

## Carpeting in Hospitals: an Epidemiological Evaluation

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Epidemiological and microbiological studies were conducted in a hospital room with carpet (CR) and in one without carpet (NCR). Microbiological profiles were determined with specimens obtained from patients admitted to these rooms. Patient records were reviewed to note infection status and other case identities. Eleven-millimeter cylindrical core samples of carpet were obtained, and swab template techniques were used on the bare floor for subsequent enumeration and identification of contaminating microorganisms. In each sampling period, higher microbial counts per square inch ( $1 \text{ in}^2 = \text{ca } 6.452 \text{ cm}^2$ ) were measured for the carpet than for the bare floor. Recovery rates of *Enterobacter* spp., *Klebsiella pneumoniae*, and *Escherichia coli* were higher from carpet samples than from bare floor samples. Typable organisms (such as *E. coli*, *Pseudomonas aeruginosa*, *K. pneumoniae*, and *Staphylococcus aureus*) obtained from patients were also more frequently recovered from the carpet than from the bare flooring. Patients who stayed in the CR were shown to be colonized with the same types of organisms as those initially recovered from the carpet. However, no statistically significant differences were found in patients in the CR versus NCR in colonization with all typable and nontypable organisms first found on the floor. Disease in patients was found not to be associated with organisms found as contaminants of the carpet or the bare floor. Air above carpeting contained more consistent concentrations of organisms than air above the bare flooring.

In the last 10 years there have been several reports on the microbiology associated with carpets in hospitals. These studies in part were done to determine (i) differences in the levels of surface microbial contamination and of the air above carpets and bare floors (1, 6, 22, 23, 25, 29, 31, 41), (ii) effects of various housekeeping procedures on levels of contamination (9, 22, 34, 38), (iii) most effective microbiological sampling techniques (1, 19, 24, 30, 32, 33, 38, 39, 40), and (iv) the effectiveness of disinfection procedures in general and of pretreating carpets with antimicrobial agents (5, 9, 10, 29). The advantages (7, 18, 29, 35, 36) and disadvantages (2-4, 11, 13, 14, 20, 27) of using carpets in patient-care facilities also have been discussed.

There has been no epidemiological evidence to show that carpeted floors cause patient infections or raise the infection rate in hospitals, nor have data been available on the relative infection rates in hospitals with and without carpeting. Investigations conducted earlier at the Centers for Disease Control (1) showed that high levels of microbial contamination were found on pre-sterilized carpet strips 7 days after they were

placed in several pediatric patients' rooms. Levels of contamination appeared to be directly related to length of exposure. Qualitative studies demonstrated that organisms commonly isolated from nosocomial infections were present in the carpet fibers. In addition, survival studies demonstrated that *Staphylococcus aureus* organisms could be recovered from a hospital carpet as late as 35 days after it was placed in an environmental chamber. *Enterobacter* and *Escherichia* spp. were isolated from carpet in this chamber throughout the sampling period. These results indicate that carpets may be a microbial reservoir (particularly in busy areas associated with patient care), but they do not provide information on which to judge whether this reservoir is epidemiologically relevant to disease in patients. This investigation was conducted to obtain specific microbial and epidemiological data to determine whether microbes are transmitted between carpets and patients.

### MATERIALS AND METHODS

**Study setting.** Studies were conducted for approximately 11 months in patients' rooms with (CR) and without (NCR) carpeting in a pediatric hospital in an effort to measure the degree to which patients were affected by specific microbial carpet contaminants. Patients randomly admitted to the two rooms were medically and microbiologically studied. During this

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study, data were obtained (i) on specific microorganisms contaminating the carpet and the bare floor and on organisms isolated from the patients during hospitalization and (ii) from patients' case histories to ascertain the type of microbial infection or colonization and the possibility that these organisms were associated with the inanimate environment.

**Preparation of carpet and pad material.** A densely packed, loop-pile, wool carpet was used in this investigation. The carpet was cut to the dimensions of a private pediatric patient room and installed on the vinyl tile floor. Three-inch (ca. 7.6-cm) air-conditioning duct tape was used to hold down the carpet edges.

To assure low levels of microbial contamination before installation, rolled carpet and pad materials were prehumidified at 26.6°C and 70% relative humidity for 48 h and decontaminated in a sealed, polyethylene envelope (16 by 6 ft [ca. 487 by 182 cm]) containing a 10-pound (ca. 4.5-kg) cylinder of ethylene oxide. The gas valve was then opened, and the ethylene oxide was allowed to act for 48 h.

After they were aired, carpet and hair-felt pad materials were aseptically placed in the study room; two individuals dressed in sterile garb (gowns, masks, gloves, hair caps, and shoe covers) installed the carpet and pad.

**Cleaning procedures for carpet and hard floor.** The carpet was routinely cleaned with a Kent Microstat vacuum cleaner (The Kent Co., Elkhart, Ind.). This machine contains a high-efficiency internal filter to remove microorganisms from exhaust air. The carpet was deep vacuumed (i.e., a heavy vacuuming, in which the wand with attached carpet tool was passed over the carpet surface at least five times with heavy pressure applied) three times a week to maintain an aesthetically clean appearance. Floor areas were mopped daily by the one mop-one bucket cleaning technique with a phenolic detergent germicide.

**Sampling of carpeted and bare floors.** A hand-held hollow sterile punch and a hammer were used to cut 11-mm-diameter plugs from the carpet for evaluation (1). Plug samples were taken immediately after the carpet was installed to obtain baseline information, and additional samples were taken at 2- to 7-day intervals thereafter. The carpet pad was not cultured.

Six pools of carpet plugs (three plugs per pool) were obtained in each sampling period. Pooled carpet samples were taken from six randomly selected areas (3 by 4 ft [ca. 91 by 122 cm]) of the carpet before it was vacuumed: pool 1, by the entrance door; pools 2, 3, and 4, around the sides and end of the patient's bed; pool 5, in front of the couch used by visitors; and pool 6, in front of the entrance to the bathroom.

Carpet plugs were assayed with procedures described earlier (1), except for the following: three 11-mm plugs composed a pool, a 1:4 dilution was made by adding one 30-ml sample of each pooled carpet suspension to 90-ml dilution blanks containing 0.25% peptone water, and colony counts per square inch of total carpet thickness were extrapolated from total volume of fluid present. Only colonies present with Trypticase soy agar (TSA; BBL Microbiology Systems, Cockeysville, Md.) pour plates containing 0 to 300 colonies were used for colony counts.

A swab-template sampling method was used to obtain six samples of the vinyl tile floor surfaces in the NCR before it was cleaned. Sample locations were

comparable to those in the CR. Swabs were moistened in 0.25% peptone water and used to sample the floor area defined by a sterile template (2 by 2 inches [ca. 5 by 5 cm]) (16). Swabs were broken off into tubes containing 5 ml of 0.25% peptone water, the suspension was mixed, and 0.1- and 1.0-ml samples were withdrawn in duplicate and added to separate petri plates (15 by 100 mm). TSA medium was poured into plates, mixed, and incubated for 48 h at 37°C. Plates containing 0 to 300 colonies were counted, multiplied by the appropriate dilution factor, and expressed as total organisms per square inch (ca. 6.452 cm<sup>2</sup>) of floor.

Plates used in identifying isolates were prepared by adding 0.5 ml of each undiluted suspension to the surfaces of phenylethyl alcohol, TSA with 5% sheep blood (TSAB), and MacConkey agars, in duplicate. Each liquid was spread over an agar surface with an up-down rotation and was allowed to dry before plates were incubated at 37°C for 48 h. In addition, 0.5 ml of each suspension was inoculated to brilliant green tetrathionate broth, incubated for 24 h at 37°C, and streaked to brilliant green agar plates. Selected colonies were transferred to triple sugar iron agar slants for identification.

**Collection of patient specimens.** Rectal, nasal, and throat swabs, and RODAC (16) impression plates with TSAB of the mandibular angles and left and right forearms, were taken within 12 h after admission and again before discharge from patients who had been randomly assigned to the CR or NCR. At least three series of cultures were obtained per hospitalization (or three culture series per week from patients receiving extended care) to provide a basis for characterizing the microbial flora of each patient.

Specimen swabs were inoculated and streaked directly to phenylethyl alcohol, TSAB, and MacConkey agar plates and broken off in tubes of brilliant green tetrathionate broth. The tetrathionate broth was incubated for 24 h at 37°C and then streaked onto brilliant green agar plates. All plates, including impression plates, were incubated for 48 h at 37°C.

**Microbial air sampling.** Air samples were evaluated to determine the level and kind of microbial air contamination over the two types of floor coverings. Continuous 8-h air samples were obtained on each of 8 days near the end of the study. Samples from the first four days of this period were used in qualitative microbial determinations, whereas those from the last 4 days were used in quantitative analyses. Levels of air contamination were determined through at least one cycle of bed making, daily housekeeping, and meal service during a patient's hospitalization. Two cart-mounted versions of the Fort Detrick slit-incubator sampler (12, 42) were set at 3 ft (ca. 91 cm) above floor level and placed at the foot of the bed. The number of people going in and out of the room during the period of air sampling and the nature of their activities in the room were recorded.

Each air sampler was set to sample 0.5 ft<sup>3</sup> (ca. 0.014 m<sup>3</sup>) of air per min or 240 ft<sup>3</sup> of air per 8-h sampling period. Viable particles were impinged on sampling trays containing TSAB. The agar trays were removed from the sampler after 8 h and incubated for 48 h at 37°C. Concurrently, carpet and bare floors in test rooms were sampled for microbial content as described above.

TABLE 1. Organisms isolated from carpet and bare flooring samples

Organism	No. of times (%) <sup>a</sup>	
	Carpet	Floor
<i>Enterobacter</i> spp.	35 (60.3)	12 (20.6)
<i>P. aeruginosa</i>	3 (5.1)	5 (8.6)
<i>S. aureus</i>	26 (44.8)	19 (32.7)
<i>K. pneumoniae</i>	16 (27.5)	1 (1.7)
<i>E. coli</i>	13 (22.4)	3 (5.1)

<sup>a</sup> Percentage of samples positive for specific organisms.

**Identification of selected organisms.** Organisms that could be further characterized with appropriate typing systems included: *Klebsiella pneumoniae*, *Escherichia coli*, *Salmonella* spp., *Shigella* spp., *Pseudomonas aeruginosa*, and *S. aureus*. In addition, organisms identified as *Enterobacter* spp. and *Proteus* spp. were included in the analyses.

Types of organisms present were determined by gross colony morphology, Gram stain reaction, cell morphology, and reaction on triple sugar iron agar. Gram-positive cocci were identified as *S. epidermidis* and *S. aureus* with mannitol salt and coagulase tests. *S. aureus* was identified by positive mannitol and coagulase test results; mannitol-positive (or -negative), coagulase-negative cultures were designated *S. epidermidis*.

Isolates of *S. aureus* were phage typed by standard procedures (8). Colonies suggestive of gram-negative rods were picked to triple sugar iron agar slants and identified with standard biochemical and serological methods (15, 21). Bacteriocin production (pyocin typing) was used to type the *P. aeruginosa* isolates (17).

**Patient case histories.** Data were obtained by abstracting individual patient records to lend specific information that might be related to the contamination profile of the CR and the NCR. Length of stay, presence of infection on admission or hospital-acquired infection, site of infection, type of infection, severity of infection, and other pertinent factors from case histories were evaluated.

## RESULTS

**Floor contamination.** The level and type of microbial contamination in the wool carpet in a

TABLE 2. Organisms isolated from patient specimens in CR and NCR

Organism	No. of times (%) <sup>a</sup>	
	CR	NCR
<i>Enterobacter</i> spp.	12 (52.1)	12 (42.8)
<i>P. aeruginosa</i>	2 (8.7)	7 (25.0)
<i>S. aureus</i>	8 (34.7)	9 (32.1)
<i>K. pneumoniae</i>	15 (65.2)	15 (53.5)
<i>E. coli</i>	14 (60.8)	14 (50.0)
<i>Proteus</i> spp.	2 (8.7)	3 (10.7)

<sup>a</sup> Percentage of patients positive for specific organisms.

TABLE 3. Association of typable environmental isolates with patients in CR and NCR

Organism	No. of patients colonized with typable strains from:		Site of colonization
	Carpet <sup>a</sup>	Floor <sup>b</sup>	
<i>E. coli</i>	1 <sup>c</sup>	0	Throat
<i>P. aeruginosa</i>	1 <sup>d</sup>	0	Throat
<i>K. pneumoniae</i>	1 <sup>e</sup>	0	Throat
<i>S. aureus</i>	3 <sup>f</sup>	0	Nares (2); forearm
Total	6	0	

<sup>a</sup> Twenty-three patients admitted to CR.

<sup>b</sup> Thirty-six patients admitted to NCR.

<sup>c</sup> Serological type O6:H undetermined.

<sup>d</sup> Pyocin type O.

<sup>e</sup> Quellung type 26.

<sup>f</sup> Phage types 53/85, 85, and 29/52.

pediatric patient room were determined for 58 sampling periods in the 302-day study. Colony counts were proportional to elapsed time. No organisms were isolated from the carpet immediately after it was installed. Four days later, the level of contamination was 9,000 organisms/in<sup>2</sup> (ca. 6.452 cm<sup>2</sup>); the level continued to rise to 201,000 organisms/in<sup>2</sup> after 12 days. Throughout the rest of the study counts did not fall below 10<sup>3</sup> organisms/in<sup>2</sup>, and on some occasions counts rose as much as 10- to 100-fold between sampling (Fig. 1).

The levels of microbial contamination on the bare floor in the NCR varied somewhat more than those of the carpet during the study period, with counts from the former ranging from 20 to 1,000 organisms/in<sup>2</sup>.

Gram-negative rods and gram-positive cocci were recovered from both carpet and bare floor. Recovery rates of *Enterobacter* spp. (60.3 ver-

TABLE 4. Association by body site of all typable and nontypable environmental isolates first found on the floor with patient colonization in CR and NCR

No. of patient colonizations with typable and nontypable strains <sup>a</sup> from:		Site of colonization
Carpet	Floor	
5	1	Rectal
2	0	Nose
5	0	Throat
4	2	Skin
16 <sup>b</sup>	3 <sup>b</sup>	

<sup>a</sup> Strains included: *E. coli*, *P. aeruginosa*, *Proteus* spp., *S. aureus*, *Enterobacter* spp., and *K. pneumoniae*.

<sup>b</sup> Differences not statistically significant,  $P = 0.095$ , two-tail Mann-Whitney  $U$  test.

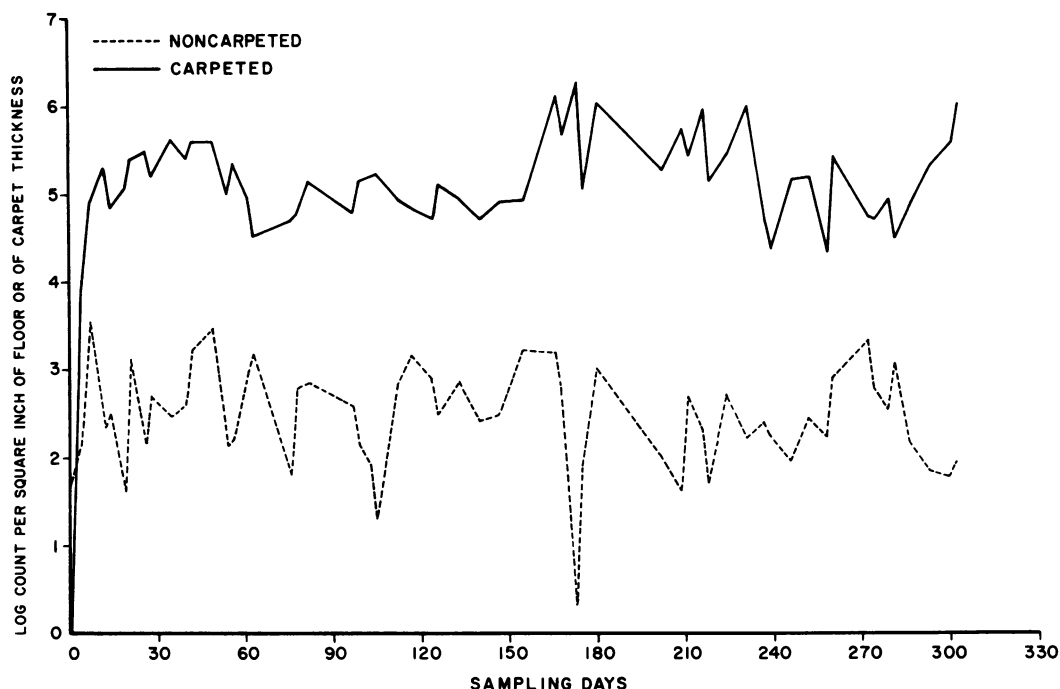


FIG. 1. Microbial contamination in samples of a wool carpet and from floor samples in a pediatric hospital.

sus 20.6%), *S. aureus* (44.8 versus 32.7%), *K. pneumoniae* (27.5 versus 1.7%), and *E. coli* (22.4 versus 5.1%) per sampling period were higher from the carpet than from the bare floor (Table 1). *S. aureus* was isolated more often from carpet than from bare floor (44.8 versus 32.7%), and *P. aeruginosa* was isolated more often from the bare floor than from carpeting (8.6 versus 5.1%).

**Patient colonization.** The number and percentage of times a specific organism was isolated from patients in the CR or NCR are shown in Table 2. Twenty-three patients were admitted to the CR, and 36 patients were admitted to the NCR in the study period. The 23 patients admitted to the CR and the 36 admitted to the NCR were hospitalized for an average of 6.9 and 7.0 days, respectively. No statistical difference was observed for the number of times *Enterobacter* spp., *P. aeruginosa*, *S. aureus*, *K. pneumoniae*, *E. coli*, and *Proteus* spp. were isolated from rectal, nasal, throat, and skin cultures of patients newly admitted to the CR or NCR.

Table 3 shows the typable organisms with which patients in the CR were colonized. Six patients were colonized with organisms that appeared identical to those recovered from carpet samples; cultures obtained on admission from these six patients were negative for the same organisms. These organisms were isolated

from the carpet 2 to 30 days before patients were shown to be colonized. Of the typable isolates obtained from the bare floor, none were later isolated from patients in the NCR.

However, these differences in colonization of patients after admission to CR versus NCR were not found when comparisons were made of colonization after admission with all typable and nontypable organisms first found on the floor. Table 4 shows comparisons of all new colonizations. There were 7 patients newly colonized 16 times in the CR and 2 patients newly colonized 3 times in the NCR. These differences in colonization were not statistically significant.

**Patient infections.** Sixteen of 23 patients in the CR were believed to have either a community-acquired (CA) (14) or a hospital-acquired (HA) (2) infection. A burned patient isolated in the CR developed a wound infection with *P. aeruginosa* 10 days after being admitted, although no isolates of this organism were found in carpet samples in this period. The second patient with an HA infection acquired it before being transferred to the CR.

Two of the 36 patients in the NCR had hospital-acquired infections, 24 were admitted with CA infections, and 10 had no infections. One patient had had an HA infection in an earlier admission, and the other patient an HA staphylococcal wound infection. There was no appar-

TABLE 5. Association of typable patient organisms with the environment in CR and NCR

Typable strains	No. of strains from:	
	Carpet	Floor
<i>E. coli</i>	2 <sup>a</sup>	0
<i>P. aeruginosa</i>	2 <sup>b</sup>	0
<i>K. pneumoniae</i>	2 <sup>c</sup>	0
<i>S. aureus</i>	5 <sup>d</sup>	2 <sup>e</sup>
Total	11 (7) <sup>f</sup>	2

<sup>a</sup> Serological types O18:H7 and O6:H undetermined.

<sup>b</sup> Pyocin type O.

<sup>c</sup> Quellung types 25 and 29.

<sup>d</sup> Phage types 83A/85 and 29/52.

<sup>e</sup> Phage types 29/52 and 83A.

<sup>f</sup> Eleven isolates from seven patients.

ent association between typable isolates from the bare floor and infected patients. The number of CA and HA infections associated with the CR and NCR did not differ significantly.

**Transmission of patient organisms to environment.** Table 5 shows the association between typable patient organisms and floor covering. In the CR, 11 of 53 (20.7%) typable strains of an opportunistic pathogen recovered from 7 of the 23 patients were later also recovered from the carpet. These environmental strains were isolated from the carpet at 6- to 29-day intervals after the patient was culture positive for the specific type. Two typable *S. aureus* strains (2 of 54, or 3.7%) isolated from the bare floor were of the same phage types (29/52 and 83A) as strains recovered earlier from 2 of the 36 patients within 2 days after they were admitted to the NCR.

**Air sampling.** The results of 8 days of microbial air sampling (sampling periods 59 to 66) in the

CR and NCR are shown in Tables 6 and 7. *S. aureus*, *S. epidermidis*, *K. pneumoniae*, *E. coli*, *Enterobacter* spp., and gram-negative nonfermenting organisms were isolated from air and carpet in the CR. *K. pneumoniae*, Quellung type 28, isolates were obtained from both carpet and air the same sampling day. Quellung types 22, 66, and 21 recovered from air had been earlier isolated from the carpet. *S. aureus*, *S. epidermidis*, gram-negative nonfermenting rods, *Enterobacter* spp., and *K. pneumoniae* were isolated from air in the NCR. The same strains, except for *K. pneumoniae*, were also recovered from the bare floor.

Microbial air counts ranged from 1,200 to 2,100 organisms per 240 ft<sup>3</sup> of air on 4 days of air sampling in the CR. Counts for carpet samples ranged from 47,000 to 176,000 organisms/in<sup>2</sup>. Counts from air samples above the floor in the NCR ranged from 600 to 4,000 per 240 ft<sup>3</sup> of air in the same period. Counts in samples from the bare floor in the NCR from 50 to 4,000/in<sup>2</sup> (Table 7).

## DISCUSSION

The plug method was used in this investigation to determine microbial levels in carpet installed in a pediatric room. Although destructive to the carpet, this procedure is the only currently available carpet-sampling method with which to obtain reproducible quantitative and qualitative results (1). The swab method involving a template (2 by 2 inches) was used to sample the bare floor surface in the NCR. We believe that samples obtained with a moistened swab and a standard amount of rubbing provided the best means of determining levels of contamination on bare flooring and that this technique was

TABLE 6. Types of organisms present in intramural air above carpeting and bare flooring

Sampling period	Organisms associated with CR		Organisms associated with NCR	
	Carpet	Air	Floor	Air
59	<i>S. aureus</i> <i>S. epidermidis</i> <i>K. pneumoniae</i> <i>E. coli</i> Nonfermenter <sup>a</sup>	<i>S. aureus</i> <i>K. pneumoniae</i> <i>E. coli</i> <i>Enterobacter</i> spp. Nonfermenter	<i>S. aureus</i> <i>S. epidermidis</i> Nonfermenter	<i>S. aureus</i> Nonfermenter
60	<i>Enterobacter</i> spp. Nonfermenter	<i>Enterobacter</i> spp. Nonfermenter	<i>S. aureus</i> Nonfermenter	<i>Enterobacter</i> spp. Nonfermenter
61	<i>Enterobacter</i> spp. <i>E. coli</i> Nonfermenter <i>K. pneumoniae</i>	<i>Enterobacter</i> spp. <i>E. coli</i> Nonfermenter	<i>S. epidermidis</i> Nonfermenter	<i>S. epidermidis</i> Nonfermenter
62	<i>S. aureus</i> <i>Enterobacter</i> spp. <i>S. epidermidis</i> Nonfermenter	<i>Enterobacter</i> spp. Nonfermenter	<i>Enterobacter</i> spp. Nonfermenter <i>S. epidermidis</i>	<i>Enterobacter</i> spp. <i>K. pneumoniae</i> Nonfermenter

<sup>a</sup> Nonfermenter other than *P. aeruginosa*.

TABLE 7. Comparison of surface and air colony counts in NCR and CR

Sampling period	NCR contamination		CR contamination	
	Count/in <sup>2</sup> of floor	Air <sup>a</sup>	Count/in <sup>2</sup> of carpet	Air
63	200 <sup>b</sup>	800	79 × 10 <sup>3</sup>	1.7 × 10 <sup>3</sup>
64	50	600	154 × 10 <sup>3</sup>	1.2 × 10 <sup>3</sup>
65	3 × 10 <sup>3</sup>	4 × 10 <sup>3</sup>	176 × 10 <sup>3</sup>	1.6 × 10 <sup>3</sup>
66	4 × 10 <sup>3</sup>	1.9 × 10 <sup>3</sup>	47 × 10 <sup>3</sup>	2.1 × 10 <sup>3</sup>

<sup>a</sup> Air counts per 8 h, 240 ft<sup>3</sup> sampled.

<sup>b</sup> Samples taken in early morning.

a sufficiently comparable procedure used for carpet sampling (16).

In both procedures, samples were agitated in fluid to separate particulate matter, thus resulting in multiple-cell expression and higher counts. Trends of the microbiological profiles of each floor covering could be determined with the two procedures, although we could not reliably compare results because of inherent differences in the techniques and because of enormous differences in the surface areas of 1 in<sup>2</sup> of carpet and of vinyl tile.

This investigation confirms an observation during an earlier study (1) in which high levels of microbial contamination were associated with carpets in patients' rooms. Even though one author (31) criticized the method of reporting levels of carpet contamination in the earlier publication, our study results reinforce the fact that carpets eventually become heavily contaminated with and may harbor microorganisms.

In this first report of a study in which an epidemiological approach was used to investigate the microbiology of hospital carpeting, we found no association between contamination of the carpet and HA infection; however, we did demonstrate that patients in the CR (but not in the NCR) were colonized with the same types of organisms that contaminated the carpet (Table 3). Although rates of recovery of *Enterobacter* spp., *K. pneumoniae*, and *E. coli* were higher from carpet samples than samples from bare floors, we found no association between contamination of the carpet and HA infection. Furthermore, there were no statistically significant differences found in patients in the CR versus NCR in colonization with all typable and nontypable organisms first found on the floor (Table 4). Although for at least a century authors have warned that disease may be transmitted from contaminated carpet (26), we have found only one report of such transmission of disease (37).

Members of the family *Enterobacteriaceae* (*Enterobacter* spp., *K. pneumoniae*, and *E. coli*) were more frequently isolated from carpet material than from bare flooring. These varying levels

of contamination probably resulted from differences in floor-cleaning procedures. A phenolic germicidal detergent used daily to clean the floor in the NCR in our study consistently lowered the levels of contamination with enteric organisms. On the other hand, vacuuming carpets had no apparent effect on the frequency with which enteric organisms were isolated.

Although no disinfecting carpet shampoos are currently available, several companies are attempting to improve the carpet sanitizers being marketed. Organic materials that accumulate in carpets in hospital rooms (e.g., dirt, dust, skin sloughs, fecal material, urine, and carpet components) can have an adverse effect on the antimicrobial action of chemicals used to clean that floor covering.

Microbial counts in air above carpeting varied less than those above bare flooring. Several variables can influence levels of air contamination, but the day-to-day activity in a room and the type of contamination present on surfaces in that room during 8 h of air sampling appear the most important. Both are directly related to microbial air counts above each floor covering. The level of contamination of bare flooring appeared to affect air counts in the NCR more markedly than any other variable; i.e., the levels of air contamination were proportional to the microbial counts per square inch from the floor in the NCR (Table 7). Levels of air contamination varied less over carpeting than over bare flooring, perhaps because high counts of microorganisms were consistently found in the carpet.

The method of cleaning used was probably related to the types of organisms isolated from air above the two types of floor surfaces. Enteric bacilli, nonfermenters, and *S. aureus* were frequently isolated from air above the carpet. Nonfermenters and coagulase-negative staphylococci (but few enteric organisms) were frequently isolated from air samples taken above the bare floor (Table 6).

The cleaning regimens used for carpets in hospitals vary considerably; there are no standard methods for carpet cleaning. Most often,

the executive housekeeper, and in some cases the environmental control department, establishes carpet-cleaning policy. We chose the particular cleaning procedure of deep vacuuming because the method was similar to housekeeping procedures used in many hospitals to render carpets ostensibly clean. Earlier reports (1, 32, 38) demonstrated only small decreases in microbial counts after vacuuming, measured by the plug-sampling technique; in some cases, increased carpet counts after vacuuming were observed. We feel that it is difficult to disinfect adequately carpeting in a practical and routine manner.

Some hospitals have advocated the use of other carpet cleaning procedures, i.e., deep steam cleaning, dry and wet foam shampooing, damp mopping, disinfectant spraying, and scrubbing. These procedures most likely would reduce levels of microbial contamination to some extent but are not practical to use on a daily, routine basis. Previous investigations (1, 30) have found only small and transient reductions in microbial contamination associated with shampooing of carpets. But to our knowledge there are no other published reports showing greater microbial reductions with these cleaning procedures than with the method used in this study. Carpeting must be kept dry after cleaning. A wet carpet (i) could promote microbial growth, (ii) causes odor problems, and (iii) increases hospital room "down" time between patients. Hard-surface floors can be readily disinfected, and they dry fast.

With the methods used in this study, the carpet tested was found to contain much higher levels of microbial contamination per square inch of the entire carpet thickness than those measured for each square inch of a hard surfaced floor. However, we did not find that any frank disease in patients was caused by potentially pathogenic organisms found first in carpet or bare flooring samples.

Because data have shown that carpets are easily contaminated, costly to clean, and difficult to disinfect, and because they do not dry as quickly after spills as do bare floors, it may be more wise not to use carpets in the following areas: intensive care units (except those used for cardiac care), nurseries, pediatric patient care rooms, isolation rooms, operating and delivery rooms, kitchens, laboratories, autopsy rooms, bathrooms, and utility rooms.

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