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Infectious risks during bed making?

Summary

Background: Microorganisms of infected and colonized patients can be found in the inanimate environment and also on bed linen. We investigated whether micro organisms being dispersed during bed making may pose infectious risks to other patients or staff.

Methods: We measured aerial concentration of bacteria, particles and ultra fine particles near the beds of 96 patients immediately before and during bed making. Cultured bacteria were identified at least to genus level, potential nosocomial pathogens to species level.

Results: The concentrations of particles > 5 µm and bacteria significantly rose during bed making. Occasionally potential nosocomial pathogens such as *Staphylococcus aureus*, Enterobacter cloacae, *Acinetobacter baumanii* and *Stenotrophomonas maltophilia* were found in the air during bed making.

Conclusion: Bed making should be included in risk assessment according to TRBA 250 (a German rule for occupational safety in healthcare settings). Bed making of patients who have infectious diseases or who are incontinent should be assigned to protection level 2 (infectious tuberculosis protection level 3). Personal protective equipment should comprise gowns, gloves and masks.

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Introduction

Bed making is one of the most common of all hospital tasks. Even in the absence of visible contamination, e.g. resulting from excretions or vomiting, bed line, pillow covers and mattresses can be contaminated with pathogens. Evidence of this has been provided by environmental investigations conducted in isolation rooms occupied by MRSA-infected or colonised patients [1,2,3], on a burns ward [4] and in the case of patients with cystic fibrosis [5,6]. The hands and clothing of nursing personnel can become contaminated when making beds [7]. Bloomfield et al. [8] therefore recommend that, in addition to hygienic hand disinfection before and after making beds, a plastic apron or protective gown be worn to protect uniforms against contamination. Another contentious issue is whether an orofacial mask is needed when caring for MRSA-infected or colonised patients, including when making their beds [9]. Whether the type and number of airborne microorganisms released when making the beds of non-infectious patients, however, poses a risk of infection to other patients and staff is unclear and was investigated by us in the present study.

Materials and Methods

In four clinics (angiology, gynaecology, ophthalmology, urology) we measured the particle, fine dust and bacterial concentrations of the air in patient rooms before and during bed making. The patients were referred to us by nursing personnel.

Measurements were carried out at a height of around one metre above floor level and at a maximum distance of one metre from the patient's bed. All patients were able to leave the bed while it was being made.

To determine the colony forming units (cfus) per cubic metre air we collected 50 litres of air with the MAS-100 (Merck) onto Columbia blood agar medium (Oxoid), which was incubated at 37 °C for 48 hours under aerobic conditions. Conventional laboratory methods were used to identify microorganisms (catalase test, Staphytect Plus Oxoid, API-biomérieux). We used the APC plus (Biotest) to count particles.

The ultra-fine dust of a particle size between 0.02 µm and 1 µm was measured with the P-Trak Ultrafine Particle Counter (TSI).

All measurements were conducted in triplicate. The measuring head of the MAS 100 was autoclaved each day. To verify

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Table 1: Concentrations of airborne particles, fine dust and bacteria before and during bed making (median, range).

	n		Particles ⩾ 0.3 µm x 10^4/m^3	Particles ⩾ 0.5 µm x 10^4/m^3	Particles ⩾ 1 µm x 10^4/m^3	Particles ⩾ 5 µm/m^3	Fine dust/cm^3	Bacteria cfu/m^3
All	96	before	654.9 0.2–3531.5	56.6 5.5–1395.6	14.9 1.7–434.6	5221 1048–401810	7420 761–66200	1270 90–3780
		during	653.7 0.16–3531.5	61.6 6.1–138.1	16.3 2.0–364.5	10106 2248–393747	7400 207–53733	1600 220–5540
			n.s.	p ⩽ 0.001	p ⩽ 0.001	p ⩽ 0.001	p = 0.014	p ⩽ 0.001
Gynaecology	35	before	367.1 52.8–1709.6	36.2 5.5–347.7	11.5 1.7–120.8	3920 1095–38811	6107 761–66200	1540 90–3780
		during	399.3 56.6–1732.6	43.6 6.1–368.0	12.1 2.0–96.5	7734 2413–30194	6683 207–53733	2140 220–5540
			n.s.	p = 0.002	p = 0.001	p ⩽ 0.001	n.s.	p = 0.041
Urology	21	before	905.1 0.2–1632.20	81.9 14.0–1395.6	22.6 3.8–172.2	8570 1448–401810	10600 4150–20000	1620 270–2880
		during	856.2 0.2–1655.5	87.8 15.5–1381.0	24.1 5.3–167.5	13137 2496–393747	10148 1966–17600	1900 450–3400
			n.s.	n.s.	n.s.	p = 0.009	n.s.	p = 0.006
Ophthalmology	20	before	676.0 241.7–1845.6	39.6 13.6–498.7	11.1 3.5–89.9	4109 2095–5580	9333 4437–24200	880 140–1620
		during	694.5 266.8–1842.8	48.6 19.7–517.5	14.6 5.8–97.6	10077 3873–20553	8725 4760–22366	1360 420–3120
			n.s.	p = 0.002	p = 0.028	p ⩽ 0.001	n.s.	p ⩽ 0.001
Angiology	20	before	1581.1 356.8–3531.5	280.8 14.8–940.3	65.4 2.3–434.6	12537 1048–325366	6273 2577–19600	920 90–2360
		during	1602.2 353.5–3531.5	277 16.0–829.9	66.8 2.9–364.5	21195 2248–383988	5957 2020–18066	1455 260–3000
			n.s.	p = 0.033	p = 0.028	p = 0.001	n.s.	p = 0.001

background APC plus counts, we used the cleaning filter recommended by the manufacturer. Measuring equipment was calibrated in accordance with the manufacturer's instructions.

In addition to the measured data, we recorded the patients' clinical data such as the presence of wounds, urinary tract catheters, skin diseases or current infections. Statistical evaluation (Wilcoxon test, Spearman correlation) was conducted with SPSS. Results were deemed to be significant for values of $p<0.05$.

Results

We conducted a total of 96 measurements (in each case before and during bed making), of which 35 measurements were carried out in the gynaecology clinic, 21 in urology and 20 in both the ophthalmology and angiology clinics.

Forty-two beds were occupied by men, and 54 by women. Seven patients had a urinary bladder catheter in place and 17 had a wound.

The particles, fine dust and bacterial concentrations of the air measured before and during bed making are shown in Table 1. Figure 1 shows box plots of bacterial concentrations in the air before and during bed making in the various clinics.

In all clinics significantly more bacteria and significantly more particles > 5 µm were detected in the air during bed making than before bed making. The number of bacteria detectable in the air correlated with the concentration of particles > 5 µm before but not during bed making. The airborne concentrations of particles > 5 µm and of bacteria were independent of whether the bed was occupied by a man or a woman. In the case of patients with a wound, the bacterial concentrations in the air before bed making were significantly higher than in the case of patients without a wound (median 2240 cfu/m^3 versus 1160 cfu/m^3, p = 0.037), but not during bed making (median 2240 cfu/m^3 versus 1540 cfu/m^3). The incidence and type of microorganisms detected in the air during bed making are shown in Table 2, while Table 3 shows the concentrations of selected microorganisms of relevance in a nosocomial setting.

Discussion

Other studies, too, have demonstrated a rise in the airborne concentrations of particles and bacteria during bed making, but these differed from our study in terms of study design.

On wards occupied by patients with streptococcal infections, Thomas et al. [10] noted an increase in the concentration of the number of streptococci detected in the room air of two 4-bed rooms during bed making.

Roberts et al. [11] measured throughout an entire day the particle concentrations at 5-minute, and bacterial concentration at 30-minute, intervals in the

Table 2: Number of patients for whom the microorganisms listed in the table were detected.

Microorganisms	Number of patients
Micrococci	89
Coagulase-negative staphylococci	88
Aerobic spore-forming bacteria	85
Moulds	71
Pantoea spp.	15
Viridans streptococci	13
Acinetobacter baumanii	8
Staphylococcus aureus	7
Moraxella spp.	7
Non-differentiated non-fermenters	5
Yeasts	3
Enterococcus faecalis	2
Escherichia hermanii	2
Enterobacter cloacae	2
Branhamella catarrhalis	2
Streptococcus pneumoniae	1
Corynebacteria	1
Pasteurella spp.	1
Stenotrophomonas maltohilia	1
Burkholderia cepacia	1

room air of a respiratory diseases' department, but they did not engage in further identification of the microorganisms detected in the air. During bed making, an increase was observed in the concentrations of particles > 3 µm and of bacteria in the room air.

In the air of isolation rooms occupied by MRSA-infected or colonised patients, Shiomori et al. [12,13] detected MRSA counts whose concentrations during bed making significantly rose between 25- and 26-fold, reverting to the baseline count within 30 to 60 minutes after bed making.

That the source of the microorganisms detected in the room air during bed making was also the contaminated bed linen was demonstrated experimentally by Overton [14]. He contaminated bed linen with Bacillus stearothermophilus and conducted measurements of airborne microbial counts before, during and after bed making. The B. stearothermophilus airborne count increased during bed making and reverted to almost the baseline count within 30 minutes. The bed linen can be contaminated with microorganisms from the skin as well as from the intestinal tract. Each day up to 3×10^8 skin scales are shed into the environment by every person because of clothing rubbing against the skin [15, 16]. Between around 5 and 10% of the skin scales shed harbour bacteria. That amount is a function of bacterial colonisation of the skin surface. Patients with skin diseases shed more particles harbouring bacteria into the environment [17]. In MRSA isolation rooms, bed linen is one of the environmental surfaces most commonly and most heavily contaminated with MRSA [1,2,3]. That bed linen can also be contaminated with the patient's intestinal microorganisms has been demonstrated indirectly by a study conducted by Sanderson et al. [7]: after bed making, coliforms were detected on the hands of 13 % of nursing personnel on a general orthopaedics wards and this figure was as high as 20 % for a ward occupied by patients with bone marrow diseases. There are reports of hepatitis A and *Salmonella hadar* being transmitted via contaminated bed linen [18,19].

Table 3: Concentrations (cfu/m3) of airborne bacteria of potential nosocomial relevance during bed making.

Microorganisms	cfu / m³
Gram-positive	
Staphylococcus aureus	5 to 53,3
Streptococcus pneumoniae	86
Enterococcus faecalis	6,7 and 26,7
Gram-negative	
Pantoea spp.	6,7 to 130
Enterobacter cloacae	86 and 175
Acinetobacter baumanii	6,7 to 60
Stenotrophomonas maltohilia	20

As opposed to the studies carried out hitherto, we did not select patients on the basis of a particular disease or because they were infected or colonised with a certain pathogen. None of the patients in our study was incontinent. Furthermore, the patients were referred to us by the nursing staff and it was obvious that there was no bias in terms of selecting those patients on the ward who had severe diseases or acute infections so that, by including all patients in a ward, it is more likely that higher airborne concentrations, and possibly more pathogenic microorganisms, could be expected.

Our study showed that when making the beds of non-infectious patients, it was possible to detect pathogens in the air, albeit these were relatively less common and in a lower concentration. The total microbial counts in the room air measured by us during bed making hardly dif-

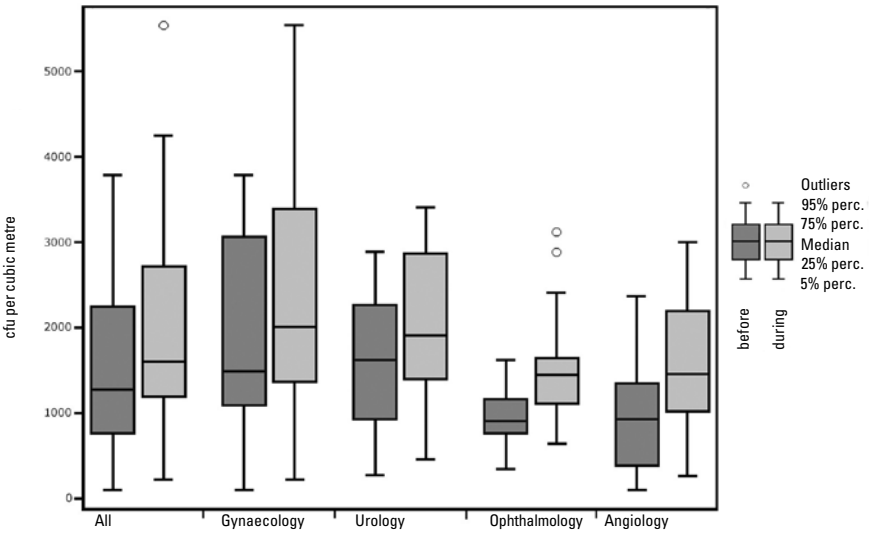

Figure 1: Box plots of airborne bacterial concentrations before and during bed making in the various clinics.

fered from those detected in a study by Roberts [11]. However, compared with previous investigators [12,20,21], we detected *Staphylococcus aureus* less commonly and at a lower concentration in the air of patient rooms before and during bed making, Noble [20] carried out air measurements on three wards over a period of four years, and detected airborne *S. aureus* counts of more than 35 cfu /m³ on 3 % of study days. During bed making a rise in the airborne concentrations of *S. aureus* was seen more often than in the case of the overall other microorganisms. Our findings can be compared with those of Noble only subject to certain restrictions, because on two of the three wards investigated by Noble wool blankets were being used, which possibly had given rise to a higher count of particles harbouring bacteria. In patient rooms of a burns unit, Rutala [21] measured during a MRSA outbreak mean MRSA concentrations of 71 cfu/m³. It is well known that patients with an MRSA-infected or colonised wound shed more MRSA than do patients who have no wound [1]. There is no literature available on detection of Enterobacteriaceae in the room air of patient rooms, in particular during bed making. It can be assumed that the airborne bacterial load during bed making is often higher than that evidenced by our study, since our study did not include any incontinent, bedridden patients or those needing nursing care.

Our findings reveal that in general the risk posed to other patients or personal during bed making is in all probability low, but not something that should be discounted. But it must be pointed out that this issue has hardly been investigated to date and, hence, no well-founded studies have been conducted into the real infection and colonisation risk. The airborne bacteria detected by us before and during bed making were facultative pathogenic microorganisms that were detected not only in other areas of the hospital, but also, albeit in a lower concentration, outside the hospital in the indoor air [22,23,24]. There is evidence of potential airborne transmission of infection in the case of certain bacteria (*Staphylococcus aureus* [16,25], *Pseudomonas aeruginosa* in the presence of cystic fibrosis [6]), but the minimum infectious dose or the requisite air concentration is not known. Furthermore, when evaluating the microbial air concentration it must be borne in mind that the sensitivity to drying varies among different bacterial species and that their duration of infectiousness in the room air also varies [26,27,28]. In any case, bed making must definitely be included in hazards evaluation, e.g. pursuant to the German Technical Regulation on Biological Substances (TRBA 250) [29]. Bed making of patients with a diagnosed infection (e.g. noroviruses, rotaviruses and other intestinal diseases, hepatitis A, MRSA, VRE, ESBL, *Clostridium difficile*) and, as borne out in particular by our study, of incontinent patients must be assigned to protection level 2, and to protection level 3 for patients with open tuberculosis 3. This lends credence to the structural demands, in technical and organisational respects, for creation of a greater number of single rooms, as are being currently introduced and discussed on a massive scale in Anglo-American countries [30,31,32]. As regards personal protective equipment, the use of disposable gowns, orofacial masks (at least FFP1) as well as of disposable gloves is recommended for protection level 2.

Conflict of Interest

The authors declare that there is no conflict of interest as understood by the International Committee of Medical Journal Editors.

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