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ICU ward design and nosocomial infection rates: a cross-sectional study in Germany

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SUMMARY

Background: There is increasing interest in the effects of hospital and ward design on multi-faceted infection control. Definitive evidence is rare and the state of knowledge about current ward design is lacking.

Objective: To collect data on the current status of ward design for intensive care units (ICUs) and to analyse associations between particular design factors and nosocomial infection rates.

Methods: In 2015, operational infrastructure data were collected via an online questionnaire from ICUs participating voluntarily in the German nosocomial infection surveillance system (KISS). A multi-variate analysis was subsequently undertaken with nosocomial infection rates from the KISS database from 2014 to 2015.

Findings: In total, 534 ICUs submitted data about their operational infrastructure. Of these, 27.1% of beds were hosted in single-bed rooms with a median size of 18 m^2 (interquartile range 15–21 m^2), and 73.5% of all ICU beds had a hand rub dispenser nearby. The authors were able to match 266 ICUs in the multi-variate analysis. ICUs with openable windows in patient rooms were associated with lower device-associated lower respiratory tract infections [odds ratio (OR) 0.73, 95% confidence interval (CI) 0.58–0.90]. ICUs with >40% two-bed rooms were associated with lower primary bloodstream infection rates (OR 0.66, 95% CI 0.51–0.86).

Conclusion: Only minor associations were found between design factors and ICU infection rates. Most were surrogates for other risk factors.

Introduction

Infection control is a primary goal for hospitals and is particularly challenging for intensive care units (ICUs). In 2011 and 2012, the European Centre for Disease Prevention and Control conducted a point prevalence survey in 29 European Union/European Economic Area Member States and Croatia. It included 231,459 patients in 947 participating hospitals. In

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ICUs, 19.5% of patients were found to have at least one healthcare-associated infection.[1]

Hospital and ward design is an emerging infection control strategy. Van Steelandt *et al.* described the relationship between ward structure and the activities of its staff.[2] They indicated that the hospital environment can make it easier for healthcare workers to perform infection prevention procedures. Accordingly, several studies have found a benefit for patient care in single-bed rooms compared with multi-bed rooms.[3–8] Additionally, an easily accessible hand rub dispenser near each patient's bed increases the compliance rate of healthcare workers.[9–11] However, little is known about the current architecture of hospitals to date. The present authors conducted this survey, which gathered data on German ICUs, to fill this gap. In addition, the structural properties of ICUs were analysed to determine if and how hospital architecture affects infection rates.

Materials and methods

The German nosocomial infection surveillance system [Krankenhaus-Infektions-Surveillance-System (KISS)] has been collecting data on nosocomial infection rates and multi-drug-resistant pathogens from voluntarily participating hospitals since 1997.[12] Overall, 1357 hospitals participated in KISS in 2015. An electronic survey was sent to the healthcare worker responsible for the survey in each participating hospital. The survey was conducted from March to June 2015. In the survey, each hospital was allowed to choose how many ICUs to include in their response. When the completed survey was received, it was checked for quality and coherence. When necessary, representatives from each participating hospital, primarily infection control practitioners and physicians responsible for infection control, were contacted to verify the data provided. Detailed information regarding the questionnaire and descriptive data of constructional elements in hospitals as well as wards and ICUs can be found in a separate publication.[13]

Statistical methods

Initially, a descriptive analysis was performed to calculate numbers and percentages as well as medians and interquartile ranges (IQR) for the ICUs.

ICUs were included in the multi-variate analysis if they completed the questionnaire and had participated in ICU-KISS for at least six months during 2014/2015. Regression analysis using generalized linear models with negative binomial distribution was employed to estimate the association of the number of ICU-acquired infections [device-associated urinary tract infections, primary bloodstream infections (PBSIs) and lower respiratory tract infections (LRTIs) collectively and individually] with several risk factors and confounders. Adjusted incidence rate ratios with 95% confidence intervals (95% CI) were calculated. The log number of patient-days (or device-days) was treated as an offset in the model.

The following risk factors and confounders were considered: hospital size ($\leq$/$>$ median); no. of ICU beds ($\leq$/$>$ median); occupancy rate ($\leq$/$>75^{th}$ percentile); ICU type (surgical, medical, interdisciplinary, other); years of participation in KISS ($\leq$2/$>$2); mean length of ICU stay ($\leq$/$>75^{th}$ percentile); year of ICU construction (1960–1989, 1990–2000, after 2001); device utilization rates for urinary catheters, central venous catheters and ventilators ($\leq$/$>75^{th}$ percentile); proportion of single-bed rooms, two-bed rooms and multi-bed rooms ($\leq$/$>75^{th}$ percentile); size of different room types ($\leq$/$>75^{th}$ percentile in m^2); proportion of beds with a hand rub dispenser within one arm's length (100%/$<$100%); openable window (yes/no); and ICU air conditioning system (yes/no). Additionally, the association between available numbers of ICU-acquired multi-drug-resistant organisms [MDROs, vancomycin-resistant enterococci (VRE), meticillin-resistant *Staphylococcus aureus* (MRSA) and multi-drug-resistant Gram-negative bacteria] and the same risk factors was investigated. In addition, community-acquired MDROs (present/not present on admission) and the type of screening were taken into consideration in the analysis.

All variables were dummy coded. All parameters were included in the full model. First, all risk factors with $P>0.05$ were excluded step wise from the model. $P<0.05$ was considered to indicate significance.

All analyses were performed using R 3.0.3 [R Core Team (2013); R Foundation for Statistical Computing, Vienna, Austria] and SAS 9.2 (SAS Institute Inc., Cary, NC, USA).

Table I
Design characteristics of 534 intensive care units (ICUs) in Germany

		N	Proportion (%)	Median (IQR)
Total rooms		4134		7 (5–9)
Total beds		6817		12 (8–16)
Single-bed rooms	Number	1846	44.6	3 (2–4)
	Beds	1846	27.1	
	Room size (m^2)			18 (15–21)
Two-bed rooms	Number	1947	47.1	2 (3–5)
	Beds	3894	57.1	
	Room size (m^2)			28 (23–33)
Multi-bed rooms ($>$two beds)	Number	341	8.2	0 (0–1)
	Beds	1077	15.8	
Respiratory places		5307	77.9	9 (6–13)
Beds with AHRD within one arm's length		5013	73.5	9 (5–14)
ICUs with air conditioning systems and openable windows	Number	259	48.5	
ICUs with air conditioning system but non-openable windows	Number	151	28.3	
ICUs with openable windows but no air conditioning system	Number	112	21.0	
ICUs without information on room ventilation	Number	12	2.2	

AHRD, antiseptic hand rub dispenser; IQR, interquartile range.