Epidem. Inf. (1989), **102**, 231–238
Printed in Great Britain

Sink flora in a long-stay hospital is determined by the patients' oral and rectal flora

HENDRIK K. F. VAN SAENE,[1] JEANNET C. VAN PUTTE,[2] JORIS J. M. VAN SAENE,[2] THOMAS W. VAN DE GRONDE[3] AND EDUARD G. A. VAN WARMERDAM[3]

[1] *Department of Medical Microbiology, University of Liverpool, P.O. Box 147, Liverpool L69 3BX, UK*

[2] *Department of Pharmaceutical Technology and Dispensing, University of Groningen, Antonius Deusinglaan 2, 9713 AW Groningen, The Netherlands*

[3] *Long Stay Hospital Innersdyk, Ypemaheerd 2a, 9736 MA Groningen, The Netherlands*

(*Accepted 25 August 1988*)

SUMMARY

Sinks in a new long-stay hospital (LSH) were cultured weekly during 4 consecutive months to evaluate the microbial profile before and after occupancy of the hospital. From the elderly patients admitted to the patient care rooms oral and rectal specimens were collected to examine the contribution of the patients' flora to the sink contamination. Isolates were typed biochemically, serologically and by susceptibility pattern. Before occupancy Gram-negative bacilli were not isolated. Once the elderly patients, who were highly colonized on admission, occupied their rooms identical strains gradually contaminated the sinks. *Escherichia coli*, *Klebsiella*, *Pseudomonas* and *Acinetobacter* species were the major correlating strains. The mean concentration of the correlating isolates was higher in throat and intestines compared to the mean concentration of the non-correlating strains. These strains seem to have a greater chance to be shed and then transferred via the hands of personnel to sinks. This resport shows that the major route of environmental contamination is from patient carriers to sinks, and not the reverse way.

INTRODUCTION

Many studies have shown that infected patients disperse and contaminate the inanimate environment (Harris *et al.* 1969; Tinne *et al.* 1967). The hands of attendants have been implicated as the mode of transmission (Maki, 1982). Although the environment may be a major reservoir of microorganisms, this type of flora rarely colonizes patients (Levin *et al.* 1984) and contributes little to hospital infections (Maki *et al.* 1982). Practically all these studies are done in hospitals and usually in patients admitted to the intensive care units.

Long-stay hospital patients are surprisingly similar to intensive care unit patients, from the pathophysiological and microbiological point of view. Both

populations suffer reduced peristalsis and show high colonization and infection rates (Rockstein, 1968; Nicolle *et al.* 1984; Brown *et al.* 1985). In 1986, on 20 October the long-stay hospital of Groningen moved from its 70-year-old building into a new, considerably more spacious facility. This change of location provided a unique opportunity to examine prospectively the contribution of the patients' flora to the environmental contamination.

The two major aims of this investigation were: (1) the evaluation of the contamination pattern of the inanimate environment before and after occupancy of the new long-stay hospital, and (2) the contribution of the oral and rectal flora of the patients to the microbial profile of the inanimate environment.

PATIENTS AND METHODS

Patients

Fifteen patients, under the care of two of the authors (T. W. vd. G, E. G. A. v. W.) were the subjects of this prospective study. All but one had demential syndrome: three of them also suffered with diabetes mellitus type 2. There were 11 women and 4 men; their ages ranged from 77 to 100 years, with a mean of 84·6 and a median of 83·0 years. None had been in an acute care facility during the prior 3 months nor within the 2-month study period.

Environment

The sinks in the 10 patient-care rooms (7 single and 3 double bedrooms) were chosen for environmental surveillance. Two patients left their single bedrooms, which were occupied immediately by patients 14 and 15 during the study.

All ten sinks are in the patient-care area and are often used by the LSH personnel caring for the patients. After caring for the patients the sinks are cleaned by means of a decalcifying agent daily.

Study design

Sink specimens were obtained by swabbing until the cotton-tipped swab was soiled. Sampling frequency was once weekly during four periods: the month before taking occupancy (October 1986), and during the 3 months following occupancy (November, December 1986 and January 1987). From the LSH patients admitted to the ten patient-care rooms, oral and rectal specimens were collected. All samples from both patients and sinks were collected by the same investigators (H.K.F.v.S., J.C.v.P.) at the same time of day, after the patients had been washed and dressed but prior to sink cleaning.

Microbiological methods

All oral and rectal specimens were inoculated on to four solid and one fluid media within 1 h of collection. Sink samples were inoculated on to two solid and one fluid media within 1 h of collection. The patients' samples were plated out on to four solid media: MacConkey agar (Gibco, Paisley, Scotland, No. 152–3000); blood agar (Gibco, Paisley, Scotland, No. 152-0600); kanamycin aesculin azide agar (Lab M, Salford, England, No. 106) and yeast morphology agar (Merck, Darmstadt, GFR, No. 13849). The two solid media used for the sink samples were

MacConkey and blood agar. After inoculating the solid plates, the tips of the swabs were put into brain heart infusion broth (Lab M, Salford, England, No. 49). Inoculation was performed by the four quadrant method, and solid media and broth were incubated at 37 °C for 18 h. Blood and yeast morphology agar plates needed two nights of incubation. If the broth was turbid, inoculation was performed onto the above-mentioned four solid media for the patients' samples and the two mentioned media for the sink samples. The microorganisms sought were Enterobacteriaceae/Pseudomonadaceae, *Acinetobacter* spp., *Staphylococcus aureus*, *Enterococcus faecalis* and *Candida* spp. The number of microorganisms was estimated on a scale of 1+ to 5+. If only the broth was positive, the growth density was recorded as 1+ (corresponding to $< 10^1$ colony forming units (c.f.u.) per ml or g); macroscopic growth in the first quadrant scored 2+($< 10^3$ c.f.u. per ml or g); colony growth in the second quadrant, 3+($< 10^5$ c.f.u. per ml or g); colonies present in the third quadrant 4+($< 10^7$ c.f.u. per ml or g) and when bacteria grew in each of the quadrants, 5+($> 10^7$ c.f.u. per ml or g). Identification and typing of different microorganisms were done using standard procedures (API-20E biotyping combined with serotyping and antimicrobial susceptibility pattern) (van Saene *et al.* 1983).

Definitions

(1) *Carriage* of a particular microorganism was defined as the condition in which a study patient showed a minimum of two consecutive oral and/or rectal specimens positive for that microorganism.

(2) *Colonization index* was defined in this study as the ratio of the sum of all semi-quantitative growth densities divided by all positive samples. The index was calculated for both patient's throat and rectum, and sinks.

(3) *Correlating and non-correlating strains.* The patient's and sink isolate were accepted as forming a correlating pair if both had the same type and susceptibility pattern. For example, a *Pseudomonas* strain isolated from a sink was considered to be similar to a strain carried by a longstay hospital (LSH) patient if both isolates showed identical serotype 10 and were susceptible to gentamicin, tobramycin and amikacin. If the LSH patient carried a *Proteus* strain in throat and/or rectum and the sink became contaminated by identical bioprofile 0736000 but the sink isolate was resistant to trimethoprim-sulphamethoxazole (used as the drug of choice for 7 years) the pair was considered to be non-correlating.

(4) *Criteria for determining the relation between sink and patient isolates.* It was considered that an elderly patient may have acquired a sink strain if the following criteria were met: the patient's and the sink isolate had the same type and susceptibility pattern; the strain was found in a sink before it was cultured from the patient; and the strain had not been isolated from any other patient just before or during the period of acquisition (Levin *et al.* 1984).

RESULTS

Patients

The 15 patients studied carried a total of 58 Enterobacteriaceae/Pseudomonadaceae and *Acinetobacter* species. After identification and typing of these 58 strains, 43 were considered to be different. Table 1 shows the different

https://doi.org/10.1017/S0950268800029903 Published online by Cambridge University Press

Table 1. *Number of patients carrying* Enterobacteriaceae/Pseudomonadaceae *and* Acinetobacter *spp.*, E. faecalis, S. aureus *and* Candida *spp. in the long-stay hospital*

Microorganisms	Oropharyngeal cavity	Rectal cavity
Enterobacteriaceae		
E. coli	2	15
Klebsiella spp. (*oxytoca/pneumoniae*)	4	8
Proteus spp. (*mirabilis/vulgaris*)	0	6
Morganella spp. (*morganii*)	0	1
Providencia spp. (*stuartii*)	0	1
Enterobacter spp. (*cloacae/aerogenes/agglomerans*	3	0
Hafnia spp. (*alvei*)	0	1
Citrobacter spp. (*freundii*)	1	1
Pseudomonadaceae (*Pseudomonas aeruginosa/putida*)	0	3
Acinetobacter spp.	3	0
Enterococcus faecalis	12	15
Staphylococcus aureus	2	–
Candida spp.	15	5

Enterobacteriaceae strains that were obtained. Besides *E. coli*, *Klebsiella* and *Proteus* species predominated. It was noteworthy that all elderly patients carried yeasts and almost all patients were colonized by *E. faecalis* at the oropharynx. Only two elderly patients carried *Staphylococcus aureus*. Out of the 15 patients, 3 women developed infections (two respiratory tract and one conjunctival infections) during the study period. Oral trimethoprim-sulfamethoxazole cured both episodes of bronchitis, and topical neomycin was effective in treating the conjunctivitis.

Environment

A total number of 180 samples as collected over the 4-month study period (Table 2). Fifty-seven samples were sterile. Only Enterobacteriaceae, Pseudomonadaceae and *Acinetobacter* species were isolated from the sinks whereas staphylococci, enterococci and yeasts were not cultured at all from the sinks. None of the sinks was found to be contaminated by Enterobacteriaceae, Pseudomonadaceae and *Acinetobacter* species before patients were admitted to the new hospital. All sinks were contaminated by *Acinetobacter* species immediately after the patients had been admitted. Enterobacteriaceae gradually colonized the sinks: *E. coli* (7×), *Enterobacter* (6×), *Citrobacter* (4×), *Klebsiella* and *Pseudomonas* (3×), *Proteus*, *Morganella* and *Providencia* (1×) spp.

Semi-quantitative culturing allowed calculation of the colonization index. The contamination level gradually increased in time for the group of Gram-negative bacilli, except for *Pseudomonas* species.

Table 2. *Microbial profiles of the sinks in the new long-stay hospital before and after occupancy*

	Before occupancy	After occupancy		
	Oct. 1986	Nov. 86	Dec. 86	Jan. 87
Number of specimens (total = 180)	40	40	50	50
Number of specimens showing no growth (total = 57)	40	7	7	3
	Colonization index			
Enterobacteriaceae/ Pseudomonadaceae/*Acinetobacter* spp.	0	2·2	2·4	2·7
Enterobacteriaceae	0	1·7	1·9	2·4
E. coli	0	1·7	1·3	2·2
Citrobacter spp.	0	1·7	2·3	3·0
Klebsiella spp.	0	2·0	2·0	4·0
Enterobacter spp.	0	1·8	2·1	2·6
Proteus/Morganella spp.	0	1·0	1·5	0
Providencia spp.	0	0	2·0	0
Pseudomonadaceae	0	1·0	2·3	1·8
Acinetobacter spp.	0	2·7	2·8	2·9
Staphylococci	—	—	—	—
Enterococci	—	—	—	—
Yeasts	—	—	—	—

Table 3. *Colonization indices of correlating microorganisms isolated from both patients and sinks in the long-stay hospital*

Rooms	Correlating microorganisms	Colonization index patient carrier		Colonization index sink
		Oropharyngeal	Rectal	
1	—	—	—	—
2	—	—	—	—
3	*Acinetobacter* sp.	1·5	—	2·2
	Enterobacter sp.	2·0	—	2·0
	E. coli	—	4·9	1·3
4	*E. coli*	—	4·7	1·3
	E. coli	—	3·8	2·5
5	*E. coli*	—	4·3	1·0
6	*E. coli*	—	3·9	2·0
	E. coli	—	2·9	1·0
7	*E. coli*	2·0	3·0	2·3
	Pseudomonas sp.	—	2·0	2·1
8	*E. coli*	—	3·1	1·0
	Klebsiella sp.	—	2·0	1·0
9	—	—	—	—
10	*Acinetobacter* sp.	2·7	—	3·9
	Klebsiella sp.	1·5	—	3·5
	E. coli	—	3·0	1·0
	Providencia sp.	—	3·0	2·0
	Proteus sp.	—	3·8	1·5
	Pseudomonas sp.	—	1·6	1·0
Mean colonization index		1·9	3·2	1·8

https://doi.org/10.1017/S0950268800029903 Published online by Cambridge University Press

Table 4. *Colonization indices of non-correlating microorganisms isolated from patients in the long-stay hospital*

Rooms	Non-correlating microorganisms	Colonization index patient carrier	
		Oropharyngeal	Rectal
1	*E. coli*	—	3·5
	Klebsiella sp.	2·0	2·7
	Morganella sp.	—	1·3
	Enterobacter sp.	2·0	—
	E. coli	—	3·6
	Klebsiella sp.	—	3·1
	Proteus sp.	—	1·0
2	*E. coli*	2·1	3·8
3	*Klebsiella* sp.	1·8	2·6
4	*E. coli*	—	4·4
	E. coli	—	4·7
	Klebsiella sp.	—	3·0
5	*E. coli*	—	3·8
	Klebsiella sp.	1·0	2·7
	Proteus sp.	—	2·8
	Pseudomonas sp.	—	1·8
	Klebsiella sp.	—	2·3
	Proteus sp.	—	1·0
	Citrobacter sp.	—	2·5
6	*Klebsiella* sp.	—	1·7
	Proteus sp.	—	2·0
	Hafnia sp.	—	3·0
7	—	—	—
8	*Enterobacter* sp.	1·5	—
	Citrobacter sp.	2·0	—
	Acinetobacter sp.	2·0	—
	E. coli	—	4·0
9	*E. coli*	—	2·9
10	*E. coli*	—	2·8
	E. coli	—	3·7
	E. coli	—	3·6
Mean colonization index		1·8	2·9

Correlating and non-correlating microorganisms

Out of 36 strains isolated from the sinks, 18 (50%) correlated with strai carried by patients (Table 3). All patients first carried the strain in oropharynge and/or rectal cavity, before contamination of the sink occurred. In this stu sinks were not found to be sources of microorganisms colonizing LSH patien The majority of correlating strains were rectal colonizers, while four or colonized the throat. On one occasion both throat and rectum were positive for t identical strain. Half of the correlating strains were *E. coli*. *Acinetobacter*, *Klebsie* and *Pseudomonas* species were found correlating twice. *Proteus*, *Providencia* a Enterobacter species were each present in both patient and sink, only once. T mean colonization indices for correlating strains in throat and rectum did

https://doi.org/10.1017/S0950268800029903 Published online by Cambridge University Press

significantly differ from the mean colonization indices for the non-correlating strains (1·9 and 3·2 versus 1·8 and 2·9) (Table 4).

DISCUSSION

The gradual increase in sink contamination in the new long stay hospital after occupancy suggests that microorganisms present in sinks originate from patients admitted to the rooms. And secondly, patients need not be infected to contaminate the inanimate environment.

Long-stay hospital patients are highly colonized in the throat and intestines with Enterobacteriaceae/Pseudomonadaceae and *Acinetobacter* species (Phair, Kauffman & Bjornson, 1978; Nicolle *et al.* 1986). This high carriage rate depends on a decreased colonization defence occurring in advanced age, underlying diseases and on medication. Oral and rectal colonization implies 'shedding', more specifically in the elderly with decreased hygiene as a consequence of incontinence of saliva and faeces. They are heavy dispersers and will contaminate clothing and bedding and will readily contaminate the hands and clothing of attendants. Microorganisms can be transferred to the sinks via the hands of hospital personnel (Garibaldi, Brodine & Matsumiya, 1981). Before occupancy Gram-negative bacteria were not isolated at all. This finding could be explained by the fact that the tap-water was connected only a few days before the hospital was opened and at this time *Acinetobacter* spp. appeared in the sinks. Enterobacteriaceae and Pseudomonadaceae began to appear once the elderly patients occupied their rooms. The elderly patients were heavy dispersers of these microorganisms and contamination of the sinks occurred, perhaps via the hands of attendant personnel.

This report shows that the major route of environmental contamination is from patient carriers to the sinks, and not the reverse way. We were able to demonstrate this patient-to-sink transfer on the basis of qualitative evidence. The mean concentration of the correlating strains was higher in throat and intestines compared to the mean concentration of the colonizing non-correlating strains. Although this difference is not statistically significant, microorganisms colonizing the patient in higher concentrations have a greater chance to be shed and then transferred via the hands to the sinks.

All patients carried yeasts and enterococci. However, neither species was isolated from the environment. Our observation confirms Maki's finding (Maki, 1978). Yeast transfer via the hands is described in the literature (Burnie, 1986). It is probable that conditions in sinks are unfavourable for yeast growth.

Staff may be a potential source contributing to the contamination of the inanimate hospital environment. Specimens of LSH personnel were not included in this study for the following reasons. Healthy nurses and domestics normally do not carry 'hospital' flora. For example, *Pseudomonas* species – if present in throat and/or intestine – are mostly transient colonizers in low concentrations only, because of the integrity of colonization defence. Moreover, personnel – although being part of the chain of transmission from LSH patient to sink – are unlikely to be responsible for 'shedding' of their own oral and/or rectal flora because of intact hygiene and absence of incontinence in healthy people.

A question that immediately emerges following this study is how long does it take for an equilibrium to be established? In order to identify a continuous interchange between long-stay hospital patient and sink an identical study over the same time should be repeated in the future.

In conclusion, elderly patients who are not infected are highly colonized by Enterobacteriaceae/Pseudomonadaceae and *Acinetobacter* species in the throat and rectum. Persons with heavy salivary and faecal colonizations are not only carriers but also 'shedders'. They guarantee a continuous supply of bacteria into the environment.

We are very grateful to Professor Tony Hart for reviewing the manuscript and we thank Mrs Betty Kitchen for secretarial assistance.

REFERENCES

Brown, R. B., Hosmer, D., Chen, H. C., Teres, D., Sands, M., Bradley, S., Opitz, E., Swedzinski, D. & Opalenik, D. (1985). A comparison of infections in different ICUs within the same hospital. *Critical Care Medicine* **13**, 472–476.

Burnie, J. P. (1986). *Candida* and hands. *Journal of Hospital Infection* **8**, 1–3.

Garibaldi, R. A., Brodine, S. & Matsumiya, S. (1981). Infections among patients in nursing homes. Policies, prevalence, and problems. *New England Journal of Medicine* **305**, 731–735.

Harris, D. M., Orwin, J. M., Colquhoun, J. & Schroeder, H. G. (1969). Control of cross-infection in an intensive care unit. *Journal of Hygiene* **67**, 525–532.

Levin, M. H., Olson, B., Nathan, C., Kabins, S. A. & Weinstein, R. A. (1984). *Pseudomonas* in the sinks in an intensive care unit: relation to patients. *Journal of Clinical Pathology* **37**, 424–427.

Maki, D. G. (1978). Control of colonization and transmission of pathogenic bacteria in the hospital. *Annals of Internal Medicine* **89**, 777–780.

Maki, D. G., Alvarado, C. J., Hassemer, C. A. & Zilz, M. A. (1982). Relation of the inanimate hospital environment to endemic nosocomial infection. *New England Journal of Medicine* **307**, 1562–1566.

Nicolle, L. E., McIntyre, M., Zacharias, H. & MacDonell, J. A. (1984). Twelve-month surveillance of infections in institutionalized elderly men. *Journal of the American Geriatrics Society* **32**, 513–519.

Nicolle, L. E., McLeod, J., McIntyre, M. & MacDonell, J. A. (1986). Significance of pharyngeal colonization with aerobic Gram-negative bacilli in elderly institutionalized man. *Age and Ageing* **5**, 47–52.

Phair, J. P., Kauffman, C. A. & Bjornson, A. (1978). Investigation of host defense mechanisms in the aged as determinants of nosocomial colonization and pneumonia. *Journal of the Reticuloendothelial Society* **23**, 397–405.

Rockstein, M. (1968). The biological aspects of ageing. *Gerontologist* **8**, 124–125.

Tinne, J. E., Gordon, A. M., Bain, W. H. & Mackey, W. A. (1967). Cross-infection by *Pseudomonas aeruginosa* as a hazard of intensive surgery. *British Medical Journal* iv, 313–315.

Van Saene, H. K. F., Stoutenbeek, C. P., Miranda, D. R. & Zandstra, D. F. (1983). A novel approach to infection control in the intensive care unit. *Acta Anaesthesiologica Belgica* **34**, 193–208.