Journal of Hospital Infection Volume 63, Issue 4 , August 2006, Pages 406-411

doi:10.1016/j.jhin.2006.03.015

Hand rub consumption and hand hygiene compliance are not indicators of pathogen transmission in intensive care units

T. Eckmanns[a,*], F. Schwab[a], J. Bessert[a], R. Wettstein[a], M. Behnke[a], H. Grundmann[b], H. Rüden[a] and P. Gastmeier[c]

[a]Institute of Hygiene and Environmental Medicine, Charité, University Medicine Berlin, Germany
[b]Centre for Infectious Disease Epidemiology, National Institute for Public Health and the Environment, Bilthoven, The Netherlands
[c]Institute of Medical Microbiology and Hospital Epidemiology, Hanover Medical School, Hanover, Germany

Received 23 December 2005; accepted 13 March 2006. Available online 12 June 2006.

* Corresponding author. Address: Hindenburgdamm 27, 12203 Berlin, Germany. Tel.: +49 30 84454883; fax: +49 30 84454486.

Summary

The objective of this study was to investigate whether nosocomial infection (NI) rates, hand hygiene compliance rates and the amount of alcohol-based hand rub used for hand disinfection are useful indicators of pathogen transmission in intensive care units (ICUs), and whether they could be helpful in identifying infection control problems. All isolates of 10 of the most frequent pathogens from patients who were hospitalized in an ICU for >48 h were genotyped to identify transmission episodes in five ICUs. The incidence of transmission was correlated with hand hygiene compliance, hand rub consumption and NI rates. The incidence of transmission episodes varied between 2.8 and 6.8 in the five ICUs. The NI rate was 8.6–22.5 per 1000 patient-days, hand hygiene compliance was 30–47% and hand rub consumption was 57–102 L per 1000 patient-days. There was no correlation between the incidence of transmission episodes and hand rub consumption or hand hygiene compliance. The correlation between transmission rates and NI rates was 0.4 ($P = 0.5$), and with the exclusion of one ICU, it was 1 ($P < 0.01$). The incidence of NI is a relatively good indicator for the identification of pathogen transmissions, but hand rub consumption and hand hygiene compliance, at least with the relatively low level of compliance found in this study, are not indicators of pathogen transmission.

Introduction

Nosocomial infections (NIs) are an important problem in intensive care units (ICUs) and engender substantial morbidity and mortality. There are, however, a wide range of NI control problems throughout ICUs, depending on patient mix and infection control conditions.[1 and 2]

The gold standard for assessing an infection control situation is probably the identification of transmission episodes of nosocomial pathogens using genotyping

methods, as described in some recent ICU studies.[3 and 4] This method requires the collection of all patient isolates, strain genotyping, and epidemiological evaluation of the cross-infections. Consequently, it is not cost effective and some easily applicable indicators for detecting infection control problems would be very helpful.

Surveillance of NI is generally recommended for detecting infection control problems;[5] however, according to the definitions of the Centers for Disease Control and Prevention (CDC), NI includes both exogenous and endogenous infections.[6] This may mask existing infection control problems. Due to the enormous importance of hand hygiene in the avoidance of cross-infection, some authors recommend monitoring compliance with hand hygiene procedures and measuring the amount of alcohol-based hand rub used for hand disinfection to identify infection control problems.[7, 8 and 9]

This study attempted to evaluate these two indicators, i.e. NI surveillance data and compliance with hand hygiene procedures, against the gold standard of monitoring the frequency of transmission episodes of nosocomial pathogens in five ICUs in two university hospitals.

Methods

Reference method

Identification of transmission episodes of nosocomial pathogens has been described extensively elsewhere.[10] Over an 18-month period (February 2000–July 2001), all patients who had been hospitalized for ≥48 h in five ICUs at two university hospitals were studied. All participating ICUs were encouraged to maintain their routine microbiological investigation policies, and they all collected clinical microbiological specimens at high density. All the clinical and screening isolates of 10 'indicator organisms' from study patients were collected and stored at −80 °C (Microbank, Viva, Cologne, Germany). These indicator organisms were the most common pathogens to cause NI in ICU patients: *Acinetobacter baumannii-complex*, *Enterobacter aerogenes*, *Enterobacter cloacae*, *Escherichia coli*, *Enterococcus faecium*, *Enterococcus faecalis*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Stenotrophomonas maltophilia*. Only primary isolates from each patient were submitted for molecular typing; *S. aureus* and enterococci by pulsed-field gel electrophoresis and the Gram-negative pathogens by arbitrary primed (AP)-polymerase chain reaction and a double primer amplified fragment length polymorphism (AFLP) method. After typing, genetically indistinguishable organisms isolated from different sites in the same patient were excluded. Genetically indistinguishable organisms can exist in different patients as the result of a recent cross-transmission or an independent colonization outside the hospital, often with the same clone existing in the general population. A pragmatic approach was adopted to identify a potential transmission episode, defining it as identification of genetically indistinguishable isolates in two or more patients who had been treated either during overlapping intervals or within a nine-day period in the same ICU.[10] Transmission rates (i.e. transmissions per 1000 patient-days) were calculated to compare data from the individual ICUs.

The indicators

The two indicators investigated were incidence density of NIs (per 1000 patient-days) and compliance with hand hygiene procedures (measured as a percentage of all indicated hand hygiene possibilities). Hand rub consumption per 1000

patient-days was also investigated as a surrogate parameter for compliance with hand hygiene, as this information was easily accessible.

Incidence density of NIs

Two investigators trained in NI surveillance were responsible for daily data collection and recording NIs according to standard CDC criteria.[6 and 11] NI incidence per 1000 patient-days was calculated.

Compliance with hand hygiene procedures and calculating the consumption of hand rub

The following procedures (before and after) were considered as indications for hand hygiene action: catheter care, wound care, ventilation care, urinary catheter care, ventricle drainage care, preparation of intravenous solutions and contact with patients.[7] Two observation studies were performed, one immediately after the transmission study period and one 10 months after the end of the study. The observer was one of the investigators responsible for surveillance during the main study, so ICU staff were familiar with this individual's presence in the ward. It was thus possible to perform one observation period without advance notice and one observation period after prior notification. Each observation study consisted of 10 separate observation periods of 120 min, and included all hand hygiene activities. The methods of a previous study were adopted to observe compliance with hand hygiene procedures.[12] In the first (unannounced) observation period, the observer stayed by the chart at the foot of a patient's bed for 15 min, carrying out his observations from this position, as he had done when collecting the surveillance data for each patient in the ward during the main study. In the second observation period, the investigator moved to areas with hygiene-relevant activities. Hand disinfection was considered as compliance with hand hygiene. Glove use was only considered as compliance with hand hygiene if hand disinfection followed glove removal. In order to limit random effects from the observation periods when describing situations in the individual ICUs, the data of both observation periods were combined.

Hand rub consumption for the study period was obtained from pharmacy data and calculated per 1000 patient-days.

Correlation between the reference standard and indicator data

Reference data were correlated with indicator data for the individual ICUs by plotting information. Correlation was calculated by Spearman's rank-order correlation coefficient.

Results

Between February 2000 and July 2001, 7269 admissions totalling 35 817 patient-days were recorded in the five ICUs. For 1876 admissions (25.8%), treatment intervals lasted for ≥48 h [28 498 patient-days (79.6%)] (Table I).

Journal of Hospital Infection Volume 63, Issue 4 , August 2006, Pages 406-411

Table I.

Number of patients, patient-days, length of stay, Simplified Acute Physiology Score II (SAPS II) and ventilator utilization rates of the five intensive care units (ICUs). Data only reflect those patients who were admitted for >48 h

ICU	Number of beds	Patients	Patient-days	Median length of stay (days)	Mean SAPS II score	Ventilator utilization rate (%)
A (medical)	24	630	9618	8	38.3	56.8
B (interdisciplinary)	11	171	3097	11	40.4	71.4
C (interdisciplinary)	14	356	6543	11	34.8	52.8
D (surgical)	10	292	4309	8	28.9	47.7
E (neurosurgical)	12	427	4931	9	33.1	43.9
Total	71	1876	28 498	9	35.2	53.9

The reference standard

The microbiology laboratory received 30 033 specimens from study patients. This corresponded to an average investigation density of 1.05 samples per patient per day. One hundred and forty-one transmission events were identified and a density of 5.0 transmissions per 1000 patient-days was calculated. Forty-one (29%) of the transmissions were associated with NIs. The highest transmission rates were found in ICUs A and B, and the lowest transmission rates were found in ICUs D and E (Table II).

Table II.

Microbial investigation density per 1000 patient-days, indicator organisms and transmissions in the individual intensive care units (ICUs). Data only reflect those patients who were admitted for >48 h

ICU	Microbiological investigation density per 1000 patient-days	Indicator pathogens (primary isolates)	Transmission episodes	Transmission episodes per 1000 patient-days (95% CI)
A (medical)	830.8	435	57	5.9 (4.5–7.7)
B (interdisciplinary)	1679.4	167	21	6.8 (4.2–10.4)
C (interdisciplinary)	983.9	241	33	5.0 (2.2–5.3)
D (surgical)	847.3	98	12	2.8 (1.4–4.9)
E (neurosurgical)	1369.5	323	18	3.7 (2.2–5.8)
Total	1053.9	1264	141	5.0 (4.2–5.8)

CI, confidence intervals.

Journal of Hospital Infection Volume 63, Issue 4 , August 2006, Pages 406-411

The indicators

Incidence density of NIs

In total, 431 NIs occurred, representing an incidence density of 15.1 per 1000 patient-days. Table III provides details of incidence density in each ICU. The highest NI rate was found in ICUs B and E; in both cases, this was significantly greater than the mean of all five ICUs.

Table III.

Nosocomial infections and incidence density of nosocomial infections in the individual intensive care units (ICUs). Data only reflect those patients who were admitted for >48 h

ICU	Nosocomial infections	Nosocomial infections per 1000 patient-days (95% CI)
A (medical)	153	15.9 (13.5–18.7)
B (interdisciplinary)	69	22.3 (17.3–28.2)
C (interdisciplinary)	61	9.3 (7.1–12.0)
D (surgical)	37	8.6 (6.0–11.8)
E (neurosurgical)	111	22.5 (18.5–27.1)
Total	431	15.1 (13.1–16.6)

CI, confidence intervals.

Compliance with hand hygiene procedures and consumption of hand rub

In total, 2808 hand hygiene opportunities were observed. During the unannounced observation period, overall compliance was only 29% compared with 45% in the observation period after prior notification. Data for the individual ICUs are shown in Table IV. The highest rates of compliance were found in ICUs B (with the highest transmission rate) and E (with a relatively low transmission rate). In total, 2482 L of alcohol-based hand rub were used during the study period, representing an average of 87 (range 57–102) L per 1000 patient-days.

Journal of Hospital Infection Volume 63, Issue 4 , August 2006, Pages 406-411

Journal of Hospital Infection Volume 63, Issue 4 , August 2006, Pages 406-411

Table IV.

Compliance with hand hygiene procedures and hand rub consumption in the individual intensive care units (ICUs)

ICU	Unannounced observation period		Announced observation period		Combined compliance		Hand rub consumption (L)	Hand rub consumption (L) per 1000 patient-days
	Hand hygiene opportunities	Compliance (%)	Hand hygiene opportunities	Compliance (%)	Hand hygiene opportunities	Compliance (%)		
A	167	23	359	33	526	30	704	73
B	211	31	395	55	606	47	316	102
C	178	29	507	43	685	39	611	93
D	210	22	324	45	534	36	346	57
E	171	40	286	51	457	46	505	102
Total	937	29	1871	45	2808	40	2482	87

Correlation between the reference standard and indicator data

Correlation between hand rub consumption and hand hygiene compliance was 0.87 (P = 0.05) (Figure 1a). There was, however, no correlation between the transmission rates of nosocomial pathogens, hand rub consumption (0.5, P = 0.4) and hand hygiene compliance (0.3, P = 0.6) (Figure 1b,c). Correlation between the transmission rate and the NI rate was 0.4 (P = 0.5) (Figure 1d). When the data for ICU E were excluded, correlation was 1 (P < 0.01).

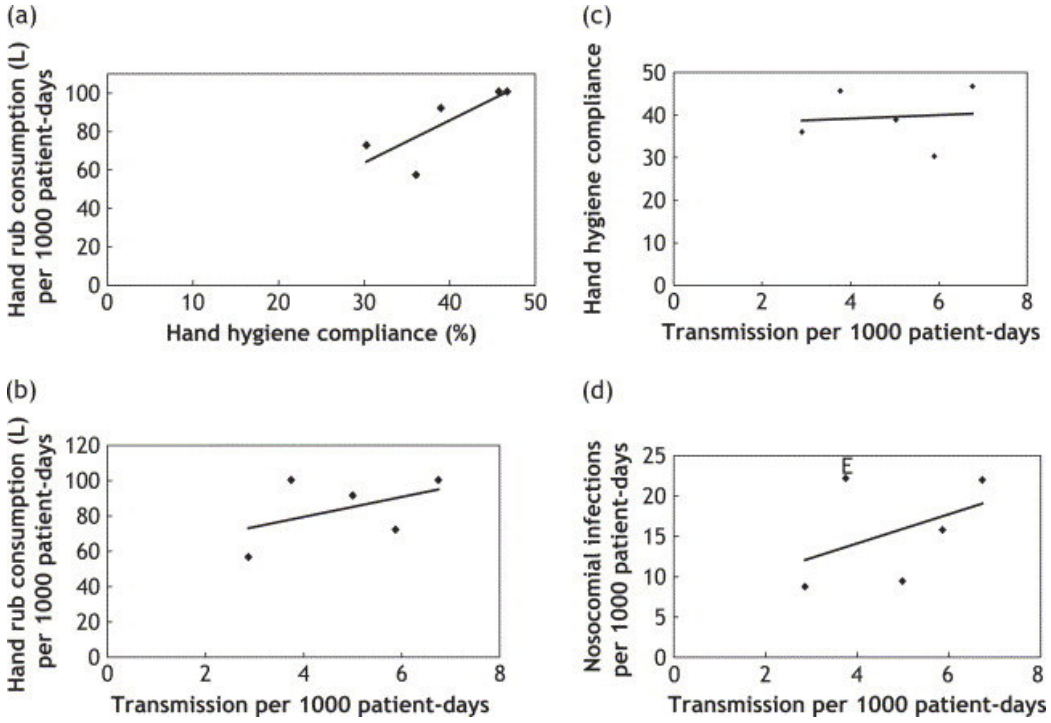

Figure 1. Correlation and P values between indicators: (a) hand hygiene compliance and hand rub consumption per 1000 patient-days (r = 0.87, P = 0.05); correlation and P value between reference standard and indicators; (b) transmission per 1000 patient-days and hand rub consumption per 1000 patient-days (r = 0.5, P = 0.4); (c) transmission per 1000 patient-days and hand hygiene compliance (r = 0.3, P = 0.6); and (d) transmission per 1000 patient-days and nosocomial infections per 1000 patient-days (r = 0.4, P = 0.5). E, Intensive Care Unit E.

Discussion

The authors believe that hand hygiene is an extremely valuable instrument for preventing NI. However, in this study, hand hygiene compliance was not a good indicator for pathogen transmission. There may be at least three explanations for this. First, average compliance with hand hygiene procedures was only 40% in this study. This is within the range reported in other studies in ICUs. [9, 12 and 13] This is at such a low level that proper distinction between the individual ICUs was not possible. For example, one might assume that with an average level of 80% compliance, differentiation between the transmission rates in the ICUs would be much clearer. Secondly, it is not yet known if the calculation of total observed hand hygiene complaince is a sound indicator for pathogen transmission. It may be, for instance, that in a given ICU, many hand hygiene procedures are performed in the context of low-risk manipulations and compliance could be poor

during high-risk manipulations, as shown by Pittet *et al.*[8] Thirdly, hand hygiene observations were not performed during the cross-transmission study. Nevertheless, there was a significant correlation between the amount of hand rub used during the study period and the hand hygiene compliance rate observed later, so this was not likely to be a major limiting factor. Furthermore, there were no major structural modifications in the ICUs and no change in the case mix.

A difference was noted between the compliance rates in the studies conducted with and without prior notification. However, this difference was to be expected and probably had no influence on the assessment of the overall situation.

The incidence of NI was found to be a relatively good indicator for the identification of pathogen transmission. There was one exception; ICU E differed from the other ICUs by having exclusively single rooms, which could explain the low transmission rate. Furthermore, there were differences in the severity of patients' illnesses, e.g. the high NI rate of ICU B may have been associated with the high mean Simplified Acute Physiology Score II score.

This study is the first ICU study to use transmission rates instead of NI rates as the reference standard for evaluating indicators of infection control problems. Clearly this approach has some limitations. Only five ICUs were studied, which is insufficient to perform correlation studies. As this study focused on patients' clinical isolates, the number of transmission episodes detected was an 'at least' number; there may also be differences between the transmission rates of the individual ICUs due to differences in the frequency of microbiological investigations.

NI surveillance and observation of hand hygiene procedures were performed in all ICUs by the same investigators, so investigator bias can be excluded.

Although no correlation was found between compliance with hand hygiene directives and the transmission rates identified, the authors strongly recommend compliance with hand hygiene procedures in ICUs. Providing feedback to staff provides an opportunity to discuss the importance of hand hygiene as well as the best hygiene methods. This would stimulate infection prevention and achieve a level of hand hygiene compliance where the recognition of differences between various ICUs may become more transparent.

Acknowledgements

This paper was made possible due to the data of the SIR 3-Study (Spread of infections and resistance), for which the authors thank their colleagues participating in this project, particularly Sina Bärwolff, Adriana Tami, Christine Geffers, Elke Halle, Ulf Goebel, Reinhold Schiller, Daniel Jonas, Ingo Klare, Klaus Weist, Wolfgang Witte, Kathrin Beck-Beilicke and Martin Schumacher.

References

1 Anonymous. National Nosocomial Infections Surveillance (NNIS) System. Report, data summary from January 1992 to June 2002, issued August 2002, *Am J Infect Control* **30** (2002), pp. 458–475.

2 P. Gastmeier, C. Geffers, D. Sohr, M. Dettenkofer, F. Daschner and H. Rüden, Five years working with the German nosocomial infection surveillance system (Krankenhaus Infektions Surveillance System), *Am J Infect Control* **31** (2003), pp. 316–321.

3 P. Chetchotisakd, C.L. Phelps and A.I. Hartstein, Assessment of bacterial cross-transmission as a cause of infections in patients in intensive care units, *Clin Infect Dis* **18** (1994), pp. 929–937.

4 K. Weist, K. Pollege, I. Schulz, H. Ruden and P. Gastmeier, How many nosocomial infections are associated with cross-transmission? A prospective cohort study in a surgical intensive care unit, *Infect Control Hosp Epidemiol* **23** (2002), pp. 127–132.

5 T.G. Emori, D.H. Culver and T.C. Horan *et al.*, National nosocomial infections surveillance system (NNIS): description of surveillance methods, *Am J Infect Control* **19** (1991), pp. 19–35.

6 J.S. Garner, W.R. Jarvis, T.G. Emori, T.C. Horan and J.M. Hughes, CDC definitions for nosocomial infections, *Am J Infect Control* **16** (1988), pp. 128–140.

7 J.M. Boyce and D. Pittet, Guideline for Hand Hygiene in Health-Care Settings. Recommendations of the Healthcare Infection Control Practices Advisory Committee and the HIPAC/SHEA/APIC/IDSA Hand Hygiene Task Force, *Am J Infect Control* **30** (2002), pp. S1–S46.

8 D. Pittet, S. Hugonnet and S. Harbarth *et al.*, Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. Infection control programme, *Lancet* **356** (2000), pp. 1307–1312.

9 D. Pittet, Compliance with hand disinfection and its impact on hospital-acquired infections, *J Hosp Infect* **48** (2001) (Suppl. A), pp. S40–S46.

10 H. Grundmann, S. Barwolff and A. Tami *et al.*, How many infections are caused by patient-to-patient transmission in intensive care units?, *Crit Care Med* **33** (2005), pp. 946–951.

11 T.C. Horan, R.P. Gaynes, W.J. Martone, W.R. Jarvis and T.G. Emori, CDC definitions of nosocomial surgical site infections, 1992: a modification of CDC definitions of surgical wound infections, *Am J Infect Control* **20** (1992), pp. 271–274.

12 T. Eckmanns, A. Rath, H. Brauer, F. Daschner, H. Rüden and P. Gastmeier, Compliance with hand hygiene in intensive care units, *Dtsch Med Wochenschr* **126** (2001), pp. 745–749.

13 S. Harbarth, D. Pittet, L. Grady and D.A. Goldmann, Compliance with hand hygiene practice in pediatric intensive care, *Pediatr Crit Care Med* **2** (2001), pp. 311–314.