

# Hospital Sanitation: the Massive Bacterial Contamination of the Wet Mop

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Following the demonstration of massive spread of bacterial contamination throughout the hospital by the wet-mopping techniques in use, quantitative studies were undertaken to determine the source of contamination and to institute measures of control. It was found that mops, stored wet, supported bacterial growth to very high levels and could not be adequately decontaminated by chemical disinfection. Laundering and adequate drying provided effective decontamination, but build-up of bacterial counts occurred if mops were not changed daily or if disinfectant was omitted from the wash-water. Recommendations were based upon the experimental findings.

It is generally agreed that a modern hospital should be clean and that its standard of cleanliness reflects its standard of hygiene. There is also an uneasy feeling that dirt may in some way be linked to infection rates, though this is by no means proven. For these reasons, housekeeping procedures are always of major concern to Infection Control Committees, but, apart from the excellent study of Litsky (4, 5), whose results and conclusions we confirm and extend in this publication, there is in the literature an almost total lack of hard data relating bacteriological findings to particular housekeeping techniques and relating either of these to incidence of hospital-acquired infection. In the absence of such data, it is very difficult to convince the financial administration of the need for instituting any changes which require additional funds, even when the inadequacy of current procedures is freely admitted.

The investigation here reported was undertaken to obtain factual data at a time when the Infection Control Committee and the Hospital Administration were gravely concerned about the inadequacy of cleaning services provided by the firm under contract. It was hoped that the study would provide a rational basis for action, and this proved to be the case. The Infection Control Committee was able to make recommendations, backed by factual bacteriological evidence, regarding cleaning procedures, disinfectant-detergent, and laundering of mops, and these were immediately accepted by the Administration and Medical Advisory Committee. The findings are here published in the hope that they may be of

service to other hospitals faced with similar problems.

Most hospitals depend upon wet-mopping with the two-bucket system for floor-cleaning, even when wet vacuum pickup is available for certain areas. It has long been accepted that, if mops are not kept adequately cleaned and disinfected, and if the water is not changed frequently enough in the buckets, the mopping procedure may spread heavy contamination through the hospital. For this reason, the frequent laundering of mops is a standard recommendation (1, 4-6), but this recommendation is usually ignored either because of the cost involved or for lack of facilities. More usually, mops are briefly washed out after use in an inadequate concentration of disinfectant and hung up on a rack to "dry." They continue to be used in this way until they fall to pieces under the influence of bacterial decomposition, when they are reluctantly discarded.

A preliminary survey in our hospital, involving 134 cultures of floors before and after mopping, and of mops and cleaning materials before and after use, showed that the "cleaning" procedures were in fact spreading gross contamination throughout the hospital. A quantitative study was therefore undertaken.

## MATERIALS AND METHODS

**Extraction of mops.** Clean metal pails were thoroughly washed with a 1:80 dilution of disinfectant-detergent followed by thorough rinsing under running tap water.

One gallon (4.5 liters) of tap water was then run into each bucket for extraction of the mops to be

tested. A 0.01-ml sample of water from each bucket was streaked to a blood-agar plate [Trypticase Soy Agar base (BBL) with 5% human blood], by use of a quantitative loop, to determine the initial contamination of the water. Growth was rarely obtained from this inoculum.

Mop-heads were of 24-oz (680-g) nominal weight and consisted of "pure" cotton. Each mop-head to be tested was extracted by being firmly "dunked" five times into the clean water in one pail and then removed.

Tenfold serial dilutions of the extract were made in sterile water and inoculated to blood-agar by use of a 0.01-ml quantitative loop.

**Sampling from materials in use.** Culturing of "soap" and "rinse" water was carried out by obtaining samples at various times from buckets in actual use on the floors. Samples were taken immediately to the Infection Control Laboratory and titrated as above, dilutions being made in letheen broth (Difco 068-01) to neutralize residual disinfectant.

**Incubation.** All cultures were examined and counted after 24-hr incubation at 37 C.

**Disinfectant-detergent.** A phenolic disinfectant-detergent, *Beaucoup* (Huntingdon Ltd.), has proved to be the most satisfactory and effective of a number tested in this hospital and was used throughout the present experiments.

## RESULTS

**State of "clean" mops and their decontamination.** Two experiments were carried out to assess the degree of contamination of "clean" mops and to find an adequate practical method of decontamination. In the first experiment, six "clean" mops, washed and hung to dry in the usual manner, were obtained before issue to the day cleaning staff.

Each was extracted as described above, squeezed as dry as possible, and then immersed for 30 min in *Beaucoup* disinfectant-detergent. The recommended use-dilution for the latter is 1:128, but it was used in the present experiment at three dilutions, 1:80, 1:53, and 1:26.5. At the end of 30 min, the disinfectant solution was titrated for organisms. The results of this experi-

TABLE 1. *Decontamination of mops by chemical disinfection*

Mop no.	Disinfection dilution <sup>a</sup>	Viable count (thousands/ml)	
		Before	After
1	1:80	8,000	2
2	1:80	21,000	300
3	1:53	245,000	31,000
4	1:53	300,000	70,000
5	1:26.5	82,000	9
6	1:26.5	472,000	7,000

<sup>a</sup> Recommended use-dilution, 1:128.

TABLE 2. *Decontamination of mops by laundering*

Mop no.	Viable count (thousands/ml)	
	Before	After
1	8,000	2.4
2	47,000	1.0
3	4,000	1.1
4	5,000	0.3
5	23,000	0.7
6	52,000	0.6
7	225,000	8.1
8	20,000	1.2
9	148,000	0.4
10	96,000	0.9
11	300,000	1.1
12	300,000	1.8

TABLE 3. *Comparison of decontamination of mops by laundering and chemical disinfection*

Treatment	Avg viable count (thousands/ml)		Reduction in viable count
	Before	After	
Laundering . . . . .	102,300	1.6	×60,000
Chemical disinfection . . . . .	188,000	18,050	×10

ment are presented in Table 1, in which the viable count is expressed in thousands per milliliter.

The massive initial contamination of the mop-heads is obvious. For mop number 6, the figure represents more than  $10^{12}$  organisms released by the very mild extraction procedure used. It is also evident that chemical disinfection is not capable of effecting adequate decontamination even at uneconomical concentrations of disinfectant. In general, the higher the initial count, the less was it reduced by the disinfectant treatment.

In the second experiment, 12 mop-heads were extracted and then sent for laundering in the hospital laundry by the standard washing and drying procedure, after which they were again extracted. The results are shown in Table 2.

The average counts and the degree of reduction obtained by the two methods are compared in Table 3.

It was concluded that standard laundering provided acceptable decontamination of even heavily contaminated mop-heads, but that chemical disinfection, even with a good phenolic disinfectant at uneconomically high concentration, was ineffective.

**Build-up of contamination during floor cleaning.** To determine a rational floor-cleaning pro-

TABLE 4. Build-up of contamination on mops during use

Date <sup>a</sup>	Mean counts/ml		Per cent showing			
	Clean water	Dirty water	No growth	Growth	Count below 10 <sup>4</sup> /ml	Count over 10 <sup>4</sup> /ml
Sept. 9..	20	1,300	59	41	100	0
10..	975	1,987	8	92	100	0
11..	287	3,933	25	75	94	6
12..	25	5,400	50	50	100	0
15..	240,000	400,000	0	100	0	100

<sup>a</sup> On 9-12 September, clean new mops were used each day with Beaucoup (1:160). On 15 September, the same mop was used as on 12 September. On 16 September, unrehearsed spot checks were made (see Table 5).

TABLE 5. Unrehearsed spot checks

Time	No. of specimens	Nature of specimens	Counts (thousands/ml)	
			Mean	Range
AM				
8:15-9:30	12	Clean (starting)	1,056	84-2,700
9:30-12:00	22	Dirty (40 min)	3,480	220-6,000
Lunch break				
PM				
1:00-1:10	6	Clean (changed)	346	300-1,820
2:40	8	Dirty (90 min)	Over 5,000	—

cedure, it is necessary to determine the rate of build-up of contamination during floor cleaning.

Clean new mops were, therefore, issued to one member of the cleaning staff on each of three successive days, and counts of his cleaning water were made at the start and after various time intervals ranging from 30 to 60 min during which the water was not changed. Beaucoup at a 1:128 dilution was included in both "soap" and "rinse" buckets.

"Soap" and "rinse" buckets were assessed separately, but since they showed no real differences, their counts were pooled to obtain averages which are summarized in Table 4 for the period of the study. The figures for 9-11 September show the satisfactory results obtained on three successive days.

On 12 September, it had been intended that a standard "clean" mop should be used for com-

parison, but the cleaner obtained another new mop, so the results merely confirmed those of the previous 3 days. However, this new mop was carefully washed by the cleaner and stored secretly over the weekend to be used again on 15 September. A substantial increase in contamination is obvious despite the presence of disinfectant in both the wash and rinse waters.

On 16 September, an extensive series of spot-checks were carried out on several floors to act as an unrehearsed control for the series of experiments. The results, shown in Table 5, again demonstrate the massive contamination spread by the standard cleaning procedures and are in sharp contrast to those of Table 4.

On 16, 17, and 18 September, the previous experiment was repeated, but a detergent without disinfectant action was substituted for Beaucoup. The results (Table 6) were again good, but indicated a progressive and unacceptable build-up of floor contamination not observed in the presence of disinfectant.

**Rate of build-up of contamination.** The experiments carried out so far demonstrated clearly that, provided a new mop was issued each day, and detergent-disinfectant was used, contamination was held at an acceptable level.

Laundry facilities are, however, limited and it was necessary to determine the length of time for which a mop could be used before the contamination level became unacceptable. The results of the series of observations shown in Table 7 indicate that, even as early as the second day of use, a bacterial count in the millions was obtained. A second experiment extending over 3 days confirmed this result.

It was concluded that mops should be used for 1 day only.

**Bacterial isolates.** Apart from *Bacillus* species, the great majority of organisms isolated during this study were *Enterobacteriaceae*. In most of the examinations, identification was not carried further than counting of lactose-positive and

TABLE 6. Build-up of contamination on clean new mops during use with a detergent without disinfection action

Date	Mean counts/ml		Per cent showing			
	Clean water	Dirty water	No growth	Growth	Count below 10 <sup>4</sup> /ml	Count over 10 <sup>4</sup> /ml
Sept. 16..	1,150	6,750	8	92	83	17
17..	1,000	25,650	—	100	70	30
18..	4,183	280,000	—	100	50	50

TABLE 7. Build-up of contamination after overnight storage

Expt	Specimens	Viable count (thousands/ml)			
		Day 1		Day 2	
		Wash	Rinse	Wash	Rinse
1	Clean	1.0	3.0	80	3,300
	45 min	3.8	12.0	110	3,410
	90 min	14.1	36.0	70	12,000
	135 min	—	—	360	>25,000
2	Clean	2.5	6.1	180	2,920
	45 min	3.3	5.4	150	4,260

TABLE 8. Distribution of 1,461 organisms isolated from patients with infection, October-December 1970

Organism causing infection	No.	Per cent
<b>Gram-negative</b>		
<i>Escherichia coli</i> .....	331	22.7
<i>Pseudomonas aeruginosa</i> ...	106	7.2
<i>Salmonella-Shigella</i> .....	7	0.5
Other <i>Enterobacteriaceae</i> and water organisms.	355	24.3
Total for group.....	799	54.7
<b>Gram-positive</b>		
<i>Staphylococcus aureus</i> .....	282	19.3
<i>Streptococcus</i> group A....	25	1.7
Total for group.....	307	21.0
Miscellaneous infections....	355	24.3

lactose-negative "enteric" organisms, but in one series of 14 samples organisms were more precisely identified and had the following distribution: *Alcaligenes* sp., eight isolates; *Enterobacter aerogenes*, three; *Citrobacter* sp., two; *Escherichia coli*, two; *Bacterium anitratum*, one; *Pseudomonas aeruginosa*, one; and *Streptococcus* (non-hemolytic), one. Three samples showed no growth. This distribution may be compared with that found in 1,151 infections treated in the hospital over a 3-month period (Table 8).

## DISCUSSION

After consideration of these experimental results, the Infection Control Committee of the Ottawa General Hospital made the following recommendations: (i) that two dry, freshly laundered mop-heads be issued at the start of

each shift to all cleaners undertaking wet mopping within the hospital; (ii) that the use of mop-heads for a second day be expressly forbidden; (iii) that Beaucoup disinfectant-detergent at a 1:128 dilution, or other disinfectant-detergent at appropriate concentration, as approved by the Hospital Administration on the recommendation of the Infection Control Committee, be included in "wash" water; (iv) that both "soap" and "rinse" waters be changed at not longer than 60-min intervals; (v) that at the lunch break mops be wrung out and pails emptied; (vi) that at the end of the work period mop-heads be washed, wrung out, and sent for laundering; (vii) that the laundering process be stipulated to include *thorough* drying; and (viii) that these recommendations be specifically included in any future contract agreed between the hospital and any cleaning contractor. (The use of Beaucoup at the 1:128 dilution was decided upon as a result of other experimental work. This is the makers recommended use-dilution.)

It is not possible to determine with certainty the role of mop-spread contamination in the production of nosocomial infection, but reference to Table 8 will show that over half the infections treated in this hospital over a 3-month period were caused by gram-negative organisms (excluding *Haemophilus*, *Bacteroides*, and *Neisseria*). The most frequent single infecting organism was *E. coli*. These findings agree closely with those of Brachman and his colleagues for nosocomial infections in community hospitals (7). Although our own figures cannot be broken down to extract those infections acquired in hospital, it is certain that many of the gram-negative infections were nosocomial in origin. Again, the epidemiology of such infections is by no means clear and the role of environmental contamination is uncertain. However, Jellard and Churcher (3) found it necessary to institute a strict cleaning routine with the use of a disinfectant-detergent effective against *Pseudomonas* to control a nursery outbreak of infection due to this organism, and Hurst and Sutler (2), faced with similar persistent *Pseudomonas* infections, found that the organism survived on the floor for 5 weeks after closure of the ward.

In our own study, *Pseudomonas* was encountered only once and *E. coli* was not a predominant organism, but both were repeatedly isolated by Litsky (4), and their importance in nosocomial infections is well documented.

Despite the epidemiological uncertainty, it is our view that the daily painting of hospital floors

with thick suspensions of such organisms must be regarded as an unsatisfactory practice.

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