NASAL CARRIAGE OF *STAPHYLOCOCCUS AUREUS* IS A MAJOR RISK FACTOR FOR SURGICAL-SITE INFECTIONS IN ORTHOPEDIC SURGERY

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ABSTRACT

OBJECTIVE: To determine the relative importance of different risk factors for the development of surgical-site infections (SSIs) in orthopedic surgery with prosthetic implants.

DESIGN: In a cohort of 272 patients, the following possible risk factors were studied: age, gender, method of hair removal, duration of operation, surgeon, underlying illness, and nasal carriage of *Staphylococcus aureus.* Infections were recorded following the Centers for Disease Control criteria. The relation between risk factors and SSI was tested in univariate and multiple logistic regression analysis.

SETTING: Community hospital in Breda, The Netherlands.

RESULTS: 18 (6.6%) of 272 patients experienced SSI: 11 superficial and 7 deep SSI. These infections led in three cases to removal of the prosthesis and caused 286 extra days in hospital. The main causative pathogen was *S aureus.* In multiple logistic regression analysis, the following factors were independent risk factors for the development of SSI: high-level nasal carriage of *S aureus* (*P*=.04), male gender (*P*=.005), and surgeon 1 (*P*=.006). The only independent risk factor for SSI with *S aureus* was high-level nasal carriage of *S aureus* (*P*=.002).

CONCLUSION: High-level nasal carriage of *S aureus* was the most important and only significant independent risk factor for developing SSI with *S aureus (Infect Control Hosp Epidemiol* 2000;21:319-323).

One of the most important risk factors for the development of surgical-site infection (SSI) is the degree of contamination of the wound at the moment of surgery.[1,2] Although orthopedic surgery typically is classified as clean, and strict aseptic techniques and antimicrobial prophylaxis commonly are employed, SSIs continue to be important complications.[2] In several large studies, infection rates between 1.3% and 2.9% were reported.[3-6] In a recent Dutch multicenter surveillance study, the following infection rates were found: collum fractures, 3.1%; replacement of femur head, 6.0%; total hip prosthesis, 3.0%; and total knee prosthesis, 4.1%.[7] These infections, and especially the deep prosthetic infections, can have serious consequences for the patient and are associated with high extra costs of care.[8-13] In this prospective cohort study, the relative importance of different risk factors for SSI in patients undergoing orthopedic surgery with prosthetic implants was evaluated.

METHODS

Study Population

The study was performed from June 1995 until April 1996 at the department of orthopedic surgery at the Ignatius Hospital, Breda, The Netherlands. All patients undergoing hip, knee, or back surgery in which prostheses were implanted or revised were included. Patients were included only once. Generally, patients were admitted the day before surgery. On that day, hair removal was performed, and a nasal swab was taken for culture. Cefamandole was given as perioperative antibiotic prophylaxis to all patients, according to the schedule of the hospital guideline: 1 g 30 to 60 minutes before surgery followed by 1-g doses 8 and 16 hours thereafter. All procedures were performed in a standard operation theater with standard air conditions (no ultraclean air) and standard clothing.

Variables and Surveillance Method

The following variables were recorded: age, gender, date of admission, method of hair removal, type of procedure, date of surgery, date of discharge, total length of hospital stay, postoperative length of stay, duration of the operation, surgeon (numbered 1 to 6), and presence of malignancy or diabetes mellitus. The ward was visited daily by one of the investigators. The medical records of all patients were studied for the presence of SSI based on criteria as defined by the Centers for Disease Control (CDC).[14,15] Date of onset and pathogens involved were recorded.

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TABLE 1
TYPE OF PROCEDURE AND CORRESPONDING NUMBER OF OPERATIONS, MEAN AGE, MEAN DURATION OF OPERATION, MEAN LENGTH OF HOSPITAL STAY, AND NUMBER OF SURGICAL-SITE INFECTIONS (SSIs)

		Mean (Standard Deviation)			
Procedure	**Frequency**	**Age, y**	**Duration of Operation, min**	**Length of Hospital Stay, d**	**No. of SSIs (%)**
Total hip	136	65.3 (12.7)	77.6 (26.3)	17.3 (10.7)	12 (8.8)
Revision total hip	21	71.0 (11.8)	94.1 (46.6)	20.0 (11.5)	1 (4.8)
Total knee	65	64.3 (11.2)	71.2 (17.8)	16.1 (6.5)	2 (3.0)
Revision total knee	7	64.7 (8.2)	89.7 (42.3)	17.3 (10.8)	0 (0)
Back	43	46.9 (16.0)	133.9 (72.3)	12.8 (7.7)	3 (7.0)
Total	272	62.5 (14.6)	86.7 (43.4)	16.5 (9.6)	18 (6.6)

Significant *P* values after correction for multiple comparisons: age: total hip vs back: $P<.001$; revision total hip vs total knee: $P=.04$; revision total hip vs back: $P<.001$; total knee vs back: $P<.001$; and revision total knee vs back: $P=.04$.
Duration of operation: total hip vs back: $P<.001$ and total knee vs back: $P<.001$.
Length of hospital stay: revision total knee vs back: $P=.047$.

TABLE 2
ORGANISMS ISOLATED FROM SUPERFICIAL AND DEEP SURGICAL-SITE INFECTION (SSI)

Organism	Superficial SSI (%)	Deep SSI (%)	Total SSI (%)
Staphylococcus aureus	4 (36)	5 (71)	9 (50)
Staphylococcus epidermidis	2 (18)	0 (0)	2 (11)
Pseudomonas aeruginosa	2 (18)	1 (14)	3 (16)
Other	3 (27)	1 (14)	4 (22)
Total	11 (100)	7 (100)	18 (100)

Nasal Culture

The day before surgery, both nares were sampled using a Dacron swab. The swab was processed in the laboratory the same day. A blood-agar plate was inoculated, and the amount of *Staphylococcus aureus* in the nasal swab was determined semiquantitatively using four quadrants. Two levels of growth were distinguished: growth limited to the first two streaks on the agar plate was defined as low-level nasal carriage of *S aureus;* growth in the third or fourth streak was defined as high-level nasal carriage of *S aureus.*

Statistical Analysis

Results were analyzed using the Statistical Package for Social Sciences (SPSS, Chicago, IL). Differences between groups were tested by the *t* test, Fisher's Exact Test, or Wilcoxon Sum Rank Test, analysis of variance with Bonferroni correction, Kruskal-Wallis Test, or Mann-Whitney Test when appropriate. To correct for interference of the different variables, multiple logistic regression was used. Statistical significance was accepted at $P<.05$.

RESULTS

Of the 272 patients included, 190 (69.9%) were female. The mean age was 63 (standard deviation [SD], 14.5; range, 14-94) years. The mean duration of surgery was 86.7 (SD, 43.3) minutes. The mean length of stay in the hospital was 16.5 (SD, 9.6; range, 4-72) days. Table 1 shows the different types of procedures and the corresponding mean duration of the procedure, the mean age of the patient, and the mean length of hospital stay.

The operations were done by six surgeons. The number of operations per surgeon ranged from 24 for surgeon 2 to 79 for surgeon 1. Total hip, revision of total hip, and total knee operations were performed by all surgeons, except surgeon 3, who did not perform any total knee operations. All total knee revision operations were done by surgeons 1 and 4, and almost all back operations were done by surgeons 5 and 6.

Hair removal was done by clipping or depilatory cream (14.3%), by shaving with a razor blade (58.8%), or not done (26.8%).

S aureus was carried by 27% of patients: 17% high-level and 10% low-level.

Overall, 18 patients (6.6%) developed SSI (Table 1): 11 superficial and 7 deep (Table 2). *S aureus* was the causative pathogen in 9 (50%), including 5 (71%) of 7 deep SSIs. Six of the 9 patients with SSI caused by *S aureus* had a positive nasal swab before surgery. All other pathogens were isolated only once.

Table 3 shows the mean duration of operation, age, and length of hospital stay associated with superficial, deep, or no SSI. No significant relation was found between mean age or duration of operation. Length of stay was significantly related to SSI: those with superficial SSI stayed a mean of 5 days longer than those with no SSI, and those with deep SSI stayed a mean of 33 days longer. Besides this prolongation in hospital stay, in three patients with a deep SSI, the prosthesis had to be removed.

In univariate analyses, male gender, high-level nasal carriage of *S aureus,* and having surgery performed by surgeon 1 were significantly associated with SSI (Table 4); underlying illness and any nasal carriage of *S aureus* (high or low level) were significantly associated with *S aureus* SSI.

To correct for confounding, logistic regression analysis was done for the outcomes "SSI" and "SSI with *S aureus."* Every variable recorded was included in the

TABLE 3
MEAN DURATION OF OPERATION, AGE, AND LENGTH OF POSTOPERATIVE HOSPITAL STAY BY SURGICAL-SITE INFECTION (SSI) OUTCOME

		Mean (Standard Deviation)		
SSI	**Number**	**Duration of Operation, min**	**Age, y**	**Length of Postoperative Hospital Stay, d**
Superficial	11	82.3 (55.3)	68.4 (9.1)	20.6 (5.2)
Deep	7	108.4 (61.6)	64.9 (18.4)	48.4 (25.9)
None	254	86.3 (42.3)	62.1 (14.6)	15.4 (7.2)
*P**		NS	NS	<.01

Abbreviation: NS, not significant.
* Analysis of variance.

analyses. The following factors were independent risk factors for the development of SSI: high-level colonization with *S aureus* (*P*=.04), male gender (*P*=.005), and surgeon 1 (*P*=.006). The only independent risk factor for SSI with *S aureus* was high-level *S aureus* colonization (*P*=.002).

DISCUSSION

High-level nasal carriage of *S aureus* by the patient was the most important and only significant independent risk factor for SSI with *S aureus* and also was a significant independent risk factor for any SSI. This is the first study to document this risk factor in orthopedic surgery with prosthetic implants. Nasal carriage of *S aureus* was identified as a risk factor for SSI approximately 4 decades ago in several excellent studies. In the late 1950s, the observation was made that some patients developed infections with *S aureus* strains that had been isolated previously at other sites from the same patient and not from other potential sources in the environment. In 1959, three independent reports were published that had investigated primarily the relation between nasal carriage of *S aureus* and the development of surgical-wound infections.[16-18] A number of studies followed in the next decade, most of which showed a significantly increased risk for development of a wound infection by nasal carriers.[19] The causal relationship was strengthened by showing a correlation between the colonization density of *S aureus* at the carriage site and the risk of infection.[20-22] Recently, a case-control study was performed to evaluate the importance of nasal carriage as a risk factor in cardiothoracic surgery for the development of sternal-wound infection with *S aureus* after sternotomy.[23] Preoperative nasal carriage was identified as the most important risk factor (odds ratio, 9.6; 95% confidence interval, 3.9-23.7). Moreover, phage typing of both the pre- and postoperative isolates of *S aureus* showed that all 10 pairs were identical. In our study, nasal carriage had a relative risk (RR) of 8.9 for SSI with *S aureus,* which is practically identical to results for the patients in cardiothoracic surgery. An increase in RR was observed when the number of colony-forming units of *S aureus* present in the nasal cavity increased. This dose-effect relationship strengthens the causal relationship between nasal carriage and the development of SSI. The carriage rate found in the present study was 27%. In the general population, a mean carriage rate of 37.2% (range, 19.0%-55.1%) was found, based on many studies over the years 1934 to 1994.[24] Therefore, the carriage rate in the current study was within the expected range.

TABLE 4
RISK FACTORS FOR SURGICAL-SITE INFECTION ([SSI] UNIVARIATE ANALYSIS)

Risk Factor	RR	CI_{95}
Any SSI		
Male gender	4.1	1.5-10.9
Underlying illness	2.6	0.9-7.7
Removing hair with razor blade	2.4	0.5-11.3
Surgeon 1	3.4	1.3-8.8
Staphylococcus aureus nasal carriage (any)	2.3	0.8-6.4
S aureus nasal carriage (high level)	3.1	1.1-9.0
S aureus SSI		
Male gender	3.0	0.8-11.5
Underlying illness	4.4	1.1-17.0
Removing hair with razor blade	2.6	0.3-22.1
Surgeon 1	3.1	0.8-12.2
Staphylococcus aureus nasal carriage (any)	8.9	1.7-45. 5
S aureus nasal carriage (high level)	16.0	3.1-82.2

Abbreviations: CI_{95}, 95% confidence interval; RR, relative risk.

The other risk factors for developing SSI that were found to be significant in univariate analysis and remained significant in logistic regression analysis were male gender and surgeon 1. No explanation could be found for male gender as an independent risk factor for developing SSI, and male gender is not considered to be an important risk factor for SSI in general.[2] A specific explanation for surgeon 1 being an independent risk factor could not be found either. It is known that different surgeons can have different infection rates, and it has been shown that infection surveillance and feedback of infection rates to surgeons leads to lower infection rates, but the exact cause for this has never been identified.[3,5,25-29]

The overall infection rate was 6.6%. The infection rate for total hip replacements in this study was higher than in a large Dutch multicenter surveillance study (8.8% vs 3.0%), whereas the infection rate was lower for total knee replacement (3.0% vs 4.1%). Many other infection rates for orthopedic surgery have been reported, varying from 1.3% to 6.0%.[3-7] It is difficult, however, to compare infection rates. Differences in surveillance methods, differences in the criteria applied, and differences in characteristics of the patient population are major causes of differences in infection rates.[2] The prophylactic regimen also may influence the SSI rate. In this study, a 24-hour schedule with two postoperative doses was used (it should be mentioned that this regimen, although not uncommon, is not consistent with the recommendation that prophylaxis not extend beyond the end of surgery). Another factor that can influence the infection rate is the duration of follow-up. We performed follow-up until discharge and included events identified when patients were readmitted to the hospital. From the results of a large Dutch multicenter surveillance study, the effect of postdischarge surveillance in a comparable population can be estimated.[7] In that study 18,063 operations were included, and surveillance was done according to the CDC criteria and was extensively validated. The group "bone and muscle surgery," which is comparable with our group of patients, consisted of 9,831 procedures. Some centers systematically performed postdischarge surveillance, others did not. In the group of centers with postdischarge surveillance, 38.4% of SSI were found after discharge; in the group of centers without systematic postdischarge surveillance, 25.2% of SSI were found after discharge. Thus, without systematic postdischarge surveillance, 13.2% of SSI were missed. Accordingly, we may have missed 10% to 15% of all infections. However, these would be the late infections, which typically are caused by organisms other than *S aureus.* When a late deep infection with *S aureus* arises, this would be a serious problem, which would result in readmission to hospital. Therefore, it is highly unlikely that an important part of infections caused by *S aureus* would have been missed, and therefore the conclusion regarding the risk factor "nasal carriage" is valid. We might have slightly underestimated the SSI rate, but this would concern especially infections with organisms other than *S aureus.* As a result, we might have slightly overestimated *S aureus* as a risk factor, but the effect of the short duration of follow-up should be very small and not influence the conclusions of the study.

The complications associated with the 18 SSIs were considerable. The 11 superficial infections were associated with a mean prolongation of hospital stay of 5 days per patient, or 55 days overall. However, the 7 deep infections were associated with a mean prolongation of hospital stay of 33 days per patient, for a total of 231 extra days. Besides this, in three patients with deep SSI, the prosthesis had to be removed; so, deep SSI have especially important implications for the patient and the hospital, and preventive measures should primarily be aimed at preventing deep SSI. In deep SSI, *S aureus* was by far the most important organism (71% of deep SSI). Risk-factor analysis showed that high-level nasal carriage of *S aureus* in the patient was the only significant, independent risk factor for developing SSI with *S aureus.* Measures aimed at preventing SSI with *S aureus* therefore should be directed toward eradication of nasal carriage. A recent study found a significantly lower SSI rate in cardiothoracic surgery after perioperative eradication of nasal carriage with mupirocin nasal ointment.[30] In that study, an SSI rate of 7.3% was found before eradication of nasal carriage versus 1.7% in patients treated perioperatively with mupirocin ($P<.0001$). A major disadvantage of the study was the use of a historical control group, and therefore these results need to be confirmed in placebo-controlled, randomized, double-blinded studies. Nevertheless, the concept of perioperative eradication of nasal carriage is attractive. Since nasal carriage is an important risk factor for the development of SSI, eradication of this risk factor is likely to reduce the SSI rate. Mupirocin nasal ointment is a relatively cheap and safe agent, which is highly effective in eradicating nasal carriage.[19] A study on the cost-effectiveness of mupirocin as perioperative prophylaxis showed that, provided that perioperative eradication with mupirocin is effective in a well-designed study, this measure will be highly cost-effective.[31] Therefore, we are now performing a double-blinded, randomized, placebo-controlled study of mupirocin in patients undergoing orthopedic surgery in which prosthetic implants are used.

REFERENCES

1. Weigelt JA. Risk of wound infections in trauma patients. *Am J Surg* 1985;150:782-784.
2. Kluytmans JAJW. Surgical infections including burns. In: Wenzel RP, ed. *Prevention and Control of Nosocomial Infections.* 3rd ed. Baltimore, MD: Williams & Wilkins; 1997:841-865.
3. Cruse PJE, Foord R. The epidemiology of wound infection: a 10-year prospective study of 62,939 wounds. *Surg Clin North Am* 1980;60:27-40.
4. Haley RW, Culver DH, Morgan WM, White JW, Emori TG, Hooten TM. Identifying patients at high risk of surgical wound infection: a simple multivariate index of patient susceptibility and wound contamination. *Am J Epidemiol* 1985;121:206-215.
5. Olson MM, Lee JT Jr. Continuous 10-year wound infection surveillance. Results, advantages and unanswered questions. *Arch Surg* 1990;125:794-803.
6. Culver DH, Horan TC, Gaynes RP, Martone WJ, Jarvis WR, Emori TG, et al. Surgical wound infection rates by wound class, operative procedure, and patient risk index. National Nosocomial Infections Surveillance System. *Am J Med* 1991;91(suppl 3B):152S-157S.
7. Mintjes-de Groot AJ, Van den Berg JMJ, Veerman-Brenzikofer MLV, De Boer AS, Smook AOA. Frequentie van postoperatieve wondinfecties in Nederland. *Ned Tijdschr Geneeskd* 1998;142:22-26.
8. Green JW, Wenzel RP. Postoperative wound infection: a controlled study of the increased duration of hospital stay and direct cost of hospitalization. *Ann Surg* 1977;185:264-268.
9. Coello R, Glenister H, Fereres J, Bartlett C, Leigh D, Sedgwick J, et al. The cost of infection in surgical patients: a case-control study. *J Hosp Infect* 1993;25:239-250.
10. Kluytmans JA, Mouton JW, Ijzerman EP, Vandenbroucke-Grauls CM, Maat AW, Wagenvoort JH, et al. Nasal carriage of *S aureus* as a major risk factor for wound infection after cardiac surgery. *J Infect Dis* 1995;171:216-219.
11. Ehrenkranz NJ, Meakins JL. Surgical infections. In: Bennet JV, Brachman PS, eds. *Hospital Infections.* 3rd ed. Boston, MA: Little Brown and Co; 1992:685-710.
12. Kluytmans JAJW, Mouton JW, Maat APWM, Manders MAAJ, Michel MF, Wagenvoort JHT. Surveillance of postoperative infections in thoracic surgery. *J Hosp Infect* 1994;27:139-147.
13. Petty W. Infections of skeletal prostheses. In: Bennet JV, Brachman PS, eds. *Hospital Infections.* 3rd ed. Boston, MA: Little Brown and Co; 1992:749-766.
14. Garner JS, Jarvis WR, Emori TG, Horan TC, Hughes JM. CDC definitions for nosocomial infections, 1988. *Am J Infect Control* 1988;16:128-140.
15. Horan TC, Gaynes RP, Martone WJ, Jarvis WR, Emori TG. CDC definitions of nosocomial surgical site infections, 1992: a modification of CDC defini-

tions of surgical wound infections. *Am J Infect Control* 1992;20:271-274.
16. Colbeck JC, Robertson HR, Sutherland WH, Hartley FC. The importance of endogenous staphylococcal infections in surgical patients. *Canad Serv Med J* 1959;15:326-331.
17. Weinstein HJ. The relation between nasal-staphylococcal-carrier state and the incidence of postoperative complications. *N Engl J Med* 1959;260:1303-1308.
18. Williams REO, Patricia-Jevons M, Shooter RA, et al. Nasal staphylococci and sepsis in hospital patients. *BMJ* 1959;2:658-662.
19. Kluytmans JAJW, van Belkum A, Verburgh H. Nasal carriage of *Staphylococcus aureus:* epidemiology, underlying mechanisms, and associated risks. *Clin Microbiol Rev* 1997;10:505-520.
20. Calia FM, Wolinsky E, Mortimer EA, Abram JS, Rammelkamp CH. Importance of the carrier state as a source of *S aureus* in wound sepsis. *J Hyg Camb* 1969;67:49-57.
21. White A. Increased infection rates in heavy nasal carriers of coagulase-positive staphylococci. *Antimicrob Agents Chemother* 1963;30:667-670.
22. Bruun JN. Postoperative wound infection. Predisposing factors and the effect of a reduction in the dissemination of staphylococci. *Acta Med Scand* 1970;514(suppl):1-89.
23. Kluytmans JAJW, Mouton JW, Ijzerman EPF, Vandenbroucke-Grauls CMJE, Maat AWPM, Wagenvoort JHT, et al. Nasal carriage of *S aureus* as a major risk factor for wound infections after cardiac surgery. *J Infect Dis* 1995;171:216-219.
24. Kluytmans J, Van Belkum A, Verbrugh H. Nasal carriage of *Staphylococcus aureus:* epidemiology, underlying mechanisms, and associated risks. *Clin Microbiol Rev* 1997;10:505-520.
25. Condon RE, Schulte WJ, Malangoni MA, Anderson-Teschendorf MJ. Effectiveness of a surgical wound surveillance program. *Arch Surg* 1983;118:303-307.
26. Olson M, O'Conner M, Schwartz ML. Surgical wound infections. A 5-year prospective study of 20,193 wounds at the Minneapolis VA medical center. *Ann Surg* 1984;199:253-259.
27. Mead PB, Pories SE, Hall P, Vacek PM, Davies JH Jr, Gamelli RL. Decreasing the incidence of surgical wound infections. Validation of a surveillance notification program. *Arch Surg* 1986;121:458-461.
28. Britt MR, Schleuper CJ, Matsumiya S. Severity of underlying disease as a predictor of nosocomial infection: utility in the control of nosocomial infection. *JAMA* 1978;239:1047-1051.
29. Hooton TM, Haley RW, Culver DH, White JW, Morgan WM, Carroll RJ. The joint association of multiple risk factors with the occurrence of nosocomial infection. *Am J Med* 1981;70:960-970.
30. Kluytmans JA, Mouton JW, VandenBerg MF, Manders MJ, Maat AP, Wagenvoort JH, et al. Reduction of surgical-site infections in cardiothoracic surgery by elimination of nasal carriage of *S aureus. Infect Control Hosp Epidemiol* 1996;17:780-785.
31. VandenBergh MF, Kluytmans JA, van Hout BA, Maat AP, Seerden RJ, McDonnel J, et al. Cost-effectiveness of perioperative mupirocin nasal ointment in cardiothoracic surgery. *Infect Control Hosp Epidemiol* 1996;17:786-792.

Decrease in Nosocomial Infections During 3-Year Period in Norwegian Hospitals

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Andersen and coinvestigators from the Department of Hospital Infection, Ulleval University Hospital, Oslo, Norway, analyzed hospital-acquired infections (HAI) by repeated point-prevalence studies (four each year) performed simultaneously at 14 hospitals in a health region (860,000 inhabitants) during the period 1996 to 1998. The study included 3,200 beds and 121,000 discharged patients each year. An overall prevalence rate of HAI of 6.5% (interhospital range, 1.4%-11.7%) was found for the 32,248 patients studied. The rate of HAI was reduced from 7.7% in 1996 to 5.9% in 1998. Smaller hospitals (<200 beds) generally had lower rates of HAI, community-acquired infections (CAI), postoperative infections, and use of antibacterial agents than the large regional hospital (1,200 beds).

HAI was reduced in nonoperated patients from 5.8% in 1996 to 4.4% in 1998 and in operated patients from 13.2% in 1996 to 10.5% in 1998. The risk of developing HAI was twice as high after surgery. From 1996 to 1998, there was a reduction in urinary tract infections from 2.4% to 1.7%, lower respiratory tract infections from 1.5% to 0.8%, and postoperative wound infections from 5.7% to 4.3%, whereas septicemia remained unchanged (from 0.5% to 0.4%). Rehospitalization because of HAI was registered in 0.6% (interhospital range, 0.3%-1.1%) of patients. The CAI rate in hospitals increased from 8.3% in 1996 to 10.8% in 1998. Approximately 16% (range, 14.4%-20.6%) of the patients had an infection.

FROM: Andersen BM, Ringertz SH, Gullord TP, Hermansen W, Lelek M, Norman BI, 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.