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Prevalence of hospital infection and antibiotic use at a University Medical Center in Hong Kong

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Summary   Hospital infection prevalence surveys were performed in our 1400-bed University medical centre in Hong Kong from 1985 to 1988. We investigated the rates of four major hospital-acquired infections (HAIs) (pneumonia, symptomatic urinary tract infection, surgical site infection and laboratory-confirmed bloodstream infection) in order to identify current distribution and any changes after 15 years. A one-day point prevalence study was performed on 7 September 2005. All inpatients were surveyed for HAIs, community-acquired infections (CAIs), risk factors, pathogenic isolates and antibiotics prescribed. Infections were diagnosed according to Centers for Disease Control and Prevention (CDC) criteria. In total, 1021 patients were surveyed; of these, 41 had 42 HAIs (4% prevalence) and 389 (38%) were receiving antibiotics. The commonest HAI was pneumonia (1.4%) followed by bloodstream infection (0.9%) and symptomatic urinary tract infection (0.8%). The prevalence of postoperative surgical site infection was 5.6%. The nosocomial prevalence rate was highest in the Intensive Care Unit, followed by the Pediatric and Neonatal Intensive Care Units, Children's Cancer Centre/Bone Marrow Transplant Unit and Orthopaedics with Traumatology. Meticillin-resistant *Staphylococcus aureus* and *Pseudomonas aeruginosa* were the commonest pathogens. The rates are significantly lower than previously and reflect the increased resources for infection control made available following the outbreak of severe acute respiratory syndrome (SARS).
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Introduction

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Hospital-acquired infections (HAIs) are common causes of morbidity and mortality among hospitalized patients. Surveillance for nosocomial infections

(NIs) is an important component of an effective infection control programme.[1] The National Nosocomial Infections Surveillance (NNIS) system coupled with feedback and interventions successfully reduced the infection rate among participating hospitals.[2] Unfortunately such prospective surveillance is costly and labour intensive. Prevalence surveys are relatively inexpensive and easy to perform, although rates obtained are higher than comparable incidence rates and may be statistically less stable.[3] Despite their limitations they provide a useful estimate of HAI. French *et al.* conducted serial point prevalence surveys in our hospital 15 years ago. These proved to be a practical and useful way of documenting the trend of HAIs and assessing the impact of an infection control programme.[4] Conducting a prevalence survey also raises awareness among healthcare professionals of infection risks in hospital settings.[5,6] The objectives of this study were to determine the rate of nosocomial infection and the use of antibiotics. Knowledge of the current situation and major changes in distribution of nosocomial infections should help to prioritize resource allocation, allow a more effective infection control policy and enable a targeted prospective surveillance programme.

Methods

Setting

The Prince of Wales Hospital (PWH) is a 1400-bed teaching hospital in Hong Kong. Our laboratory is accredited by the National Association of Testing Authorities (NATA) and offers a wide range of bacteriology and virology services. The study was performed on 7 September, 2005. All inpatients at 09:00 as documented by the hospital computer system were included except those who were temporarily under observation in the Accident and Emergency department.

Definitions

CDC definitions for nosocomial infections were used. HAI was defined as occurrence of infection after hospital admission, without evidence that the infection was present or incubating (≤ 48 h) on admission.[7] Four major infections were surveyed: pneumonia, symptomatic urinary tract infection (SUTI), surgical site infection (SSI) and laboratory-confirmed bloodstream infection (LCBSI). Infections of more than one site in the same patient were counted as separate infections.

Only active infections (i.e. those undergoing antimicrobial treatment, symptomatic or considered ongoing by medical staff) were included.

Data collection

Demographic information, admission diagnosis, use of medical device and antibiotic were recorded by the ward nursing staff who had attended briefing sessions on each ward on the point prevalence survey with instructions on correct filling of a data collection form. Other relevant data were recorded by our investigators (infection control nurses and medical microbiologists: total = 10) on a separate standardized data collection form. They visited each ward and examined the clinical records, microbiology results and drug charts. A return visit was made if patient or medical record was not available. Completed data collection forms were checked on the same day by the survey coordinator to avoid absence of data. Microbiological data were collected up to two weeks after the study period.

Statistical analysis

Statistical analysis was conducted using SPSS software (SPSS, Inc., Chicago, IL, USA). $P < 0.05$ was considered statistically significant. The results were fed back to the hospital infection control committee and individual departments after the survey.

Results

Demography

In all, 1021 patients were surveyed and their distribution by specialty is shown in Table I. Ages ranged from 1 day to 102 years. The mean and median age was 46.9 and 52 years respectively; 52% were male and 48% were female. Hospitalization ranged from 1 to 886 days. Most patients (42.4%) were admitted for two days or less, nearly 80% admitted for 10 days or less. The mean and median durations of hospitalization were 12.5 and four days respectively.

In 607 patients, 801 devices were present. Peripheral intravenous catheter ($N = 442$), urinary catheter ($N = 269$) and central venous catheter ($N = 61$) were the most common. Of these, 427 patients had one device, 166 had two and 14 patients had three. Twenty patients were receiving mechanical ventilation.

Table I Hospital-acquired infection distribution by types and specialty

Specialty	Total no. (%) of patients	HAP	HA-SUTI	SSI	HA-LCBSI	HAI prevalence (%)
ICU	15 (1.5)	3	1	0	0	4 (26.7)
PICU/NICU	20 (2)	0	2	1	1	3 (15)
CCC/BMT	25 (2.4)	1	0	0	2	3 (12)
Orthopedics and Traumatology	101 (10)	0	1	8	0	9 (8.9)
SCBU	69 (6.8)	0	0	0	3	4 (5.8)
Surgery	251 (24.6)	3	3	1	2	9 (3.6)
Medical and Therapeutics	279 (27.3)	6	1	0	1	8 (2.9)
Pediatric surgery	44 (4.3)	0	0	1	0	1 (2.3)
Oncology	63 (6.2)	1	0	0	0	1 (1.6)
Ostetrics and Gynaecology	107 (10.5)	0	0	0	0	0 (0)
General Pediatrics	47 (4.6)	0	0	0	0	0 (0)
Total	1021	14	8	11	9	42
Prevalence (%)		1.4	0.8	1.1	0.9	4.1
CI		0.68—2.12	0.25—1.35	0.46—1.74	0.32—1.48	2.88—5.32
Prevalence (%) among operated patients				5.6		
CI				2.36—8.84		

No. of SSIs stratified by surgical wound class and site infection

Surgical wound classification	SSI			Total SSI (%)	Total operated patients (%)
	Superficial SSI	Deep SSI	Organ space infection		
Clean	3	1	0	4 (4.5)	88 (45.5)
Clean—contaminated	1	0	0	1 (2)	52 (27)
Contaminated	1	5	2	8 (20)	25 (13)
Dirty	0	1	1	2 (3.6)	28 (14.5)

HAP, hospital-acquired pneumonia; HA-SUTI, hospital-acquired symptomatic urinary tract infection; SSI, surgical site infection; HA-LCBSI, hospital-acquired laboratory-confirmed bloodstream infection; HAI, hospital-acquired infection; ICU, Intensive Care Unit; PICU/NICU, Pediatric/Neonatal ICU; CCC/BMT, Children's Cancer Centre/Bone Marrow Transplant Unit; SCBU, Special Care Baby Unit; CI, confidence interval.

Hospital-acquired infection rate

Forty-four HAIs were diagnosed in 43 patients. Two patients had acquired the infections in another hospital and were excluded, leaving 42 HAIs in 41 patients giving a 4% HAI rate. The most common HAI was pneumonia (1.4%), followed by SSI (1.1%), LCBSI (0.9%) and finally SUTI (0.8%) (Table I). There were two cases (18%) of ventilator-associated pneumonia (VAP) among the 11 cases of hospital-acquired pneumonias (HAP). Fifty-seven percent of hospital-acquired urinary tract infections were catheter related.

The ICU had the highest prevalence rate of nosocomial infection (26.7%), followed by the Pediatric/Neonatal ICUs, Children's Cancer Centre/Bone Marrow Transplant unit (CCC/BMT) and Orthopaedics and Traumatology (Table I).

The prevalence of SSI among those patients who had undergone operation was 5.6% (Table I). Approximately 11% of the surgical patients underwent operations classified as 'contaminated' or 'dirty' were diagnosed with SSI. Four percent and 2% of those who had 'clean' and 'clean—contaminated' operations had SSIs (Table I).

Risk factors

Patients with nosocomial infection had a median hospital stay of 19 days compared to 4 days for non-infected patients. Duration of hospital stay, operation, invasive ventilation and intravascular device were independent risk factors for HAI ($P < 0.05$) (Table II).

Table II Risk factor analysis

Univariate analysis comparing patients with or without hospital-acquired pneumonia in relation to presence of risk factors

	No. of patients with hospital acquired infection	No. of patients with non-infected	OR (CI)	P-value
Male	29	463	2.3 (1.13—4.93)	0.012
Hospitalization >4 days	37	371	13.5 (4.55—44.93)	0.000
Operation	22	167	5.2 (2.62—10.21)	0.000
Invasive ventilation	5	15	8.3 (2.48—26.24)	0.000
Peripheral IV catheter	24	366	2.1 (1.07—4.16)	0.019
Central venous catheter	9	51	4.8 (1.99—11.06)	0.000
Urinary catheter	19	226	2.6 (1.33—5.15)	0.002

Multiple logistic regression analysis comparing patients with or without HAI in relation to presence of risk factors

	OR (CI)	P-value
Hospitalization >4 days	10.974 (3.813—31.580)	0.000
Intravascular device	4.192 (1.874—9.377)	0.000
Invasive ventilation	3.913 (1.188—12.888)	0.025
Operation	2.84 (1.45—5.57)	0.002

OR, odds ratio; CI, confidence interval.

Community-acquired infection rate

Sixty-six patients were diagnosed with CAI. The prevalence rate was 6.5%. Together with HAI (41 patients with HAI and two other patients with HAI from other hospitals), the overall prevalence rate of infection in hospital was 10.7%.

Microbiology

Among 41 patients with HAI, 97.6% had relevant microbiology and serological tests performed and 77.5% had positive cultures. The commonest organisms isolated were *Pseudomonas aeruginosa* and meticillin-resistant *Staphylococcus aureus*.

Antibiotics

A total of 389 patients (38%) were receiving antibiotics; 213 (20.9%) received one antibiotic, 132 (12.9%) received two and 31 (3%) received three or more. The five most commonly prescribed antibiotics were amoxicillin-clavulanate, metronidazole, cefuroxime, cloxacillin and gentamicin (Table III). The commonest antibiotic combinations were cefuroxime + metronidazole (N = 20), gentamicin + penicillin (N = 13), ampicillin + cloxacillin (N = 11), ampicillin + cefuroxime + metronidazole (N = 7) and gentamicin + vancomycin (N = 6).

Discussion

Though some of our findings are similar to those in other parts of the world, they are useful for local healthcare workers. The last survey in our hospital was performed over 15 years ago and some interesting changes in nosocomial infection rate and antibiotic use were found.

Differences in methodologies and patient population do not allow stringent comparison of prevalence between different surveys and meaningful comparison of infection rates requires adjustment for intrinsic and extrinsic risk factors. The impact of case mix on infection rates was well illustrated with the example of hospital size in the study by Sax's group.[8] Detailed information on patient demographics, duration of hospital stay and invasive devices/antibiotic use has been illustrated for reference in this single hospital study.

The CDC definition of infections was adopted. Although it was not used in the previous surveys, it is now one of the most widely used and objective standards. All our investigators were qualified medical and nursing staff with relevant infection control training. Inter-observer bias was minimized by ensuring that the investigators agreed on the interpretation of the diagnostic criterion before the survey. However, Gastmeier *et al.* showed that despite the use of specific CDC criteria, there could still be subjectivity in the diagnosis of nosocomial infections.[9] The investigator effect was not known in the current survey.

Table III Courses of antibiotics and indication

Antibiotics	Courses	Indication		%
Amoxicillin/clavulanate	102	Therapeutic		93.7
Metronidazole	67	Pneumonia	25	43.4
Cefuroxime	50	Urinary tract infection	11.3	
Cloxacillin	41	Surgical site infection	4.3	
Gentamicin	32	Laboratory confirmed bloodstream infection	2.8	
Ampicillin	30	Clinical sepsis/no known source	17.6	50.3
Cefoperazone/sulbactam	27	Skin and soft tissue infection	10.3	
Vancomycin	26	Gastrointestinal	9.5	
Penicillin	23	Ear, nose and throat	3.5	
Ceftazidime	19	Lower respiratory tract infection other than pneumonia	2	
Cefotaxime	17	Reproductive tract infection	2	
Piperacillin/tazobactam	15	Bone and joint infection	1.8	
Cefuroxime axetil	14	Central nervous system	1.8	
Cefazolin	13	Cardiovascular system	1	
Cefepime	10	Systemic disseminated infection	0.8	
Meropenem	10	Prophylactic		6.3
Imipenem/cilastatin	3			
Linezolid	3			

Unnecessary use of antibiotics	ICU	M&T	O&G	Surgery	Ped Surg	O&T	Ped	Onco	Total
Metronidazole +									12
Amoxicillin/clavulanate	1	2		3					
Cefoperazone/sulbactam		2		2					
Meropenem								1	
Piperacillin/tazobactam		1		1					
Ampicillin + cloxacillin		1		1		9			11
Cloxacillin +									10
Amoxicillin/clavulanate						2			
Cefuroxime						3			
Ceftazidime						1		1	
Cefoperazone/sulbactam		1							
Cefepime		1							
Imipenem/cilastatin								1	

ICU, Intensive Care Unit; M&T, Medical and Therapeutics; O&G, Obstetrics and Gynaecology; Ped Surg, Pediatric Surgery; O&T, Orthopedics and Traumatology; Ped, Pediatrics; Onco, Oncology.

Only four major infections were studied. The prevalence of HAI was 4%. In point prevalence surveys using the CDC diagnostic criteria and involving the four major sites of infection (SUTI, LRTI, SSI and BSI) conducted in France, Italy, Norway and Lebanon, the prevalence of HAI ranged from 3.5 to 6.8%.[5,10–13] The inclusion of all sites of infection tends to increase the overall prevalence rate by 20–30% as compared with studies that included only major sites.[6,14] Thus, if corrected, the HAI prevalence rate estimated for all sites would be 5–6%. This rate was much lower than those found in 1985–1988 in PWH (7.3%),[15] as well as in other countries (6.5–13.95%).[6,14,16–19] Apart from the overall rate, rate reductions were found in HAP (from 1.8 to 1.4%), SSI (from 1.5 to 1.1%), and UTI (from 2.6 to 0.8%) without making case-mix adjustments[15] (Figure 1). This probably relates to improved infection control following the SARS crisis in Hong Kong, as evidenced by increased resources and heightened awareness among healthcare workers (HCWs). Our hospital had one infection control nurse per 250 beds after 2003 as compared to the previous ratio of 1:700. Infection control programmes, such as 'alert organism' reporting, biannual hand hygiene audit, regular infection control educational/training to HCWs and SSI surveillance have since been implemented. Heightened infection control awareness was demonstrated by the high compliance rate in hand hygiene audit among HCW. The low prevalence may also relate to a short duration of hospital stay and rapid transferal to convalescence hospitals after initial diagnosis and stabilization.

The prevalence of nosocomial pneumonia, LCBSI and SSI was similar to that reported in European
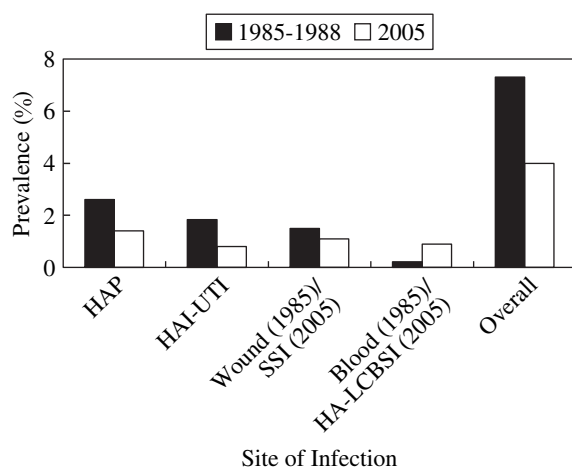
Figure 1 Prevalence of hospital-acquired infection (HAI) in the Prince of Wales Hospital in 1985—1988 and 2005. HAP, hospital-acquired pneumonia; UTI, urinary tract infection; SSI, surgical site infection; HA-LCBSI, hospital-acquired laboratory confirmed blood stream infection.

surveys. The prevalence of nosocomial LCBSI was relatively high, possibly due to a high overall blood culture rate and simple application of the diagnostic criteria.

The rate of nosocomial urinary tract infection (UTI) was lower than the 1.5—4.5% reported from other surveys.[5,10—12,16—17] The greatest problem with defining SUTI is that if the urine is not analyzed, UTI cannot be diagnosed. Secondly, the definition did not take into account urinary catheters, as symptoms of UTI other than fever cannot be assessed in catheterized patient.[20] The frequency of SUTI therefore depended upon: (i) Frequency of catheter use: 26% of the patients had an indwelling urinary catheter; (ii) Urine analysis protocol: in our hospital, urine is only analysed when the signs and symptoms indicate a UTI or when a catheterized patient develops a fever. Symptoms of UTI in patients with a serious major disease of other organs may have been ignored; and (iii) Physician's diagnosis: data collection based on doctor's diagnosis may not have been sensitive enough to record all UTIs.

Furthermore asymptomatic bacteriuria was not evaluated. These factors may account for the underestimation of rate of UTI compared with other studies.

The distribution of nosocomial infection among different specialties was similar to published European studies. The prevalence of nosocomial infection was greatest in ICU at 26.7%, which compared with 35.5% 15 years ago,[15] and was similar to that of other studies.[5,6,14,18] The Special Pediatric unit ranked second for nosocomial

infection. HAI, not limited to SSI, has been shown to be twice as common in postoperative patients.[6,11]

Thirty-eight percent of patients received at least one antimicrobial agent, more than in other studies (16.6—44%), but only 10% had an infection according to the CDC criteria.[14—18,21] Indications for antibiotic prescription were reviewed retrospectively in order to investigate this discrepancy (Table III). Prophylactic use (6.3%) and treatment for infections that were not being investigated in the current survey (50%) may have accounted for antibiotic use in 37% of patients. The remaining 35% may have represented treatment of infections not fulfilling the CDC criteria or inappropriate antibiotic prescription. Recent surveys showed that suboptimal antimicrobial prescription is frequent in our hospital.[22] Though appropriateness of antibiotic prescription was not the aim of current study, unnecessary antibiotic combinations were noted (Table III). Broad-spectrum antibiotics, e.g. imipenem, meropenem and cefepime, accounted for about 20% of the antibiotics being prescribed on the day of survey. Audit of 'big-gun' antibiotics in local university hospitals revealed that 20—25% of the prescriptions were not justified or suboptimal.[22,23] The upcoming antibiotic stewardship programme targeting this group of drugs should help to optimize use of antimicrobials in the hospital.[23]

In summary, provision of better resources appears to have had a definite effect in reducing HAIs. The ICU, Special Pediatric and Surgical/Orthopaedic units warrant targeted surveillance of nosocomial infection followed by a relevant infection control programme. Another target would be improvement in nosocomial bloodstream infection by promoting proper intravenous catheter care. Repeated prevalence surveys are useful for monitoring trends in rates of both HAI and effectiveness of such intervention strategies.[4]

Acknowledgements

References

1. Haley RW, Culver DH, White JW, *et al*. The efficacy of infection surveillance and control programs in preventing nosocomial infections in US hospitals. *Am J Epidemiol* 1985;**121**:182—205.

2. Gaynes R, Richards C, Edwards J, *et al*. Feeding back surveillance data to prevent hospital acquired infections. *Emerg Infect Dis* 2001;**7**:295−298.

3. Freeman J, Hutchison GB. Prevalence, incidence and duration. *Am J Epidemiol* 1980;**112**:707−723.

4. French GL, Cheng AF, Wong SL, Donnan S. Repeated prevalence surveys for monitoring effectiveness of hospital infection control. *Lancet* 1989;**2**(8670):1021−1023.

5. Eriksen HM, Iversen BG, Aavitsland P. Prevalence of nosocomial infections in hospitals in Norway, 2002 and 2003. *J Hosp Infect* 2005;**60**:40−45.

6. The French Prevalence Survey Study Group. Prevalence of nosocomial infections in France: results of nationwide survey in 1996. *J Hosp Infect* 2000;**46**:186−193.

7. Centers for Disease Control and Prevention. *National Nosocomial Infection Study Site Definition Manual*. Atlanta, GA: Centers for Disease Control and Prevention; 1999.

8. Sax H, Pittet D, Swiss-NOSO network. Inter-hospital differences in nosocomial infection rates: importance of case-mix adjustment. *Arch Intern Med* 2002;**162**:2437−2442.

9. Gastmeier P, Kampf G, Hauer T, *et al*. Experience with two validation methods in a prevalence survey on nosocomial infections. *Infect Control Hosp Epidemiol* 1998;**19**:668−673.

10. Gastmeier P, Kampf G, Wischnewski N, *et al*. Prevalence of nosocomial infections in representative German hospitals. *J Hosp Infect* 1998;**38**:37−49.

11. Lizioli A, Priviteria G, Alliata E, *et al*. Prevalence of nosocomial infections in Italy: result from the Lombardy Survey in 2000. *J Hosp Infect* 2003;**54**:141−148.

12. Scheel O, Stromark M. National Prevalence Survey on Hospital Infection in Norway. *J Hosp Infect* 1999;**41**:331−335.

13. Azzam R, Dramaix M. A one-day prevalence survey of hospital acquired infections in Lebanon. *J Hosp Infect* 2001;**49**:74−78.

14. Vaque J, Rossello J, Arribas L. Prevalence of nosocomial infections in Spain: EPINE study 1990−1997. *J Hosp Infect* 1999;**43**(Suppl):S105−S111.

15. French GL, Cheng AF. Prevalence of hospital infection at the Prince of Wales Hospital. *J Hong Kong Med Assoc* 1989;**41**:226−229.

16. Anderson BM, Ringertz SH, Petersen GT, *et al*. A three-year survey of nosocomial and community-acquired infections, antibiotic treatment and re-hospitalization in a Norwegian health region. *J Hosp Infect* 2000;**44**:214−223.

17. Zotti CM, Messoriloli G, Charrier L, *et al*. Hospital-acquired infections in Italy: a region wide prevalence study. *J Hosp Infect* 2004;**56**:142−149.

18. Valineteliene R, Jurkuvenas V, Jepsen OB. Prevalence of hospital-acquired infection in a Lithuanian hospital. *J Hosp Infect* 1996;**34**:321−329.

19. Hughes AK, Ariffin N, Huat TL, *et al*. Prevalence of nosocomial infection and antibiotic use at a university medical center in Malaysia. *Infect Control Hosp Epidemiol* 2005;**26**:100−104.

20. Vandenbroucke-Grauls C, Schultsz C. Surveillance in infection control: are we making progress? *Curr Opin Infect Dis* 2002;**15**:415−419.

21. Kallel H, Bahoul M, Ksibi H, *et al*. Prevalence of hospital-acquired infection in a Tunisian hospital. *J Hosp Infect* 2005;**59**:343−347.

22. Ho PL. Antibiotic guidelines and optimization programme. In: Yuen KY, Wong SY, editors. *Infectious Diseases Update: Course 6*. Hong Kong: Center of Infection, University of Hong Kong; 2004. p. 1−110.

23. Ho PL, Cheng JCF, Ching PT, *et al*. Optimising antimicrobial prescription in hospitals by introducing an antimicrobial stewardship programme in Hong Kong: consensus statement. *Hong Kong Med J* 2006;**12**:141−148.