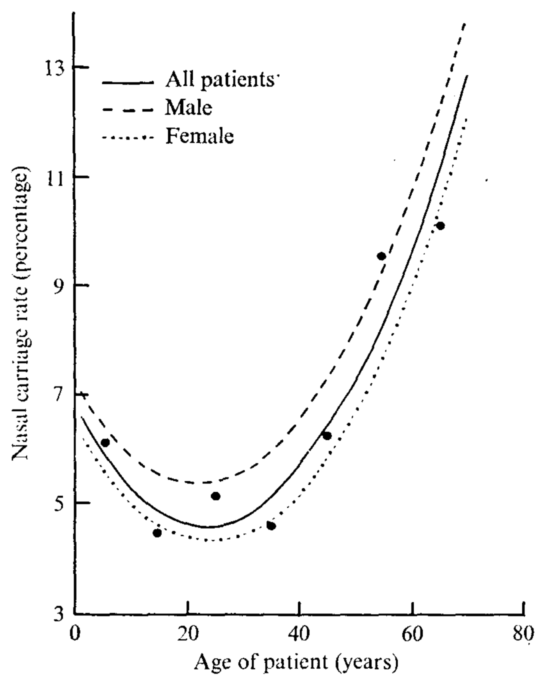

Fig. 2. The relation between age and nasal carriage of tetracycline-resistant *Staph. aureus*.

A high correlation coefficient was found to exist between the rate of carriage and the age of a patient, and a quadratic gave the best representation of the data. The best equation is:

$$Y = 6{\cdot}718 - 0{\cdot}179X + 0{\cdot}0038X^2;\ \text{SSD} = 2{\cdot}08,$$

where Y is the nasal carriage rate at age X. The proportion of the variance about the mean absorbed is 95%. The minimum carriage rate appears at 23·5 years.

Male and female carriage rates

As in the case of the wound infection analysis, the results for nasal carriage were further classified into male and female groups. The nasal carriage rate for male patients was 8·43% and that for female patients (6·47%) was found to be signifi-

Table 8. *Nasal carriage rate and length of stay in hospital*

Days in hospital	No. in group	Carriage rate (%)
1–2	2362	3·6
3–4	1517	4·0
5–6	1206	4·7
7–8	1042	6·3
9–10	758	6·5
11–15	1388	8·9
16–20	792	12·1
21–30	916	15·0
31–40	446	20·4
41–50	275	18·5
51–80	396	18·4
Over 80	618	19·4
Total	11716	8·6

cantly lower ($\chi^2 = 12{\cdot}1$, 1 D.F., $P < 0{\cdot}005$). A quadratic again gave the best representation of the data.

The carriage rate for male patients is given by the equation:

$$Y = 7{\cdot}17 - 0{\cdot}164X + 0{\cdot}0037X^2;\ \text{SSD} = 4{\cdot}06,$$

with 90 % of the variance about the mean absorbed and a minimum carriage rate at 22 years.

The carriage rate for female patients is given by the equation:

$$Y = 6{\cdot}49 - 0{\cdot}18X + 0{\cdot}0037X^2;\ \text{SSD} = 2{\cdot}08,$$

with 94 % of the variance about the mean absorbed and a minimum carriage rate at 24 years.

Nasal carriage and length of stay in hospital

The length of stay of the patient was considered for this analysis to be the number of days spent in hospital up to the day the nose swab was taken. The length of stay was divided into 12 groups varying in size from 1–2 days to over 80 days. An interval of 2 days was taken for the first 10 days and then varying time intervals were taken to give reasonable group sizes for analysis. Table 8 gives the classification of nasal carriage rates of all patients in the survey into categories depending on their length of stay in hospital.

From Table 8 it is evident that the maximum rate of carriage was reached by 31–40 days. The carriage rate increased rapidly at first, and was then more or less stabilized. Over the first 40 days a linear relation between carriage rate and length of stay fits the data very closely, with a correlation coefficient as high as 0·998. The best fit is given by the equation:

$$Y = 2{\cdot}52 + 0{\cdot}507X,$$

where Y is the nasal carriage rate and X the length of stay.

Beyond 40 days an empirical curve can be drawn to represent the observations and this is shown in Fig. 3.

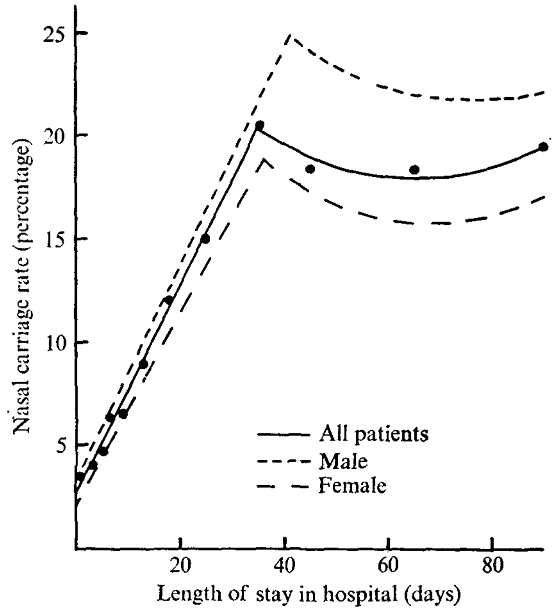

Fig. 3. The relation between length of stay in hospital and nasal carriage of tretacycline-resistant *Staph. aureus*.

Carriage rate for male and female patients

The patients in each length of stay group were further grouped in relation to length of stay by sex. The male patients reached a maximum carriage rate at 41–50 days, and the female group at 31–40 days. After reaching the maximum level of carriage, both rates were more or less stabilized. The data can again be represented by a linear function followed by an empirical curve. The regression equation for male patients up to the 41–50 day group was:

$$Y = 3{\cdot}235 + 0{\cdot}523X,$$

with a correlation coefficient of 0·988.

The regression equation for female patients up to the 31–40 day group was:

$$Y = 2{\cdot}11 + 0{\cdot}467X,$$

with a correlation coefficient of 0·982.

Figure 3 shows that the carriage rate for males was higher than that for females at all lengths of stay and that the male carriage rate reached a higher level, associated with the maximum carriage rate being attained somewhat later. The apparent fall in carriage rate after reaching a maximum is probably due to differences in sample sizes in the different age groups.

Age, length of stay and nasal carriage rate

Since carriage increases with age, the increase with length of stay might be due to the presence of geriatric patients who are often in hospital for long periods. Patients were therefore classified in two major age groups, 0–59 years and 60 years and over and were further classified in terms of the length-of-stay categories previously described.

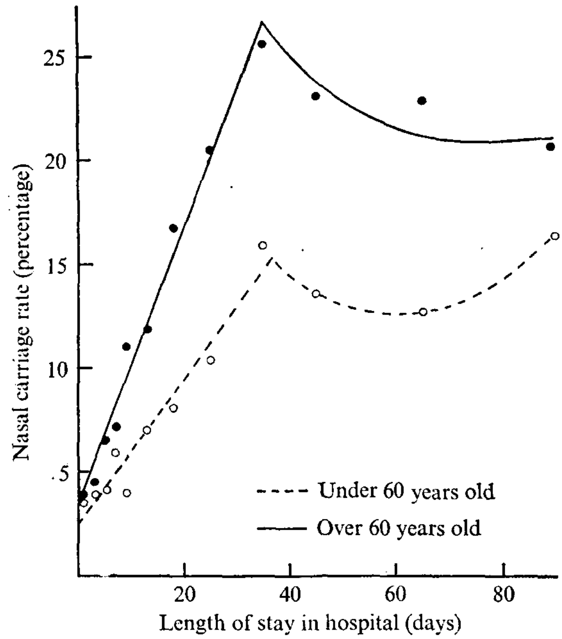

Fig. 4. The relation between length of stay in hospital and nasal carriage of *Staph. aureus* for two age groups.

As expected, the patients in the $\geqslant$ 60 years old group have a significantly higher carriage rate than the 0–59 years old group (χ^2, 1 D.F. = 180·0, P < 0·005). For patients staying up to 6 days in hospital, the difference between the two age groups was not significant (χ^2 = 2·33, P < 0·10) but the difference was significant in patients staying in hospitals over 7 days.

The relation between nasal carriage and length of stay for both age groups was similar to that previously described, i.e. reached a stabilized state after a linear increase in carriage rate up to 30–40 days in hospital. This is shown in Fig. 4. Both age groups reached the maximum carriage rate in 31–40 days, but the older patients showed a higher rate of increase. The regression equation for the 0–59 years group was:

$$Y = 2{\cdot}44 + 0{\cdot}352X,$$

with a correlation coefficient of 0·974.

For the over 60 years group:

$$Y = 3{\cdot}42 + 0{\cdot}666X,$$

with a correlation coefficient of 0·991.

A further subdivision into males and females showed that male patients had a significantly higher carriage rate in the over 60 group (χ^2, 1 D.F. = 4·11, P < 0·05). For patients staying less than 10 days or over 50 days in hospital in this age group, the difference in carriage rates between male and female patients was not significant. However, for patients staying in hospital between 11 and 49 days, the difference between male and female patients was significant (χ^2, 1 D.F. = 5·33, P < 0·025).

Table 9. *Nasal carriage rates in operated and non-operated patients*

	Operated	Non-operated
Number of patients	4159	7557
Carriage rate (%)	9·5	8·2
Male (number of patients)	10·6 % (1966)	8·6 % (3357)
Female (number of patients)	8·4 % (2193)	7·8 % (4200)

Table 10. *Nasal carriage rates and antibiotic treatment*

	No antibiotic	One or more antibiotic
Number of patients	8594	3122
Carriage rate (%)	7.5	11·6
Male (number of patients)	7·8 (3703)	12·8 (1620)
Female (number of patients)	7·3 (4891)	10·3 (1502)

In the 0–59 year group the difference between the total carriage rate for male and female patients was not statistically significant (χ^2, 1 D.E. = 3·36, $P <$ 0·10 > 0·05), although significant differences were shown for patients staying over 50 days (χ^2, 1 D.F. = 4·7, $P <$ 0·05) and between 11 and 50 days in hospital (χ^2, 1 D.F. = 4·27, $P <$ 0·05). The difference between male and female carriage rates was not significant for patients staying up to 10 days in hospital.

Nasal carriage of resistant Staph. aureus *in operated and non-operated patients*

Table 9 shows the nasal carriage rate in operated and non-operated patients. There was a higher carriage rate in the operated group (9·45 %) than in the non-operated (8·16 %). This difference is statistically significant (χ^2, 1 D.F. = 5·46, $P <$ 0·025). The difference between the two groups was significant for male patients (χ^2, 1 D.F. = 5·95, $P <$ 0·025), but not for females (χ^2, 1 D.F. = 0·6).

Chemotherapy

Patients receiving one or more antibiotics (or other chemotherapeutic agents) at the time of the survey were included in the 'antibiotic' group and were further divided into male and female groups. Table 10 shows that patients receiving antibiotics had a significantly higher carriage rate than those not receiving antibiotics (χ^2 1 D.F. = 48·8, $P <$ 0·005). In the antibiotic-treated, but not in the untreated group, males showed a significantly higher carriage rate than females (χ^2 1 D.F. = 4·99, $P <$ 0·05). The results also show that 26·6 % of patients were treated with antibiotics, and that more males (30·4 %) than females (23·5 %) received antibiotics. Surgical operation showed a variable effect on these groups, which is summarized in Table 11.

Table 11. *Nasal carriage in relation to operation, antibiotic use and sex*

Test	χ^2	D.F.	Status
Male operated antibiotic *v.* no antibiotic	9·5	1	Significant ($P < 0{\cdot}005$)
Male non-operated antibiotic *v.* no antibiotic	21·19	1	Significant ($P < 0{\cdot}005$)
Female operated antibiotic *v.* no antibiotic	1·8	1	Not significant
Female non-operated antibiotic *v.* no antibiotic	13·3	1	Significant ($P < 0{\cdot}005$)
Operated no antibiotic male *v.* female	0·96	1	Not significant
Operated antibiotic male *v.* female	5·29	1	Significant ($P < 0{\cdot}025$)
Non-operated no antibiotic male *v.* female	0·09	1	Not significant
Non-operated antibiotic male *v.* female	0·84	1	Not significant

Table 12. *Nasal carriage rate in relation to types of antibiotic*

Antibiotic	Number in group	Carriage rate (%)	χ^2, 1 D.F.	Significance
None	8594	7·5		
Streptomycin	267	9·4	1·31	NS
Erythromycin	43	11·6	1·02	NS
Nitrofurantoin	131	22·9	43·2	Sig.
Sulphonamide	126	11·9	3·2	NS
Cloxacillin	281	10·0	2·6	NS
Penicillin	463	6·3	1·01	NS
Ampicillin	1058	10·4	10·7	Sig.
Tetracycline	634	14·8	42·3	Sig.
Neomycin	57	7·01	0·001	NS
Topical applications other than neomycin	221	8·1	0·07	NS

The effect of administration of individual chemotherapeutic agents is shown in Table 12. The statistical significance of each agent was tested against the no antibiotic group for differences in carriage rate. A significantly higher carriage rate is shown for patients treated with tetracycline, ampicillin and nitrofurantoin. Patients treated with benzylpenicillin or an oral penicillin showed a lower carriage rate than in the untreated group, but this was not significant. Other antibiotics such as fusidic acid or cephalosporins were not included, as their use was too infrequent.

DISCUSSION

This study differs from others on factors related to hospital infection in that the results are based on cross-sectional or prevalence surveys. In addition to providing data for computer analysis of factors in wards related to wound infection or staphylococcal cross-infection, information was obtained in a variety of different

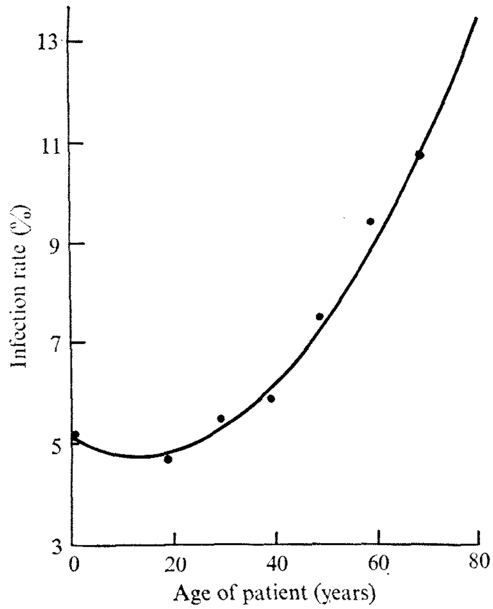

Fig. 5. The relation between age and wound infection rate (derived from National Research Council results (1964)).

hospitals. Reports were sent to the hospitals surveyed and improvements were often subsequently made (Ayliffe *et al.* 1969). However, the number of operation wounds was usually too small to compare infection rates in different hospitals.

The total rate for acquired infection reported (Ayliffe, 1971) was 10·4 % which is higher than the rate usually obtained from continuous surveys. The infections were mainly of the urinary tract (2·9 %), surgical wound (3·4 %), and respiratory tract (3·2 %). Since it was often difficult to decide whether infections other than those of surgical wounds were acquired in hospital, the analysis was made from infections of surgical wounds only. Whenever possible a wound was examined personally by one or two observers, but occasionally this was not possible and the infection was classified by the ward staff. Definitions of infected wounds are variable, and as the presence of pus is often the accepted criterion of assessment by ward staff, this criterion was included. For the purpose of this study, all infected wounds in the categories 'mild', 'moderate' and 'severe' were included in the analysis. Although over 3000 operation wounds were included, the numbers in individual categories were too small to be analysed separately with the factors under investigation.

The total incidence of wound sepsis is related to age and sex and the quadratic curves shown in Fig. 1 are similar to one we have derived from the data in the Report of the National Research Council of the USA (Fig. 5). Similar wound infection rates using purulence as a criterion have been reported (Cruse, 1970; Davidson, Clark & Smith, 1971). The higher infection rate in males, shown in this study was not shown in other large studies on wound infection, but infection rates in operations common to males and females in this study still showed a significantly higher incidence in males. As expected, the percentage of staphylococcal wound infections was lower than that found in the earlier surveys (Public Health Laboratory Service, 1960) and was associated with a relative increase in infections with gram-negative bacilli.

Nasal carriage of tetracycline-resistant *Staph. aureus* is a convenient method of measuring cross-infection transmitted on dry vehicles or in the air of the hospital. A swab was easily obtained from all patients, and tetracycline resistance is a suitable measure of hospital acquisition except in neonatal wards. *Staph. aureus* spreads in the air as well as by contact, and is the pathogen most likely to be influenced by changes in general environmental conditions, such as overcrowding or subdivision of wards. The correspondence of our findings on the effects of age, sex, length of stay and antibiotic treatment with those that have been reported by other workers in continuous surveillance (Lidwell, 1961; Lidwell *et al.* 1971, 1975) illustrates the usefulness of results obtained in a cross-sectional type of survey. The presence of resistant staphylococci in the nose shows a similar relationship to the age and sex of patients as does the incidence of infection in operation wounds. Length of stay of over 10 days and age of over 40 years are found to be important in relation to the chances of infection. In both males and females the incidence of carriage increases in a linear relationship with length of stay up to about 30–40 days. The carriage rate in males rises to a significantly higher level than in females, but in both groups there is no further increase beyond this time. It can be concluded from the study of Lidwell *et al.* (1975) that a similar plateau between 45 and 85 days exists, which was followed by a further rise in the rate of nasal carriage, up to as high as 40 % when the duration of stay in hospital exceeded 130 days. Presumably many people have a local immunity to colonization with *Staph. aureus* but the mechanism of this immunity is unknown. The old and the very young are known to be more susceptible to infection, and this seems to apply also to nasal colonization. The reason for the difference in infection and carriage rates between males and females is also uncertain. In some studies, males have been shown to be heavier staphylococcal dispersers than females and settle-plate counts tend to be higher in wards occupied by male patients (Ayliffe, Collins, Lowbury & Wall, 1971). It seems likely that the different texture of the skin in males and females has a bearing on the differences in carriage and dispersal.

In this study 26·6 % of patients were receiving chemotherapeutic agents at the time of the survey. The relation between use of antibiotics and resistance of *Staph. aureus* in patients' noses has been described elsewhere (Ayliffe, 1973). As expected tetracycline-resistant nasal carriage was associated with the use of tetracycline since such strains of staphylococci are selected and replace sensitive strains when patients are treated with the antibiotic. Ampicillin is the most commonly used antibiotic, and the correlation which was found was to be expected, but relationship of increased tetracycline-resistant carriage with the use of nitrofurantoin was unexpected. This relationship may be due to the fact that the patients treated with nitrofurantoin and also carrying resistant staphylococci were often elderly patients who had been in hospital for longer than the average period. They also often had fractures or bed-sores, and were likely to have a urinary-tract infection caused by ampicillin or sulphonamide-resistant organisms.

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