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Blankets and air hygiene: a report of a trial of blanket disinfection

By a Newcastle Regional Hospital Board Working Party*

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INTRODUCTION

Blankets have long been suspected of playing an important part in hospital infection. This suspicion is based on the knowledge that they are rarely washed after each use by long successions of patients and that they often harbour enormous numbers of bacteria, including the now troublesome *Staphylococcus aureus*. Evidence is accumulating that direct infection of a patient from the blankets in which he lies is uncommon, and that cross-infection from carriers amongst the hospital staff and self-infection from the patients' own noses are more important. Contamination of the air in a hospital ward is, however, often profuse during bed-making and the possibility remains that this is a factor in creating nasal carriers of *Staph. aureus* amongst patients and staff, from whom self-infection and cross-infection then occur.

It has been suggested that blankets should be washed after use by each patient, in the hope that this will reduce the load of organisms in them, and thus reduce aerial contamination in the ward, the number of *Staph. aureus* carriers and, eventually, the amount of staphylococcal sepsis. There are conflicting reports on the efficacy of blanket disinfection in achieving this ultimate purpose and the present investigation was not an attempt to settle this matter directly. It was planned to determine whether or not regular blanket disinfection can reduce the amount of aerial contamination and therefore whether a reduction of carrier rates and sepsis can even be hoped for. A second purpose of the investigation was to study the economics of disinfecting blankets and the acceptability, to patients and staff, of some new types of blanket that have been introduced because they are easier to disinfect than the conventional woollen ones.

MATERIALS AND METHODS

General plan of the trial

The trial took place in six units, each of two wards serving the same speciality; there were one maternity, one paediatric, one orthopaedic, one general surgical, and two medical units. The trial started in January 1959 and lasted for 24 weeks, divided into three periods of 8 weeks. In each ward, one of the 8-week periods was used as a *control period* during which the 'normal' blanket routine was applied; that is to say, woollen blankets, previously treated by a shrink-resistant process, were occasionally washed—but not disinfected—at the discretion of the ward

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sister when they were visibly soiled. During the two 8-week *test periods*, blankets were washed and disinfected whenever a bed was vacated, so that each new patient came into a bed with clean and disinfected blankets. In each pair of wards, four types of blanket were used during the test periods so that their acceptability, ease of disinfection and their costs could be compared. They were: conventional woollen, cellular cotton ('Leno' weave), cotton terry towelling, and the fibro-cotton laminated blankets described by Calnan (1959). Each unit tested every type of blanket at some time, and all four types, as well as the undisinfected woollen controls, were under test in some ward at any one time to eliminate effects of weather and 'investigation consciousness'.

Ward routine was not changed in any other way during the trial. Sheets were changed according to the normal practice. One unit used under-blankets and another used rugs for patients who were sitting in chairs; in each case the blankets in use at the time were used for these purposes. Different types of blanket were stored separately and were all washed at least once before the trial.

Laundry methods

During the control periods, woollen blankets were washed by the usual low-temperature method followed by hydro-extraction and drying in a hot-air tunnel. This had no significant effect in reducing the bacterial content of the blankets. During the test periods, woollen blankets were washed and disinfected at low temperature with a combined detergent-quaternary ammonium preparation, and were finished as above; the three types of cotton blanket were all washed at near-boiling point and were usually calender-dried, though each called for a different finishing technique. Separate trials of the quaternary ammonium and the high-temperature washing methods showed that each gave virtually sterile finished articles.

Bacteriological methods

After each change of blanket type in a ward, 4 weeks were allowed for aerial contamination to become stabilized at its new level, then sampling was done on two days during each of the next 4 weeks. Four $5\frac{3}{4}$ in. Petri dishes were exposed in the same sites and for a constant period which included a bed-making round. Total colony counts were made after overnight incubation at 37° C., and *Staph. aureus* counts after leaving the plates for another 24 hr. at room temperature. Thus 32 plates were counted for each type of blanket in each ward—a total of 1152 plates in all.

Apart from the main investigation, a separate study was made to determine the rate at which disinfected blankets were recontaminated during use. Two four-bedded wards were equipped with disinfected blankets, quaternary-treated woollen in one ward and boiled cotton cellular in the other. A similar ward was equipped with un-disinfected woollen blankets which served as controls. The under-blanket on each bed was sampled by the sweep-plate method of Williams (Blowers & Wallace, 1955) before the bed was occupied and then on each of the next 15 days after the admission of a patient.

Collection of opinions

Questionnaire forms, devised to avoid investigation bias, were distributed to all patients over the age of 15 years, and to nurses. Patients were asked to compare each type of blanket with 'ordinary blankets' for comfort, warmth, and appearance; nurses were asked to make the comparison for ease of bed-making, appearance and shedding of fluff, and to arrange in order of preference all the blankets of which they had experience. General comments were invited from patients and nurses.

Costing

For each disinfecting routine and for each type of blanket the *cost per bed per year* was calculated, to include water, steam, detergent and disinfectant, wages, overhead expenses of running the laundry, and depreciation and replacement costs of the blankets. This last was based on the initial purchase price of each type of blanket and the number of launderings that each would stand before becoming unfit for use. This information was already available for woollen blankets (Newcastle Regional Hospital Board, 1957) and was determined for the new types by repeated high-temperature washing in a hospital laundry until they were judged to be unfit for use. The decision on when a blanket should be condemned was taken not only on shrinkage and loss of weight but also on an experienced judgement of appearance and 'feel'.

RESULTS

Bacteriological

Analysis of general bacterial counts

Results for each blanket in each ward were summarized by averaging the counts from 32 plates, and expressing the results as colonies per square foot per hour.

The average counts were lower at the end of the trial than at the beginning. In the first period (February), the average count was 2380 colonies/sq. ft./hr., in the second period (April) it was 2210, and in the third period (June) it was 1820. These figures genuinely represent the situation in the three periods, since each is composed of results from each of the 12 wards, and in each period four wards were using untreated woollen blankets and two wards were using each type of disinfected blanket. (In statistical terminology *periods* were orthogonal to *wards* and *blanket types*.) It is therefore necessary, before examining the results, to correct each count for the period in which it was taken, reducing the February and increasing the June counts. The corrected results are shown in Table 1.

The improvements from using each of the four types of disinfected blanket were assessed by subtracting the corrected result for each of them from that for the control (untreated woollen) blankets *in the same ward*. The results of doing this are shown in Table 2. In two hospitals (Units nos. 3 and 6), great reductions were observed with all the disinfected blankets, but in another hospital (Unit no. 2), the counts were very much higher with the disinfected than with the control blankets. No explanation is offered for the anomalous results at this hospital.

Averaged over all hospitals, the trial blankets as a group gave a reduction of 528 in the total count, reducing it by some 20%, from about 2500 to about 2000 colonies/sq. ft./hr.

Table 1. *General colony counts corrected for period of the year*

Each result is the mean count from 32 plates.

		Colonies/sq. ft./hr.				
Unit	Ward	Untreated wool	Disinfected wool	Cellular	Terry	Laminated
1	A	684	541	609	—	—
	B	296	—	—	558	174
2	A	2373	3329	—	—	3881
	B	2071	—	2530	3198	—
3	A	7280	4848	—	3518	—
	B	3358	—	1450	—	1547
4	A	2365	1725	1923	—	—
	B	2730	—	—	3011	2994
5	A	840	541	621	—	—
	B	992	—	—	736	753
6	A	3529	1517	1359	—	—
	B	3358	—	—	2411	3312

Table 2. *Differences in general colony counts from the trial blankets*

Each figure represents the difference between the count for the trial blanket and that for unsterilized wool (after correction for period).

Positive figures mean that the count from the trial blanket was higher than that from the unsterilized wool in the same ward, and negative figures that it was lower.

	Colonies/sq. ft./hr.				
Hospital unit	Disinfected wool	Cellular	Terry	Laminated	Average
1	−143	−75	+262	−122	−20
2	+956	+459	+1127	+1508	+1013
3	−2432	−1908	−3762	−1811	−2478
4	−640	−442	+281	+264	−134
5	−299	−219	−239	−256	−253
6	−2012	−2170	−947	−46	−1294
Average	−762	−726	−546	−77	−528

The differences between the various types of disinfected blanket are not significant, however, in the light of the great variability of the results they gave in the different hospitals. The standard error of the mean improvement for any disinfected blanket type was ±235 colonies/sq. ft./hr., and that for all disinfected blanket types together was ±117 colonies/sq. ft./hr. Though the result for the laminated blanket was apparently worse than those for the other types, *the extreme studentized deviate test* of Pearson & Hartley (1954) shows that this could easily be due to chance.

Analysis of Staph. aureus *counts*

The actual number of *Staph. aureus* colonies counted on any plate was small, and it is necessary to take this into account. The total of the 32 *Staph. aureus* counts for each blanket type tested in each ward would be an observation from a Poisson distribution, on the assumption that the general level of bacterial contamination remained about constant. This assumption is not strictly valid because a series of high counts was sometimes observed when there was a case of staphylococcal sepsis in a ward. Nevertheless, it seemed advisable to use some technique that would reduce the effect of very high counts—which are statistically unreliable—and approximately equalize the variance. The method used was to take the square root of the total of the 32 counts. The results of this square-root transformation are shown in Table 3. As with general counts, *Staph. aureus* counts were higher in February than in the other periods (April and June).

Table 3. Staph. aureus *scores corrected for period of the year*

Each score is the square root of the total of the *Staph. aureus* counts (colonies/sq.ft./hr.) on 32 plates in each ward.

		Square root of *Staph. aureus* count				
Unit	Ward	Untreated wool	Disinfected wool	Cellular	Terry	Laminated
1	A	1·3	1·7	1·6	—	—
	B	1·2	—	—	1·1	2·5
2	A	4·2	2·2	—	—	3·1
	B	3·9	—	3·1	7·3	—
3	A	3·4	—	2·9	—	3·0
	B	6·0	9·3	—	4·8	—
4	A	4·3	4·0	4·8	—	—
	B	4·3	—	—	17·5	16·0
5	A	1·5	1·3	3·3	—	—
	B	1·4	—	—	2·2	1·7
6	A	4·3	—	—	2·4	8·0
	B	7·8	4·0	2·0	—	—

The method of analysis from this point onwards is the same as for the general counts. In Table 4, the improvements over the untreated control blankets used in the same ward are shown. Two types of trial blanket—disinfected wool and cellular—showed very little difference from the untreated control, while the other two showed results very much worse than the control. This was entirely due to the results in one ward of Hospital Unit no. 4. The complete analysis of variance shows that there were no significant differences between the four types of disinfected blanket nor was the combined average for the disinfected blankets significantly worse or better than that for the untreated control.

In view of possible invalidity of the assumptions made, a further analysis was made of the number of plates that showed *Staph. aureus* counts above a certain arbitrary level—a count of 20 on a $5\frac{3}{4}$ in. diameter plate exposed for 2 hr. and

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pro rata for other exposures. The results are shown in Table 5. The untreated control blankets gave an average of 5·7 % of plates showing high counts, and the disinfected blankets gave such counts on 3·4 % of the plates, varying from 0·9 to 13·5 %. This method also has its drawbacks. High counts occurring in one of a pair of wards showed no relationship to high counts in the other ward of the pair, suggesting that they were due to a localized source in the ward at the time rather

Table 4. *Differences in* Staph. aureus *scores achieved by the trial blankets*

Each figure represents the difference between the square root of the colony count for the trial blanket and that for unsterilized wool.

	Square root of *Staph. aureus* count				
Hospital unit	Disinfected wool	Cellular	Terry	Laminated	Average
1	+0·4	+0·3	−0·1	+1·3	+1·9
2	−2·0	−0·8	+3·4	−1·1	+0·1
3	+3·3	−0·5	−1·2	−0·4	+0·3
4	−0·3	+0·5	+13·2	+11·7	+6·3
5	−0·2	+1·8	+0·8	+0·3	+0·7
6	−3·8	−5·8	−1·9	+3·7	−2·0
Average	−0·4	−0·8	+2·4	+2·6	+0·9

Table 5. *Numbers of high* Staph. aureus *counts*

A 'high count' was arbitrarily assumed to be any exceeding 20 colonies on a $5\frac{3}{4}$ in. circular plate exposed for 2 hr., or *pro rata* for longer exposures.

Blanket type	Untreated wool	Disinfected wool	Cellular	Terry	Laminated
No. of plates with high count	22	17	2	17	26
% of plates with high count	6	9	1	9	14

than to the blanket type. The laminated blanket, with 26 high counts against it, had 16 of these in a single ward. The reason for these high counts may have been *a single source of contamination which remained for 3 of the 4 weeks during which* the plates were exposed. Had the cellular blanket, with only one high count against it, been on trial in this ward at the time, it too might have had more high counts. In other words, the apparent superiority of the cellular and inferiority of the laminated blanket in this respect can be attributed to chance.

Acceptability of new blanket types

Patients

Over 700 forms were returned by patients who had experience of cellular, terry, or laminated blankets. In reply to a question on comfort, 77 % of the patients with cellular blankets thought them more comfortable than ordinary blankets; 66 % found terry more comfortable, and 53 % found laminated more comfortable than ordinary blankets. Some patients thought the new types were less comfortable than ordinary blankets—28 % for laminated, but less than 5 % for cellular and terry. These differences are statistically significant, so in patients' opinions on

comfort, cellular was first, terry a fairly close second, and laminated a rather poor third.

Patients complaining that they were not warm enough were 1 % of those using cellular blankets, 2 % of those using wool, and 6 % each for the other two. Warmth, of course, depends not only on the type but also on the number of blankets used. Accurate records of the numbers in use on each bed were not kept, but ward sisters made a return of the average numbers in each ward. Though the modal figure for each type in the whole series was two blankets per bed, the mean figure was lower for terry than for any other kind, including wool.

For appearance, the terry blankets were definitely preferred; 91 % of patients thought they looked better than ordinary blankets, compared with 72 % and 70 % respectively for the other two new types.

Patients were also invited to make other comments and, after allowance for the cancellation of opposing views, the following were the comments that were made most often; 66 % of those commenting on the laminated blanket thought it too stiff and heavy; 45 % of those who commented on the cellular blanket thought it lighter and therefore better, whilst the same view was expressed in respect of terry by 22 % of those who commented on it.

Nursing staff

Nurses completed 181 forms relating to the new blankets. Cellular was preferred to ordinary wool for ease of bed-making by 68 % of the nurses, compared with 42 % and 43 % respectively for terry and laminated. However, as many nurses found these two latter types more difficult for bed-making as found them easier.

The order of preference for the new blankets was further analysed by finding how many of those with experience of a particular pair of types expressed preference for one of them by ranking it higher than the other. There was a clear preference for both cellular and terry over the laminated blanket. As between cellular and terry there was no significant difference.

Nurses' opinions on the appearance of the blankets showed no significant differences between the three new types, but 70 % of nurses preferred them to ordinary woollen blankets. They also found overwhelmingly that they made less fluff than ordinary blankets but, again, there was no difference between the three new types in this respect. 40 % of nurses made additional comments and after cancellation of opposing views, 86 % of those commenting on the laminated blanket thought it too stiff and heavy, 38 % thought cellular was lighter and therefore better, and 28 % thought terry was too heavy though this last comment was perhaps related to the fact that the terry blankets were rather too large for the beds on which they were used. Other comments of interest were that the laminated blankets did not tuck in comfortably round the patients and were not so 'cuddly'; that the cellular blankets occupied less storage space but were apt to catch and pull threads when used in orthopaedic wards; and that the terry blankets might be a temptation to pilfering because they could readily be cut into useful smaller pieces!

Costs

The mean frequency of laundering blankets from each bed was about seven times a year before the investigation began and during the control periods; and was about 29 times a year during the trial periods of the investigation.

Results of the laundry investigation into the life of cellular, terry, and laminated blankets are shown in Table 6, together with those from the Newcastle Regional Hospital Board's (1957) comparable study of the life of woollen blankets.

Table 6. *Effect of laundering on various types of blanket*

Type of blanket (1)		No. of times laundered before condemnation (2)	Percentage decrease in size and weight when condemned		
			Length (3)	Width (4)	Weight (5)
Wool*		60	11	5	29
Cotton cellular	Average of eight types	181	13	14	11
	Trial blanket	195	12	15	13
Cotton terry	Average of four types	191	11	8	9
	Trial blanket	185	4	4	11
Fibro-cotton laminated	Trial blanket	190	10	10	18

* Figures from Newcastle Regional Hospital Board's Report on Shrinkage of Woollen Blankets, 1957.

Table 7. *Costs of various blanket types and laundry routines*

The costs, which include depreciation of blankets and laundry expenses, are the averages from the six units in the trial.

Frequency of laundering	Cost per bed per year for each type of blanket				
	Wool (washed only) £ s. d.	Wool (washed and disinfected) £ s. d.	Cotton cellular (washed and disinfected) £ s. d.	Cotton terry (washed and disinfected) £ s. d.	Fibro-cotton laminated (washed and disinfected) £ s. d.
Only when visibly soiled (seven times per year)	1 10 9	1 13 0	17 8	1 7 4	1 7 10
After use by each occupant of bed (29 times per year)	6 2 2	6 11 1	3 10 1	5 8 5	5 10 4

From this information and the various costs listed under 'Materials andMethods' the average annual costs per bed for laundering, disinfecting, and depreciation were calculated and are shown in Table 7. Washing and disinfecting blankets for every new patient increased the cost rather less than fourfold; and whatever the frequency of treatment, cotton cellular blankets cost considerably less than any of the others. These costs will, of course, be proportionately altered in hospitals

where the average stay for each patient differs from that (12·5 days) during this trial; but the relative costs of the different blanket types will remain the same.

DISCUSSION

The method of air sampling used in this trial is far from perfect. Contamination of exposed culture plates is influenced proportionately more by large than by small dust particles and these latter may be important in the creation of nasal carriers of *Staph. aureus*. It might, therefore, have been more satisfactory to use slit-samplers for this study. However, they were not available in all the participating units, so the possible fallacies of sedimentation sampling had to be accepted. Though this method could not exactly measure aerial contamination under the various conditions of the trial, it probably did provide a reasonable means of comparison.

Table 8. *Daily sweep-plate counts from blankets on beds of newly admitted patients*

Each type was in a separate ward containing four beds.

	Mean sweep-plate counts for four blankets		
Days in use	Unwashed woollen blanket	Boiled cotton blanket	Quaternary treated woollen blanket
1	2	3	4
0	230	0	0
1	261	115	60
2	222	135	115
3	309	115	115
4	324	215	140
5	298	218	230
6	388	160	180
7	265	120	190
8	245	215	210
9	227	245	230
10	312	198	250
11	244	495	290
12	207	230	335
13	334	230	380
14	296	390	320
15	265	290	365

During the trial, disinfection of blankets after use by each patient caused only a small and probably insignificant reduction of aerial contamination. This may mean that blankets are not important agents in the aerial distribution of bacteria and therefore that airborne infection will not be reduced by disinfection of blankets.

Another and perhaps more likely explanation is that the rapid recontamination of clean bedding after it is put into use nullifies the benefit of disinfection. In a separate study, this possibility was examined by making daily sweep-plate counts from blankets that had been put into use immediately after disinfection by heat. They were heavily contaminated after one day's use and were indistinguishable

from undisinfected blankets after eight days (Table 8, cols. 2 and 3). This difficulty might be overcome by providing clean bedding for each patient every day, but the cost of this would be very great. A chemical process conferring self-disinfecting properties on the blanket fibres might delay recontamination and thus provide a more economical solution, but the quaternary ammonium compound used in this trial did not do so (Table 8, col. 4). Earlier work on quaternary treatment of blankets has shown that enough disinfectant remains in the fibres to inhibit staphylococci on a culture plate (Barnard, 1952; Blowers & Wallace, 1955). But, as already shown by Rubbo, Stratford & Dixson (1960), this residue is evidently unable to destroy bacteria in dry dust particles.

This trial has yielded no convincing evidence of bacteriological benefit from present methods of blanket disinfection, but has not ruled out the possible advantage of even more frequent disinfection, or a method of chemical disinfection with a prolonged action. There is, however, a growing body of opinion that, sepsis apart, patients are entitled to clean bedding. The calculation of its cost during the trial may therefore be of more than theoretical interest. Regular washing and disinfection of blankets increases their laundering and replacement costs between three- and fourfold. One of the blankets used in the trial—cotton cellular—was more popular with patients and nurses and was more economical than the conventional woollen blanket or any of the other new types. There may, therefore, be some benefit in its general adoption quite apart from the reason for which it was originally tried—its ease of disinfection.

SUMMARY

1. The effect of blanket-disinfection on aerial contamination of exposed culture plates was studied during a six-month trial in six hospital units, containing a total of 270 beds.

2. Disinfecting blankets after use by each patient did not significantly reduce general bacterial or *Staph. aureus* counts on exposed culture plates.

3. Disinfected blankets were heavily recontaminated after only a few days' use. A quaternary-ammonium rinse during laundering conferred no self-disinfecting properties on them.

4. Cotton-cellular blankets were more economical and more popular with patients and nurses than were conventional woollen and two other types of cotton blanket.

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