King Edward's Hospital Fund for London

DIVISION OF HOSPITAL FACILITIES

An Interim Report

on the

CLEANSING AND STERILIZATION

of

HOSPITAL BLANKETS

November, 1959

PRICE 2/-
(Post Free)

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(1) Introduction.

In the past few years increasing attention has been paid to the problems of cleansing and sterilizing hospital blankets. These blankets have come to be considered as actual or potential reservoirs of infection, and in consequence many hospitals have decided that blankets should be laundered and sterilized far more frequently than was the case in the past.

This development has naturally led to a demand for types of blanket that can withstand whatever cleansing and sterilizing processes may be considered necessary, and it has also stimulated research into the problem of finding methods of cleansing and sterilizing that will do the minimum of harm to the fabric of any blanket. As a result, numerous tests and trials have been and are being carried out in hospitals and laboratories all over the country and abroad, and a number of extremely interesting reports have already been published on this subject.

The conclusions and opinions expressed in some reports seem to conflict with those in others, and it still appears to be by no means certain what types of blanket or methods of cleansing and sterilization are likely to prove most suitable for hospitals. The Division of Hospital Facilities itself has frequently been asked for information or advice on various aspects of the problem, and the general uncertainty and lack of conclusive experience has led the Fund to try to correlate some of the many experiments that are in progress or being planned, in the hope that unnecessary duplication may be avoided and that information of general value may be obtained. In conducting its investigations the Division has enjoyed the advice and support of many hospitals, organisations and individuals, and it is abundantly true to say that any value that this report may have is entirely due to the co-operation that the Division has received from many different sources.

It seems clear that the question of blankets forms but one aspect of the very complex problem of hospital cross-infection, and much work remains to be done before any final conclusions can be reached—indeed in a sense the work is unending, as developments in the design and construction of blankets are constantly taking place, as are improvements in the methods of cleansing and sterilization. Nevertheless, it is felt that it may be of help to hospitals if an attempt is made to correlate some of the information that has already accumulated and to indicate some of the questions that appear to require still further investigation.

By way of warning, it is fair to say that this report does not claim to offer many new or original thoughts on this problem; nor does it attempt to discuss at length many of the bacteriological or epidemiological questions associated with the problem, as others are far better fitted to deal with such matters. Likewise, it is appreciated that quotations taken out of their full context can be somewhat misleading, and some people may feel that the appendices to this report do not provide an adequately representative and objective picture of the situation. However, the principal object of the report is to collate and classify some of the information that is already available in such a way as to stimulate further criticism and investigation, and it is hoped that the presentation of the report in this way will be of use to hospitals and others interested in these problems.

Lastly, on a point of terminology and for the sake of simplicity, the term "sterilization" has been used throughout the report, though it is appreciated that in a number of instances the term "disinfection" would perhaps be more strictly appropriate.

(2) Blankets as a source of infection.

It has not yet been definitely established to what extent blankets may be a source of infection in hospital wards. Blankets may collect and harbour dust on the bed, and increased amounts of dust and fluff are generally to be found in the air in wards during and after the time for bed making. However, there does not seem to be any conclusive evidence to indicate whether or not this dust or fluff is a major cause of infection, nor does it seem to be certain that the blankets themselves are the principal source of dust or fluff. In spite of this uncertainty, an increasing number of hospitals appear to be coming round to the view that the blankets on a bed should be cleansed and sterilized each time a patient is discharged from that bed, and possibly even more frequently.

Ref: Appendix A.

(3) Types of blankets.

The apparent difficulty of effectively cleansing and sterilizing woollen blankets at frequent intervals without causing them to deteriorate rapidly has led many hospitals to try out substitutes for woollen blankets. The following is a brief list of the principal different types of non-woollen blankets that are being used:

(a) *Cellular cotton blankets.* This type is at present probably the most widely-used substitute for the woollen blanket. Different specifications of blanket are being produced, and research is being conducted by various organisations and manufacturers to determine which specification is likely to prove most suitable for hospital use. Some hospitals use plain loomstate blankets, whilst others prefer the blankets to be fully finished and pre-shrunk. Tucking-in strips, 8″—9″ wide on each side, are generally specified for both types.

(b) *Terry towelling blankets.* A number of hospitals are using this type of blanket, in which the towelling can be made with loops in any variation of the terry weave. As is the case with cellular cotton blankets, there are different specifications in use and opinions vary on which is the most suitable for hospital purposes; the cheapest at present appears to be that in which the weave is arranged to give a pattern of indentations over both sides of the blanket.

(c) *Calnamesh blankets.* This type of blanket originated in the Oxford region, and is now being used in a number of hospitals. It consists essentially "of two Fibro-cotton sheets between which is placed a warp-knitted mesh fabric of Fibro-cotton blend yarns. The three layers are then sewn together on a needle machine in the form of a quilt."

(d) *Blankets of man-made fibres.* Blankets of Terylene, nylon and other man-made staple fibres have been tried in a number of hospitals, and some hospitals are also testing blankets made of continuous filament fibres. Some authorities feel cautious about using blankets of man-made fibres because of electrostatic hazards: opinions vary on the extent of the dangers from this source, and at least one hospital has found that the addition of chemicals in the wash satisfactorily solves the problem.

(e) *Blankets of mixed fibres.* Research is also continuing into the development of blankets of mixed types such as Fibro (i.e. Courtauld's viscose rayon staple) and Terylene; Fibro, cotton and nylon; wool and cotton; and extensive trials of 55% wool/45% Fibro blankets have taken place.

On the continent, some countries traditionally use cotton-covered quilt-type bed coverings filled with down or other material, and one or two hospitals in this country have contemplated using this type of bed covering instead of blankets; plastic foam is also being considered as a filling for such types of bed covering.

The wool industry is of course greatly concerned over these developments, and is devoting great attention to the problems of improving the quality of woollen blankets and of determining the best method of cleansing and sterilizing them.

British Standard 1681: 1951 'Wool Blankets for use by hospitals and local authorities' is in the process of being revised in the light of current requirements, and it is expected that the revised specifications will admit the use of other materials and mixtures such as the 55% wool/45% Fibro material mentioned above.

In comparing woollen blankets with others, it is important that the term "woollen" should be correctly defined. The description "woollen" has at times been given to blankets that are a mixture of wool and other fibres, and in some cases the percentage of wool in a so-called "woollen" blanket has been shown to be extremely low.

Ref: Appendix B.

(4) Warmth of blankets.

The relative warmth of different types of blanket is obviously a matter of importance, and it is again difficult at this stage to come to any firm conclusions. The measurement of warmth is not a simple matter, and it is difficult to make comparisons between blankets of different thickness, weight, size and texture. However, some laboratory tests indicate that, after Calnamesh, woollen blankets are about the warmest of all, but practical experience so far seems to indicate that patients generally do not make any great distinction between woollen and cellular cotton blankets. In many hospitals counterpanes are used as a top covering and this practice certainly tends to minimise the difference, so far as warmth is concerned, between woollen and cellular cotton blankets. From the point of view of the hospital purchasing new blankets, it does not on balance seem that there is any great dfference in the number of woollen or cellular cotton blankets that would be required to keep any given number of patients warm, especially if counterpanes are used as well. If counterpanes or other top coverings are not used, then some authorities consider that a greater number of cellular cotton blankets are needed, but opinion is far from unanimous on this point. It appears that fewer Calnamesh blankets would be needed to achieve the same result, and some hospitals (but by no means all) think that towelling blankets are also somewhat warmer than cellular cotton ones.

Ref: Appendix C.

(5) Blanket dust and fluff.

As mentioned in section 2, it is uncertain to what extent blanket dust or fluff is a source of danger, but it seems generally desirable that blankets should add as little as possible to the amount of dust and fluff in the wards. There appear to be two points to consider in this connection: first, dust or fluff that originates from the breakdown of the fibres of the blanket itself; and secondly, dust or fluff that settles on the blankets and is then subsequently shaken into the air at the time of bed-making or other relatively vigorous movement.

With regard to the first point, many of the reports concerning the amount of dust caused by blankets appear to be based upon "opinion" rather than upon objective observation or tests. One of the few detailed tests that have been carried out on this matter indicates that much of the dust in a ward may be of cellulose rather than of wool fibre, though dust particles of wool are larger and more visible than those of cotton. On the second point, oiling of blankets has been shown to be an effective method of reducing the distribution of dust and fluff, but it does not appear to be a practice that is widely adopted at present in this country. Further investigation is probably desirable on both these questions.

Ref: Appendix D.

(6) Shrinkage of blankets.

Until comparatively recently woollen blankets were not usually given any anti-shrink treatment before sale to hospitals (or on the domestic market) nor were hospital blankets expected to be washed very frequently. This situation has of course now changed drastically, and many untreated woollen blankets have been. subjected to frequent processing at the laundry, often with unfortunate results.

However, laboratory tests and practical trials in laundries have indicated that blankets of wool and wool/Fibro can be given an anti-shrink treatment that enables them to withstand various cleansing and sterilizing processes with relatively little ill effect. Similarly, pre-shrunk cotton blankets are now widely used in hospitals, and these are also capable of withstanding frequent processing.

The experience of a large number of hospitals indicates that shrinkage need not be a major factor in assessing the relative merits of cotton and woollen blankets, since both types of blanket can be supplied in pre-shrunk or shrink-resistant form. Blankets of man-made fibres can also be cleansed and sterilized with relatively little risk of shrinkage. Investigations are continuing to determine the most efficient and economical methods of achieving shrink-resistant or pre-shrunk blankets.

Ref: Appendix E.

(7) Inflammability of blankets.

No great fire risks are normally associated with hospital blankets, and the relative inflammability of wool, cotton or other fibres is possibly not a matter of major importance in this respect.

Though the fire risk of any blanket may be small, it is fair to say that wool is appreciably less inflammable than cotton. Some man-made fibres (such as nylon or Terylene) have low flammability, whilst others are rather more inflammable than wool.

Opinions are varied on the question whether or not cotton blankets for hospital use should be given flame-proofing treatment. If they are to be so treated, it will of course add to their cost, and investigations will be necessary to determine the effects of various cleansing and sterilizing processes upon the flame-proofing.

Ref: Appendix F.

(8) Colour of blankets.

Some hospitals prefer to use blankets of a pastel or scarlet colour, in preference to white, and with blankets expected to withstand frequent cleansing and sterilization processes, colour fastness obviously becomes a matter of importance. Some processes can lead to serious discoloration, and investigations are continuing to determine which procedures and chemicals are least harmful to the colours of blankets of the various different materials. From the economic point of view, white blankets are cheaper in first cost, and able to withstand cleansing and sterilization processes that can cause coloured blankets to fade or deteriorate.

In the case of cotton, azoic dyes may be used, and in the deeper shades there may be a slight risk of dermatitis being caused to susceptible people. The risk is very small, but it is a factor that should be borne in mind, particularly if scarlet cotton blankets are required.

Ref: Appendix G.

(9) Cost of blankets.

Other things being equal, hospitals will buy the type of blanket that meets their requirements at the lowest cost. There are considerable differences in price between blankets of different materials and also between blankets of the the same basic material but of different design or finish, but at the moment the cellular cotton type of blanket appears to be the cheapest.

However, cheapness has to be considered in relation to the other qualities required of any blanket, such as durability, warmth, ability to withstand cleansing and sterilizing processes and the minimum tendency to cause or harbour fluff or dust. No final assessment can yet be made on these questions, but it is probably fair to say that the cellular cotton blanket is at present considered by many hospitals to come nearest to meeting all these requirements. However, there are also advocates who favour towelling, Calnamesh, wool or mixed fibre blankets: future developments of these types of blankets, and of those of man-made fibres, may well alter the present situation, as may developments in cleansing and sterilizing processes.

Ref: Appendix H.

(10) Cleansing and sterilization of blankets—general.

A great variety of tests and trials have been and are being conducted to determine the most effective methods of cleansing and sterilizing different types of blanket. In some cases, the processes of cleansing and sterilization can be carried out in one sequence of operations, whilst in others there is a clear distinction between the process of rendering the blankets visibly clean from dirt or soiling, and the process of rendering them suitably sterile.

From the hospital's point of view, there is perhaps much to be said in favour of a simple process (e.g. addition of suitable chemicals to laundry wash or rinse) that enables both cleansing and sterilization to be achieved in one sequence of operations. At the same time, though many hospitals consider that the blankets on a bed should be sterilized each time a patient is discharged, if not more frequently, the blankets are often not sufficiently soiled to warrant a separate cleansing process as well. Time and money may be saved, and the life of the blankets prolonged, by subjecting only soiled blankets to the full cleansing and sterilizing procedure, and by giving unsoiled blankets just the sterilization treatment alone.

With regard to the frequency of processing, some hospitals have adopted the practice of cleansing and sterilizing the blankets from a bed each time a patient is discharged from that bed, which means that the blankets are processed at irregular intervals. Other hospitals take the view that the blankets become contaminated within a very few days of being put on the bed, and that they should therefore be processed at regular intervals of a week or so; this means that all blankets are processed very frequently, and the system is relatively easy to operate from the administrative point of view provided that the laundry has the capacity to deal with the large numbers of blankets involved.

There are varying opinions on the suitability and effectiveness of different sterilization procedures. Some authorities criticise certain chemical methods of sterilization (e.g. quaternary ammonium compounds, formaldehyde vapour, etc.) because they fail with some organisms. High temperature washing and boiling also have similar limitations, though these latter methods, and particularly boiling, are generally considered to be more effective bacteriologically. For general purposes, however, many hospitals seem to accept one or other of the methods described above as capable of achieving a reasonable degree of sterility for most practical purposes, subject to the reservation that in the event of certain types of infection more stringent methods of sterilization (e.g. autoclaving) may be necessary. Whatever methods are advocated, it is important that they should be capable of reasonably easy application and control. Elaborate procedures that give good results in laboratory tests may be quite impracticable under normal working conditions in hospital or commercial laundry.

Evaluation of the suitability of different processes and materials depends largely upon the sampling of airborne dust and dust collected from blankets. Various methods are used for sampling, such as slit-samplers, exposure of culture-plates, sweep-plates, etc. Care is clearly needed in comparing the results of sampling tests, as bacteriologists may be using different methods and seeking the answers to different questions.

Ref: Appendix I.

(11) Cleansing and sterilization of woollen blankets.

Until recent years, the average hospital blanket was seldom sent to the laundry or sterilized; when it was, the results were often disastrous, largely due to errors in the laundry or sterilization process. The situation has altered greatly in the past few years, and hospital blankets in the future may be expected to be cleansed and sterilized as frequently as

25 times a year or more. At first, it seemed that woollen blankets could not stand up to such treatment, but research has indicated that with due care and control woollen blankets can in fact successfully withstand various methods of cleansing and sterilization, including formaldehyde vapour, boiling, low and high temperature washing with or without the addition of chemical sterilizing agents, and in this connection it has been made clear that shrink-resist treatment of woollen blankets is of great advantage in any process involving frequent laundering, whether at high or low temperature. Details of the various methods are shown at some length in the appendix to this section.

Ref: Appendix J.

(12) Cleansing and sterilization of cotton and other blankets.

One of the principal reasons for the development of cotton blankets for hospital use was the apparent ability of cotton blankets to withstand cleansing and sterilization processes, and particularly boiling, more successfully than was the case with woollen blankets. In this respect the margin of difference between cotton and wool now seems to have been narrowed (ref. previous section) and both materials can be successfully cleansed and sterilized by a variety of methods. Some hospitals nevertheless feel that cotton blankets can withstand more robust treatment than woollen ones, in the sense that more care and control is needed to ensure successful processing of woollen blankets, and that failure in this respect has far more damaging results on woollen blankets than on ones of cotton or man-made fibres. Blankets of cotton (and of many man-made fibres) can also be autoclaved, if necessary, with less likelihood of damage than is the case with pure woollen ones, and this may be a factor of considerable importance in some cases.

Ref: Appendix K.

(13) Re-contamination of blankets

It is obviously important that once blankets have been subjected to a sterilizing process they should not become re-contaminated before they are used on patients' beds. Some hospitals have found that airborne bacteria from the dirty sorting room at the laundry pass through the laundry itself and re-contaminate the blankets (and other fabrics) almost at once. Care is also evidently necessary to prevent re-contamination of the blankets whilst in transit and in storage before issue.

Control of ventilation and air movement within the laundry can help greatly to reduce the risks of re-contamination, and some hospitals have adopted the practice of wrapping their blankets in polythene, or other protective material, immediately after they have been processed. It is also claimed that some of the chemicals used in certain processes may have a lasting bactericidal effect, which help to neutralize any bacteria that may settle on the blanket after processing, but the effect will vary with materials of different fibres.

Once a clean blanket has been issued to a patient, it is evident that it may become heavily contaminated within a very few days, and remain thus in a state of potential menace until the blanket is sent away for cleansing and sterilization, which may not be for 2-3 weeks. Some hospitals consider that oiling of blankets minimizes the risks inherent in this situation (ref. section 5), and in America "hygienated" blankets have been developed which are claimed to have received an "exclusive antiseptic treatment that makes this blanket resistant to germs and bacteria for the life of the blanket."

This aspect of contamination is probably among the more important of the problems still requiring attention. Ideally, perhaps, the blankets should be so made that they are permanently resistant to bacteria, or the cleansing and sterilization process should be one that provides the blanket with residual bactericidal properties that will be effective throughout the period the blanket is in store or in use between times of processing. Investigations and tests are at present being conducted to determine the effectiveness of the "hygienating" process: success in this field might greatly alter the whole situation.

Ref: Appendix L.

(14) General.

In the preceding paragraphs, an attempt has been made to collect together various facts and opinions on the subject of cleansing and sterilizing blankets. From the evidence so far obtained, it is evident that there are still a number of questions to which as yet there appears to be no certain answer, and it is therefore impossible to come to any final conclusions. The following paragraphs represent an attempt to summarise a number of factors that appear to be of major concern at present:

(a) It is still uncertain to what extent blankets may be responsible for the spread of infection. In the general concern about blankets, insufficient attention has perhaps been paid to other items, such as mattresses, pillows, bed linen and curtains. Blankets in fact represent only one aspect of the situation.

(b) It seems that further investigations are needed to trace the actual sources of dust in the wards and to determine whether this dust is dangerous. There is also perhaps a need for further investigation concerning methods of suppressing dust or fluff: though oiling of blankets has been favoured by some hospitals, it does not appear to be a practice that is widely accepted.

(c) There are a variety of different types of blankets available, and there is a need for further large-scale experiments to determine the relative merits of different types under ordinary hospital and laundry conditions, in addition to small-scale tests of a few blankets under laboratory conditions.

(d) British Standard 1681: 1951 for wool blankets is being revised, and with blankets of other materials there are various specifications that are being used. More research is needed to determine which specifications are most suitable for hospital use, and there may well be considerable scope for the further development of blankets of man-made fibres or of mixed natural and man-made fibres.

(e) Generally speaking, cellular cotton blankets appear to be the cheapest currently available. True comparisons of price must depend upon the assessment of such qualities as warmth, durability, etc., as well as upon the relative cost of pre-shrunk or shrink-resistant materials, colour dyes, flame-proofing, etc. Taking these (often controversial) factors into account, many hospitals seem to feel that cellular cotton blankets at present give best value for money, but more evidence is needed before this claim can be fully substantiated.

(f) Various tests and trials have demonstrated that woollen blankets can be cleansed and sterilized by a number of different methods, including boiling, and the advantages of shrink-resist treatment have been made very clear. More research is needed to determine which type of blanket material withstands better, in the long run, the frequent application of cleansing and sterilizing processes; at present, many hospitals seem to think that cotton blankets are more durable in this respect, though again more evidence is needed.

(g) High temperature and boiling washes have been successfully applied to blankets of all materials, and so have low-temperature washes incorporating chemical sterilizing agents. Formaldehyde vapour disinfection has also been used with evident success, and the necessary adaptations to existing sterilizing apparatus have been made at relatively low cost. For the individual hospital, the suitability of any one method will depend largely upon the laundry and sterilizing facilities actually available. Though it is fortunate that there appear to be such a variety of cleansing and sterilizing processes from which a choice can be made, it seems clear that very few of the processes at present in use in this country impart any really lasting bactericidal properties to the blankets. In this respect, the quaternary ammonium compound process appears more effective than others, but further investigation is probably desirable to determine the relative merits of different methods of sterilization.

(h) The cost of the various processes will vary from hospital to hospital, again according to the facilities available. More research is needed to try to assess the costs of different methods, and in this respect more attention might be paid to the relative costs of different chemical processes, such as quaternary ammonium compounds, synthetic phenolic compounds, etc.

(i) The re-contamination of blankets after processing is a serious possibility, and particular attention needs to be paid to the ventilation of the laundry. Similarly, precautions should be taken to minimise the risk of re-contamination of blankets in transit or in store before issue.

(j) Whatever the state of the blanket before issue, it seems that it may become heavily contaminated within a very few days and remain so until it is removed from the bed. In view of this, more attention might be paid to dust-suppressive measures and to the possibility of so treating blankets (e.g. in the process of manufacture or with chemical agents in the wash) that they have some lasting bactericidal properties. In this, a measure of success has been reported with some chemicals and one firm in America claims to have produced a blanket that is "resistant to germs and bacteria for the life of the blanket." Investigations are in progress on this aspect of the problem, which is perhaps one of the more important of those requiring attention at the present time, and a successful solution to it might possibly alter the approach to the cleansing and sterilization of hospital blankets.

In conclusion, it appears that just as there are still a great many questions to be answered, so there are a great many possibilities for future developments in blanket materials and cleansing and sterilizing processes. At this stage, there seems to be little justification for any dogmatic assertions concerning the universal suitability of any one type of material or process. From the evidence so far collected, it also seems clear that there are a variety of materials and processes from which the individual hospital can choose those which are most suited to its own circumstances, and at the same time there is ample scope for further investigations.

In the course of its investigations, the Division has been greatly helped by a large number of hospitals and other organizations and individuals.

Acknowledgment is due to the officers of the Ministry of Health, who have given much help and advice to the Division; to all those whose views or reports are quoted in the appendices; and to the following hospitals in the London area, which have helped to provide much useful information:

- Charing Cross Hospital
- Chelsea H.M.C.
- Greenwich and Deptford H.M.C.
- Guy's Hospital
- London Hospital
- Hammersmith Hospital
- King's College Hospital
- Middlesex Hospital
- St. Bartholomew's Hospital
- St. George's Hospital
- St. Helier H. M. C. and Carshalton Central Laundry
- St. Thomas' Hospital
- Tottenham H.M.C.

Outside the Metropolitan area, Portsmouth H.M.C. and Southampton H.M.C. have offered much assistance and so have hospital authorities in the Birmingham, Leeds, Liverpool, Newcastle, Oxford and Sheffield regions.

Apart from hospital authorities, a number of other organizations have co-operated with the Division, including many blanket manfacturing companies and the following:

- Wool Textile Delegation and Blanket Manufacturers' Association.
- International Wool Secretariat.
- Wool Industries Research Association.
- British Cotton Industry Research Association (Shirley Institute).
- British Launderers' Research Association.
- Commonwealth Scientific and Industrial Research Organization (C.S.I.R.O.), Wool Research Laboratories, Australia.

Last but by no means least, especial thanks are due to Dr. R. E. O. Williams of the Medical Research Council's Public Health Laboratory Service, whose advice and guidance have been invaluable on all aspects of these investigations, and in particular upon the medical and bacteriological problems involved.

The Division is deeply appreciative of all the help that has been so readily given in the course of its investigations. Whatever value this interim report may have is due to those who have given this help.

November, 1959.

APPENDIX A.

Blankets as a Source of Infection.

(*a*) MARSH, F.; RODWAY, H. E. (1954) *Lancet i. 125.*

Dust-suppressive measures, such as damp dusting and sweeping, the oiling of linoleum-covered and wooden floors, and the use of disinfectants sprayed into the air, were ineffective alone in reducing the dispersal of dust-borne organisms into the air during bedmaking and ward activity.

The disinfection of blankets with Fixanol C, and of mattresses and pillows in a formalin sterilizing machine, was effective in reducing the bacterial contamination of ward dust and the risks of cross-infection; but despite this it did not lead to a decrease in the number of nasal carriers of Staph. pyogenes among the infants born in the hospital.

(*b*) CLARKE, S. K. R.; DALGLEISH, P. G.; PARRY, E. W.; and GILLESPIE, W. A. (1954) *Lancet ii, 211.*

The failure of dust-suppression to reduce the nasal and wound cross-infection rates suggests that dust, or at any rate bed-clothes dust, played at most a minor part in the transfer of penicillin-resistant Staph. aureus from person to person in our test ward. Further work is needed to determine the effects of other changes in ward environment and procedures on the spread of the organism. Elucidation of the reasons for differences between cross-infection rates in different wards, such as were found in our two wards, might give valuable information about the relative importance of the several routes by which staphylococci may spread.

(*c*) PERRY, W. D.; SIEGEL, A. C.; RAMMELKAMP, H.; WANNAMAKER, L. W.; and MAPLE, E. C. (1957) *American Journal of Hygiene Vol. 66 p. 85.*

During the past two decades studies of the role of contaminated environments in the spread of disease have been directed toward mechanical or technical attempts to prevent infection by such means. Thus, techniques have been developed to control dust, to treat clothing and bedding and to sterilize small particles suspended in the air. In general, the majority of attempts to control infected environments have sharply reduced the degree of environmental contamination but have resulted in little or no decrease in the incidence of streptococcal or nonstreptococcal infections. These data, therefore, lend no support to the concept that contaminated dust, clothing, bedding and other articles are an important means of spread of streptococcal infections.

. . . The studies with naturally contaminated blankets showed quite clearly that an increased risk to streptococcal infection was not produced in the recipients of such bedding. Indeed it is doubtful whether any infections could be attributed to organisms from the blankets.

. . . Others have observed that in many instances individuals sleeping with contaminated blankets do not acquire streptococci.

(*d*) FRISBY, B. R. (1957) *British Medical Journal ii. 506.*

Hospital blankets, unless specially laundered, are bacteriologically contaminated and potentially dangerous.

(*e*) *Annotation* (1958) *Lancet ii. 736.*

Hospital blankets have long been suspected of harbouring and spreading infection. They are, indeed, often teeming with bacteria—including, of course, Staphylococcus aureus. This is not surprising, because in most hospitals they are neither washed nor disinfected after use by each patient. There is, however, so far little evidence that dirty blankets are often responsible for hospital infection.

(*f*) SCHWABACHER, H.; SALSBURY, A. J.; FINCHAM, W. J. (1958) *Lancet ii. 709.*

We made two experiments to assess the effect of blankets on bacterial infection in hospital.

The first experiment showed that the use of freshly washed blankets, disinfected with quaternary ammonium compounds, for each patient admitted to a test ward, reduced the total bacterial count (and especially the Staphylococcus aureus, phage-type 80, which was previously endemic) and also decreased cross-infection.

The second experiment showed that there was a moderate reduction of the total bacterial count when Terylene blankets were used instead of woollen* blankets. But the total bacterial count was reduced more, and there was no cross-infection, during the time that cotton blankets were used. After the first washing cotton blankets did not produce the fluff which seems to be a major factor in the spread of infection.

(* These 'woollen' blankets evidently contained less than 20% wool.)

(*g*) SHEFFIELD R.H.B. (1959) *Report upon an investigation into the hospital use, laundering and sterilisation of blankets.*

It is acknowledged that the bedding of an infected patient provides a means of dispersing organisms and that the risk of cross-infection from this source can be reduced by laundering, using a process which effectively reduces the bacterial load carried by the bedding.

(*h*) ST. HELIER H.M.C. (1959) *Questionnaire.*

Sepsis rate seems to have fallen in wards where both types of blankets have been processed and tested. Blanket treatment has probably been one factor in obtaining this result, but it is also due to other measures and the fact that staff are more cross-infection-conscious.

(*i*) GILLESPIE, W. A.; SIMPSON, K.; TOZER, R. D. (1958) *Lancet ii. 1075.*

. . . It was surprising to find that the disinfection of blankets and garments had no effect on cross-infection. It is sometimes suggested, but difficult to prove, that staphylococci when dried in dust or blankets are less virulent than when transferred direct from a lesion or a carrier site. Nevertheless, the disinfection of blankets was not necessarily valueless. If the other sources of staphylococci had first been reduced, blankets might have been found to play a significant part in cross-infection.

APPENDIX B

Types of Blanket.

(*a*) *C.S.I.R.O.* WOOL RESEACH LABORATORIES (1958) *Progress Report. Specification for wool hospital blankets.*

Although investigations are not yet complete, it is apparent that the existing specification* for the cotton warp-woollen weft blankets, normally used by hospitals in Australia, is not satisfactory. Work so far has suggested that:—

(i) Coarse wools give more serviceable blankets than fine wools; 56's crossbred wool as normally used should be specified.

(ii) All-wool blankets are superior to the usual (Australian) wool-cotton mixture. They have greater wear resistance and are easier to free of stains.

(iii) A shrink-resistant treatment is essential if a wool blanket is to stand the repeated laundering normally encountered in institutional use. Several shrink-resistant methods are commercially available.

(iv) Besides specifying a maximum felting shrinkage as tested by the Standards Association of Australia method, a maximum relaxation shrinkage should also be included in the specification.

(v) Careless operation during the mill application of a shrink-resistant treatment can cause rapid deterioration of wool in use, hence it would be advisable to include in any specification for shrinkproofed hospital blankets, appropriate damage tests.

(* Standards Associaton of Australia, 1941, Commercial Standard No. 10.)

The work of Bogarty et al. (Bogarty, H., Weiner, L. I., Sookne, A. M. Cozart, M. L., and Harris Milton, *Textile Research Journal,* 1951, 21, 102.) on the effects of construction on the laundering shrinkage of wool fabrics is also of interest, although most of the fabrics examined were normal clothing materials which were not milled to the extent usual in blankets.

Their conclusions were: —

(i) Fabric stability depends on compactness. It is increased by using a larger number of ends per inch, by using higher twist yarns, and heavier yarns.

(ii) No improvement is obtained by the use of multi-ply yarns.

(iii) Felting is least when warp and weft yarns have the same direction of twist.

(iv) Plain weave gives less shrinkage than various twills.

The Australian Wool Testing Authority, 351 Royal Parade, Parkville, N.2, Victoria, a recently-established independent Commonwealth Government statutory body, is arranging to undertake the textile testing of blankets for hospital use.

(*b*) BAYES, A. W. (1958) *Lancet ii. 907.*

Hospital blankets are much in the news but their terminology in the medical press is confusing. Blowers et al. referred to "loomstate cotton weave" and have been so quoted. Your note refers to "tufted towelling, cellular cotton, and turkish towelling". A questionnaire has been circulated which seeks to distinguish between terry towelling and turkish towelling. These terms have well-authenticated meanings in the textile industry; so it would be well for those who wish to discuss or to buy hospital blankets to use the terms accordingly.

Firstly, 'loomstate' is the condition of all woven cloths immediately after weaving and before any washing, bleaching, or dyeing process, so the term cannot possibly refer to any particular weave or fabric structure. The blanket which Blowers and others describe as 'loomstate' was evidently made from loomstate cloth but the structure of the fabric was cellular and produced by leno weaving. This type of blanket should therefore be described as a cellular-woven blanket, or, perhaps preferably, as leno blanket, and further qualified by the type of fibre and the finishing process—e.g. wool, dyed, or cotton, loomstate.

Secondly, towelling, whether called tufted, turkish, or terry, is all basically the same weave. The adjectives tufted and terry are synonymous, but tufted is technically incorrect. Such towelling is made with loops in any of many variations of the terry weave. Blowers and others used bleached terry, or turkish (as you wish), towelling with a long pile of fine yarn and found it expensive and inefficient as a heat-insulating layer in bedclothes.* Tufting, in the textile trade, connotes a process in which lines of cut or uncut loops of coarse yarn are formed in cloth after weaving, as in tufted bedspreads. The so-called "tufted blankets" used in the London Hospital were made by Ashton Brothers after extensive experiments to produce a blanket better than either the cellular woven blanket or the bleached terry blanket; but they have not been made by the tufting process. They are terry blankets, but the weave is arranged to give a pattern of indentations over both sides of the blanket so that when the blanket is used between sheet and counterpane the indentations form separate cells of air which are very effective insulators.

(* See Appendix Cf.)

(*c*) Sheffield R.H.B. (1959) *Report.*

Cotton blankets, either cellular or string mesh, appear to be the most satisfactory alternative, especially as laundering at high temperatures is simple and effective and does not injure the fabrics. They are generally less expensive than all-wool blankets. Many types of cellular cotton blankets are now on the market and the advantages of locked weave in both directions, the degree of twist in the yarn to provide tensile strength, and edges strengthened by binding or whipping, will be apparent to the experienced Supplies Officer in recommending the type to be purchased.

In submitting the foregoing recommendations based on the available information, it is noted that many parallel investigations have been and are being made and that the conclusions published to date do not in all cases coincide. It is known, for instance, that some groups prefer terry towelling blankets to cellular type blankets and have been experimenting with alternative types, some of which are comparable in price to the cotton cellular blankets to which reference has been made. This Report therefore can be regarded as not more than a contribution to the pooling of information on a matter of common and immediate concern to the hospital service. At the same time, however, it represents the results of careful and unbiased enquiry and should serve as a useful guide to the Hospital Management Committees in the Sheffield Region and through them to the Area Contracting Committees.

(*d*) Schwabacher, H.; Salsbury, A. J.; Fincham, W. J. (1958) *Lancet ii. 709.*

The patients found little difference between the Terylene and woollen* blankets. The Terylene ones shrank a little on washing, and after 20 washes they had lost much of their fluffiness and were harder.

The nurses noticed that a considerable amount of dust and fluff was emitted from them during bed-making, and this was reflected in the number of particles on exposed plates.

The nurses also noticed a moderate amount of dust from the new cotton blankets, and they were somewhat critical of the open nature of the mesh. These blankets shrank by about 10% when washed, but this was found to be an advantage because the mesh became closer, and the material was more pliable afterwards. No deterioration was observed after 50 washings. But the most important feature was that after washing no dust was noticed and no fluff was found on the plates exposed while cotton blankets were being used.

(* These 'woollen' blankets evidently contained less than 20% wool.)

(*e*) CHELSEA H.M.C. (1958) *Report.*

Types of blankets used:—
- (a) Wool.
- (b) Cellular cotton.
- (c) Terry towelling.

(a) Woollen blankets have been found to shrink in the laundering, so much so that it is impossible to half cover a patient bed and quite impossible to use on beds where a cradle is in position. Woollen blankets which have had to be sterilized and autoclaved, have become dried, brown and practically useless so far as warmth is concerned.

(b) Cotton cellular blankets have been tried out in Maternity Department, Children's Ward and Male Medical Ward. They have been found light and warm, they launder easily and store easily, they can be boiled and if Osman's blanket is procured it is found to be a smaller mesh and therefore does not ladder. Less fluff is noticed under the beds and I quote a patient's comments when the cotton cellular blanket was tried out on his bed:—

Weight:—Appears to be similar to ordinary woollen type.

Warmth:—Ditto.

Blanket Fluff:—Unlike the normal woollen type there are no drifting particles of fluff.

(c) Terry towelling:—These have been tried out in the Maternity Department Labour Wards. One only is required per patient. The patients find them warm and comfortable. They are absorbent and therefore when the mother is perspiring she finds the terry towelling blanket more comfortable. There is no fluff, and they are able to be boiled, in which case with the cotton cellular and the terry towelling there is less chance of cross-infection. The nursing staff in both instances are very pleased with these two blankets. These blankets have not been in use sufficiently long for us to assess their wearing qualities.

(*f*) CALNAN, J. S. (1959) *Lancet i. 300.*

In attempting to find a blanket substitute it seemed reasonable to define the qualities in the material sought. These fall naturally into two groups: social or housekeeping qualities, and hygienic or surgical requirements:

Social Requirements. The material must provide warmth comparable to the conventional wool blanket.

It must be of about the same weight.

It should be easy to handle, soft and flexible.

It should not pull out of shape easily nor catch on projections of the bed. A smooth surface would be an advantage.

It should be easy to clean and wash, and be resistant to the usual washing soaps, detergents, and bleaching agents.

It should be hard-wearing and look "as new" for at least a year or two. It should not shrink or alter in texture.

It should be reasonably cheap initially and cheap to repair.

It should be resistant to moths and other household pests.

It should be easy to store.

Surgical and Hygienic Requirements. It should be capable of being sterilized by boiling. It should be capable of being washed at regular intervals without appreciable deterioration. A set of clean blankets for every patient on admission to hospital should be a minimal requirement. In certain cases, being able to change the blankets as frequently as the sheets on a bed would be an advantage.

The technique for washing the blanket should not be complex, and preferably should not disrupt the normal laundry routine.

It should not actively attract bacteria.

It should be capable of being rendered bactericidal for an appreciable time.

It should not produce fluff.

(*g*) OXFORD R.H.B. (1958) *Report of ad hoc Committee on blankets and Staphylococcal infection.*

Further experience having tended to confirm the fact that woollen blankets are entirely unsatisfactory and that no way has been found of making them satisfactory, the Committee recommend that they be replaced generally throughout the hospitals in the Region by either Calnan or Aertex blankets (both having been recommended by the Central Pathological Advisory Committee), and that these must be both sterilised and rendered aseptic after boiling. The Committee point out that the Calnan blanket is the only one that can be made static free.

(*h*) PRESSLEY, T. A. (1959) *Letters.*

Full-scale washing trials of all types of blanket available in Australia were conducted by the Royal Melbourne Hospital laundry. The blankets were measured for shrinkage and examined closely at regular intervals. So far some blankets have completed over 200 washing and tumble drying cycles and are still in reasonable condition. Blankets still under test are cotton terry towelling and various shrink-resistant all-wool blankets. Discarded varieties, with the nature of their failure, are: (1) raised (i.e. fluffy finish) cotton, rapidly lost its nap; (2) raised "Terylene", acquired a static electrical charge which the laundry personnel considered most objectionable; (3) raised "Terylene"/viscose, the rayon failed mechanically resulting in large tears; (4) untreated wool/cotton and untreated all-wool shrank excessively; (5) shrink-resistant wool/cotton was likely to give staining problems because of the different chemical affinities of wool and cotton, and had poorer wearing characteristics than all-wool in accelerated tests.

. . . I sincerely hope co-operating hospitals are aware of the composition of blankets currently used and that the term 'woollen' will not be used loosely for any raised, fluffy blanket. I was disturbed to find hospitals here describing as 'woollen' blankets containing 30 per cent. cotton, and alarmed to find an analysis of one 'woollen' blanket showed only 10 per cent. wool.

(*i*) Copenhagen Hospital Municipal Service (1958) *Letter.*

A "Dyne" (a thick eiderdown used in Denmark in place of blankets) is made of feather-proof cotton, size 160 by 200 cm., and furnished with six canals filled with in all about 1 kg. of goose and duck down, making the total weight of the "Dyne" about 1,600 grammes.

A "Dynebetraek" (eiderdown slip), size 160 by 200 cm., is made of sateen, Danish Standard D.S. 76. Weight about 1,100 grammes. Changed according to requirements, and washed as ordinary cottons.

The above bedclothing is issued to all types of patient, though of a smaller size for children.

When disinfecting "dyne" and pillows no autoclave is used. The articles mentioned are placed in a disinfection room in which formalin (1 part 40% solution of formaldehyde to 3 parts of water) is evaporated. After 2½ hours the formalin is neutralized by ammonia-vapours (1 part 25% ammonia water to 4 parts of water) for about 1½ hours.

Finally the vapours are drawn out by means of a vacuum pump. To each disinfection cycle is used 1 litre formaldehyde solution and ½ litre ammonia water.

The volume of the disinfection room is about 14 cu. meters—or close to 500 cu. ft.

It must be mentioned that the "dyne" is disinfected before the slip is removed.

(*j*) St. Thomas's Hospital (1959) *Letter.*

Blankets of man-made fibre: you may be interested to know that the problem of static electricity in blankets of synthetic fibres has to all intents been solved here by the use of a Q.A.C.

(*k*) Collins, G. J. (1959) *Letter.*

The basic construction is a particular plastic foam which is perforated and enclosed in a sheet container. The blanket is placed on the bed next to the patient, and is tucked in the normal manner.

The cost will be probably in the region of 50/-, plus or minus that figure and it will be a substitute for one sheet and two wool blankets.

Its most apt application is in the treatment of badly burned patients where exceptional light weight, warmth, and the ability to survive repeated sterilization without harm makes it an ideal bedcover.

I might mention in passing that British and Overseas Patents are pending on this article.

(*l*) Blanket Manufacturer (1959) *Letter.*

I think it is of general interest to make clear that trials are being carried out by certain hospitals on an entirely new type of blanket woven from bulked continuous nylon yarns (Terylene could be used) which are therefore by definition free from fibre fluff.

. . . The writer personally feels that the whole question of static has developed into a bogey and all sense of proportion has been lost. People in hospitals have seriously told me that it would be dangerous to use a nylon blanket on a bed in a ward because of the danger of explosions, and when asked "What explosion?" the answer was "Oxygen explosions". Since smoking was permitted in the wards in question it was obvious that the problems were not understood and there was complete confusion on the matter. The enclosed table seems to show that small additions of simple chemicals applied in the wash off can make a blanket made of man-made fibre at least as resistant to static as a cotton blanket and very much more so than the normally used woollen ones.

Electrical resistance in ohms x 10^8

Finish	0.1%	0.2%	0.3%	0.4%	0.5%	Relative Humidity
Nonidet P42 ...	8,600	3,100	1,800	1,700	1,300	25%
Cetavlon ...	43,000	930	480	320	420	25%
Cirrasol OD ...	45,000	3,160	670	125	62	25%
Arquad 2 HT	8,300	2,450	68	26	17	25%
Quatres ...	40,000	27,000	4,300	1,150	730	25%
Nonidet P42 ...	2,300	1,100	780	800	570	50%
Cetavlon ...	7,300	223	19	4.6	5.4	50%
Cirrasol OD ...	6,500	57	13.2	5.7	2.4	50%
Arquad 2 HT	246	75	7.2	5.7	3.6	50%
Quatres ...	9,000	3,300	380	77	51	50%

Untreated nylon blankets—scoured	over 50,000	25%
	over 50,000	50%
Calnan pad (cotton cover—viscose filling)—scoured	400	25%
	50	50%
Terry towel cotton blanket—scoured	1,900	25%
	19	50%
Wool blanket—scoured	over 50,000	25%
	8,900	50%

Test carried out under the following conditions:
Test voltage: 500v.
Electrode spacing: 1 cm.
Sample width: 5 cm.
Samples conditioned for 48 hours at 50% relative humidity and 70°F. temperature

(*m*) Frisby, B. R. (1959) *Report* (*in the press*).

The three cotton blankets on B ward underwent very little shrinkage during the six months they were under trial. The flannelette type showed matting of its fluffy surface and wore the least well. The towelling ones were not regarded as being very warm by the patients and were comparatively expensive. The original cellular blankets showed pulling of their threads and were not very warm. The improved cellular blanket with edges of sheeting for tucking-in and closer weave appears to be much better and has the same heat retaining properties as the Calnan blanket. The latter proved to be the most successful, and although not initially the cheapest, is undoubtedly the strongest of the four types. It also has the advantage that it can be obtained coloured and will enable the bedspread to be dispensed with. It has the disadvantage that it takes twice as long to dry in a tumbler dryer compared with the cellular blanket. It may be an advantage to use a Calnan blanket on the top of the bed with a cellular blanket underneath.

(*n*) POTTER, J. (1959) *Lancet ii. 739.*

In 1955 we decided to try Turkish (terry) towelling in place of woollen blankets on the beds in hospital wards because it could be boiled without shrinking. Patients found them equal in comfort to the woollen blankets. They were boiled and treated easily at the laundry, in the same way as the rest of the bed linen. The nurses found it easier to make a bed with terry towelling than with woollen blankets. A report was published[1] in 1957.

This further report shows how cotton blankets have stood up to prolonged use. When we originally tried the terry towelling, it was suggested that clean woollen blankets be supplied every month and also to each new patient. In our 1957 report we showed that we could change the towelling blankets weekly. The towelling blankets are now changed daily.

Following the success of terry towelling, I asked the Shirley Institute of the British Cotton Industry Research Association at Manchester if they could suggest any other cotton product which would be better than terry towelling. They felt that terry towelling would be extremely successful, but that we could try out a cotton cellular blanket, which we previously described under the name of a Loomstate blanket in the previous report. The correct title is really cotton cellular blanket, and I would suggest, as a standard is obviously required for comparison, that this particular blanket is referred to as the Shirley Cotton Cellular Blanket, since it was originally made and suggested by the Shirley Institute.

These were tried out in the ward, they were very easy for bed-making and much lighter than terry towelling. The cotton cellular blankets have now been in use for 3½ years in the plastic-surgery ward at Hemlington Hospital. They have been changed weekly so that the number of boilings at the laundry has been approximately 80 times each blanket.

Three years ago the children in the plastic ward were moved to the Stockton Children's Hospital and a ward was allocated for plastic and burns cases. This was completely equipped with terry towelling blankets, and these have been in use there for three years. Because of the many burns cases it was felt that a weekly change of blankets was inadequate, so they were changed daily. The result has been that the blankets in this ward have been, on an average, to the laundry 200 times. In this children's ward, the children are quite comfortable with only one terry towelling blanket on the bed. No woollen blankets have been used.

In the adults' ward where the cotton cellular and terry towelling blankets are used, one cotton cellular blanket and one terry towelling blanket give adequate warmth and comfort. The Shirley Institute has examined a typical cellular blanket after 80 boilings and a typical terry towelling blanket after 200 boilings and their findings are shown in the accompanying table. Their report says:

COMPARISON OF NEW AND USED BLANKETS

Blanket	Weight (oz./sq. yard)	Thickness (in.)	Thermal Resistance (togs)	Bulk specific volume (c.cm. per g.)
Raised wool (new)	14.6	0.324	2.05	16.6
Raised wool (used)	11.6	0.181	1.14	11.7
Cellular cotton (new) ...	9.0	0.200	1.26	16.6
Cellular cotton (used) ... (80 launderings)	10.9	0.194	1.23	13.4
Cotton terry (new)	15.0	0.270	1.71	13.5
Cotton terry (used) ... ... (200 launderings)	16.2	0.308	1.95	14.2

The tog is a unit of thermal resistance applied to clothing materials. 1 tog represents the thermal insulation provided by a textile fabric about 1/16 in. thick.

"When new, the cellular cotton blanket is equal in ranking to the wool blanket on the warmth-to-weight basis, both being superior to the terry blanket. In single thickness, the wool blanket is thicker and therefore warmer than the cellular cotton blanket, but it is also correspondingly heavier.

"After use, both cotton blankets have shrunk, as evidenced by the increase in their weights per unit area, and whereas there has been little change in the thickness of the cellular blanket, the terry blanket has become thicker. The wool blanket, however, has lost heavily both in weight and in thickness, and there has obviously been a considerable loss of material with this blanket during laundering and use.

"We would add that the above results and comments apply to the particular blankets examined; and while they indicate the kind of changes that are likely to occur in use they should not be taken, as necessarily fully representative of the three classes of material. The construction of the blankets used may not be absolutely the best possible, but careful work should reveal any necessary technical improvement."

Bedclothes should be regarded as a part of the patient's wound dressings, and should be free from pathogenic organisms. It has been shown that by providing blankets which can be boiled and changed daily, this is possible.

It is very hard to prove that a reduction in infection in a ward is due to any one factor; but it seems correct to remove infected bedding and replace it by clean bedding as frequently as possible.

These materials have proved satisfactory, they are easy to use and laundering has caused no problems. Repairs have been few in the Turkish towelling—only six small repairs in 106 blankets in three years' use—and no repair in cotton cellular blankets.

A standard might be laid down for cotton cellular blankets in accordance with the Shirley Institute report. These materials may not prove the final answer, but careful work should lead to any necessary technical improvement.

I wish to thank the British Cotton Industry Research Association, Manchester, for their help, Dr. Leonard Colebrook for his advice, and Dr. Robert Blowers for his help with this problem.

1. Blowers, R., Potter, J., Wallace, K. R. *Lancet,* 1957, i, 629.

APPENDIX C.

Warmth of blankets.

(a) WOOL INDUSTRIES RESEARCH ASSOCIATION (1959) *Letter.*

The results of many tests on a variety of fabrics lead to the conclusion that warmth is determined almost entirely by thickness. This subject is covered very well in a review by G. J. Morris (J.T.I. 44, T449, 1953). The problem of obtaining maximum warmth hinges on achieving as low a bulk density as is possible, bearing in mind the necessity to produce a material which is serviceable under user conditions. With traditional blankets the limit is imposed by manufacturing methods. With regard to cellular blankets, although in theory these can be made as open as one desires the condition of low density conflicts with the conclusions given in Appendix B (a) (i) on fabric stability.

(*b*) BLOWERS, R.; POTTER, J.; WALLACE, K. R. (1957) *Lancet i. 629.*

Turkish towelling. The patients were satisfied with the warmth and comfort of the towelling and found it equal in all respects to the usual woollen blanket.

Loomstate cotton weave. These were a little less warm than the woollen and towelling blankets and some patients needed four of them instead of the usual three.

Terylene. In warmth and appearance these blankets are equal to new woollen ones.

(*c*) POPE, E. A. (1959) *Nursing Times Vol. LV. 5 p. 134.*

Weight for weight, cotton blankets appear to give as much warmth as woollen blankets. Patients have felt comfortable with one terry blanket, or with two cellular blankets, in wards with an air temperature, taken in the centre of the ward, of 65°F.

(*d*) CALNAN, J. S. (1959) *Lancet i. 300.*

Calnan blanket. All the patients found these blankets comfortable and warm and several patients were even unaware of anything unusual about the bed coverings. One patient asked for three blankets on his bed, but later discarded one of them, and two patients found that a single blanket on the bed was sufficient even in the winter.

(*e*) SHEFFIELD, R. H. B. (1959) *Report.*

The patients have found the cellular and string blankets comfortable as regards weight and warmth. The terry towelling blankets appeared heavier and to the patients not as warm.

(*f*) BLOWERS, R. (1958) *Lancet ii. 1016.*

The other material we used was, as Mr. Bayes states*, bleached terry (or turkish) towelling. Mr. Bayes states that we found this a poor heat insulator. We did, in fact, report it as an admirable material for this purpose. Its insulation value has since been measured and is slightly greater than that of a woollen blanket. Patients using it confirm this.

*See Appendix Bb.

(*g*) ST. GEORGE'S HOSPITAL (1959) *Report.*

Some people claim that a basis of one cotton cellular for one woollen blanket is sufficient. On the other hand some claim that three cotton blankets are needed to replace two woollen blankets.

(*h*) KING'S COLLEGE HOSPITAL (1959) *Questionnaire.*

Cellular cotton blankets. Patients like them very much and find them light but warm. Usually three blankets are needed, occasionally four. Not so warm as woollen blankets, but lighter and softer.

Terry towelling blankets. Patients like these blankets, find them warm, soft and comfortable. Occasionally complain they are too heavy. Usually two blankets are sufficient—three are too heavy. Heavier and warmer than woollen blankets, we usually use three of these.

(*i*) THOMPSON, K. (Selly Oak Hospital, 1959) *Letter.*

From the point of view of warmth our physical tests in the laboratory showed that the cotton cellular blankets after repeated washings were averaging 80% of the thermal efficiency of a brand new "Earlywarm" wool blanket to British Standard specification, hardly noticeable on the beds, I think. The wards that we have changed over to cotton cellular have been on the ratio of 1 for 1 and the patients have actually said that they feel warmer with cotton cellular than with the old hospital woollen ones.

(*j*) ST. THOMAS' HOSPITAL (1959) *Letter.*

The nylon blankets which are being used in one of our wards at Hydestile appear to be as warm, if not warmer, than woollen blankets. Independent tests have indicated that woollen blankets and the nylon cellular blankets were approximately equal in their heat retention qualities.

(*k*) BAYES, A. W. (1959) *Letter.*

I think it would be a great help if something could be said about the physical principles of heat insulation. It is not generally realised that effective blankets contain 5% of fibre by volume and 95% of air. It is, therefore, of quite minor importance what the heat conductivity of the fibre substance may be. The important thing is the effectiveness of trapping the air. There seems to be little difficulty in immobilising a layer of air about one-third of an inch thick, but above this thickness convection currents tend to develop.

In comparing insulation quality and cost, the important characteristics are specific volume (e.g., weight per cubic foot) and price per cubic foot, both based, of course, on blankets in their normal condition of use, that is washed and fully shrunk. For obtaining the specific volume, the area and weight are easily measured, but the thickness is more difficult as this should be measured at a very low pressure, equivalent say to the weight of one or two blankets. This is of the order of 0.001 lb./sq. inch.

APPENDIX D.

Blanket dust and fluff.

COLEBROOK, L. (1955) *Lancet ii. 885.*

(a) We should, I think, make it our aim to diminish the amount of contaminated dust in our wards—and to prevent its dispersal by air currents, so far as possible.

A large part of the dust in a ward comes from bedding, especially from sheets and blankets. The former are normally sterilized by boiling in the laundry when each patient is discharged, and at frequent intervals while he remains in hospital. It is quite otherwise with the blankets. Because of the risk of shrinkage and felting they are never boiled in most hospital laundries, nor are they washed more often than is strictly necessary.

I have myself cultivated haemolytic streptococci (by mere swabbing) from the laundry in a hospital where many burns were being treated (Colebrook et al. 1945). Using a vacuum-cleaner device Lemon (1943) has shown that the blankets used by a scarlet-fever patient may sometimes harbour very large numbers of haemolytic streptococci. Rountree and Armytage (1946) with a similar technique found that 31 out of 47 blankets from surgical wards gave a culture of these organisms. (Of the 24 from a male ward 19 were positive; and of the nine samples from the ear, nose, and throat wards eight were positive.) Hamburger and his colleagues (1946) have also demonstrated the very heavy contamination of bedding used by patients with streptococcal infection in the nose.

Staphylococci are found still more commonly and often in very large numbers. These, and haemolytic streptococci, can remain viable in the dust disseminated from blankets for many weeks.

During the war, when this potential source of hospital (and barracks) infections was recognised as a problem affecting the health of civilians and of the Armed Forces, considerable progress was made in dealing with it. It was shown by Andrewes and his colleagues in 1940 that the scatter of fluff could be much diminished by the oiling of woollen bedding and bed-clothing with a mineral oil; and later, when stabilisers, such as cetyl pyridinium bromide, were included in the emulsion, it was found that these could also exert a considerable bactericidal effect (Rountree, 1946). Trial of this oiling procedure on all the bedding in a measles ward, combined with oiling of the floor, was reported to give a great reduction of the streptococcal content of the air by comparison with that of an untreated control measles ward; and also a great reduction of the cross-infection rate (Wright et al. 1944). In America it was claimed (Puck et al. 1945) that still greater control over cross-infections was obtained by combining these dust-suppressive measures with vaporisation into the air of triethylene glycol.

These were important steps forward; but, with the return of peace-time conditions, interest in this problem seems to have lapsed and it is probable that few hospitals have continued to take the menace of infected bedding seriously. In the Burns Unit of the Birmingham Accident Hospital oiling of the blankets has continued and no serious disadvantages have been encountered. Low-temperature sterilization (5 lb. for 20 minutes) has also been adopted. This has seemed to cause less shrinkage and felting than the usual laundering.

Recently chemical sterilization, combined with laundering, has been advocated by Blowers and Wallace (1955). They used a solution of cetyl trimethylamine bromide, but it is not yet clear that this is the best antiseptic for the purpose. The authors admit that it is not very effective against Ps. pyocyanea; they have not excluded the possibility that it may cause troublesome sensitisation effects in some patients (as does the nearly related cetrimide); nor have they established that repeated soaking of the blankets will not cause serious shrinkage.

In short, we do not know at present what is the optimal procedure for dealing with hospital bedding, and there would seem to be need for an ad-hoc collaboration of applied bacteriologists and representatives of the laundering and textile industries. Such a joint investigation might yield large dividends in increased control over hospital infections.

(*b*) Pressley, T. A. (1958) *Lancet ii. 712.*

All samples of airborne dust collected in three hospitals consisted essentially of cellulose fibres. Very few wool fibres could be found. Most samples subjected to bacteriological examination contained coagulase-positive Staphyloccus aureus. This suggests that cross-infection with Staph. aureus is primarily due to transfer of the bacteria by some agency other than fluff from blankets, and that therefore replacement of wool blankets with those made from other textile fibres, or the application of an oiling technique to blankets only, is unlikely to reduce cross-infection.

. . . The dust collector consisted of a "Ventaxia" fan (diameter 6 in.) mounted on a wooden frame so that its centre was 34 inches above the floor. A circle of fine "Terylene" curtain fabric (approximately 100 warp and weft thread per inch, and with a pore size of about 0.1 mm. diameter) was fastened by means of a spring band to the inlet side of the fan. The efficiency of the filter was increased by the electrostatic charge acquired by the Terylene and by the mat of fibres forming on the surface of the fabric.

(*c*) Watson, K. H. (1959) *Lancet i. 413.*

I should like to explain why the results obtained from the tests described by Mr. Pressley were not in line with expectations.

Dust is either not charged electrically at all, charged positively, or charged negatively according to the molecular make-up of the individual dust particles. Consequently the dust with the opposite charge to that of "Terylene" would all be collected, that with the same charge would be repelled, while a fair amount with no charge would be collected. From the results of these tests, we can infer that the protein particles have a similar charge to the Terylene filter, and any other deductions are useless. Similarly, plastic insulating materials have differing charges.

If this were not so, by making up solutions of the right electrostatic charge and by atomising them into the air, dust could be made into heavy blobs which would fall to the ground, and the air could be completely freed of dust.

I would strongly advise anyone intending to carry out similar tests in this country to consult the Department of Scientific and Industrial Research regarding suitable filters for collecting the samples with no electrostatic characteristics at all.

PRESSLEY, T. A. (1959) *Lancet ii. 672.*

(d) . . . Darmois and Marais[1,2] state that 'Dacron' (Terylene) acquires a negative and wool a positive charge. Hayek's electrostatic series[3] confirms this, Dacron being near the negative end and wool near the positive end. Cotton is approximately in the centre of the series.

Direct experiment in this laboratory with a goldleaf electroscope has shown that Terylene fabric is readily charged negatively either by merely opening folded material, by placing open fabric in a 50°C laboratory oven fitted with a forced-draught fan, or by shaking previously dried fabric in the air. The charge obtained by such methods was found to be relatively strong and persistent. Wool was more difficult to charge, but a pre-dried all-wool blanket could be charged positively by opening rapidly or by ironing between sheets of blotting-paper. The charge conferred on the blanket by these methods was weak and it rapidly leaked away. Cotton fabric was charged with difficulty by the rapid opening of dried, folded material. This charge varied in sign and had only transitory existence, leaking away in a few seconds.

Hence, under normal atmospheric conditions, the Terylene filter would be negatively charged and both the wool and cotton uncharged. In a very dry atmosphere (for example, in a heated ward in winter) the wool could become positively charged and attracted to the Terylene. Thus any electrostatic charges developed would tend to lower the proportion of cellulose fibres collected and not increase it as suggested by Mr. Watson.

Confirmation that the fibres in hospital dust are preponderously cellulose has now been obtained by an entirely different method. Petri dishes containing 2½% gelatin (settle plates) were exposed at bed height and the fibres settling on the gelatin layer were recovered by melting the gelatin and filtering it through a sintered glass Gooch crucible. This method collected fibres from a specific site, whereas the forced-draught filter previously used provided an average ward sample. Hence the settle-plate method is more sensitive to position than the other method and it collects more wool if near a bed than if located at a distance. The usual result obtained was similar to that shown previously when using the Terylene filter method, over 90% of fibres collected at bed height being cellulose.

1. Darmois, E., Marais, A. *C.R.Acad. Sci., Paris,* 1953, **236,** 1456.
2. Darmois, E., Marais, A. *J. Phys. Radium,* 1954, **15,** 189.
3. Hayek, M. *Amer. Dyestuff Rep.* 1954, **43,** 368.

(*e*) COWLING, D. C. (1959) *Lancet i. 987.*

Because the dust from bed linen is less conspicuous, unless exposed to the proverbial beam of light after bed-making, and because linen is readily sterilized by laundering, it tends to be ignored as a source of infective particles.

(*f*) CALNAN, J. S. (1959) *Lancet i. 300.*

Following the introduction of the (Calnan) blanket pads there was a noticeable reduction in the amount of dust and fluff on the floor in the ward, which was remarked on by both patients and staff.

(g) SHEFFIELD, R. H. B. (1959) *Report.*

Attention was drawn to the difficulty of avoiding airborne fluff in bed-making when woollen blankets were used in the wards. There is less fluff with cotton blankets which reduces the risk of cross-infection due to air contamination.

(h) BLOWERS, R.; WALLACE, K. R. (1959) *Lancet i. 1250.*

Oiling reduces the dissemination of particles from blankets but there are objections to this process: it is difficult to control, and the blankets may be unpleasantly oily; moreover, after some methods of oiling, organisms are still present.

(i) ANDERSON, K. F.; SHEPPARD, R. A. W. (1959) *Lancet i. 514*

These experiments confirm what is known of the general properties of blanket dust. This dust falls rapidly to the ground and is readily disseminated by sweeping. Infected fibres can be detected at bed height, four feet from a shaken blanket—which is the average distance between hospital beds. Nurses commonly stand between beds when folding linen; so in practice infected fibres probably have only half this distance to travel in order to contaminate adjacent sheets and blankets. Experiments carried out to investigate the role of blankets in cross-infection must be specifically related to bed-making, and sampling methods must be used which will detect rapidly falling fibres in the vicinity of disturbed blankets. Samples taken at times unrelated to bed-making, or at some distance from the bed-making area and above bed level, may fail to detect infected fibres originating from blankets.

. . . Apart from the transfer of organisms by direct contact, either to the patient or to the nurse, the release of clouds of fluff during bed-making is probably an important mechanism in the transfer of infection to other bed linen and to the anterior nares of staff and patients.

(j) MARSH, F. (1959) *Paper read to Association of Clinical Pathologists*

Blankets are among the most important inanimate carriers of pathogenic micro-organisms: mainly Staphylococcus aureus.

Classical or traditional methods of bed-making in hospital wards involve much violence; pillows are punched, mattresses violently assaulted and blankets forcibly shaken, so that the air is full of flying particles, many of them fragments of wool fibre, on which, like a witch on her broomstick, microbes ride across the ward. Blankets carry infective particles even into the operating theatre.

It seems obvious that some method for disinfecting blankets is essential. In addition to sterilizing the fibres, the method of disinfection should give a lasting anti-bacterial coating to the warp and woof of the fabric.

(k) SWANSON, A. L. (1958) *Address reported in Canadian Hospital, March, p. 37.*

Many authors have claimed substantial reduction in the numbers of airborne bacteria in hospital areas following introduction of the linen oiling process.

The oiling procedure is simple and consists mainly of adding a small amount of a light spindle oil to the final rinse water during each washing process. Four ounces of oil per hundred pounds of linen or approximately three-quarters of a pint to each washing machine load is used. A bactericidal agent such as Fixanol C may be added to the oil if desired. Most commercial preparations of the oil have a bacteriostatic agent already added.

Several advantageous side effects of oiling linen have been observed which will more than justify its continued use even if little or no reduction in the numbers of infections is secured.

(1) The linen is softer to the touch and diaper rashes and other skin irritations have been sharply reduced since oiling of linen was begun.

(2) The linen maintains its whiteness and washes much more quickly and easily with a resultant saving of 27% washing time. This speeds laundry service to the hospital and also effects an economy.

(3) Oiled linen shows much less wear following repeated washings than does non-oiled linen and lasts a great deal longer. At University Hospital (Saskatchewan) the average loss in tensile strength following 20 washings was reduced from 9% to 6.5% following introduction of the oiling process.

(4) Ironing is quicker, easier and better.

(5) The cost of the oil is small and is more than compensated for by the savings in time, in prolonged linen life and in improved patient care.

APPENDIX E.

Shrinkage of blankets.

(*a*) NEWCASTLE, R. H. B. (1957) *Report on shrinkage of woollen blankets.*

Summary of Conclusions.

(1)—That the minimum size to which a blanket can shrink to be of use in a ward is 70 inches by 58 inches.

(2)—That with a normal washing process a woollen blanket of 90 inches by 68½ inches is reduced to below this size in 20 washings.

(3)—That with a shrink-resisting process a woollen blanket with a normal washing process is never reduced below this size in the course of its life.

(4)—That with a shrink-resisting process a woollen blanket can survive 60 washings when it has lost weight to such an extent as to be of no further use in a ward.

(5)—That throughout its life the treated blanket is pleasant to handle and maintains a good colour.

(6)—That the minimum economy to be expected is £35 19s. 0d. per annum per hundred hospital beds.

(7)—That blankets which have shrunk but are not too badly felted can be reclaimed by stretching in a wet condition and submitting them to a shrink-resisting process.

(8)—That the low temperature sterilisation process recommended by Dr. Blowers and Mr. Wallace can safely be used on treated blankets without fear of shrinkage.

(*b*) ROYAL MELBOURNE HOSPITAL (1959) *Central Linen Service and Group Laundry Report.*

Tests conducted at the Royal Melbourne Hospital in conjunction with the C.S.I.R.O. Wool Research Laboratories have provided much useful information in relation to woollen blankets and their traditional difficulties of shrinkage and sterilization.

The following conclusions have so far been drawn:—

(*a*) An all-wool blanket is preferable to a wool/cotton union.

(b) Blankets, whatever their composition, should be laundered more frequently than has been customary in the past.

(c) To permit more frequent laundering, blankets should be treated by some shrink-resist process.

(d) Shrink-resistant blankets can safely be sterilized by boiling.

Shrink-Resistance of Woollen Blankets:

This is a necessary pre-requisite to any programme which includes frequent laundering. Several processes are commercially available, and whilst it is felt that most of them are reasonably satisfactory, it is proposed to conduct, in the near future, exhaustive tests to determine which process is preferable.

Good results have been obtained from blankets which have been treated for shrink-resistance by wet chlorination, and pending the outcome of the tests referred to above, a method of shrink-resistance by wet chlorination is set out hereunder.

Wet Chlorination of blankets to confer shrink-resistance:

Treatment is best carried out by specialist textile finishers; only if their services are not available is operation in a laundry justified. It is advisable to carry out the initial trial in co-operation with a technically qualified person such as the pharmacist.

It is most important that *ALL OPERATIONS ARE CARRIED OUT COLD,* that the pH (acidity) is carefully controlled, and that the hypochlorite is well diluted and added gradually while the machine is running. Chlorination should be done at pH3 (limits 2 to 4) but as the hypochlorite addition raises the pH an initial figure of 2 to 3 is desirable.

Quantity of Chlorine:

The amount of chlorine used depends on the effect desired. Increased chlorine gives greater resistance to felting but causes harsh handle, increased liability to discolour, and increased fabric damage. Hence keep the chlorine content as low as is compatible with a reasonable degree of shrinkage resistance. Probably 2% on the wool weight is sufficient in small hospitals where line drying is possible, up to 3%, where blankets must be tumble-dried. It is suggested that the lower quantity be tried first and increased in subsequent batches if necessary. Using the normal sodium hypochlorite with 12½% available chlorine, this means eight to 12 fluid ounces of hypochlorite per new blanket.. Hypochlorite rapidly deteriorates on storage. Remember that the basis for size in shrinkage tests must *not* be the new blanket, but the blanket after washing or shrink-resisting, that is after relaxation shrinkage has taken place.

Method:

A two-speed machine of non-corrodible metal is essential. Wet out blankets thoroughly, using a trace of wetting agent (such as Lissapol N, Penetrax, Nonidet) if necessary.

Add any dilute acid (such as acetic) to adjust the pH to between 2 and 3 ("narrow range" indicator papers are adequate, universal indicator is insufficiently accurate).

Add well diluted sodium hypochlorite slowly (8 to 12 ounces per blankets, see above). Check pH and readjust to about 3. Run at slow speed (10-12 r.p.m.) for at least 20 minutes. Dump. Rinse.

Remove residual chlorine with sodium hydrosulphite or sodium bisulphite using about half-ounce per blanket. The quantity should be adjusted to give a very faint smell of burning sulphur. Run at least 10 minutes. Dump. Rinse.

(*c*) C.S.I.R.O. Wool Research Laboratories (1959) *Report.*

Shrinkproofing of woven wool fabrics: This report describes a convenient method for shrinkproofing woven wool fabrics on standard dyehouse equipment. The method is particularly suited to treatment of blankets and for shrinkproofing woollen and worsted fabrics for washable non-iron effects, as described in Report No. G.9.

The process has advantages in low cost, evenness and ease of treatment and no adverse effect on colour or handle of the wool. Mill trials on this method have shown that it can be easily adapted to normal routine without need for strict analytical control.

Outline of method: Treatment is with potassium permanganate in concentrated salt solution followed by clearing with sodium bisulphite to remove manganese dioxide which is formed on the wool.

No analyses are required on the reagents used or on the shrinkproofing liquors. The permanganate treatment is finished when the pink colour of the solution has disappeared, and the clearing treatment is over when all residual manganese dioxide has been removed from the wool.

For economy, the salt solution should be used as a standing bath. This has raised no difficulties in practical trials where the same bath has been used for 10 consecutive treatments.

Directions for treating piece goods: Treatment is carried out in a stainless winch machine.

The concentrated salt solution is made up by dissolving at least 300 lb. common salt in each 100 gal. water. The specific gravity of the solution must be not less than 1.16 (20°Be, 32°Tw).

The goods may be wet out in the salt solution with 0.5–1% nonionic wetting agent on the weight of wool, but this is slow and it is easier to wet the goods before running into the salt solution.

The liquor:goods ratio should be at least 15:1 but it is better to use 30 or 40:1.

After the goods have been thoroughly wet in the salt, potassium permanganate, 4–6% on the weight of wool is dissolved in the minimum amount of water and added over 2–5 min. Care is taken to see that this strong solution is not poured directly on to the wool. For goods which are to be piece-dyed afterwards the solution is kept at 90°F or lower for about 30 min., then gradually heated to about 120°F until the bath is exhausted. For dyed goods, the temperature may be raised immediately to about 120°F, when the treatment normally takes 20–30 min.

When the permanganate bath has exhausted, the salt solution is pumped to a storage tank, or alternatively the goods may be withdrawn and taken to another machine for clearing.

The fabric is then rinsed thoroughly before cleaning in the same machine.

Sodium bisulphite, 5–10% on the weight of wool, is added to the rinsing bath together with about 5% sulphuric or acetic acid on the weight of wool (liquor ratio about 30:1). The fabric is treated at about 100°F until clear. This may take 30–45 min. with acetic acid and is much faster with sulphuric acid. However, if the goods are required to be near neutral after shrinkproofing, the lengthy neutralisation required after treatment in sulphuric acid cancels the time saved in the actual clearing treatment.

A thorough wash-off after clearing is essential to remove manganese salts from the wool.

APPENDIX F.

Inflammability of blankets.

(*a*) WOOL TEXTILE DELEGATION (1959) *Letter.*

So far as flame-proofing is concerned, it would not appear that any specification is required for All Wool blankets, as fabrics of this weight should present no fire hazard.

(*b*) SHIRLEY INSTITUTE (1959) *Letters.*

We have not compared the flame resistance ratings of cotton sheets and cotton blankets but we have little doubt that, if this were done according to the usual methods, cotton cellular blankets would be found to be more inflammable than cotton sheeting. . . . We do not think however that the usual tests are appropriate for assessing the fire risks associated with bedding in hospital use. Hospitals no doubt already have experience of the kind of risks involved and the new situations brought about by the substitution of cotton for wool blankets will need to be examined in the light of this knowledge. It certainly seems likely that all-cotton bedding will be more easily set smouldering by a cigarette end than would a bed made up with woollen blankets. It is not possible for us to decide, however, what kind of precautions would be justified by this new risk.

. . . . Cotton blankets cannot be regarded as flame resistant and hospital authorities may consider it desirable to treat them with a flame-proofing agent because of the danger of ignition by cigarette ends. The agent could be a temporary one, such as 70:30 borax; boric acid mixture, 6% add-on, which would have to be renewed after each laundering, or one of those claimed to resist removal by laundering. There are three of the latter type available at present.

(*c*) COTTON BLANKET MANUFACTURER (1959) *Letter.*

We have carried out tests at our own laboratory on the propagation of flame with various materials, using specifications standard in hospitals. You will note that sheeting and bedspreads propagate flame more speedily, and in view of the fact that the turn-over of the sheet is over the blanket, it will be the first material to come in contact with any lighted cigarette. This would indicate that the flame-proofing of the sheet would be more important than that of the blanket. Further, as the bedspread is over the blanket and over the sheet, this material also is likely to come into contact with a lighted cigarette before the blanket. Since this type of material propagates flame more speedily than the blanket, it would again appear that if flame-proofing is necessary this also should be flame-proofed.

Alternatively, if flame-proofing of cotton blankets were thought necessary, flame-proofing of sheets and pillow cases would seem even more necessary!

The cost, however, of flame-proofing all the bed linen on hospital beds would evidently be enormous, and as in the past it would probably be regarded as disproportionate to the extra security obtained. In these circumstances we suggest that the question whether cotton cellular blankets alone should be flame-proofed scarcely arises as a practical issue.

LABORATORY REPORT

SUBJECT: Test for Flammability.

Q.C.L. Ref: I.I. 2/106.

Hospital wool blanket has been tested. Comparative tests of bedding are listed below. High number of resistance rating indicates that the cloth burns slowly—low rating number indicates that the flame spreads quickly.

Tested according to Method A—B.S. 2963: 1958.

Specimen:	Flame resistance rating.	Remarks.
1. 100% cotton cellular cloth treated into a flame proof finish.	*FLAME NOT PROPAGATED*	Length of 10″ is not burnt in 12 secs.
2. Hospital wool blanket (used).	*FLAME NOT PROPAGATED*	As above.
3. 100% cotton cellular cloth*.	150.0	50″ length burnt in 75 secs.
4. 100% cotton bedspread "Styal".†	111.5	50″ length burnt in 55.7 secs.
5. 100% cotton. Loomstate sheeting 60 x 60—18s./8s.	100.0	50″ length burnt in 50 secs.
6. 100% cotton. Loomstate sheeting 60 x 60—16s./14s.	69.0	50″ length burnt in 34.5 secs.
7. As above. Finished state.	69.0	50″ length burnt in 34.5 secs.

* In BS 3121: 1959, it is stated on page 4 (third paragraph) that according to the competent BSI Committee "the level of safety to be specified should be not less than the equivalent of a flame-resistance rating of 150 when assessed by the appropriate British Standard Method of test." The method of test has been issued as B.S. 2963.

† This type of folk-weave bedspread is in frequent use in hospitals.

(*d*) CALNAN, J. S. (1959) *Letter.*

Inflammability of blankets:

Recent tests (to be published soon) showed the following "Flame-resistance rating" as tested by Method A (6 ft. vertical strip) of B.S. 2963: 1958.

Cotton aertex	75
Calnamesh unused (new)	180
Calnamesh used	200
Vantona	125
Cotton Terry towel	140

APPENDIX G.

Colour of blankets.

(*a*) BAYES, A. W. (1959) *Letters.*

We find that there is a demand for these blankets dyed red, presumably following the common red woollen blanket, and we wonder if this development has been considered from the point of view of the suitability of red cotton dyes for hospital purposes. We believe that the dyes used for wool are usually acid colours and are quite harmless. The dye which would normally be used on cotton to produce an equivalent brilliant red shade would be an azoic dye, and azoic dyes have been proved to be a cause of dermatitis. We believe that the dangerous constituent is free amine which may be left in the dyed cloth, and which is removed in subsequent washings, but it may be that well-washed azoic dyed cloth can still irritate a sensitive skin.

The risk is small because the proportion of susceptible people is very small and the condition required to produce dermatitis may not occur. However, the risk may well be of the same order as that from static explosions in operating theatres, rare infections, etc.

The risk from azoic dyes depends on the depth of shade; azoic dyes may be used for pale shades of pink, though other and safer dyes are available, but the risk from pink would be quite negligible. The alternative dyestuffs are: vat dyes, which do not provide anything like the brilliance of colour in reds; direct dyes, which are not fast to washing or bleaching, and easily stain white goods; and Procion dyes, which are not fast to hypochlorite bleach, so stains which the hospital laundry might well attempt to remove with bleach would finish as a dirty white mark. I think that an easily indentifiable coral red could be provided in azoic dye which would be satisfactorily safe, but any attempt to match the current shade of scarlet common in wool blankets should be discouraged.

(*b*) C.S.I.R.O. WOOL RESEARCH LABORATORIES (1958) *Progress Report.*

Discolouration of wool blankets on repeated washing was pronounced in these trials using a nonionic detergent with a cationic bactericidal rinse. As discolouration is not serious until the blankets have been through approximately 40 washing cycles, investigation of colour changes is necessarily slow.

Systematic laboratory trials have been undertaken in an endeavour to prevent colour deterioration while retaining the effective and relatively inexpensive method of sterilizing blankets by boiling. Up to 40 vigorous boilings, each of 5 minutes' duration, have now been given to 6 in. squares of shrink-resistant blanket in the laboratory trials without serious colour loss or shrinkage.

Pilot scale tests on whole blankets are being carried out in a reversing paddle type of washing machine fitted with a steam lead so the water may be boiled. Work so far has followed the New Zealand pattern of plunging the dry blanket into a boiling detergent solution, agitating for 5 minutes, spinning off the boiling liquid and rinsing in cold water. After rinsing for about 2 minutes the blanket is centrifuged and tumble-dried. Colour deterioration in these large-scale tests has been found to be more serious than in the preliminary laboratory tests with small pieces, but the colour was still acceptable after 40 washing cycles.

It appears that for colour retention the choice of detergent is important, and so far the best results have been obtained with a specially compounded preparation. A search for a commercial detergent with similar properties is being made.

(*c*) BLANKET MANUFACTURERS' ASSOCIATION (1959) *Letter.*

(Woollen Blankets). The important thing is that the washing liquor should be neutral or slightly acidic. The high temperature and minimum agitation wash should be suitable for white blankets treated with a shrink-resist. Dyed goods should *never* be treated with high temperature process, and indeed some colour loss may be expected after repeated washing at the lower temperature.

(*d*) COURTAULDS LTD. (1959) *Letter.*

It should be pointed out that blankets of the "Calnamesh" type or the traditional woollen type made from a blend of 45% "Fibro"/55% wool can be easily and effectively coloured by the introduction of spun-dyed viscose rayon staple in place of the undyed fibre normally used. This is a fibre in which the colour pigment is inserted into the spinning solution before the fibre is made. It has excellent fastness resistance to light and severe laundering, and sterilization. The cotton in the case of the "Calnamesh" and the wool in the traditional type are left undyed.

A range of pastel colours, i.e. pink, blue, green and yellow, can be produced.

The cost of spun-dyed viscose staple is relatively cheap compared with traditional dyeing to obtain similar fastness. The advantages of the method of colouring can be envisaged when the "Calnamesh" blanket serves the dual role of counterpane and blanket.

APPENDIX H

Cost of Blankets

(a) This schedule shows the comparative prices for an order of about 250 blankets, at period August/September, 1959. Most manufacturers supply blankets in a variety of different sizes, in addition to those shown here.

Blanket Material	Manufacturer	Overall Size (including tucking-in strip, if any)	Weight	Type	Tucking-in strip	Grey, or un-bleached, loomstate	Cost per blanket: White, bleached	Cost per blanket: Pastel	Cost per blanket: Scarlet
Wool	A	72″ x 96″	4 lb. 14 oz.	Shrink-resistant	—		46/4	48/9	48/9
Wool	B	72″ x 96″	4 lb. 14 oz.	Shrink-resistant	—		47/7	51/2	48/9
Wool	C	72″ x 96″	4 lb. 14 oz.	Shrink-resistant	—		49/11	52/10	52/10
Wool	D	72″ x 96″	4 lb. 14 oz.	Shrink-resistant	—		54/10	55/8	55/8
Wool	E	72″ x 96″	4 lb. 14 oz.	Shrink-resistant	—		56/1	56/1	56/1
The cost of the shrink-resistant treatment, included in figures above, varies from 2/- to 4/11 per blanket									
Wool	E	62″ x 82″	3 lb. 8 oz.	Grey, not shrink-resistant	—	27/6			
Wool	B	72″ x 96″	4 lb. 14 oz.	Grey, not shrink-resistant		29/7			
Cellular Cotton	F	72″ x 96″	3 lb. 11 oz.	Pre-shrunk	9″	28/9	29/9	34/3	
Cellular Cotton	G	78″ x 94″	3 lb. 4 oz.	Loomstate	8″	26/-			
		78″ x 94″	3 lb. 4 oz.	Yarn bleached or yarn dyed	8″		31/6	34/-	
Cellular Cotton	H	78″ x 96″	3 lb. 4 oz.	Loomstate	8″	25/11			
		70″ x 96″	3 lb. 4 oz.	Pre-shrunk	8″		30/-	33/6	
Cellular Cotton	I	78″ x 96″	2 lb. 8 oz.	Loomstate	8″	28/-			
		72″ x 96″	2 lb. 8 oz.	Pre-shrunk	8″		30/9	33/11	42/3
Cellular Cotton	J	68″ x 88″	1 lb. 15 oz.	Pre-shrunk, made on lace machine	9″		24/-	25/6	
Terry Cotton	K	76″ x 103″	4 lb. 7 oz.	Loomstate; tufted	11″	36/5			
		72″ x 90″	4 lb. 5 oz.	Pre-shrunk; tufted	11″		41/3	43/2	
Terry Cotton	L	72″ x 96″	4 lb. 8 oz.	Pre-shrunk; plain	—		61/6	64/-	
Terry Cotton	M	81″ x 103″	4 lb. 12 oz.	Loomstate; tufted	12″	36/-			
		72 x 96″	4 lb. 8 oz.	Pre-shrunk; tufted	12″		38/3	43/8	51/-
		81″ x 103″	3 lb. 12 oz.	Honeycomb weave	12″	34/-		37/-	
Calnamesh	N	72″ x 96″	5 lb. 12 oz.	Fibro/cotton mesh between Fibro/cotton sheet	8″		66/9	66/9	
Wool & Rayon (50% each)	A	72″ x 96″	4 lb. 14 oz.	Shrink-resistant	—		41/-	43/6	43/6
Terylene	B	72″ x 96″	4 lb. 10 oz.	100% Terylene	—		85/4		
Acrilan	E	70″ x 100″	3 lb. 14 oz.	100% acrylic fibre	—		75/7	75/7	75/7
Courtolon	O	66″ x 88″	2 lb.	100% bulked continuous filament nylon	—		63/-	69/-	69/-
Foam Plastic & Cotton	P	72″ x 96″	4 lb. 12 oz.	Perforated plastic foam between cotton sheets	9″	50/-			

(*b*) SHEFFIELD R. H. B. (1959) *Report.*

In the Sheffield Region between 4,000 and 5,000 blankets (excluding cot blankets) are purchased each year. Cost is therefore a matter which must receive careful consideration in conjunction, of course, with quality and suitability. The current prices of the blankets referred to in this report are approximately as follows:—

Type	Nominal Size	Weight	Average price
			s. d.
All-wool	72″ x 90″	4 lb. 9 oz.	36 0 each
All-wool treated	72″ x 90″	4 lb. 7 oz.	42 0 each
Cotton/wool/rayon-			
Mixture "A"	70″ x 90″	4 lb.	33 0 each
Mixture "B"	70″ x 90″	4 lb.	30 0 each
Mixture "C"	70″ x 90″	4 lb.	33 0 each
Cotton cellular	76″ x 96″	3 lb. 7 oz.	30 0 each
Cotton terry	80″ x 100″	5 lb. 2 oz.	66 0 each
Cotton string	70″ x 90″	3 lb.	35 0 each

It will be seen therefore that of the blankets shown by the tests to be less likely to be affected adversely by laundering and sterilisation and also cheaper than pre-shrunk all-wool, are the cotton cellular and cotton string mesh. In view of the amount of shrinkage referred to previously, it might however be advisable to purchase a larger size of cellular blanket involving slightly higher initial cost.

APPENDIX I

Cleansing and sterilization of blankets—General.

(*a*) BLOWERS, R.; WALLACE, K. R. (1955) *Lancet i.* 1250.

The whole subject of the washing and sterilisation of hospital blankets deserves more thought than is often given to it. In many hospitals, blankets are washed only if the patient dies or has had an infectious disease. We believe that this is not only wrong but also dangerous. Many workers have now shown that patients in hospital quickly become nose and skin carriers of antibiotic-resistant staphylococci. Blankets are largely responsible for the transfer of these organisms from patient to patient, and should be washed and sterilized afresh for each new occupant of the bed. Possibly this routine would be more acceptable to hospital authorities if the great damage done to blankets by heat sterilisation could be avoided.

The efficacy of quaternary ammonium compounds for the sterilisation of blankets has been suggested by the results of other workers, who did not, however, neutralise residual disinfectant remaining in the blankets. Their results have thus failed to show that organisms in the blankets are killed. The experiments reported here show that susceptible organisms are actually killed and not merely inhibited on the culture plates. Sterilisation of blankets with cirrasol is simple and should be used as a routine procedure in hospital laundries. The only precaution necessary is to ensure that preliminary washing is done with non-ionic detergent. The first treatment of old blankets by the process we have described sometimes gives unsatisfactory results, but subsequent treatments achieve near-sterilisation. We think that this is because the blankets contain a residue of soaps or anionic detergent, in which they were previously washed, which partly neutralises the bactericidal properties of cirrasol.

(*b*) STEINGOLD, L.; WOOD, J. H. F.; FINCH, W. E. (1954) *Journal of Applied Bacteriology, Vol.* 17, *No.* 2, *p.* 159.

Hospital blankets are undoubtedly an important source of cross-infection, and much stress has been laid on their contribution to dust-borne bacterial disease (Deicher, 1927; Thomas, 1941; Spooner, 1941; Van den Ende, Edward and Lush, 1941; Garrod, 1944; Wright, Cruickshank & Gunn, 1944; Puck et al., 1946; Loosli et al., 1950). We have shown that soap-and-water laundering does nothing towards sterilising blankets and, in fact, *only redistributes* the bacteria among them thus indicating a route of infection from patient to patient and even from ward to ward. Similar conclusions regarding the danger of washing machines and soap-and-water laundering were drawn by Gilson & Bartfeld (1948), who concluded that such laundering infected the machine, did not sterilize the materials being washed and was a danger to the community. It appears essential, therefore, that blankets be disinfected before or during laundering. Rountree (1946) has suggested a combined oiling and Q.A.C. treatment, a procedure which would seem admirable for controlling both laundry and dust cross-infection, but of which we have no experience. Some form of sterilisation, usually autoclaving, is practised for blankets used for cases of notifiable disease or with obvious heavy contamination. It has been pointed out (Loosli et al., 1950) that the organisms of a case of infection can be recovered not only from the blankets used for that case but also from those of neighbouring beds. Sterilisation of the blankets of infected cases alone is therefore inadequate, but proper facilities for sterilising blankets by autoclaving or, as recommended by Cruickshank (1951), by immersion in disinfectant solution, are not generally available in hospitals. Puck et al. (1946) have criticised the use of Q.A.C.s for laundering purposes because they are not active in the dry state, and bacteria settling on such blankets will remain viable, while Butterfield, Wattie & Chambers (1950) have pointed out that natural waters contain substances inhibitory to Q.A.C.s. We have shown, however, that the degree of sterilization obtained in the laundry by methods incorporating their use is of obvious value; moreover, adsorbed Q.A.C. will for several weeks control contamination of blankets by moist bacteria as in pus, urine and cough-spray; we did not notice any loss of activity due to the water used.

It has been pointed out (Annotation, 1952) that Q.A.C.s, are ineffective against *Mycobacterium tuberculosis*. This is of importance, for with the increase of admissions of cases of tuberculosis to general hospitals cross-infection with this organism becomes more probable and the use of Q.A.C.s is no answer to this problem. Davies (1949) has indicated that Q.A.C.s are not effective against bacterial spores. We have confirmed that a very high concentration (10,000 p.p.m.) is necessary to kill the spores of *Bacillus subtilis* in 4 hrs. Bacterial spores are not at present, however, a problem in hospitals. In the concentrations achieved by adsorption they may be effective against *Pseudomonas pyocyanea* (Davies, 1949).

Nevertheless, the introduction of Q.A.C.s into the hospital laundering technique, particularly with regard to blankets, promises to be an important addition to the precautions to be taken against hospital cross-infection.

(*c*) Blowers, R.; Wallace, K. R.; Potter, J. (1957) *Lancet i.* 629.

In any serious attempt to prevent cross-infection of wounds, hospital blankets must therefore be sterilized regularly. This can be done by exposing them to steam, but after a few such treatments even at low pressure they have shrunk to some two-thirds of their original length and lost all their fluffiness. The result is a small, hard, and uncomfortable article. Repeated laundering even without sterilisation eventually gives the same result. Shrinking due to ordinary washing can be reduced if the blankets are specially treated when new, but this does not protect them against high temperature sterilisation. The cost of a 5 lb. (2.3 kg.) hospital blanket 96 x 72 in. (244 x 183 cm.) is £2 10s. or £2 15s. if anti-shrink treatment is applied, so that replacement costs are high if sterilisation and washing are done as a routine. In many hospitals, therefore, blankets remain not only unsterilised but unwashed for long periods.

To overcome some of these difficulties various methods have been suggested. Van den Ende, Lush, and Edward (1940) devised a process for treating blankets with oil so that bacteria stick to the fibres instead of being scattered during bed-making. Formalin disinfection is used, especially in infectious-diseases hospitals, but there has always been some uncertainty about its efficacy. Also it needs expensive equipment and each article has to be handled separately which increases labour costs. Disinfection of blankets with quaternary ammonium compounds has been suggested (Rountree 1946, Barnard 1952, Blowers and Wallace 1955). This is highly efficacious against the pyogenic cocci, but its action against Pseudomonas pyocyanea is poor and against tubercole bacilli doubtful.

(*d*) C.S.I.R.O. Wool Research Laboratories (1958) *Progress Report.*

Most of the work published from Great Britain refers to the application of quaternary ammonium compounds, bacteriostatic agents which are effective only when non-ionic detergents are used for washing. In U.S.A. wide use has been made of substituted phenols, such as o-phenyl phenol and p-tertiary amyl phenol, which have the advantage of being applicable in the rinse water after washing blankets with soap or anionic detergents, the cheapest materials for laundry use.

(*e*) C.S.I.R.O. Wool Research Laboratories (1959) *Progress Report.*

It is generally agreed that hospital blankets rapidly acquire a load of pathogenic micro-organisms and should be sterilised regularly. In a hospital carrying out routine sterilization of blankets, a large proportion of the blankets returned to the laundry wil be unsoiled and will require sterilization only; others will require cleaning as well as sterilization. If possible unsoiled and soiled blankets should be treated separately.

Experiments with chemical disinfection are still in progress. The usual quaternary ammonium compounds greatly reduce the count of *Staph. aureus* (which is practically unchanged by normal laundering), but other organisms (e.g. Proteus sp.) are resistant. Propylene oxide or formaldehyde are effective sterilizing agents if suitable autoclaves are used, but the necessity to evacuate to ensure adequate penetration results in a high plant cost.

Boiling is the simplest way of effectively reducing the bacterial contamination of blankets in normal laundry machinery.

(*f*) MARSH, F. (1959) *Letter.*

In our hospital group we include an infectious disease hospital: we have worked out a method for the sterilization of blankets there which is very effective in practice. Briefly:— (1) rolls of dirty and heavily contaminated blankets are placed in the hospital autoclave and treated with warm, moist, gaseous formalin. (2) the dirty (but sterile) blankets are then washed with "Hytox" in the hospital laundry. The blankets appear very clean and are sterile. No lingering antibacterial coating of the blanket fibres is effected, however. These blankets are treated in this manner every ten days.

(*g*) CAPLAN, H. (1959) *Letter; also ref. Lancet* (1959) *i.* 1088.

Regular disinfection of blankets and bedside curtains seems to be an essential measure in the prevention of cross infection, and formaldehyde vapour in vacuo at moderately raised temperature (40-60°C) is a rapid, efficient and inexpensive means of disinfection which does not damage the woollen fibres. Using a commercially available formaldehyde generator attached to the ordinary hospital autoclave, blankets are sterilized by exposure to formaldehyde vapour in a vacuum of 15 in. Hg. for 20 minutes. Hot air is then blown through to remove the smell. Up to 50 blankets can be sterilized at a time in an autoclave chamber, capacity 120 cu. ft. Following the introduction of this technique endemic infection of a surgical ward with *Staphylococcus aureus, Proteus vulgaris* and *Pseudomonas pyocyaneus* was virtually eliminated. There was one wound infection in the ensuing six months compared with 17 in the preceding six months. The incidence and severity of post-prostatectomy urinary infections were much diminished (from 70-100% down to 20-30%) and the average stay in hospital after prostatectomy was reduced from 60 to 20 days. Many blankets have been formalinised over 30 times: they have not shrunk, become matted or "felted". Over 1,000 patients have been nursed in formalin-treated blankets, and there has been no case of formalin dermatitis.

(*h*) GILLESPIE, W. A. (1959) *Letter.*

On the subject of the formalin disinfection of blankets, the method whereby a converted autoclave chamber is used has since been modified, chiefly by substituting a Nash-Hytor Water-Ring pump for the autoclave steam ejector. This gives a quicker and better evacuation of the air from the chamber, and consequently, a speedier process. We have used the formalin method, since September 1956, in one male surgical ward of 28 beds, and for periods of up to one year in three other wards. At present we are treating the blankets and pillows of three surgical and one orthopaedic ward (about 140 beds altogether). The blankets and pillows are disinfected (and the rest of the bedding laundered) every time a patient leaves hospital, or after 14 days if he has not left by then. There has been no detectable damage to the blankets. The degree of "sterility" achieved has been very satisfactory. Very few non-sporers survive the treatment of blankets, although in pillows the results have not been so good, because vapour penetration into pillows is poor.

The formalin process, using a converted autoclave, has proved to be very cheap. The blankets for the 140 acute adult beds referred to above are disinfected by our steriliser attendant, in about 10 man-hours per week. (Any soiled blankets are sent by the wards direct to the laundry, and after laundering, are treated with formalin). The capital cost to us has been very small. When we were treating the blankets of only one or two wards, we used the same autoclave for the pressure-steam disinfection of dressings; but now we have purchased a new autoclave for dressings and use the old one as a formalin chamber only.

(*i*) THOMPSON, K. (Selly Oak Hospital, 1959) *Letter.*

The full facilities of a laundry were made available, together with an adequate sum of money to purchase a laundry machine load (100 lbs. +) of all the blankets which might be considered substitutes for wool, in order that we might attempt to assess the relative life of the different woollen substitutes and find an economical laundry schedule. We found that the heavier weight of Calnamesh and terry towelling were such that it was almost essential to dry them on a calender representing a large area of laundry space and high capital cost whereas the tumbler drying represented less capital cost in laundry equipment, speedier throughput and a smaller number of staff. For a hospital of 750 beds, 24 x 14 ft. floor space would be required and the machinery would cost £4,000, including installation and two people would be required to handle it, assuming three blankets per bed per week. Our tests showed that cotton cellular blankets to the "Birmingham Specification" showed no deterioration after two years' wear.

(*j*) GILLESPIE, W. A.; SIMPSON, K.; TOZER, R. D. (1958) *Lancet ii.* 1075.

From the beginning of April, 1956, blankets and garments were disinfected during laundering with "Cirrasol OD" (Blowers and Wallace 1955). The process has been continued ever since, without injury to bedding or irritation of skin. By April 20, 1956, all articles had been satisfactorily treated. "Sweep Plates" of nutrient agar containing "Perminal Col" (Blowers and Wallace 1955) were taken from 161 of the blankets laundered during the next 14 weeks and had an average of 20.4 colonies per plate, compared with an average of 157 colonies from 226 blankets laundered previously. There was a similar reduction in sweep-plate counts from garments. The number of staphylococci isolated from laundered blankets fell from 0.40 colonies per plate before April 20 to 0.09 colonies per plate afterwards; the real reduction was probably greater, since staphylococci were sometimes difficult to detect in crowded plates.

"Settle-plates" showed evidence of a reduction of the dust-borne staphylococci in the air when blankets were disinfected. Before April 20 there was an average of 2.8 staphylococcal colonies per plate, and in the next 14 weeks 1.6 colonies per plate. The reduction persisted throughout the following winter and probably was not caused by better ventilation in the summer months.

The disinfection of bedding had no detectable effect on staphylococcal cross-infection or on the incidence of staphylococcal sepsis. In the 14 weeks after April 20, 44 (44%) of 99 2nd-day nose swabs were positive, compared with 64 (42%) of 152 taken previously. The corresponding figures for positive 2nd-day umbilical swabs were 84/137 (61%) after April 20 and 64/111 (58%) previously. Staphylococcal skin pustules occurred in 17 (6.0%) of 283 infants born after April 20, compared with 22 (5.3%) of 416 born previously.

(*k*) THOMAS, C. G. A.; WEST, B.; BESSER, H. (1959) *Report* (*in the press*).

Ethylene oxide is in some ways a more promising sterilizing agent. Kaye (1950) failed to recover organisms from blankets which had been left overnight in a mixture of ethylene oxide (10%) and carbon dioxide (90%). In general our own experiments confirm these findings, though organisms sometimes survived when the material was grossly contaminated or when areas of blanket were not freely exposed. With low concentration of ethylene oxide sterilisation of blankets is a lengthy procedure, but with pure ethylene oxide a relatively short period of exposure might be adequate. In high concentrations ethylene oxide forms an explosive mixture with air, although pure ethylene oxide has been widely and safely used in industry. Since ethylene oxide is at present the sterilizing agent of choice for a wide range of articles (including plastics, certain drugs, electrical equipment, heart-lung machines) it is almost certain that large hospitals will soon find it necessary to install plant for sterilisation with this gas. In these circumstances ethylene oxide might be found suitable for the routine sterilisation of blankets.

(*l*) STEVENSON, W. J. (June, 1959) *Report on trials at Fairfield Hospital, Melbourne.*

Dry-cleaning and sterilization of hospital blankets:

This investigation into the Lissapol-Cirrasol method of dry cleaning hospital blankets was prompted by the satisfactory results reported by the Tasmanian Health Department in collaboration with the Royal Hobart Hospital and St. John's Home, Hobart.

In order to evaluate this process the Victorian State Health Department and the Hospital and Charities Commission established a pilot dry cleaning plant at Fairfield Hospital.

The method, as developed in Tasmania, is a modification of the work of Blowers and Wallace who used this detergent antiseptic technique in aqueous solution as a laundry process. These workers claimed a marked reduction in bacterial flora on contaminated blankets and a residual bactericidal effect in treated blankets.

Materials and methods:

Standard hospital pure wool and wool-union (70% wool, and 30% cotton) blankets, previously "relaxed" by dampening, were measured before and after dry cleaning treatment. A number of blankets was subjected to 50 dry cleaning "runs."

A "run" consisted of a 28-minute washing cycle followed by spin drying and tumbler drying at temperature now exceeding 120°F. Certain blankets were air dried as controls against tumbler dried blankets. The formulation followed the recommendations of Mr. J. Clark, St. John's

Home, Hobart, namely Lissapol N300 detergent 3 ozs. (by weight) to 35 lbs. blankets in 160 gals. white spirit; Cirrasol O.D. 13 ozs. (by weight) to 18 gals. spirit. Contact between the blankets and Cirrasol occupied 12 minutes.

Blankets dry cleaned 50 times did not exhibit signs of obvious physical changes, apart from one particular brand of wool-union which evidenced moderate loss of bulk. There was little evidence of hardening of the material; no noticeable colour changes, and felting and pilling were negligible. Shrinkage was less than 6% compared with the area of relaxed blankets before treatment. However, some substances such as blood, certain foods, etc., are not removed and require preliminary soaking or washing.

Random sampling of control blankets showed an infectivity range of from 180 colonies per plate to occasional uncountable plates. The mean of plates showing less than 1,000 colonies was 340. These controls applied to both tests for sterilisation and residual effects.

Summary:

The Lissapol-Cirrasol dry cleaning process is satisfactory insofar as the physical properties of the blanket are concerned. However, there are definite limitations in regard to removing certain foodstuffs, blood, etc.

The method results in a marked reduction of staphylococci (and other non-sporing bacteria), but it does not produce a sterile blanket. Using a percussion technique with certain constants, an area of 18 sq. inches yielded a mean of four colonies after processing. This technique is considered to be more sensitive and reliable than certain other methods, particularly the "shake" and sweep-plate techniques.

A residual bactericidal effect can be demonstrated, but controlled ward trials are necessary before evaluating this effect in controlling cross-infections.

The overall cost is estimated at 15 pence per blanket.

Addendum:

Since this investigation was commenced, experiments at the C.S.I.R.O. on shrink-resistant processes applied to wool permit blankets to be boiled without obvious deterioration. This development at the present juncture appears to have certain advantages over dry cleaning. No information is available as yet regarding the application of any of these shrink-resistance processes to existing stocks of used blankets.

(*m*) THE HOSPITAL (1959) *Report, p.* 343.

Sterilising Blankets.

A recent contribution to the discussion on the sterilisation of blankets is an article in *The Pharmaceutical Journal* by Mr. W. E. Finch of the Prince Regent Tar Company Ltd. The chief difficulty about using wet laundering or wet sterilisation methods for blankets is that they usually involve mechanical agitation which may shrink by felting, but a wool fabric gives up its dirt to an aqueous detergent more easily than most other fabrics and there is no need to rotate the material continuously in the machine. Because of the possibility of damage in a wet cleaning process blankets and other woollen fabrics are often dry cleaned.

Whilst quaternary ammonium compounds have been used for cleaning and sterilising blankets, these have a limited value as germicides and it is preferable to use formaldehyde which has a broad bactericidal spectrum. When formaldehyde is used as a vapour special precautions must be taken to ensure deep penetration into the folds of the fabric, and at the end of the operation the excess of formaldehyde must be neutralised to prevent the blankets causing irritation to the patients during use.

Experiments were therefore made in the use of formaldehyde with a typical dry cleaning process. For disinfection a strong aqueous solution of formaldehyde as a fine and well dispersed emulsion was introduced into the cleaning solvent. Blankets cleaned by this process, it is claimed, suffered no physical or chemical deterioration in the fabric; there was no shrinkage by felting, even when the process was repeated several times over a short period. The processed blanket did not have the objectionable smell associated with formaldehyde, and although the possibilty of allergy remained there did not appear to be any irritation to the skin of a non-allergic person.

Tests carried out indicated that formaldehyde produced satisfactory anti-bacterial action when used in this process. Moreover the treated blanket in a dry condition retains its antibacterial property for a considerable period, and should therefore provide an extra safety factor against cross-infection. This property is lost if the blanket is washed in water but retained if cleaned by an ordinary dry cleaning process.

APPENDIX J.

Cleansing and sterilization of woollen blankets.

(*a*) WOOL TEXTILE DELEGATION (NOV. 1958) *Memorandum.*

Wool is also unique amongst fibres in its resistance to soiling in the ordinary domestic sense, and just as it does not readily pick up dirt so it is easily cleaned since wool can be washed at much lower temperatures than other fibres, 100°F being adequate.

. . . Wool, once domestically clean, can be disinfected by suitably controlled high temperature processes. High temperature processes have not been generally used with wool because it is generally believed they can cause felting. The cause of felting is, however, agitation when immersed in water, and blankets will felt even at 100°F unless care is taken to avoid undue agitation or working of the wool. Shrink-resist treatments are commercially available and will reduce felting at these temperatures. They would be more widely used if specified in buying contracts.

If agitation is cut out entirely wool blankets can be boiled with little or no risk of felting or rapid deterioration. Boiling in an alkaline condition must be avoided because it leads to chemical damage. Where blankets are visibly stained, the boiling should be preceded by an ordinary low temperature wash.

A practical process which has been successfully used for some years in certain New Zealand hospitals follows this plan (N.Z. Hospital, December, 1956, p. 36). Dry blankets are entered into boiling liquor preferably pH_5, and containing non-ionic detergents, agitation being reduced to a minimum. This process, in addition to washing the blanket, removes all organisms other than certain spore-formers. In subsequent drying it is preferable, if possible, to avoid a tumbler dryer, drying being carried out by hanging the blankets on a chain which passes through a hot air tunnel.

The use of antiseptics at normal temperatures:

Many of the well known antiseptics have to be ruled out because they possess objectionable odours or cause discolouration and even some physical deterioration of the blanket. In recent years the development of quaternary ammonium compounds has overcome these difficulties and hospital trials with cetyl trimethyl ammonium bromide (Blowers and Wallace, *Lancet*, June 18th, 1955, i. 1250 and Frisby, British Medical Journal, August 31st, 1957, ii. 506) have been most encouraging. The method is a simple one which can be carried out by ordinary laundries; after normal washing in which the detergent must be of a non-ionic type, the blankets are treated in a dilute solution of Cirrasol O.D. The above authors carried out extensive tests on blankets and were satisfied that the treatment was not detrimental to the normal appearance, and further, the blankets were odourless.

Alternative combinations of non-ionic detergents and quaternary ammonium agents from other makers have given equally good results, only two micro-organisms appearing to resist this treatment. In addition quaternary ammonium compounds confer a lasting bacteriostatic effect on the blankets.

Formaldehyde has often been recommended as a disinfecting agent for hospital equipment, but has not come into universal use for wool perhaps because it was considered to present a hazard to such protein fibres. A number of forms of apparatus for formaldehyde application are commercially available or can be improvised and have been found effective when properly used in disinfecting wool bed-covers. (Gillespie & Alder, *Lancet* (1957) i. 632). In recent work by Schopner (Krankenhaus (1957) 2, 70) a method using formaldehyde vapour followed by hot air has been found effective bacteriologically and also without hazards to the wool and without odour even when many times repeated.

The joint bodies would emphasise that the above mentioned methods are not exhaustive of those which are available but are in their view and in the light of the knowledge at present available to them the most practicable, satisfactory and economic of those which have been examined. Research on the problem of disinfection is being pursued and it is hoped that further information will come to light as the work proceeds.

(*b*) BRITISH LAUNDERERS' RESEARCH ASSOCIATION, AND THE INTERNATIONAL WOOL SECRETARIAT (June, 1959) *Joint Report.*

These experiments have shown that repeatedly washing wool blankets by the high temperature process described in this report did not lead to any greater shrinkage than that occurring in a normal low temperature laundering process.

Discolouration of white blankets was greater in the high temperature process but was not sufficient to be really objectionable in practice.

It should be noted that a stainless steel washing machine was used for the large scale trial. Greater discolouration than that obtained in this trial might result from repeated high temperature launderings in a brass machine. The high temperature process would not, of course, be suitable for coloured blankets since it might cause rapid bleeding of some dyestuffs.

The shrinkages of the different types of blankets varied, the advantages of a shrink-resist treatment being clearly demonstrated. It was possible to obtain a commercial shrink-resist type of hospital blanket which, after relaxation, shrank only a further 2.6%, on the average, of its original area during the equivalent of 50 high temperature launderings. Of the four types tested, only one, after 50 launderings by either process, fell seriously below the minimum dimensions quoted as being permissible. None of the shrink-resist treated blankets failed to satisfy the criterion. It is emphasised that good laundering practice was followed in these trials in that interrupter gear was used and that the blankets were dried without agitation in a hot air chamber and not in a tumbler drier.

Disinfection of blankets, at least at each change of occupant of a hospital bed or cot has been recommended and if the high temperature process is employed for this purpose, the result will be that in many hospitals, blankets will be laundered more frequently than formerly. Inevitably the life of some types of blanket will then be less owing to the greater number of launderings in a given period. However, the present investigation indicates that suitable types of blanket, especially those which have received an adequate shrink-resist treatment would still last a reasonable time.

Cleansing by the high temperature process of test pieces soiled with a fatty dirt was satisfactory.

The total cost of materials, water and steam used in the high temperature process is approximately one penny more per blanket than the total for a normal low temperature process, assuming average quantities of non-ionic detergent or soap for soiled blankets are used.

High Temperature Laundering Process.

Machine: 34 in. x 52 in. Weight of load: 66 lbs.
Water hardness: 0°. Speed of machine: 20 r.p.m.

Wash.

Machine filled with water heated to 100°F to dip of ...	13 in.
Ethylene oxide condensation product added—1 to 3 pints, according to degree of soiling of the blankets.	
Predissolved sodium dihydrogen phosphate added	8 oz.
Mixed well.	
Machine loaded, turned through one revolution, stopped, heated as quickly as possible to	205°F
While temperature maintained at approximately 205°F, the machine was run for 15 sec., stopped 75 sec., run 15 sec. and stopped 135 sec.	
Drained	1½ min.

Two Rinses.

Each as follows:—

Machine filled with cold water to dip of	14 in.
With 2:1 interruption, machine started and run	2 min.
Machine stopped and drained	1½ min.

(*c*) SHEFFIELD R.H.B. (1959) *Report.*

The Report has referred previously to the difficulty in obtaining sterile or near sterile conditions when woollen blankets are returned to the wards from the laundry. Difficulty however is no obstacle and methods have been evolved in recent years using quaternary ammonium compounds as a sterilising rinse with most satisfactory results. It is essential that to obtain these results these processes should be carefully controlled and executed. Details of two such processes are attached as Appendix *.

These figures might at first suggest that processes using a detergent without sterilising rinse were fairly satisfactory, as they showed a pronounced fall in plate counts after laundering. However, blankets laundered by such methods still contained pathogenic bacteria, whereas processes using a sterilizing rinse gave an even lower count after laundering and no pathogens were isolated. This suggested the possibility that this sterilising process killed most of the bacteria present but that some contamination occurred during the drying process. It therefore appeared that a process which included a sterilising rinse should be used. The processes which have been investigated seem to be equally efficient and simple to use. Blankets laundered by the Syndet/Steravol process were thought to be in slightly better condition than those washed with Comprox T as they felt "softer and fluffier" and this method is recommended.

*Appendix

SYNDET/STERAVOL WASHING PROCESS FOR ALL WOOL BLANKETS

Washer type: Rotary—Size 34" × 72"
Water hardness: All water conditions

Operation	Time (minutes)	Temperature °F	Water level ins.	Materials
Wash 1	5	110	10	Approx. 3 lb. Syndet 54
Rinse 1	2	Cold	14	
Rinse 2	2	Cold	14	
Rinse 3† (sterilising)	6	Cold	10	2¼ pints Steravol

†Proceed as follows—

Run for 1 minute and leave at rest for 2 minutes alternately for a total of 6 minutes. The work must be hydroed straight from the sterilising rinse, i.e. must *not be rinsed* again in plain water.

Operating Notes—

1. All times shown apply for after the necessary water levels (running dip) have been obtained and materials added.
2. Always stop cage when emptying liquids and do not restart until the correct dip for the next operation has been obtained.

NONIDET/ARQUAD WASHING PROCESS FOR ALL WOOL BLANKETS

Process	Dip	Temp. °F	Time (mins.)	Rotary Washer size 36″×64″ 24 blankets	Rotary Washer size 34″×48″ 18 blankets
Wash 1	12″	100	10	11 fld. ozs. of Nonidet P.42 2 ozs. Metasilicate of soda	8 fld. ozs. of Nonidet P.42 1½ ozs. Metasilicate of soda
Rinse 1	12″	100	2	—	—
Rinse 2	12″	100	2	—	—
Rinse 3	12″	100	2	7 fld. ozs. of Arquad 16.50%	5 fld. ozs. of Arquad 16.50%

(*d*) STARK, T. (September, 1958) *Report.*

It is beyond doubt that wool can be boiled for periods long enough to destroy all non-sporing organisms and some of the sporing organisms if the correct technique is used, viz.: —

(a) Feed 12″ dip of hot water into washing machine.

(b) Add detergent and bring water to the boil.

(c) Place *dry* blankets into the machine when water is at boiling point. Operate machine for 10 minutes, ensuring that the temperature is maintained at boiling point during the whole period. This period could possibly be reduced but as the fibre of the blanket is not harmed by the extended boiling time recommended in the Handbook of Bacteriology, it is felt that the accent should be on "safety to the patient". It has been proved that 10 minutes boiling is sufficient to effect 100% kill of non-sporing bacteria which had been impregnated into the blanket, as opposed to the sweep-plate technique.

(d) Release boiling water, leave blankets in machine and fill to 14″ dip with hot water for 1st. rinse of 5 minutes duration. (Temperatures ranging from 140° to 180°F have been used during tests without any apparent damage to the blanket).

(e) Release hot water and refill with cold water to dip of 14″ for 2nd. rinse of 5 minutes duration.

(f) Unload machine and transfer to hydro extractor.

(*g*) Shake blankets before being put into tumbler drier.

(h) Finish off blankets in tumbler drier and shake on removal. (In the tests carried out temperatures have been varied from 85° to 190°F without any apparent damage to the blanket.)

There is no evidence in the tests so far carried out to support the theory that agitation causes shrinkage and/or felting, and the view is held that the use of the interrupter gear can be optional. In all tests detailed, except those carried out on the 29th August, 1958, when the interrupter gear failed, it was working to maximum capacity.

(*e*) THOMAS, C. G. A.; WEST, B.; BESSER, H. (1959) *Report* (*in the press*).

. . . Different laundry techniques have been studied to compare their effectiveness in reducing the bacterial contamination of woollen blankets. In agreement with the findings of previous workers the best results were obtained by using non-ionic detergents combined with quaternary ammonium compounds. It is important to ensure that the anti-bacterial activity of the quaternary ammonium compounds is not accidentally neutralised by anionic detergents or soaps. In certain circumstances it may be better to rely on other disinfectants such as the higher phenol derivatives. None of the methods investigated can be relied upon to achieve sterility.

When blankets are thought to be more dangerously contaminated than usual they can be sterilised with little damage by brief immersion in boiling aqueous solutions. It is possible that ethylene oxide will prove to be a useful agent for sterilising blankets.

(*f*) St. Thomas' Hospital (June, 1959) *Report STH* (59) 256. (See also Fairey, M. J., Sept., 1959, *The Hospital,* p.773).

From the success of the two experiments, it was obvious that neither the process of boiling nor bringing to the boil, together with constant agitation, were detrimental to woollen blankets. The Godalming Laundry had always supposed that when woollen articles had been detrimentally affected due to their accidental inclusion in the white wash, damage had been caused by the boiling process. The two experiments demonstrate that this could not be the case. The other variable factors were the chemicals and detergents added to the wash, and accordingly the third blanket was boiled with agitation in the usual solution for a white wash—water, soap and sodium metasilicate. After only one wash in this solution, the blanket had suffered very severe felting, and jelling, a shrinkage of more than 6 in. in each direction and a loss of fibre strength so complete that while wet the blanket could be torn as though it were paper. Stark had demonstrated in his experiments that soap flakes could be successfully used as a washing medium when boiling blankets and the soap could not therefore be responsible for the damage. This left as the only other possible cause the sodium metasilicate: and the damage which it caused very amply proves the warning of the Wool Textile Delegation that "boiling in an alkaline condition must be avoided because it leads to chemical damage."

. . . The fourth experiment was designed to discover the effect on woollen blankets of the process of sterilization which Professor Hare has advocated—that is to say washing at a temperature of 140°F. The blanket was placed in a 12 in. dip of water and Teepol at a temperature of 140°F and washed with constant agitation for a period of 10 minutes. The washing solution was then released and replaced with a 12 in. dip at a temperature of 100°F in which the blanket was rinsed for 5 minutes. The blanket was then dried as in the first two experiments in a hydro-extractor and an electric tumbler. After 20 washes by this method the blanket had shrunk 2½ in. in one direction and 3½ in. in the other. There was a very slight degree of felting: the blanket was still softer to handle than a new blanket. There was no appreciable colour loss.

. . . It should perhaps be noted at this stage that a large section of the laundry trade is of the opinion that woollen blankets should only be dried in drying cupboards—a method resulting in unsightly marks on the edge of the blanket which are caused by the securing clips. The Wool Textile Delegation also supports this view (q.v.). The Godalming Laundrv however has for some time past successfully dried blankets in electrically heated tumblers at temperatures of up to 210°F, and Stark also supports this method of drying.

. . . Professor R. Hare has shown that Staphylococcus aureus may be killed in less than 5 minutes in water at only 60°C (140°F). This fact demonstrated that even if the boiling of blankets were not possible, a washing process involving temperatures of only 60°C might be employed instead.

. . . It is debatable which of the methods described in the first, second and fourth experiments is the more suitable for general application. The experiments have shown that all the three methods in question may be repeatedly applied to woollen blankets without any fear of damage. All of them will destroy Staphylococci. The laundry methods used by the hospital's present laundry contractors would be least altered by the use of a washing process of 140°F and in terms of cost such a process would undoubtedly be cheaper than one which involved boiling. On the other hand, those blankets which were boiled were softer than that washed at 140°F and though in all cases the shrinkage was minimal the blankets which were boiled shrank the least.

Finally it would seem that the experiments have demonstrated convincingly that there is no real necessity to seek substitutes for woollen blankets, on the grounds that woollen blankets cannot be effectively sterilized.

(*g*) MARSH, F. (1958) *Lancet ii.* 801.

For some years we have been looking for a means of reducing these labour costs. We had in mind a chemical which would combine the operations of "cleansing" and "sterilisation" in one process. Until quite recently we were unsuccessful in our search. A few weeks ago we gave a trial to blanket washing and sterilizing—in one operation—with "Hytox", a proprietary preparation marketed by Domestos. Hytox has now been tried at one of our hospitals with great success. The blankets emerge very white, soft, and clean, and the fibres have antibacterial properties and are sterile. Hytox also is inactivated by traces of ordinary washing-soap in the blanket or in the crevices of the washing-machine; so the first time a used blanket is washed the results may be disappointing. However, the second time the blankets are washed in a clean machine the results are very satisfactory.

(*h*) MINISTRY OF HEALTH (1954) *Report of Central Pathology Committee* (HM/54/118).

Blankets, pillows, mattresses (hair, flock, spring interior)

These articles should be sterilized by steam under a pressure of 5 lb. for 30 minutes (after a preliminary vacuum of 18-20 inches), which is equivalent to a temperature of approximately 100°C. Sterilization at pressures of 15-20 lb. (=120°C or over) has a destructive action on the fabrics. The appropriate pressure may be obtained by the use of reducing valves or preferably by the use of a separate control valve to operate at 5 lb. pressure. Blankets should not be tightly packed and should be carefully dried. Spring interior mattresses must not be bent.

ST. THOMAS' HOSPITAL

RESULTS OBTAINED IN THE EXPERIMENTS

Blankets conforming to BSI Specification 1681/1951, white, 4 lbs., 66″ x 86″.

Blanket	Size of New Blanket	Temperature of Wash	Duration of Wash	Washing Material	Temperature of 1st Rinse	Temperature of 2nd Rinse	Temperature of Tumbler	Blanket Size after 1 wash	Blanket Size after 20 washes
1.	69¼″x87¼″	212°F	10 mins.	Teepol	160/110°F	80°F	160°/210°F	70″x85½″	67⅛″x86″
2.	69½″x88½″	60°/212°F	22 mins.	Teepol	120°F	—	160°/210°F	68″x86″	68½″x85⅛″
3.	70¼″x89¾″	212°F	5 mins.	Soap, Sodium Metasilicate	120°F	—	160°/210°F	62¼″x83½″	—
4.	70⅛″x88¾″	140°F	10 mins.	Teepol	100°F	—	160°/210°F	68½″x87″	67½″x85⅛″

If a large type of steam sterilizer is not available, bedding may be disinfected by fumigation with formalin vapour in an air-tight chamber. The vapour, which is most effective in a high relative humidity and warm atmosphere, has little penetrative power and bedding must be so arranged that the vapour has access to all contaminated surfaces.

(*i*) RAVENHOLT, O. H.; BAKER, E. F.; WYSHAM, D. N.; GIEDT, W. R. (16.6.58) *Hospitals Journal of the American Hospital Association,* Vol. 32 p.75.

Preliminary studies indicated that the most promising group of disinfectants . . . might be the synthetic phenolic compounds. These disinfectants:

(1) destroy all common pathogenic bacteria, including the tubercle bacillus;
(2) are not neutralized by common soaps or detergents,
(3) are not harmful to wool fabrics,
(4) do not have an unpleasant odour,
(5) are nevertheless economical.

. . . On the basis of these findings, the synthetic phenol appears to be a suitable compound for use in blanket disinfection procedures.

(*j*) PRESSLEY, T. A. (1959) *Lancet ii.* 987.

Woollen blankets can be brought to a standard of sterility at least as high as that of normal cotton ward-blankets by gaseous sterilisation with ethylene oxide or propylene oxide, or as a normal laundry procedure by boiling at pH value not greater than 7.

(*k*) ST. ALFEGE'S HOSPITALS, GREENWICH (1959) *Questionnaire.*

Blankets used in the nursing of patients on barrier nursing are subjected to disinfection at ward level by soaking in a solution of Hibitane (chlorhexidine). They are then treated again at the laundry using the same disinfectant and then washed with a normal blanket wash process :—

Stage	*Time*	*Temp.*	*Detergent/Sterilizing Agent*
Wash	10 mins.	110°F.	1 pt. Lissapol N per 110 lb. dry weight
Rinse I	3 mins.	110°F.	
Rinse II	3 mins.	110°F.	1 pt. of Q.A.C.: 10% Solution

During the whole process interrupter gear attached to the washing machine is set at a 2:1 ratio.

Hydro 5 mins.

Drying Cabinet 120 mins. 160°F.

(*l*) St. Helen's and District H.M.C. (1958) *Report.*

The bacterial content of woollen blankets can be reduced to almost nil by processing with Syndet 54 and Cirrasol and subsequent packing in sterile polythene bags.

(*m*) Southampton H.M.C. (1959) *Letter.*

The use of Cirrasol proved costly, and after 18 months the blankets were badly felted. We then changed to Hytox and after a year this has proved economical and satisfactory from all aspects.

(*n*) Royal Melbourne Hospital (1959) *Central Linen Service & Group Laundry Report.*

Sterilization of Shrink-Resistant Woollen Blankets by Boiling:

(a) *Detergent Mixture*

Alkanate T40 (Commonwealth Fertilizers and Chemicals Ltd.). 1 gallon.*

Sodium bisulphite 3½ ounces.

Powder the bisulphite with a pestle and mortar and slowly add the Alkanate. Keep stoppered and prepare a fresh solution weekly. Other commercial preparations of similar chemical composition are also available.

* Alkanate T40 is triethanolamine dodecylbenzene sulphonate containing 40 per cent. active ingredient.

(b) *Washing Technique*

Fill the washing machine with warm (40°C., 104°F.) water, add detergent mixture at the rate of 1 pint per 100 gallons, wash with intermittent, slow agitation for 3 minutes. Dump liquor. Again fill the machine with warm water, add a further charge of detergent (1 pint per 100 gallons), raise to the boil as rapidly as possible (not exceeding 8 minutes) with agitation. Turn over a few times and dump. Rinse with cold water, hydro (for 2 minutes) and tumble dry.

(c) *General*

Use ample water, not more than 2½ lb. of blanket per cubic ft. A slow speed machine is desirable.

If severe stains (e.g. blood, faeces, food) are present, these must obviously be removed before heating. Any method at the discretion of the laundry manager may be used, but if this preliminary work is done under alkaline conditions the blankets must be thoroughly rinsed and finally "soured" with acetic acid to a pH below 7 prior to boiling.

The amount of sodium bisulphite suggested is a guide only, the quantity needed depends on the water supply and laundry conditions.

For smaller institutions shrink-resistant blankets can be sterilised in a domestic copper by plunging them into boiling water in the complete absence of soap or other alkaline preparations.

Whilst it is felt that this method will provide a fairly satisfactory blanket for hospital use, experiments are still proceeding with bacteriostatic rinses which may conceivably play a very important part in the future in the fight against hospital cross-infection.

(*o*) C.S.I.R.O. WOOL RESEARCH LABORATORIES (1959) *Progress Report.*

The widely-held belief that wool cannot be boiled is incorrect. Wool can be boiled safely under acid conditions, the pH of maximum stability being near 3. The prejudice against boiling has arisen because the traditional detergents such as soap are effective only in alkaline solution which causes wool to discolour and eventually to disintegrate at high temperatures. However, inexpensive detergents that are effective under neutral or slightly acid conditions have recently become available, making possible the high-temperature laundering of woollens, with consequent sterilisation.

(a) *Method for sterilising unsoiled blankets*

If a side-loading washing machine is available, sterilisation is achieved with the greatest output from the machine and least discoloration of the blankets by dropping the dry blankets directly into a solution of the detergent as near to boiling point as is practicable. The machine is closed, water brought to the boil as rapidly as possible and boiled with slow agitation for whatever time is considered necessary for sterilization. (In the laboratory tests boiling was continued for 5 minutes). The boiled blankets are rinsed in cold water, hydro-extracted and tumble dried.

In a laboratory test of this method using a commercial, shrink-resistant blanket, the washing and drying cycle was repeated 40 times without apparent loss of strength of the blanket, and with a felting shrinkage of less than 2 per cent. (linear) in both the length and width of the blanket. The loss of colour was slight. Boiling repeatedly in water alone or with other detergents (such as soap) gives a colour intensity comparable with that of the sample boiled in nonionic detergent.

(b) *Method for washing and sterilising soiled blankets*

Soiled blankets cannot be heated prior to cleaning or contaminating protein will be coagulated and fixed and a second washing method is therefore suggested for soiled blankets. The blankets should first be soaked if necessary to remove gross soiling, then washed in detergent solution at about 40°C. (104°F.). This liquor should then be dumped, hot water run into the washing machine, more detergent added, and this fresh solution brought to the boil as rapidly as possible. After a short boil (1 to 4 minutes, depending on the time taken to reach boiling point) the blankets are given a cold rinse, hydro-extracted and dried.

Conclusions

Blankets can be boiled, without serious colour loss or other damage in a solution (½ to 1 pint per 100 gallons) of Alkanate T40 to which sodium bisulphite has been added. The amount of bisulphite required will depend on laundry conditions but 2 lb. per 10 gallons of Alkanate T40, or 0.01 per cent. of the weight of blankets washed, is suggested for trials.

Soiled blankets should be washed in the detergent solution at low temperature, this liquor dumped, and the blankets boiled in a fresh solution of detergent.

(*p*) Copenhagen Municipal Hospital Service (1959) *Letter.*

. . . the Municipal Hospital Service also uses all wool blankets (1) as supplement to the "Dyne"; (2) in the physiotherapy departments and out-patients departments and (3) as cover for patients during transport within and outside the hospitals.

For these purposes the hospital service uses a total of nearly 18,000 wool blankets.

Until a year ago the washing procedure for these blankets was the following:—

(1) Initial rinse with high water level in the washing machine.

(2) Washing for 12 minutes with an alkaline soap product at 35° Celsius.

(3) Four rinses with high water level. To the last rinse was added hydrogensiliciumfluorid.

As this procedure was not satisfying from a bacteriological point of view we now use this:—

(1) Initial rinse with high water level (3 minutes)

(2) Washing with a solution of 80 per cent. soap powder at 60° Celsius (15 minutes)

(3) Four rinses with high water level. To the last rinse is added formic acid.

This technique has been used for a year now and so far the blankets have not shown any deterioration.

It should finally be mentioned, that it has been tried to minimise airborne infection through "oiling" of the blankets with a special compound. The result of the trial was that the procedure is considered to be too complicated, and that the washing machine as well as the floor in the laundry became oily.

APPENDIX K.

Cleansing and sterilization of cotton blankets.

(*a*) SHEFFIELD R.H.B. (1959) *Report.*

Cotton blankets on the other hand may be subjected to laundering at high temperatures without detriment to the fabric and the process used in the tests as outlined in Appendix* at temperatures at or above pasteurisation temperatures produced an article as near sterile as could be obtained. As the dirt and bacteria were removed in the wash, the high temperatures apparently killed any remaining vegetative bacteria. The continuous wash process was used, but in laundries where machines of this type are not installed, the normal white-work process, including a boil, can be used with equally good results.

*Appendix—LAUNDERING PROCESS FOR COTTON BLANKETS

(Continuous Wash)

	Temp.	*Time (mins.)*
1. Wash (Escolite, Comprox TL Soap)—		
(a) Cotton Cellular	160-170°F	10
(b) Turkish Towelling	180-200°F	10
2. Rinse	Cold	6
3. Hydro extraction	—	10
4. Dried on continuous belt.........	200-212°F	15

(*b*) POPE, E. A. (1959) *Nursing Times Vol. LV. No. 5, p. 133.*

The washing process used in The London Hospital laundry is as follows:

Cotton terry and raised cotton blankets are washed in hard washing soap and soda, 2 lb. and 2½ lb. respectively to 120 lb. weight of washing, brought to boiling temperature and kept at 180°F. for 10 to 15 minutes. This entire washing process takes one hour. The blankets are then dried in the tumbler, starting at a temperature of 100°F. and rising to 220°F., and this procedure lasts for 20 minutes. Cellular blankets are washed in water up to 100°F. and dried in an air speed drier for 15 minutes, starting at a temperature of 180°F. and rising to approximately 260°F.

(*c*) MIDDLESEX HOSPITAL (1959) *Letter.*

The Bacteriologist has reported that from his point of view cotton blankets are the only satisfactory ones as they can be autoclaved, a process which destroys woollen blankets. The Laundry Manager has also undertaken experiments. He has found that certain types of cotton blanket shrink a great deal at the first wash or so, but once allowance has been made for this, they are preferable to woollen or Terylene ones.

(*d*) ST. GEORGE'S HOSPITAL (1959) *Report.*

Disinfection. The method at present in use is by autoclave process in a Manlove Alliott steam autoclave. Formaldehyde is added in the process. Recently a Sparkhall disinfector has been installed and this will be put into use . . .

(*e*) ST. HELIER H.M.C. (1959) *Questionnaire.*

The boiling process for cotton appears to be cheaper than the Q.A.C. process but both methods effectively sterilize the material. It is too early to compare the length of life of each type, but it would seem that wool will last the better.

(*f*) SOUTHAMPTON H.M.C. (1959) *Letter.*

The cotton blankets boil very well, but are inclined to become discoloured. We are, therefore, using a Hytox wash for these also. Only time will show the comparison of durability between the woollen and the cotton blanket.

. . . Cotton blankets, sealed in plastic bags, will be issued direct from the laundry.

(*g*) CELLULAR COTTON BLANKET MANUFACTURER (1959) *Letter.*

. . . we have never laid down any definite procedure to be used on our blankets but have left this to the individual hospitals, as obviously the amount of soiling, etc., must vary depending on the type of hospital at which they are used. One Northern hospital has washed our blankets 250 times using Lissapol with a small amount of sodium metasilicate and this does not appear to have had any detrimental effect on the blanket.

We think that the most effective method of sterilisation combined with the least damage to the fabric is by boiling. Boiling does appear to be the best method of destroying bacteria and is less detrimental to the fabric than any chemical processes. In the case of blankets which require sterilising but not washing, we feel the best method would be to sterilise in an autoclave.

(*h*) TOWELLING BLANKET MANUFACTURER (1959) *Letter.*

We do not think there is any need to recommend a method of laundering, as a feature of the blanket is that it is very easy to wash; there are very few ways of spoiling it, and a normally equipped hospital laundry should have no difficulty in getting thoroughly satisfactory results. However, if specific instructions are required, we recommend that the blankets be washed as for cotton towelling in a rotary washing machine, always with part of the process at the boil in order to obtain effective sterilisation. They should be hydro-extracted, and dried in a tumbler drier or cottage drier. Chlorine bleach should be used only with the greatest caution because it rots cotton, and calender driers should not be used because they flatten the pile and spoil the heat insulation quality of the blanket. However, accidental calendering is easily corrected in a second wash.

(*i*) SHIRLEY INSTITUTE (1959) *Letter.*

No doubt the first requirement of any cleansing process to be applied to hospital blankets is that it should render them completely sterile, and this is a point which the hospital authorities will have to examine to their own satisfaction. The rate of chemical deterioration of cotton in boiling water, or even in an autoclave in the absence of air up to temperatures of 120°C., is very slight and in fact most of the deterioration that occurs in laundering is a result of the mechanical treatment in the wet state. It is therefore to the mechanical conditions of laundering that most attention should be given if it is desired to ensure the greatest life of cotton materials in use. We assume, of course, that substances such as sodium perborate or hypochlorite that degrade cotton chemically would be excluded from use.

APPENDIX L.

Re-contamination of blankets.

(*a*) THOMAS C. G. A.; LIDDELL, J.; CARMICHAEL, D. S. (1958) *British Medical Journal ii. 1336.*

When considering laundry hygiene, attention should not be directed solely to the process of washing. It is clearly important to see that freshly washed articles are not recontaminated.

In sorting dirty articles of clothing in a laundry it is usual for air contamination to reach high levels. Again, large laundries have powerful appliances which by design or accident draw in large volumes of air and then expel dust or aerosols into the environment. Obviously it is important that this contaminated air should not have access to regions of the laundry where freshly laundered articles are exposed.

By very simple methods—exposing plates to the air during normal working conditions, producing artificial contamination with aerosols of an easily recognisable organism, and studying the prevailing air currents with smoke—it is possible to detect those sources of contamination.

We cannot generalise on the steps which should be taken to remove such sources of contamination, since these will largely depend on the layout of individual laundries. However, it seems likely that quite simple alterations in ventilation or the resiting of machinery or sorting rooms and store-rooms will usually improve the hygiene of laundries where these defects still exist.

(*b*) FRISBY, B. R. (1957) *British Medical Journal ii. 506.*

The method of washing using Cirrasol thus brought about a very substantial reduction not only in the counts obtained from clean blankets but also in those from the dirty ones, indicating an accumulation of bactericidal agent in the blankets over the period.

(*c*) COWLING, D. C. (1959) *Lancet i. 987.*

The rise in bacteriological counts on boiled woollen blankets after a few days was as follows:

Type of blanket	Number counted	Mean of counts	Type of organism
Blanket from laundry machine	12	3.5	Nearly all bacillus
Blanket from ward before use	12	6	A few staphylococcal species
Top blanket 1 day of use	12	45	Mainly ,, ,,
,, ,, 2 days' use	12	112	,, ,, ,,
,, ,, 3 ,, ,,	11	209	,, ,, ,,
,, ,, 5 ,, ,,	10	215	,, ,, ,,
,, ,, 9 ,, ,,	11	421	,, ,, ,,
,, ,, 11 ,, ,,	4	420	,, ,, ,,

(*d*) St. Helier H.M.C. (1959) *Questionnaire.*

Recontamination of blankets by airborne bacteria in the laundry after processing is a very real danger, and measures should be taken to see that the laundry is properly ventilated, and that blankets are not left lying around unpacked and unprotected.

(*e*) London Hospital (1959) *Questionnaire.*

Cotton and woollen blankets are, for all practical purposes, sterile after laundering. After three days the contamination of both wool and cotton is the same.

(*f*) Frisby, B. R. (1959) *Letter.*

I have tested the Lissapol-Cirrasol method of cleansing cotton blankets and have found that it brings about a remarkable reduction, not only of the counts of the blankets when cleansed, but of the counts of blankets when dirty. The sample applies to the presence of Staphylococcus aureus in the blankets. It is no use just boiling the cotton blankets, as we have shown that they rapidly become heavily infected as do the untreated woollen ones. These facts were reported at the recent "Symposium on the Staphylococcus" held at the British Postgraduate Medical School, Hammersmith, in July, 1959.

(*g*) St. Helen's & District H.M.C. (1959) *Letter.*

It has been found more satisfactory to wrap the clean blankets in cellophane sheeting rather than in polythene bags and that the use of fibreboard boxes to convey the blankets back to the wards has been an important step in maintaining cleanliness by protecting the cellophane from tears during transit.

(*h*) Chatham Manufacturing Co., U.S.A. (1959) *Advertisement in The Modern Hospital.*

It is no longer necessary to ruin blankets by sterilisation at high temperatures or repeated immersion in strong germicides. The new Hygienated process gives lasting bacteria resistance that will not wear off, will not wash out, is assured for the life of the blanket.

(*i*) Permachem International Ltd., Nassau (1959) *Letter.*

Many U.S.A. hospitals are using the Permachem laundry formulation to treat all of their blankets, linen and patient's garments. These give the garments bactericidal/bacteriostatic properties which kill most pathogens on contact with the material.

(*j*) KLENZADE PRODUCTS LTD., U.S.A. (1959) *Product specification.*

Klenzade Klenz-stat, formula XC-800, is a chlorophenolic type bacteriostatic treatment for the final rinse operation in laundry procedures. When incorporating Klenz-stat in a wash formula, it is added to the final rinse just prior to souring. Chemically it is ortho-benzyl-para-chlorophenol.

Klenz-stat is used specifically for the control of transient bacteria in the final rinsing of blankets, linens, clothes and diapers. Bacteriostatic activity is in effect in the clothes fibres long after the clothes have dried, thus increasing the usefulness of Klenz-stat in the control of nosocomial infections.

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