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Infections acquired in medical wards

A Report from the PUBLIC HEALTH LABORATORY SERVICE†

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This is an account of an investigation into the incidence of infections acquired by patients in medical wards. Records were collected of 6740 admissions to 13 provincial hospitals between September 1961 and August 1962. Of these, 6282 were to 16 wards in which observations were made on at least 500 patient-weeks of stay, and covered the whole year. The remaining 458 patients were observed in five different wards, all but one of which were included in the investigation for a few weeks only. All 6740 patients were considered in calculations of the incidence of infections acquired in hospital, but only the 6282 patients in the first 16 wards were used in comparisons between wards. All patients admitted to the wards on or after the starting date were included. Transfers from other wards, or re-admissions to wards included in the survey, were not distinguished from other admissions.

DESCRIPTION OF THE WARDS

Table 1 shows the main characters of the sixteen wards that are considered separately in this report. A ward was defined as a section of a hospital in the charge of one day-sister. Thus, an associated pair of wards—one for males and one for females—with different sisters were considered as separate units. There were 13 general medical wards (seven for males, five for females, and one for patients of either sex), one paediatric ward, and two wards for long-stay patients with tuberculosis.

Most were of the traditional open type, with a few side rooms, but some were rather more subdivided. Ward 1 was the only one in which there were no more than four patients in any room. The distance between the bed-centres in the large

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Those marked with an asterisk, together with Dr N. S. Galbraith, Dr M. T. Parker and Dr I. D. G. Richards, constituted the committee which organized the investigation. Dr Blowers acted as secretary and was responsible for the day-to-day organization. The results were analysed by Dr Parker and Dr Richards. Dr Parker was chairman of the committee and prepared the report. Requests for reprints should be sent to him at the Central Public Health Laboratory, Colindale Avenue, London, N.W. 9.

Table 1. *Summary of characters of medical wards*

(The wards bracketed were associated male and female wards in the same hospital. M = male; F = female.)

Ward	Sex of patients	No. of beds: official bed-complement	No. of patients observed	Percentage of beds occupied	Distance between centres of beds (ft.)	Ward subdivision. No. of rooms containing beds							Isolation facilities	Staff (sisters, nurses, auxiliaries and cadets)	
						1	2	3	4	6–12	13–19	21–28		Day	Night
General medical															
1	M+F	32	344	77	*	4	2	—	6	—	—	—	Good	8	2
2	M	37	603	86	7·5	—	2	1	—	2	1	—	Moderate	9	4
3	M	26	306	77	*	2	—	—	2	2	—	—	Poor	11	2
4	F	23	331	90	8	4	—	—	—	—	1	—	Poor	12	1½
5	M	18	222	80	7	1	1	1	—	1	—	—	Moderate	8	1½
6	F	21	236	93	8	1	—	—	—	1	1	—	Moderate	8	1½
7	M	30	533	97	6·3	—	1	2	—	—	—	1	Poor	9	2
8	F	25	484	96	6·3	—	—	1	—	—	—	1	Poor	9	2
9	M	25	528	90	9	1	—	—	—	—	—	1	Poor	9	2
10	M	15	268	93	6	3	—	—	—	1	—	—	Moderate	10	3
11	M	30	704	88	6	2	—	—	—	—	—	1	Poor	9	2
12	F	29	368	90	6	2	—	—	—	—	—	1	Poor	7	3
13	F	38	601	86	9	1	—	—	—	—	1	1	Poor	13	2
Paediatric															
14	M+F	26	588	112†	6	4	4	—	—	—	1	—	Good	7½	2½
Tuberculosis: long-stay															
15	M	28	79	90	12	2	—	—	—	—	2	—	Moderate	12	1
16	F	22	87	92	10	2	—	—	—	2	—	—	Moderate	10	1
Five other wards	—	—	458	—	—	—	—	—	—	—	—	—	—	—	
		Total	6740												

* Distance between centres of beds varied. † Extra beds used.

open wards ranged from 6 to 9 ft., but was 10–12 ft. in the two tuberculosis wards. The proportion of beds occupied throughout the year was 80 % or more in all but two wards, and in the children's ward considerably exceeded the official complement.

Facilities for isolation, and the use made of them, varied widely. In over half of the wards, under 10 % of the beds were in rooms containing two or less beds. In eight of the 13 general medical wards the side rooms were seldom available for use as isolation rooms. In Table 1 we have described the isolation facilities as 'good' in two wards where at least a quarter of the accommodation was in small rooms. There were six others where it was the custom to use the few side-rooms for isolation; these facilities are described as 'moderate'. In the remaining eight wards there were virtually no facilities for isolation.

There was little difference between the general wards in the average length of stay of the patients (2·0–2·9 weeks), and less than 10 % of the patients stayed for longer than 6 weeks. The average stay in the paediatric ward was 2·3 weeks. In the tuberculosis wards, on the other hand, patients stayed on average 15·4 and 11·4 weeks respectively.

At least three-quarters of the patients in each of the general wards were aged 40 years or over. There were, however, considerable differences between wards in the proportion of old people. Two wards (nos. 4 and 8) included more than 30 %, and five others (nos. 3, 6, 11, 12 and 13) between 25 % and 30 % of patients aged 70 years and over, but in wards 1, 2 and 5 the proportion was 15 % or less. The patients in the tuberculosis wards were generally younger; less than 2 % were aged 70 years or more, and 35 % of males and 50 % of females were under 40 years of age. In the paediatric ward 40 % of the patients were less than 1 year old.

Most of the patients in the survey were suffering from one or more major medical illnesses. The commoner diagnoses included cardiovascular disease (coronary artery disease 785, cardiac failure 588, hypertension 296), pneumonia or bronchitis (1048), disease of the nervous system (890), diabetes mellitus (553), and malignant disease (446, including leukaemia).

CLINICAL OBSERVATIONS

A record form was completed for each patient. The bacteriologist visited the ward at least once a week and, together with the physician or his deputy, considered the clinical and bacteriological evidence to decide which patients had acquired an infection in hospital. A list of infections to be noted was printed on the back of the record form (see Table 2). It was made clear to participants that only clinical illness—not simply bacteriological evidence of infection—should be included. Details of antibiotic and corticosteroid treatment (including the name of the drug, the dates on which it was given, and the route), and of all surgical procedures—whether therapeutic or diagnostic (Table 3)—were also recorded.

When a patient was discharged or died, the bacteriologist and the physician jointly completed a section of the form recording the final diagnosis and stated whether any of the specified infections were present on admission or acquired in hospital. They also stated whether the clinical diagnosis of infection acquired in

hospital was supported by bacteriological evidence, and whether in their opinion the infection delayed discharge from hospital or contributed to death.

BACTERIOLOGY

Instructions were given that a nose swab should be taken from each patient on the day of admission, and thereafter weekly. Blood-agar plates were inoculated and examined for *Staphylococcus aureus* (coagulase-positive staphylococci), but enrichment cultures were not made. One colony of *Staph. aureus* from each positive plate was tested for resistance to penicillin, streptomycin, tetracycline, choramphenicol, and erythromycin by the methods in routine use in the various laboratories. All strains of *Staph. aureus* were phage-typed by the method of Blair & Williams (1961) with the 22 phages of the Basic Typing Set (Report, 1963) at routine test dilution (R.T.D.) and at R.T.D. × 1000.

The results of bacteriological investigations relevant to the survey were transferred to the record form.

Table 2. *Infections recorded*

A. Respiratory tract	Tonsillitis Bronchitis Pneumonia
B. Local sepsis	1. Primary infections of skin: pustular lesions (e.g. boils, carbuncles, styes); vesicular or crusted lesions (e.g. impetigo, pemphigus) 2. Skin sepsis secondary to other skin lesions 3. Sepsis following surgical operation, diagnostic procedure or injection
C. Urinary tract	
D. Alimentary tract	Stomatitis Gastro-enteritis
E. Conjunctivitis; otitis media	
F. Other septic lesions	

Table 3. *Surgical procedures recorded*

Surgical operation	Aspiration/injection of pleural cavity
Biopsy	Aspiration/injection of peritoneal cavity
Transfusion by needle	Aspiration/injection of joint
Transfusion by cut-down	Urinary-tract catheterization
Lumbar puncture	Bronchoscopy
Marrow puncture	Other

RESULTS

Infections acquired in medical wards

An infection causing symptoms which began 2 or more days after admission to a ward was considered to have been acquired in it. A total of 345 patients (5·1%) suffered from one or more infections; 65 patients (1·0%) suffered from local sepsis of the skin or of wounds, 134 (2·0%) developed an infection of the lower respiratory tract (acute bronchitis or pneumonia), and 80 (1·2%) acquired an infection of the urinary tract.

Table 4. *Nature of infections acquired in medical wards: results of bacteriological examination*

(In parentheses: number of times an organism was the only pathogen isolated.)

	No. of infections	Number examined bacteriologically	No pathogens isolated	No. of cultures yielding									
				Staph. aureus	*Str. pyogenes*	Faecal streptococci	Pneumococci	*Haemophilus influenzae*	Coliform bacilli	*Proteus* sp.	*Pseudomonas pyocyanea*	*Clostridium welchii*	*Candida* sp.
Lower respiratory tract infections													
Bronchitis	40	28	6	7 (6)	—	—	6 (5)	4 (3)	5 (2)	2 (1)	1 (0)	—	1 (0)
Pneumonia	95	51	3	26 (19)	—	—	15 (9)	9 (4)	8 (4)	2 (0)	1 (1)	—	—
Local sepsis of skin and wounds													
Primary skin infections: boils, styes	24	23	3	20 (20)	—	—	—	—	—	—	—	—	—
Other primary skin infections	9	8	1	7 (6)	—	—	—	—	—	1 (0)	—	—	—
Secondary skin infections	20	16	0	11 (7)	1 (0)	4 (0)	—	—	3 (1)	5 (2)	2 (0)	—	—
Wound infections	19	12	0	9 (8)	—	1 (0)	—	—	2 (1)	1 (0)	3 (1)	—	—
Urinary tract infections	81	80	1	8 (8)	—	13 (4)	—	—	53 (40)	16 (9)	4 (2)	—	1 (0)
Stomatitis	8	6	0	2 (1)	—	—	—	—	—	—	—	—	5 (4)
Tonsillitis	21	20	10	7 (7)	3 (3)	—	—	—	—	—	—	—	—
Gastro-enteritis	16	13	6	—	—	—	—	—	4 (4)*	—	—	3 (3)†	—
Conjunctivitis	23	16	8	4 (3)	—	—	1 (1)	4 (3)	—	—	—	—	—
Otitis media	13	4	0	3 (3)	—	—	—	—	—	—	1 (1)	—	—
Other septic lesions	15	10	0	6 (6)	—	—	—	—	1 (1)	—	1 (1)	2 (2)	—
Total	384	287	38	110 (94)	4 (3)	18 (4)	22 (15)	17 (10)	76 (53)	27 (12)	13 (6)	5 (5)	7 (4)

* Infantile gastro-enteritis associated with *Esch. coli* O 119.

† Food-poisoning.

There were 384 separate infections with symptoms (5·7 per 100 patients admitted). Table 4 shows the numbers in each of the main clinical groups and summarizes the bacteriological findings in them. One-third of the infections were of the lower respiratory tract (pneumonia 25%, acute bronchitis 10%), one-fifth were local infections of the skin or of wounds, and one-fifth were urinary tract infections (Fig. 1A).

Information about the bacteriology of illnesses diagnosed as *acute bronchitis and pneumonia* was obtained by examination of sputum, occasionally supplemented by cultures made *post mortem*, in 79 (59%) of the 135 patients on whom these diagnoses were made. When more than one specimen of sputum was examined, an organism was considered as a possible cause of the disease only if it was

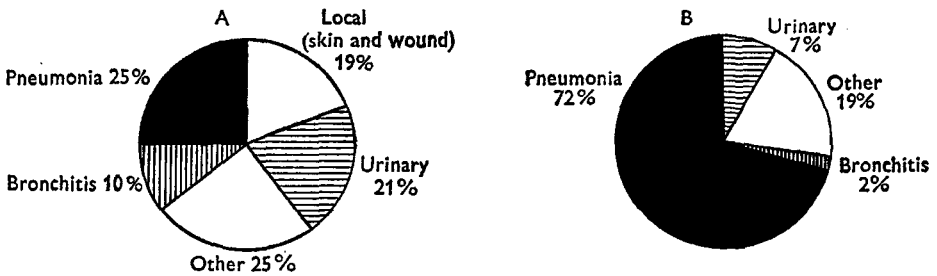

Fig. 1. Main clinical groups of infections acquired in medical wards.
A, All infections; B, infections contributing to death.

present in the first specimen taken after the onset of illness. A possible pathogen was isolated from 22 of 28 cases of acute bronchitis; *Staph. aureus* was obtained from seven, and was the only pathogen found in six; the rest yielded pneumococci, *Haemophilus influenzae*, and other organisms in various combinations. All but three of 51 cases of pneumonia yielded a possible pathogen. The commonest organism was *Staph. aureus*, which was present in 26 (51%), and was the only significant organism in 19 (37%). Pneumococci were isolated from 29%, *H. influenzae* from 18%, and various Gram-negative bacilli from 22%.

Twenty-four of the 33 primary skin infections were boils or styes, and the remainder comprised two whitlows, five septic skin rashes, one case of impetigo and another of superficial cellulitis. *Staph. aureus* was isolated from 27 of the 31 that were cultured. Secondary skin infections occurred in 18 bed-sores, one rodent ulcer, and one case of minor trauma. Half of those cultured were infected with *Staph. aureus* only, and the rest with a mixture of organisms. The wound infections were somewhat different from those usually seen in surgical wards, for only seven of them followed a major surgical operation; the rest included four infections of tracheostomy wounds, two of biopsy wounds, and five which followed injections or similar procedures. *Staph. aureus* was isolated from 9 of the 12 that were swabbed.

All but one of the 81 urinary tract infections were investigated bacteriologically. A single organism was responsible for the following percentages of cases: coliform bacilli 50, *Proteus* spp. 11, *Staph. aureus* 10, faecal streptococci 5, *Pseudomonas pyocyanea* 2; and 20% were mixed infections with similar organisms.

The 16 cases of gastro-enteritis included a small outbreak of food-poisoning due to *Clostridium welchii* affecting three patients in a general medical ward, and four infections of infants with *Escherichia coli* O 119 in the paediatric ward. There were no salmonella or shigella infections. Gastroenteritis in two patients was attributed to antibiotic therapy, but the illnesses were mild.

The 15 remaining infections described as 'other septic lesions' were various, but included several of the more severe illnesses. There were three bacterial infections of the parotid gland, two dental abscesses, a deep abscess of the buttock, an abscess of the foot, and a case of acute sinusitis. One patient had had purulent meningitis before admission, but cultures of the cerebrospinal fluid were sterile; in the ward he developed acute staphylococcal pericarditis. Two other patients, one with aplastic anaemia and the other with congestive heart failure, were found to have staphylococcal septicaemia without localized suppuration. There were two fatal infections due to *Cl. welchii*; one was a terminal gas-gangrene in a case of aplastic anaemia and the other—in a patient with rheumatoid arthritis under treatment with steroids—an acute ileal ulceration with *Cl. welchii* septicaemia. One generalized infection with *Ps. pyocyanea* in a patient with renal failure was acquired after intravenous and intra-arterial catheterization. Another probable generalized bacterial infection—in a patient with aplastic anaemia—was diagnosed histologically on post-mortem material, and may have resulted from a blood transfusion.

Consequences of infection acquired in hospital

In all, 345 patients acquired an infection in hospital, and 94 of them died before they could be discharged. In the opinion of the investigators, infection contributed to death in 59 (17 %) of these patients, and may have had some influence on the outcome of another 12. The discharge from hospital of 41 of the 251 survivors (16 %) was considered to have been delayed by infection, but the length of the delay could not be estimated accurately.

Table 5. *Acquired infections which contributed to death*

	Age (years)				All ages
	< 1	1–49	50–69	> 70	
All patients	234	2337	2811	1358	6740
Total deaths	15	78	307	331	731
Infections contributing to death					
Total	4	6	23	26	59
Pneumonia	4	6	12	21	43*
Bronchitis	0	0	1	0	1
Urinary tract infection	0	0	1	4	5*
Other	0	0	9	2	11
Fatal staphylococcal infections (pneumonia in parentheses)	1 (1)	0	8 (4)	3 (3)	12 (8)

* One patient had pneumonia and urinary-tract infection.

Infections were thought to have played a part in 8 % of the 731 deaths in the wards, and pneumonia was the infection most often implicated (Table 5; Fig. 1 B).

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The 60 infections concerned in the death of 59 patients included 43 illnesses described as 'pneumonia', 'bronchopneumonia', 'terminal pneumonia' or 'hypostatic pneumonia', and one case of acute bronchitis; but the diagnosis was, in most cases, clinical and unsupported by bacteriological evidence. No examination of the sputum of 28 of the patients was made at the relevant time. *Staph. aureus* was isolated from the sputum, or from the lung *post mortem* in eight of the 16 cases examined. Nearly half of the patients with fatal pneumonia or bronchitis acquired in the wards were aged 70 years or more, and most of them were already suffering from a serious illness; 13 had cerebral thrombosis or haemorrhage, 11 had congestive heart-failure, coronary thrombosis, or hypertension, five had generalized carcinomatosis, and three were diabetics. All four of the babies dying of pneumonia had a severe congenital defect or birth injury.

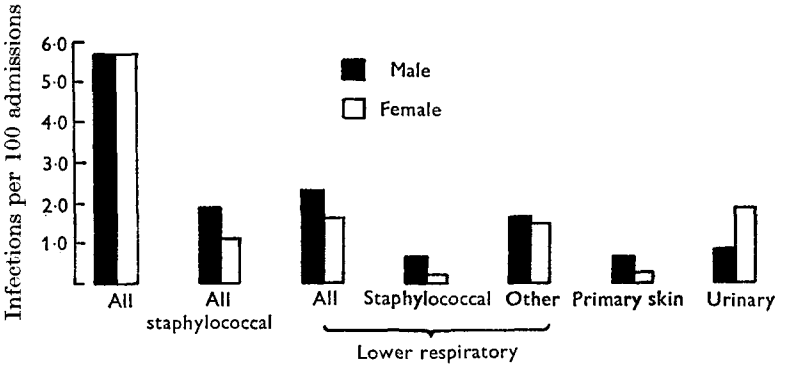

Fig. 2. Incidence of infection acquired by males and females in medical wards.

The remainder of the fatal infections included five of the urinary tract, three cases of extensive sepsis in bedsores, and six generalized bacterial infections (two due to *Staph. aureus*, two to *Cl. welchii*, one to *Ps. pyocyanea*, and one to an unknown organism).

Age and sex

Table 6 shows the incidence of infections acquired by male and female patients of various ages, expressed as the number of infections per 100 patients admitted. The rate for all infections was identical in the two sexes. The highest incidence was in the first year of life and the next highest in patients over the age of 70. The lowest was between the ages of 10 and 30, and the infection rate rose slowly through middle life.

When the individual types of infection are considered, differences between the sexes appear (Fig. 2). There was an excess of males over females in all staphylococcal infections, in infections of the lower respiratory tract, and in primary skin infections. The incidence of staphylococcal infections of the lower respiratory tract was 0·67 for males and 0·19 for females, but the remainder of the respiratory tract infections were evenly distributed between the sexes.

The excess of primary skin infections is particularly noticeable in young and middle-aged males. Nine of the 33 infections occurred in one ward for long-stay tuberculosis patients, but there was no evidence that they were caused by a parti-

Table 6. *Incidence of acquired infection by age and sex*

(M = male; F = female.)

Age (years)	No. of admissions M	No. of admissions F	Incidence per 100 patients admitted: All infections M	All infections F	All staphylococcal infections M	All staphylococcal infections F	Infections of: Lower respiratory tract M	Lower respiratory tract F	Urinary tract M	Urinary tract F	Skin (primary) M	Skin (primary) F	Skin (secondary and wounds) M	Skin (secondary and wounds) F
< 1	146	88	13·0	8·0	4·8	0	0·7	3·4	0	0	0·7	0	3·4	0
1–	200	123	4·5	4·1	0	1·6	0·5	0	0	0·8	0	0	0·5	0
10–	177	117	1·1	2·6	1·1	0·9	0	1·7	0	0	0·6	0	0	0
20–	236	188	3·8	2·7	1·3	0·5	0	1·1	0	0	1·7	0	0	0·5
30–	290	207	4·8	3·9	2·4	0·5	0·7	1·0	0·7	1·4	2·1	0	0·3	0·5
40–	498	301	4·4	2·0	1·8	0·7	1·6	0	0·4	0·3	3·0	0·3	0·4	0·7
50–	901	400	4·7	5·5	1·4	0·8	2·3	1·0	0·7	2·3	0·6	0	0·1	0·5
60–	992	518	5·6	7·1	2·0	2·3	2·6	1·9	1·0	2·7	0·2	1·0	0·8	0·6
70–	725	633	8·7	8·7	2·8	1·1	4·8	2·8	1·7	3·3	0·4	0	0·7	1·1
Total	4165	2575	5·7	5·7	1·9	1·1	2·3	1·6	0·8	1·9	0·65	0·23	0·55	0·62

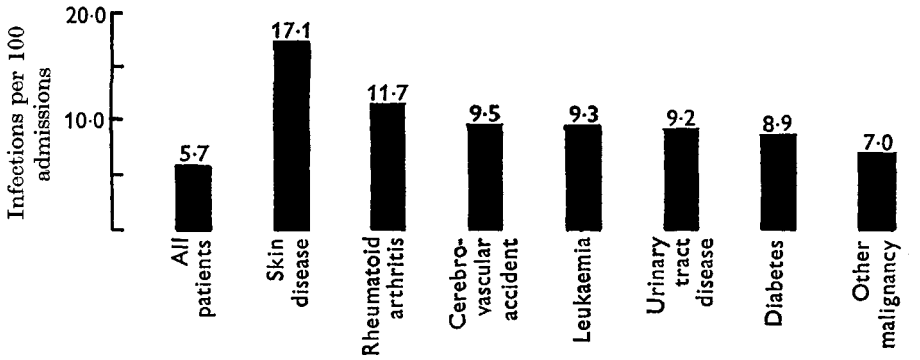

Fig. 3. Relation between primary disease and liability to infection.

cular strain of staphylococcus, and a comparable number of female patients of about the same age in an associated ward did not suffer from any primary skin infections. Apart from the cases in the tuberculosis ward the numbers of primary skin infections among males and females under 60 years of age were respectively 13 and 1.

Urinary tract infections, on the other hand, were much more common in females than in males, and were almost entirely confined to patients over 30 years of age.

Relation between primary disease and liability to infection

The incidence of acquired infections per 100 admissions by patients with particular diseases was compared with the rate for all patients (Table 7; Fig. 3). Those suffering from more than one disease were included in the total for each disease.

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The incidence of infection in patients suffering from coronary artery disease, cardiac failure, hypertension, pneumonia, bronchitis, or peptic ulceration, showed little deviation from the average for all patients, apart from a slight excess of urinary tract infections and pulmonary infections in females with congestive heart failure.

Table 7. *Infections acquired by patients admitted to hospital with certain diseases*

Diagnosis on admission	No. of admissions		Incidence per 100 patients admitted: All infections		Staphylococcal infections		Lower respiratory tract		Urinary tract infections	
	M	F	M	F	M	F	M	F	M	F
Coronary artery disease	607	178	5·8	7·3	2·1	0	3·5	1·7	0·5	2·2
Cardiac failure	359	229	5·3	9·2	1·1	0·4	1·7	3·9	1·9	3·9
Hypertension	180	116	6·1	3·4	0·6	0	4·4	0·9	0·6	0·9
Pneumonia	340	166	5·9	4·8	2·4	1·8	2·6	1·2	0·9	0·6
Bronchitis (acute and chronic)	374	168	7·0	6·0	1·9	1·2	3·5	3·0	0·5	1·8
Peptic ulcer	234	83	6·8	0	3·0	0	3·0	0	1·3	0
Urinary tract disease (including infections)	187	237	13·9	5·5	4·3	1·3	2·1	1·3	6·4	1·3
Cerebrovascular accident	242	168	10·3	8·3	2·1	0·6	5·4	1·2	1·7	5·4
Other nervous system diseases	280	160	7·9	6·3	3·6	1·2	1·4	3·1	1·4	1·3
Skin diseases	66	45	16·7	17·8	10·6	6·7	0	4·4	3·0	8·9
Malignancy (including leukaemia)	357	109	6·4	10·0	3·1	2·8	3·1	4·6	1·1	0·9
Diabetes	295	258	8·1	9·7	3·0	1·5	2·4	1·6	2·7	5·4
Rheumatoid arthritis	44	93	15·9	9·7	2·3	4·3	11·4	0	0	4·3
All patients	4165	2575	5·7	5·7	1·9	1·1	2·3	1·6	0·8	1·9

Male patients admitted with a disease of the urinary tract were liable to develop acute urinary infection while in hospital. Nine of the 12 patients in this class had retention of urine due to prostatic hypertrophy or carcinoma, and two more had gross anatomical abnormalities of the kidney or ureter; nine had been treated with a self-retaining catheter and one had had a cystoscopy. The two patients who had not been catheterized had carcinoma of the prostate.

Patients suffering from cerebral thrombosis or haemorrhage often acquired an infection in hospital. The excess of pulmonary infections, however, consisted mainly of cases of 'terminal' or 'hypostatic' pneumonia, and little bacteriological information was available about them. The incidence of urinary tract infections in these patients was also high. There was, however, a difference between the sexes in the apparent role of catheterization in causing these infections; all five of the males had recently been catheterized, three with a self-retaining catheter, but only one of the eight females had been catheterized.

Patients admitted with a disease of the skin ran a very high risk of acquiring infection (17·1 infections per 100 admissions), especially one due to *Staph. aureus* (9·0 per 100 admissions). Few of them, however, were strictly dermatological patients; most also suffered from other serious medical diseases. For this reason, and because there were only 111 such patients, no conclusions could be drawn about the hazards associated with particular skin diseases.

The rate of infection in patients with malignant disease was not as high as might be expected, but a wide variety of diseases, at varying stages of their evolution, were included. Thus, there were only eight infections among 194 cases of bronchial carcinoma, but many of the patients had been admitted to the ward for diagnosis only. There were five infections among 54 cases of leukaemia (9·3 per 100 admissions).

There was not a great excess of staphylococcal infections in diabetic patients, but half of all the staphylococcal urinary tract infections occurring among 6740 patients were in the 553 diabetics. Urinary tract infections, both in males and females, were very common. There was an association with catheterization in males but not in females; the infection followed catheterization in five of eight males, but in only four of 14 females.

Infection was common in rheumatoid arthritis (11·7 per 100 admissions), but the small number of patients at risk made further analysis difficult. There were three fatal infections among 137 patients, two due to *Staph. aureus* (one septicaemia and one pneumonia) and one to *Cl. welchii*.

Table 8. *Infections following certain surgical and diagnostic procedures*

(In parentheses: infections per 100 procedures.)

	No. of procedures			No. of infections acquired			
	Male	Female	Both sexes	Infection	Male	Female	Both sexes
Surgical operation	76	43	119	Sepsis	7	4	11 (9·2)
				Bronchitis	1	1	2 } (9·2)
				Pneumonia	4	5	9 }
Biopsy	40	24	64	Sepsis	1	1	2 (3·1)
Bronchoscopy	42	12	54	Tonsillitis	3	0	3 }
				Bronchitis	1	0	1 } (9·3)
				Pneumonia	1	0	1 }
Transfussion (needle)	186	122	308	Sepsis	1	2	3 (1·0)
Transfusion (cut-down)	51	22	73	Sepsis	2	0	2 (2·7)
Catheterization (ordinary)	48	61	109	Urinary tract	3 (6·3)	4 (6·6)	7 (6·4)
Catheterization (indwelling)	40	31	71	Urinary tract	15 (37·5)	5 (16·1)	20 (28·2)

Infections following certain surgical and diagnostic procedures

Procedures were included in this study (Table 8) only if they were performed more than 5 days before the patient was discharged from hospital, and—except for catheterization—were considered relevant only to symptoms occurring within

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7 days of them. There were 119 surgical operations, of which 11 were followed by wound sepsis and 11 by chest infection, giving a wound-infection rate of 9·2% and a total post-operative infection-rate of 18·5%. Also, two of 64 biopsies were followed by local sepsis, both in patients with skin disease.

Two transfusions by needle were followed by 'red arm', one with evidence of thrombophlebitis, and one other may have been responsible for a generalized bacterial infection. One transfusion by cannula caused local staphylococcal wound infection and another resulted in fatal generalized infection with *Ps. pyocyanea*. Unfortunately there was some confusion in the definition of the procedures to be described as transfusions: at twelve centres all intravenous therapy by drip was included, but at one centre only intravenous administration of blood was considered to be a transfusion. Thus, the sepsis-rates of 1·0% for simple transfusion and 2·7% for cannulation may be slightly too high.

Table 8 also shows the relation between urinary tract infection and previous catheterization. Simple catheterization was performed 109 times, and seven infections followed (6·4%). Self-retaining catheters were inserted 71 times, with 20 associated infections (28·2%). The incidence of urinary infection in all uncatheterized patients of both sexes was only 0·9% of all admissions. Catheterization seemed relatively more important as a cause of urinary infection in males than in females. Eighteen of 32 males, but only nine of 49 females who acquired a urinary tract infection had previously been catheterized.

No infection followed 304 lumbar punctures, 66 marrow punctures, and 105 aspirations from or injections into the pleural or peritoneal cavity or into a joint. There was one example of local sepsis after acupuncture and two intramuscular abscesses at the site of penicillin injections.

The administration of antibiotics and steroids

One-third of the patients received an antibiotic by injection or by mouth whilst in hospital, and 7% were treated with a steroid or with ACTH. Table 9 shows the percentage of patients in each ward who received an antibiotic or a corticosteroid, and also the percentage treated with penicillin, tetracycline, chloramphenicol and streptomycin. The amount of antibiotic and steroid therapy varied considerably from ward to ward, but the most striking differences were in the use of penicillin, tetracycline and chloramphenicol in different wards. The percentages receiving other antibiotics were as follows: erythromycin 1%, methicillin 0·7%, neomycin 0·6%, ampicillin 0·4%, novobiocin 0·2%, and polymyxin, bacitracin, framycetin, and kanamycin all less than 0·1%.

We tried to relate the administration of antibiotics and of corticosteroids to the subsequent appearance of infection. Courses of either given after the onset of symptoms were not considered. There was a significant excess of all infections, and of staphylococcal infections, both among those receiving antibiotics and those receiving corticosteroids. It appeared to be common practice, however, to give prophylactic antibiotics to old and sick patients who had a greater risk of contracting an infection. Similarly, the patients receiving corticosteroids included many who were already very susceptible to infection, particularly those suffering

from leukaemia and rheumatoid arthritis. It seems unwise, therefore, to draw firm conclusions about the relation of antibiotic and corticosteroid therapy to acquired infection from the information obtained in this survey.

Table 9. *Percentage of patients receiving antibiotics and corticosteroids*

(Excluding topical applications.)

Ward no.	Percentage receiving: Any antibiotic	Steroids or ACTH	Penicillin	Streptomycin	Tetracycline	Chloramphenicol
1	18	4	14	0·6	10	0·9
2	36	5	4	2	32	6
3	38	3	26	4	16	1·0
4	37	6	25	3	16	0·9
5	14	7	7	3	6	0·9
6	22	6	12	3	9	0·8
7	24	6	6	0·8	4	23
8	25	10	7	1	5	13
9	22	2	15	7	8	1·5
10	40	5	22	2	22	1·5
11	30	6	17	6	12	8
12	34	8	21	10	12	8
13	36	8	14	4	11	16
14	35	5	22	2	3	9
15	62	4	15	48	15	5
16	64	10	8	54	14	—
All patients	34	7	15	5	13	8

Incidence of infection in individual wards

Table 10 shows the number of infections per 100 weeks of ward exposure in the 16 wards where the numbers of observations were sufficient for separate analysis. The total infection rate exceeded 2·5/100 patient-weeks in seven of the general medical wards; in six of them, and only one other, the incidence of lower respiratory tract infection was greater than 1·0 per 100 patient-weeks. In general, these seven wards were also those with the highest death-rates attributable to infection, and those in which the greatest proportion of deaths were thought to have been due to infection, but there were several exceptions.

The incidence of staphylococcal infection in individual wards did not correspond closely with the total infection-rate, or with the incidence of infections contributing to death. It exceeded 0·8 per 100 patient-weeks in two of the six wards with high death-rates from acquired infection (> 0·5/100 patient-weeks), but also in two of the seven with lower death-rates. There was only one ward (no. 11) in which a high incidence of fatal respiratory tract infection was attributable, at least in part, to an excess of staphylococcal pneumonia. This was the only ward in which there was evidence of an 'epidemic' of staphylococcal infection associated with a single strain of *Staph. aureus*.

There were, however, great differences between wards in the frequency with

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which bacteriological examination was performed on patients suspected of suffering from respiratory tract infections, and this may account for part of the difference between the recorded incidences of staphylococcal pneumonia. In wards 3 and 4, for example, none of the 20 patients said to have acquired pneumonia or bronchitis had a sputum examination after the onset of the illness. There were, however, six wards in three hospitals where the sputa of at least half of the patients with these infections were examined bacteriologically. The number of observations was rather small (Table 11), but there appeared to be differences between wards in the frequency with which *Staph. aureus* was present in sputum from cases of bronchitis and pneumonia acquired in hospital.

Table 10. *Number of infections, and number of infections contributing to death, in each ward*

(In parentheses: infections per 100 patient-weeks of exposure.)

	Infections							
			Staphylococcal		Lower respiratory			Death: % attributed to infection
Ward no.	Total	Contributing to death	All	Primary skin	All	Staphylococcal	Urinary tract	
1	6 (0·6)	0	2 (0·2)	1	1 (0·1)	1	3	0
2	20 (1·5)	1 (0·1)	7 (0·5)	1	10 (0·7)	5	5	1
3	30 (3·4)	11 (1·2)	4 (0·5)	1	11 (1·2)	0	3	22
4	15 (1·7)	6 (0·7)	0	0	9 (1·0)	0	3	15
5	7 (1·5)	0	4 (0·8)	1	2 (0·4)	2	0	0
6	19 (3·2)	1 (0·2)	3 (0·5)	0	7 (1·2)	3	7	4
7	34 (2·7)	7 (0·6)	6 (0·5)	0	17 (1·4)	2	6	10
8	33 (2·8)	5 (0·4)	12 (1·0)	4	5 (0·4)	0	11	11
9	21 (1·8)	0	13 (1·1)	5	6 (0·5)	2	4	0
10	19 (3·4)	5 (0·9)	3 (0·5)	2	8 (1·4)	1	5	20
11	52 (3·7)	9 (0·6)	23 (1·6)	1	30 (2·1)	12	9	9
12	28 (3·7)	5 (0·7)	7 (0·9)	2	10 (1·3)	1	6	11
13	32 (2·3)	4 (0·3)	2 (0·1)	0	7 (0·5)	1	18	5
14	40 (2·9)	5 (0·4)	9 (0·7)	0	5 (0·4)	1	1	25
15	18 (1·5)	0	10 (0·8)	8	4 (0·3)	1	0	0
16	4 (0·4)	0	1 (0·1)	0	0	0	0	0
Other	6 (0·6)	0	4 (0·4)	1	3 (0·3)	1	0	0

Table 11. *Bacteriological findings in cases of pneumonia and bronchitis in six wards*

Ward no.	Total no.	No. examined bacteriologically	*Staph. aureus* isolated	Other possible pathogens isolated	No possible pathogen isolated
5	2	2	2	0	0
6	7	7	3	4	0
7	17	14	2	9	3
8	5	3	0	2	1
11	30	25	12	10	3
12	10	5	1	3	1

There was no apparent correspondence between the number of ward subdivisions, the quality of the facilities for isolation (Table 1), the proportion of elderly patients (p. 459), or the antibiotic policy (Table 9), and the risk of acquiring infection. The most that can be said is that the incidence of all infections was low in the general medical wards nos. 1, 2 and 5, where there were good or moderately good facilities for isolation, and few patients over 70 years of age; but the record was not much worse in several wards with less favourable physical conditions. In the long-stay tuberculosis wards, with good bed-spacing, a rather stable population, and a small proportion of elderly people, there was little evidence of serious infection.

Epidemiology of acquired staphylococcal infection

The investigators recorded 110 staphylococcal infections in 101 patients (1·5 per 100 admissions). *Staph. aureus*, alone or in association with other organisms, was implicated in the deaths of 12 patients, eight with staphylococcal pneumonia, two with terminal bacteraemia, one with pericarditis and one with a septic bedsore.

One hundred and twelve distinct cultures of *Staph. aureus* were isolated from the 110 lesions, and all but two of them were tested for sensitivity to antibiotics. Twenty-one % were sensitive to all antibiotics, 14% were resistant only to penicillin, and 65% were resistant to other antibiotics. The percentages resistant to each were as follows: penicillin 77, streptomycin 50, tetracycline 55, chloramphenicol 3, erythromycin 7.

Table 12. *Phage-typing patterns of* Staphylococcus aureus *strains responsible for infections of* 99 *patients*

	Pattern	Total cases	Endemic infection*	Sporadic infection
Phage group I	'80/81'†	27	23	4
	52A/79	4	0	4
	29 and 29 patterns	4	2	2
	Other	6	0	6
Phage group II		3	0	3
Phage group III	7/47/53/54/75	13	13	0
	83A	9	2	7
	6/7/53/75	2	2	0
	42E	3	2	1
	Other	14	0	14
Miscellaneous		5	0	5
Not typable		9	0	9
Total		99	44	55

* Two or more infections due to the same strain of *Staph. aureus* in one ward.
† Includes 52/52A/80/81 and similar patterns, if resistant to penicillin.

A nasal swab was taken within one day of admission to the ward from 95 patients who later developed 102 of the lesions. The organisms responsible for 21 of these lesions were already present in the nose when the patient was admitted, but nine of them were resistant to antibiotics other than penicillin, suggesting that

they had been derived directly or indirectly from a hospital. Admission swabs were examined from 26 patients who later suffered from primary staphylococcal skin infections, and 13 of them (50%) contained the infecting organism. Few patients who later developed other staphylococcal lesions were carrying the infecting organism at the time of admission. The proportions were as follows: for wound infections 1/8, for pneumonia and bronchitis 3/22, for urinary tract infection 0/8, and for other lesions 4/20.

Table 13. *Incidents of endemic staphylococcal infection and nasal acquisition of* Staphylococcus aureus

(Column 2. *Endemic infections.* Strains of *Staph. aureus* which gave rise to two or more clinical infections in each ward, and the number of infections caused. Column 3. *Nasal acquisition.* Staphylococcal strains responsible for 10% or more of nasal acquisitions in each ward. (In italic: phage-typing patterns at R.T.D. × 1000).)

Ward no.	No. of patients with clinical infections (1)	Endemic infections (2)	Nasal acquisition (3)
1	2	—	'80/81': 22%
2	7	'80/81': 4	'80/81': 25%
3	4	—	83A: 34%
4	0	—	'80/81': 14% 83A: 14%
5	3	'80/81': 2	*7/47/53/54/75*: 25%
6	3	—	*7/47/53/54/75*: 17%
7	6	83A: 2	'80/81': 19%
8	12	'80/81': 3 42E: 2	'80/81': 25%
9	10	'80/81': 6	'80/81': 17%
10	3	'80/81': 2	'80/81': 29% 53/54: 12%
11	21	7/47/53/54/75/77: 13 '80/81': 2	7/47/53/54/75/77: 16% 83A: 14%
12	6	'80/81': 2	'80/81': 29%
13	2	—	*6/7/42E/47/53/54/75/77*: 10%
14	9	'80/81': 2 6/7/53/75: 2	'80/81': 10%
15	7	29/52: 2	29/52: 65%
16	1	—	7/54: 18%

Phage-typing was carried out on the staphylococci from 99 lesions. The results are summarized in Table 12, in which distinction is made between endemic and sporadic infections. An endemic infection was one due to a strain of *Staph. aureus* which caused two or more clinical illnesses in the same ward during the year. Only 44 of the 99 infections belonged to incidents of endemic infection. The remaining 55 were sporadic infections due to organisms responsible for only one illness in a particular ward. Half of the staphylococci responsible for endemic infections were members of type '80/81', i.e. were lysed by phage 80 or 81, and sometimes also by phages 52 and 52A, but by no others. Endemic infection with '80/81' staphylo-

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cocci existed in eight of the 16 wards, but the incidents were all small. There was one relatively large group of 13 infections due to a strain with the phage-typing pattern 7/47/53/54/75, and four pairs each due to a different organism. Thus, the 13 distinct endemic incidents were due to organisms with only six different phage-typing patterns, and only 14 of the 55 sporadic infections were due to organisms with these patterns (see also columns 1 and 2 of Table 13).

We tried to compare the part played by certain strains of *Staph. aureus* in causing endemic infections with their ability to colonize the nose of patients. Column 1 of Table 13 shows the number of patients in each ward who acquired staphylococcal infection, and column 2 shows the incidents of endemic infection. Column 3 shows nasal acquisitions of certain staphylococcal strains as percentages of all acquisitions in the same ward. They were obtained from the regular weekly swabbing of 4100 of the 6740 patients in the survey (61 %). Only those strains are shown which accounted for 10 % or more of all nasal acquisitions.

When a staphylococcal strain caused a series of infections in a ward it was usually also being disseminated actively among the patients, but not always. Thus eight of the 13 strains responsible for two or more lesions also constituted 10 % or more of the staphylococci acquired in the nose by patients in the same ward. Three more strains were ones acquired by smaller percentages of patients, but two incidents (in wards 8 and 14) were due to organisms apparently not acquired at all by nasal carriers in the ward. In the first there was strong evidence that one patient introduced the organism into the ward and infected the other, but in the second there was no apparent connexion between the two patients.

On the other hand, there were many instances in which a staphylococcal strain that was actively disseminated among the patients did not cause a group of infections; 11 'carrier endemics', which resulted in over 10 % of all the acquisitions in a ward, were due to strains which did not cause endemic sepsis (see Table 13). Nor can the absence of endemic clinical infection by these strains be attributed to low susceptibility of the patients exposed to them, because in several instances other staphylococcal strains were causing infections at the same time (e.g. wards 5, 10, 11).

DISCUSSION

This investigation was planned as a counterpart to the Public Health Laboratory Service survey of the incidence of surgical wound-infection (Report, 1960), but it proved much more difficult to obtain a clear-cut picture of sepsis in medical wards than in surgical wards. Most patients undergoing an operation have a good prognosis, and the course of their convalescence can be predicted fairly accurately at the time of operation. Patients in medical wards, on the other hand, often suffer from diseases which are themselves fatal and which run a less predictable course. It proved impossible, therefore, to compare the expected date of discharge with the actual date, and so to assess the part played by infection in increasing the length of stay in hospital as was done in the surgical-ward survey.

The information collected was the sum of the individual clinical judgements of many physicians. They were asked to seek bacteriological confirmation of their

diagnoses whenever this seemed necessary and practicable; but the extent to which they made use of the laboratory, and the weight they attached to the bacteriological evidence varied widely.

Infections of the lower respiratory tract accounted for one-third of the acquired infections, and for nearly three-quarters of those which contributed to death. As well as being the most important single group of infections, this was the most difficult one to assess. Most of the patients affected were elderly, and nearly all were suffering from some other serious disease. Inspection of the individual case-sheets suggested that the criteria used for diagnosis were far from uniform. Great difficulties were experienced in interpreting the bacteriological findings in pneumonia. In some hospitals little significance was attached to the results of sputum culture, and the examination was seldom if ever carried out. In others, sputum was examined regularly, and the organisms isolated from patients with clinical signs of pneumonia were considered to be the cause of the disease. The number of patients on whom bacteriological investigations were made *post mortem* was too small for separate analysis, and it is doubtful whether regular post-mortem bacteriology would have contributed much additional information. It is well established (Norris & Pappenheimer, 1905; Smillie & Duerschner, 1947; Finland & Jones, 1956; Mitchell, Dunn, Lees & Hedges, 1961; Rantasalo & Hjelt, 1963; Emson, 1964) that pneumococci, *Staph. aureus* and other potential pathogens are often found in the lungs in the absence of naked-eye signs of inflammation, particularly in patients who have been in hospital for some days (Järvinen, Kahanpää, Rantasalo & Fortelius, 1961). It is therefore necessary to be very cautious in interpreting results of cultures from lung swabs and from sputum of hospital patients (see Weiss & Flippin, 1963).

In the present investigation, just over half of the patients who acquired pneumonia in hospital were examined bacteriologically. An organism to which the infection could conceivably have been attributed was isolated from 48 of the 51 patients. *Staph. aureus* was isolated from half of them, and was the only significant pathogen found in over one-third; it was also isolated from a similar proportion of the fatal cases of pneumonia, though only one-third were examined bacteriologically. If we assume that *Staph. aureus* was equally common in the cases that were not examined bacteriologically, and that all patients with clinical pneumonia and staphylococci in the sputum were suffering from staphylococcal pneumonia, we should conclude that the disease had an incidence of 48 in 6740 admissions (0·7 %) and was concerned in 22 out of 731 deaths (3 %). This is almost certainly an over-estimate.

In a concurrent autopsy survey of staphylococcal infection among medical and surgical patients (Report, in the Press), the conclusion was reached that staphylococcal pneumonia was a contributory cause in 6·4 % of 470 deaths, but between one-third and two-thirds of these infections were probably terminal events in patients who could not have expected long survival.

Local sepsis of the skin and of wounds was a relatively unimportant problem in the medical wards. Primary skin infections due to *Staph. aureus* were mild and sporadic. Half of them were due to organisms present in the patient's nose on

admission to the ward. Secondary skin infections were mainly in bedsores; three were believed to have contributed to the death of patients. Wound sepsis followed 9·2 % of surgical operations—a proportion comparable with that found in surgical wards (Report, 1960).

Urinary tract infection was over twice as common in females as in males. There was a significant association between catheterization and urinary tract infection in both sexes, but catheterization was relatively of greater importance as a cause of infection in males than in females. Thus, over half of the infections in males, but less than one-fifth of those in females, occurred in those who had been catheterized in hospital. The relatively high incidence of urinary infection in uncatheterized females is difficult to explain. Probably some of the infections thought to have been acquired in hospital were recrudescences of latent pyelonephritis.

The proportion of patients who acquired a staphylococcal infection (1·5 %) did not differ greatly from that reported in other surveys. Minchew & Cluff (1961) found evidence of staphylococcal infection other than wound sepsis in 1·1 % of patients in a general hospital (see also Farrer & Macleod, 1960; Frohman *et al.* 1964). Galbraith & Bailey (1964) recorded an incidence of 1·3 % in patients in four medical wards in one hospital. A considerably higher infection-rate (3·8 %) was, however, observed by Shooter, Girling, Matthias & Williams (1960) in a ward containing many patients with malignant and blood diseases.

An estimate of the mortality from staphylococcal disease based on the twelve fatal infections that were diagnosed bacteriologically gives a rate of 0·18 per 100 admissions, but this is an uncertain figure because of the difficulties in the diagnosis of staphylococcal pneumonia. If we assume that staphylococcal infection was as common among all fatal cases of pneumonia as it was in those examined bacteriologically, the mortality-rate for all hospital-acquired staphylococcal diseases would be 0·38 per 100 admissions. Rogers & Bennett (1958) estimated that between 0·35 and 0·95 % of medical patients in the New York Hospital acquire 'staphylococcal infections which pose a threat to life'.

The results of this survey do not indicate, as is often suggested, that staphylococcal and other serious infections are rife and are spreading uncontrolled in the wards of our hospitals; but they do show that a few patients in medical wards contract infections and suffer consequences more serious than the conditions for which they entered hospital.

The possible ways of preventing these infections are even less clear than for those occurring in surgical units, because precautions against infections of the type we studied cannot be applied—as for a surgical wound—to a defined body-site during a fairly short period of high susceptibility. Moreover, our findings do not offer great hope of control by isolating known infective patients in side-wards. Thus, though most of the staphylococcal sepsis was due to 'hospital strains' 55 % of it was due to strains which caused only one lesion in the ward during the year, so isolation of that patient would not have prevented another infection.

Many patients acquired 'hospital staphylococci' in the nose whilst in hospital, and the strains causing lesions were generally those prevalent in the noses of patients in the same ward. But there was little correspondence between the rate

of nasal colonization by a particular strain and the amount of sepsis it caused, so the value of isolating patients known to acquire it—even if this were practicable—remains doubtful. We incline to the view of Williams *et al.* (1962) that attempts to do this are unlikely to control staphylococcal disease, and that wards should therefore be built to isolate as many patients as possible from each other.

However, the increased susceptibility to infection of patients in certain age, sex, and disease categories suggests that there would be some advantage for them in protective isolation or segregation.

SUMMARY

A co-operative study was made of the incidence of infection acquired by patients in medical wards. Records were collected of 6740 admissions to 21 wards in 13 hospitals.

There were 384 clinical infections (5·7 per 100 patients admitted); 135 of them (35%) were infections of the lower respiratory tract, 72 (19%) were septic skin lesions or infected wounds, and 81 (21%) were urinary tract infections.

Infection was believed to have contributed to the death of 59 patients—17% of those infected or 8% of those dying in hospital. Nearly three-quarters of the deaths were attributed to 'pneumonia'.

Acquired infections were most common and most severe at the extremes of age. There was an excess of males over females in staphylococcal infections and in infections of the lower respiratory tract, and of females over males in urinary tract infections.

The incidence of infection was above average in patients suffering from malignant disease, diabetes, rheumatoid arthritis, cerebral thrombosis and haemorrhage, and from diseases of the urinary tract and of the skin.

There were 110 acquired infections with *Staph. aureus* and 12 deaths were attributed to them. Over half of these infections were due to staphylococcal strains which caused only one clinical infection in a ward in the course of a year.

Pneumonia was difficult to diagnose in severely ill or moribund patients, and its clinical significance was hard to assess. It was not possible to obtain a reliable estimate of the part played by bacterial infection in its causation.

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