Factors associated with a significant reduction in hospital-wide infection rates

Nancy Malone, RN, BSN, CIC[a]
Elaine Larson, RN, PhD, CIC[b]
Fort Smith, Ark., and Washington, D.C.

Objective: The purpose of this study was to identify factors associated with a significant reduction in hospital-wide nosocomial infection rates.
Methods: Methods included a 3-year retrospective and a 10-month prospective follow-up study in a 500-bed hospital with total surveillance, with data collected by two ICPs using Centers for Disease Control and Prevention (CDC) definitions.
Results: Infection rates averaged 3.9% over a decade and dropped in 1993 to 2.6% ($p < 0.001$). This change was unexplained by changes in surveillance methods. Slightly shorter lengths of stay and fewer inpatient surgeries may have had some impact. Additionally, two factors were temporally and statistically associated with the reduction: hospital-wide introduction of the Occupational Health and Safety Administration (OSHA) Blood-borne Pathogen Exposure Control Plan and Body Substance Isolation, and a barrier hand foam.
Conclusions: Introduction of the OSHA Control Plan, with concomitant increase in glove use and widespread use of a barrier hand foam were associated with a significant reduction in nosocomial infection rates. Other demographic variables (shorter hospital stays and less inpatient surgery) probably also played a role. Risk-adjusted rates are necessary to make within-hospital comparisons over time. (AJIC AM J INFECT CONTROL 1996;24:180-5)

For 19 years, total hospital-wide surveillance of nosocomial infections has been conducted in a 500-bed hospital in northwestern Arkansas. Infection rates had been stable over the past decade, ranging from 3.4% to 4.5% (mean 3.9%). In 1993 there was a significant reduction in nosocomial infection rates. The purpose of this study was to examine factors that might explain this reduction in infection rates.

METHODS

In 1993 infection rates in the 500-bed study institution in northwest Arkansas dropped from an average of 3.9% over the previous 5 years to 2.6% (chi square, 55.9; $p < 0.001$ for 1993 compared with 1991 to 1992 [Fig. 1]). In January 1994 an intensive retrospective evaluation of factors that might have been associated with this reduction was undertaken. This included review of surveillance procedures, patient risk factors, and patient care practices.

Infection control practices, including methods of surveillance and definitions used, were thoroughly reviewed. Patient demographic data and hospital statistics were obtained from central administration. Written patient care policies and procedures related to infection prevention were reviewed to determine whether any changes had been made.

As a result of the retrospective review, two events were found to be temporally associated with the change. First, in July 1992, the Occupational Safety and Health Administration (OSHA) Blood-borne Pathogen Exposure Control Plan[1] and Body Substance Isolation were formally implemented. At that time, hospital-wide inservice education of staff was conducted by the

From Infection Control, Sparks Regional Medical Center,[a] Fort Smith, and Georgetown University School of Nursing,[b] Washington.

Reprint requests: Elaine Larson, RN, PhD, CIC, Georgetown University School of Nursing, 3700 Reservoir Rd., N.W., Washington, DC 20007-1069.

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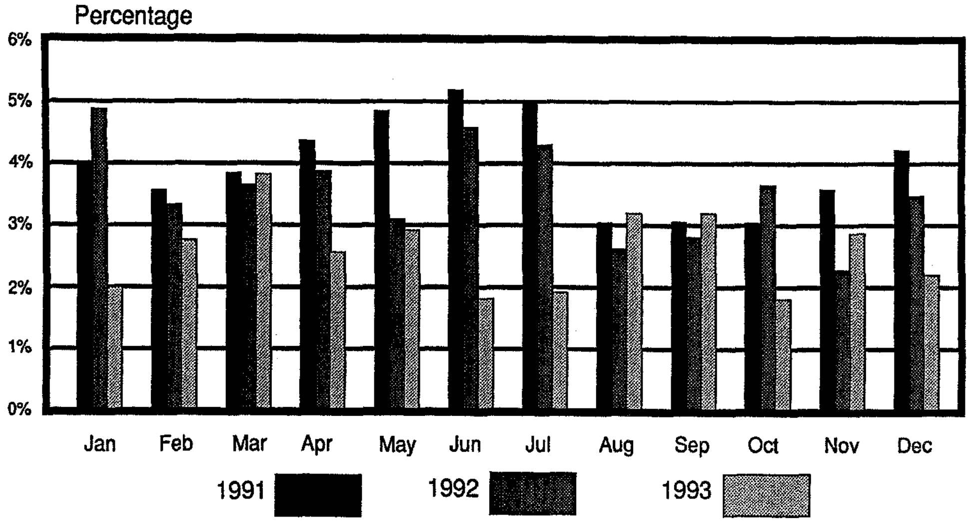

*June 1992 - OSHA Plan
**Jan 1993 - Barrier Foam usage began

Fig. 1. Nosocomial infection: overall attack rates.

infection control staff. One of the infection control professionals (ICPs) oriented the nursing education instructors to the OSHA standard and the hospital exposure control plan that had been approved by the Infection Control Committee. The instructors in turn conducted mandatory in-service programs for the nursing staff. Second, in January 1993, a new hand barrier foam product (DermaMed; Benchmark, Salt Lake City, Utah) was introduced hospital-wide as a protection against latex allergy.

To determine the extent to which these two factors had affected actual clinical practice, a written, self-report questionnaire was distributed during August 1993 by one of the ICPs to 956 health care professionals, including nurses and ancillary personnel, in most clinical departments of the hospital: all 20 inpatient units, surgery (excluding surgeons and their private scrub technicians), emergency department, gastrointestinal laboratory, environmental services, respiratory and physical therapy, and nursing administration. The survey elicited information regarding use of universal precautions, handwashing practices, and use of the barrier foam product. Data available on usage of gloves and the barrier foam product were also collected.

A prospective follow-up study was conducted in 1994 on a 23-bed inpatient dialysis unit to examine possible association between infections and use of the barrier foam. From March to June foam was used on the unit; from July to December, it was not used. This unit was selected because of its stable, homogeneous patient population and stable infection rates.

Surveillance procedures. Data throughout most of the time period were collected by the same two ICPs, one of whom had worked in infection control for 19 years and the other for 7 years. The 1988 CDC definitions[2] for nosocomial infections were used, and surveillance was primarily by review of patient records, autopsy reports, and radiographic and microbiologic laboratory data. Infection surveillance methods had remained the same since 1975.

Data analysis. The chi square statistic was used to compare infection rates and proportions of inpatient and outpatient surgery by year.

RESULTS

Patient characteristics and demographic trends

Although the total number of patient discharges increased slightly from 1991 to 1993, total patient days decreased slightly, indicating that there were more admissions but shorter stays. Patient acuity was stable, the mean ranging from 2.5 to 3.5 (scale of 1 to 4). As noted in Table 1, most nosocomial infections occurred in patients over age 65 years. The proportion of patients in intensive care increased slightly from

Table 1. Patient characteristics and demographic trends

	1991	1992	1993
Patient discharges	18,761	18,806	18,867
Patient days	127,328	131,602	122,635
Percent patients in ICU	16.9%	17.5%	17.7%
No. of patient discharges >65 yrs.	6,247	6,282	6,278
Patient days >65 yrs.	60,175 (47.3%)	65,130 (49.5%)	58,083 (47.4%)
Percent nosocomial infections in patients >65 yrs.	59.2%	61.3%	63.4%
Surgical procedures			
Inpatient	9252	9287	7539
Outpatient	11,899	15,168	10,398
Average length of stay (days)	6.8	7.0	6.5

Table 2. Sites of infection and most common causative organisms

	1991	1992	1993
Site*			
Urinary tract	37.4%	46.0%	42.0%
Respiratory	31.2%	20.1%	21.4%
Bloodstream	11.8%	13.7%	15.1%
Surgical site	6.9%	8.0%	8.8%
Other	12.7%	12.2%	12.6%
Most common organisms†			
Enterococci	12.8%	14.9%	19.8%
E. coli	11.1%	13.0%	14.3%
Pseudomonas sp.	10.9%	11.5%	9.9%
S. aureus	8.3%	12.1%	11.1%
Candida sp.	7.5%	9.7%	9.7%

df, Degrees of freedom.
*Chi square 11.36 (df = 19), $p = 0.90$.
†Chi square 12.13 (df = 19), $p = 0.85$.

16.9% to 17.7%. Inpatient surgical procedures decreased from 9252 in 1991 to 7539 in 1993. Outpatient surgical procedures also decreased in 1993 as a result of the opening of a separate ambulatory surgical facility (chi square testing difference in proportion of inpatient and outpatient surgery, 1991 to 1993, $p < 0.0001$).

There were no significant changes from 1991 to 1993 in sites of infection nor in the five major causative organisms (Table 2). Urinary tract infections accounted for 37% to 46% of infections, followed by respiratory, bloodstream, and surgical site. The most common organisms isolated were enterococci, *Escherichia coli*, *Pseudomonas* species, *Staphylococcus aureus*, and *Candida* species.

Patient care practices

No substantive changes in patient care written policies and procedures related to infection prevention were made throughout the study period, except for the implementation of the OSHA plan, Body Substance Isolation, and the use of barrier hand foam. The response rate for the survey was 85% (813/956): 69.4% of respondents were nurses, 11.9% surgical staff (excluding surgeons and their private scrub technicians), 10.9% environmental services, and 7.7% respiratory and physical therapy. Overall, 86.2% of respondents reported that universal precautions played a more important role in patient care than 1 year previously. In addition, a median of 68.3% (range 34.9% to 77.3%) of staff on the 20 inpatient units reported occasional or regular use of the barrier hand foam. Among those using the foam, 91.4% reported less dryness or irritation of hands, and 76.9% reported a resultant increase in handwashing frequency (Table 3).

In the 6 months of 1992 just before implementation of the OSHA Blood-borne Pathogen Exposure Control Plan, the infection rate was 3.5% (377/10,828 patient discharges) as compared with a rate of 2.7% (292/10,697) for the 6 months after implementation (chi square, 7.32; $p < 0.01$). Infection rates continued at the lower rate

Table 3. Personnel survey of infection control practices related to OSHA plan and use of barrier foam (n = 813)

	%
Use of universal precautions, compared with 1 yr. previously	
Increased	86.2
Same or less	8.4
Not answered	5.4
Use of barrier foam (regularly or occasionally)	
Yes	68.0
No	32.0
Reasons for use of barrier foam (n = 553)	
Protection against cross-infection	67.6
Protection against dry skin	27.4
Coworkers use it	2.7
Other	2.3
Results of use	
Less skin drying/irritation	91.4
Increased frequency of handwashing	76.9
Reasons for not using barrier foam (n = 260)	
Skin irritation	35.4
"Forgot"	28.6
Not necessary or not convinced it works	20.1
Too much trouble	7.8
Other	8.1

through 1993 (2.6%, 494/18,867 patient discharges; $p < 0.001$) after the barrier foam was introduced.

Examination glove usage increased during this time period as follows: fiscal year 1991 (July to July), 12,884 boxes; fiscal year 1992, 18,736 boxes; and fiscal year 1993, 20,452 boxes. On the dialysis unit in the 1994 follow-up study, five cans of barrier foam were used from March to June. During that time period, infection rates were 5.3% as compared with 13.4% during the 6 months when it was not in use (chi square, 7.46, $p < 0.006$) (Table 4).

DISCUSSION

Because methods of detection and surveillance of infections remained unchanged over the period of study, this factor was disregarded as a likely cause of changes in infection rates. The demographic changes noted—shorter lengths of stay and fewer inpatient surgeries—are consistent with national trends in response to efforts to reduce acute care costs and maximize efficiency. On the basis of data available in this study, the impact of these changes on infection rates is difficult to confirm.

The inappropriateness of using unadjusted and crude overall nosocomial infection rates for interhospital comparisons has been thoroughly discussed.[3,4] As demonstrated in this study, even within-hospital comparisons of rates across time are inappropriate when demographic trends are changing rapidly. An accurate determination of the effect of intrinsic patient risk characteristics or changes in patient care practices on nosocomial infection rates is only possible with risk- or device-adjusted rates. The use of total patient-days as a denominator controls for the duration of the risk period, but it does not account for differential use of devices. The Joint Commission on Accreditation of Healthcare Organizations has slated certain device-specific rates for implementation (e.g., ventilator-associated pneumonia, intravenous catheter-related bloodstream infections), but at the time that this study was conducted, device-specific rates were not calculated.

Because of the limitation of the crude overall infection rates available in this study, it is not possible to rule out the influence of patient variables on infection rates. However, whereas some factors tend to decrease risk (shorter length of stay and fewer inpatient surgeries), others increase risk (more elderly and critically ill patients).[5]

Two new patient care practices were also introduced during the study period and were temporally associated with the reduction in infections: the implementation of the OSHA plan and Body Substance Isolation with concomitant increases in glove usage and the introduction of a barrier hand foam.

Because glove use almost doubled from fiscal

Table 4, A. Infection rates and usage of gloves and barrier foam

Dates	Infection rate	Boxes of gloves used
FY1991	3.8% (724/18,919)	12,884
FY1992	2.9% (546/18,698)	18,736
FY1993	2.9% (537/18,784)	20,452

FY, Fiscal year, July–July.

Table 4, B. Follow-up study: inpatient dialysis unit

Dates	Infection rate	Cans of foam used
March–June 1994	5.8% (12/208)	4
July–December1994	13.4% (29/212)	0

Chi square 7.46, $p < 0.006$.

year 1991 to 1993 and gloves were worn for procedures such as oral care, handling of urinary devices, and intravenous site care, it is likely that this factor contributed to the reduced infection rates. The 10-month follow-up study during 1994 on a single unit with a stable population of patients undergoing dialysis, which demonstrated a significant reduction in infection rates during the months when barrier foam was used, lends support for the possibility that the protective hand product may have had some effect on infection rates.

It was interesting to note that the primary reason given by staff for using the barrier foam was to prevent cross-infection, because the product is marketed as a skin protectant from irritation and not as an antimicrobial product. Its active ingredient, dimethicone, forms a hydrophobic layer on the surface of the skin (package insert). It also contains small quantities of alcohol and triclosan, which could add some antimicrobial activity, although additional trials would be needed to determine its effectiveness as either a physical barrier to microorganisms or as an antimicrobial agent.

Clearly, gloves and barrier foam would have an impact only on those infections likely to be spread from provider to patient by direct contact. This includes organisms that are part of the patient's own flora (endogenous), which can be spread by a care provider who, for example, introduces the patient's flora into another body site on their hands or gloves. Because direct contact probably accounts for some component of transmission of infection at all body sites (urinary tract, respiratory, surgical site, bloodstream), one would anticipate that any reduction in transmission by the direct contact route would be reflected at all sites (i.e., not differentially more at some sites than others). Such was the case in this study.

The increased glove use cost this institution an additional $60,153 per year (comparing 1991 and 1993 usage). If four cases of barrier foam were used each month, the cost would be $10,080/yr. Thus the increased cost of these two interventions was $70,080/yr. If a nosocomial infection costs, on average, $5000,[6] and if the reduction in infections were associated with the increased use of gloves or the barrier foam (or a combination of both), the cost savings of the 175 nosocomial infections fewer in 1993 would be $804,767 ($875,000 − $70,000). However, it was not possible in this study to determine the impact of changing demographic trends on the infection rate as well; that is, even if the patient care practices did reduce infection risk, they are unlikely to have been the only factors involved. This highlights the importance of including a cost-benefit analysis in any evaluation of new products.

Several studies have demonstrated that compliance with universal precautions reduces risk to health care professionals of occupational exposure to patient body fluids.[7-10] Wenzel[11] estimated that the cost to prevent one case of HIV transmission could range from $1 to $10 million; 80% of the cost is for gloves. The costs of universal precautions in the United States in 1989 were estimated to be $336 million.[12] Such a cost is justifiable only if the barrier system not only reduces risk to the health care provider but also prevents transmission to patients. There is, in fact, some evidence that this is the case.

Leclair et al.[13] reported that the relative risk of nosocomial infection with respiratory syncytial virus was significantly reduced when glove and gown usage was implemented on a pediatric unit. Others[14] reported a significant reduction in nosocomial transmission of *Clostridium difficile* when disposable vinyl gloves were worn for contact with body substances. Such evidence is consistent with the findings of this study, but cost-benefit analyses are clearly indicated.

Before adding costly practices and products to routine patient care delivery, it is vital that valid assessments are made of costs and benefits. This study demonstrates that risk-adjusted rates are increasingly important in a rapidly changing health care environment for the accurate assessment of the impact of changes in practices and policies on nosocomial infection rates and the tracking of demographic changes in populations at risk.

Even taking into consideration the patient risk factors of the populations studied, the data suggest that the implementation of the OSHA plan, with concomitant increase in glove use, and the introduction of a barrier foam may have had an impact on infection rates. Because barrier hand foams are new products, data regarding the effect on nosocomial infection rates are not yet available. On the basis of our findings, we conclude that such products are deserving of additional research in clinical settings to further elucidate their potential role in infection prevention and control.

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