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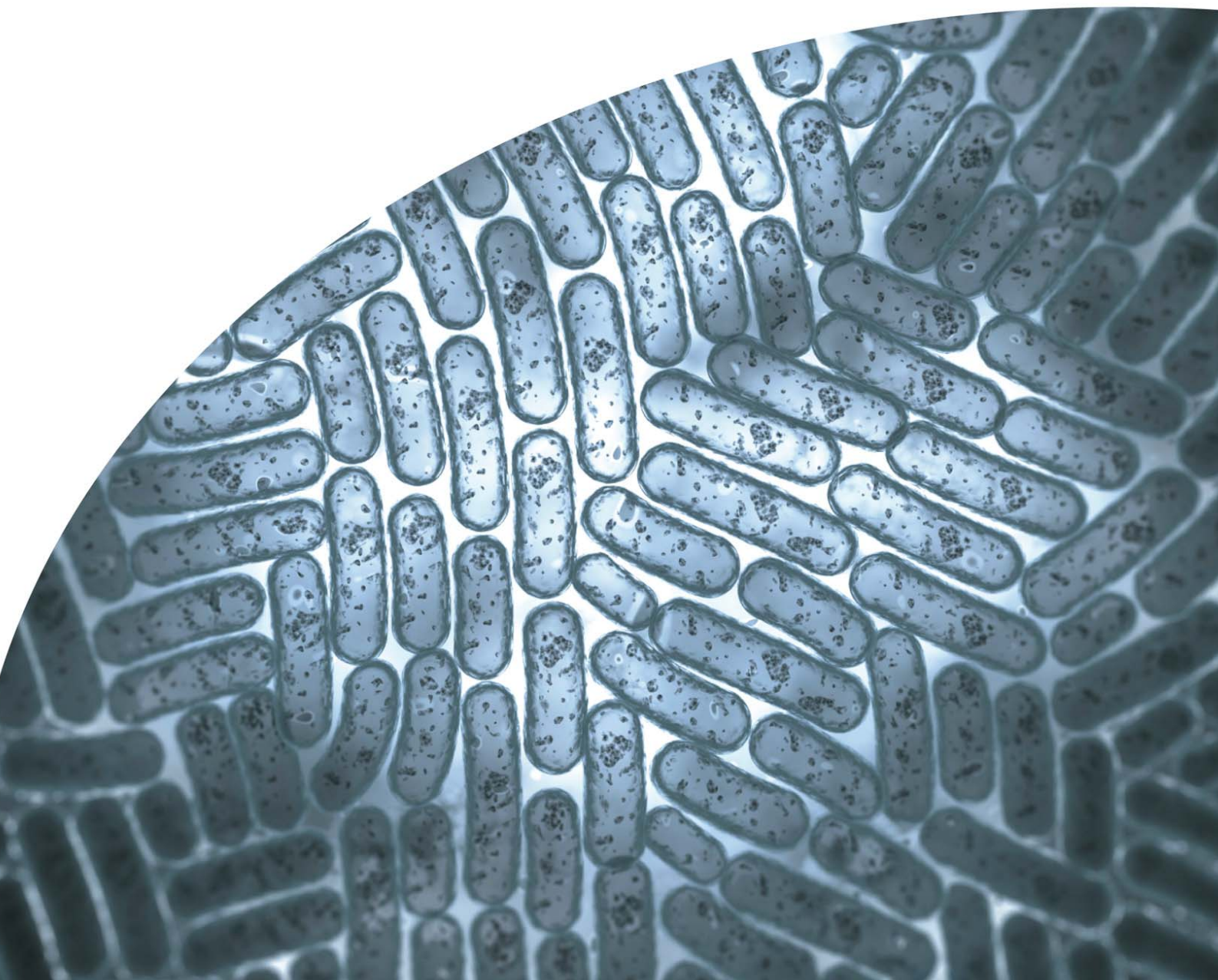
The Results

Using technology to help fight infection

HCAI Technology Innovation Programme

Showcase Hospitals report number 3

The Bioquell Hydrogen Peroxide Vapour (HPV) Disinfection System



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Policy	Estates
HR / Workforce	Commissioning
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Clinical	Social Care / Partnership Working

Document Purpose	For Information
Gateway Reference	12383
Title	The Healthcare Associated Infections (HCAI) Technology Innovation Programme: Showcase Hospitals Reports No.to be assigned: The Bioquell Hydrogen Peroxide Vapour (HPV) Decontamination System
Author	Department of Health/NHS Purchasing and Supply Agency
Publication Date	17 Aug 2009
Target Audience	PCT CEs, NHS Trust CEs, Care Trust CEs, Foundation Trust CEs , Medical Directors, Directors of Nursing, Directors of Infection Prevention and Control
Circulation List	
Description	The document reports on in use evaluation of the Bioquell Hydrogen Peroxide Vapour (HPV) Decontamination Service in selected Showcase Hospitals.
Cross Ref	N/A
Superseded Docs	N/A
Action Required	N/A
Timing	N/A
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For Recipient's Use	

The Healthcare Associated Infections (HCAI) Technology Innovation Programme

The basic ways of preventing and reducing healthcare associated infections (HCAs) are largely unchanging. The principal strategies for combating HCAs are those associated with hand hygiene/aseptic techniques, prudent antibiotic prescribing and good clinical practice. However, new technologies and equipment can support these strategies by helping get things done differently, more swiftly or more reliably.

As part of the strategy set out in *Clean, Safe Care*¹ the Department of Health is funding the HCAI Technology Innovation Programme². The Programme aims to

- Speed up the development and adoption of technologies to further help combat HCAs
- Identify which new technologies provide the best value and will have the most impact

The Showcase Hospitals Programme

In 2004 the Department of Health set up the Rapid Review Panel (RRP) to “provide a prompt assessment of new and novel equipment, materials and other products that may be of value to the NHS in improving hospital infection control and reducing hospital acquired infection”. The RRP does not undertake any product trials itself but makes recommendations based on written evidence provided by industry.³ The highest recommendation (Recommendation 1) is

Basic research and development, validation and recent in use evaluations have shown benefits that should be available to NHS bodies to include as appropriate in their cleaning, hygiene or infection control protocols.

As part of the HCAI Technology Innovation Programme, technologies which have gained a RRP Recommendation 1 are being placed in up to 7 Showcase Hospitals around the country for periods up to six months during which time a detailed evaluation of their in-use and economic features along with adoption characteristics is undertaken. Costs of the technologies are met centrally. The current Showcase Hospitals are The Royal Wolverhampton Hospitals NHS Trust, Imperial College Healthcare NHS Trust, Calderdale and Huddersfield NHS Foundation Trust, Southampton University Hospitals NHS Trust, County Durham and Darlington NHS Foundation Trust, The Lewisham Hospital NHS Trust and Central Manchester University Hospitals NHS Foundation Trust.

These are service evaluations, as defined by the National Patient Safety Agency’s National Research Ethics Service, and do not therefore require Research Ethics Committee review.⁴

¹ Clean, safe care: Reducing infections and saving lives. Department of Health, 9 January 2008.

² For further information on the Programme see <http://www.clean-safe-care.nhs.uk/index.php?pid=28>

³ For more information on the Rapid Review Panel see <http://www.hpa.org.uk/webw/HPAweb&Page&HPAwebAutoListName/Page/1158313434380?p=1158313434380>

⁴ See leaflet on defining research at <http://www.nres.npsa.nhs.uk/news-and-publications/publications/nres-research-leaflets/>

Acknowledgements

We would like to acknowledge the support of the NHS Purchasing and Supply Agency Centre for Evidence-based Purchasing and NHS National Technology Adoption Centre in the compilation of this report.

Showcase Hospitals report number 3

The Bioquell Hydrogen Peroxide Vapour (HPV) Disinfection System

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Executive summary

The Department of Health has set up a Rapid Review Panel (RRP) to assess new and novel technologies and consider their potential for reducing hospital infections. As part of the Department's Healthcare Associated Infections (HCAI) Technology Innovation Programme, technologies that have received an RRP1 recommendation ("basic research and development, validation and in-use evaluations have shown benefits that should be available to NHS bodies") have been placed in selected Showcase Hospitals for review of their acceptability in everyday use and to gather information that may be useful for other hospitals.

Bioquell's hydrogen peroxide vapour (HPV) disinfection system disinfects hospital areas and equipment which can be sealed off during the decontamination process. Bioquell's hydrogen peroxide vapour (HPV) disinfection system was awarded Rapid Review Panel (RRP) recommendation 1 in 2007.

The system was used in seven Showcase Hospitals for four months to disinfect patient rooms, clinical areas and equipment. In total 2,093 rooms were disinfected, with a total room volume of 113,345 m³. There were wide variations in usage between the Showcase Hospitals and from week to week within them, with the main issue being the availability of rooms for disinfection at the times when the Bioquell engineers were available.

The Bioquell system did not cause undue disruption and was very popular - 99% of staff would recommend it. Patients too generally liked the system and were reassured to know that rooms were disinfected. Good communications between bed managers, facilities and estates departments and the Bioquell engineers help minimise disruption.

The system is available as a fully managed service and for purchase for use by trained staff employed either by the trust or by Bioquell.

Keywords: Hydrogen peroxide vapour, Bioquell, HCAI, Rapid Review Panel

Introduction

This report sets out the findings from an evaluation in NHS Showcase Hospitals of the in-use and economic features and adoption characteristics of the Bioquell Hydrogen Peroxide Vapour (HPV) disinfection system. The Rapid Review Panel which assesses new and novel products which may help infection prevention and control has concluded that basic research and development, validation and recent in-use evaluations have shown benefits that should be available to NHS bodies to include as appropriate in their cleaning, hygiene or infection control protocols.

The objective of this document is to help Directors of Infection Prevention and Control and other stakeholders to decide whether they should consider the Bioquell system as part of their trust's strategy to reduce healthcare associated infections.

The problem Environmental contamination

Patients rightly expect hospitals to be clean and to deliver safe care. Several studies have shown that some micro-organisms, such as bacteria, viruses and fungi, are not killed effectively by standard cleaning^[1,2].

The product The Bioquell HPV Disinfection System

Bioquell HPV technology consists of a mobile vapour generator which vaporises 30% w/w aqueous hydrogen peroxide (H₂O₂) to facilitate total disinfection of hospital areas and equipment. Hydrogen Peroxide Vapour (HPV) is an oxidising agent. When it comes into contact with micro-organisms it oxidises the cells or spores, thus deactivating them. An HPV generator delivers hydrogen peroxide vapour at high speed, ensuring distribution to all parts of a room. A very fine layer of micro-condensation is formed on all exposed surfaces, deactivating micro-organisms.

HPV can be used to reach awkward inaccessible areas. However, areas not exposed to the vapour are not disinfected, so all surfaces have to be positioned for optimum exposure. Soiling reduces the efficacy of HPV³, so surfaces to be disinfected must be clear of soil.

HPV is hazardous to human health, so it can only be used in areas that can be emptied of patients and staff and sealed during the disinfection process.

HPV monitoring equipment is used to ensure that

- the necessary levels of HPV have been reached and maintained;
- there is no leakage; and
- the level of HPV has returned to safe levels before re-entry.

The process is controlled from outside the room by a computer, which provides feedback about progress to the operators.

Bioquell HPV disinfection must be used in addition to standard cleaning, not as a substitute for it. The technology can be deployed in two ways:

- The manufacturer's engineers can provide a fully managed disinfection service (as in this evaluation); or
- A hospital can purchase BioquellZ HPV generators and use either trust or Bioquell staff to undertake the HPV disinfection.

The Bioquell HPV system received an RRP 1 recommendation in 2007.

The knowledge base

What was known before this evaluation

HPV technology has been shown to be effective against a wide range of pathogens^[3,4,5]. It is highly effective in killing meticillin resistant *Staphylococcus aureus* (MRSA)^[1], and has been shown to help reduce disease associated with *Clostridium difficile*^[6].

The extent to which HPV disinfection provides any ongoing protection appears to be variable. In a study of HPV disinfection in an open-plan intensive care unit, HPV eliminated MRSA, but recontamination of the ward occurred quickly following readmission of patients colonised with MRSA^[7]. An American prospective study comparing a 10 month preintervention period with a 10 month intervention period found that intensive HPV disinfection of 5 high-incidence wards followed by hospital-wide HPV disinfection of rooms vacated by patients with *C. difficile*-associated disease reduced the incidence of disease by 44% in the high incidence wards, by 38% in the hospital as a whole, and by 53% in months in which a particular epidemic strain was present during both the preintervention and intervention periods^[8], though these results are yet to be supported by other studies. Recent evidence suggests that patients occupying rooms disinfected with HPV have reduced rates of vancomycin-resistant enterococcus and MRSA^[9].

HPV is particularly useful for disinfecting non-porous surfaces on furniture and on equipment that is difficult to disinfect manually.

Practical difficulties have been noted around the need to empty high-occupancy units during the disinfection process. A study conducted in a busy American hospital, concluded that disinfection of selected patient rooms was achievable, although more rooms were missed at times of high occupancy^[10].

The evaluation

How the evaluation was done

As part of the Showcase Hospitals programme, the Bioquell HPV service was introduced for 4 months in selected NHS hospitals with the aim of establishing

- how far it could be used to disinfect side-rooms in the time between a patient being discharged and a new patient being admitted
- how many rooms and wards could realistically be disinfected in a given time
- how far it could provide productivity markers to demonstrate value for money

- whether it was flexible enough
- whether it would fit in with hospital routines and departmental needs
- whether it could provide an overnight disinfection/delivery service for specific hospital wide equipment
- whether it could provide a ward-based equipment disinfection service. For example, could a storeroom or bathroom be used to disinfect ward equipment overnight or during the day?
- whether it could be used effectively in situations requiring a rapid response

The intention was that, at each hospital, the manufacturer would provide two trained engineers, three HPV generators and all the necessary consumables. However, at several sites only two HPV generators were actually provided.

Beforehand, the manufacturer carried out site surveys to develop plans and agree work schedules with the hospitals. The manufacturer also conducted awareness sessions with staff, in particular Estates & Facilities and Health & Safety departments.

The service was in place from 9:00 to 5:00, Monday-to-Friday, although the working hours were changed by negotiation with the engineers to suit particular hospital requirements.

The Bioquell system is not intended to, and did not, replace standard cleaning. All rooms and equipment continued to be cleaned in the usual way. Bed managers, ward staff and infection control teams identified rooms for HPV disinfection, and the disinfection was done by the Bioquell engineers.

Weekly reports were produced showing:

- the number of rooms disinfected
- the size of the rooms
- the time each room was available for disinfection
- the time each disinfection began and ended
- the time the room was available for patient use
- the number of additional pieces of equipment disinfected
- Any rooms not successfully disinfected, along with a reason for the omission, and any other problems which arose.

Information on the views of staff and patients on a range of issues, including those relating to suitability, accessibility, and the usability of the Bioquell system, was collected through interviews and questionnaires.

Did Bioquell reduce infection?

This evaluation was not designed to assess the effectiveness of Bioquell in reducing infection. However, one site reported that there appeared to be a downward trend in *C. difficile* cases, and in one ward which had been disinfected no further *C. difficile* cases occurred.

How many rooms were disinfected?

Across the seven Showcase hospitals a total of 2,093 rooms with a total room volume of 113,345 m³ were disinfected using the Bioquell system. Around 60% of rooms were disinfected as they became vacant or as part of a hospital disinfection schedule. Other reasons why rooms were selected for disinfection included MRSA (around 15%), *C. difficile* (around 9%), diarrhoea and vomiting, hepatitis B and C, norovirus, pseudomonas and salmonella as well as other high risk patients and refurbishments, recommissions and deep cleans.

There were wide variations between the Showcase Hospitals in terms of the types of room and the room volumes that were disinfected, and there were also wide variations from week to week.

Figure 1 shows the average room volume disinfected in a week in each showcase hospital.

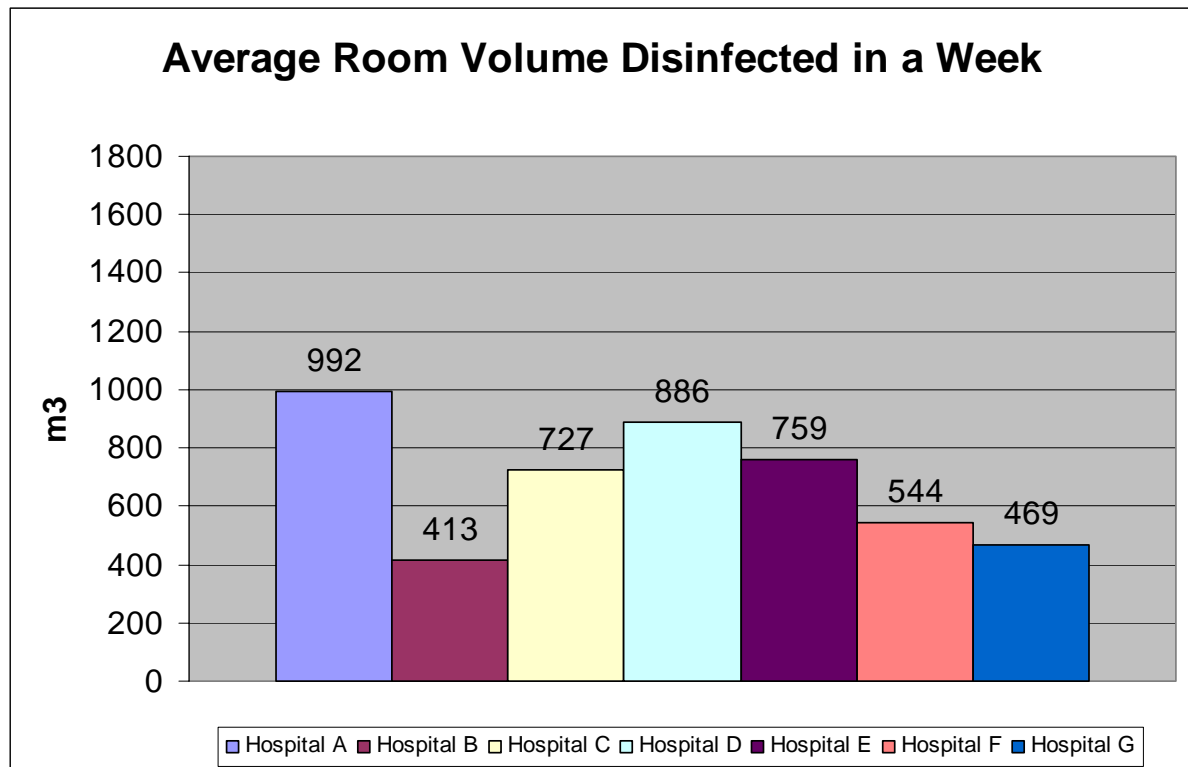


Figure 1: Average room volume disinfected in a week

Figure 2 shows the maximum room volume disinfected in a week in each showcase hospital.

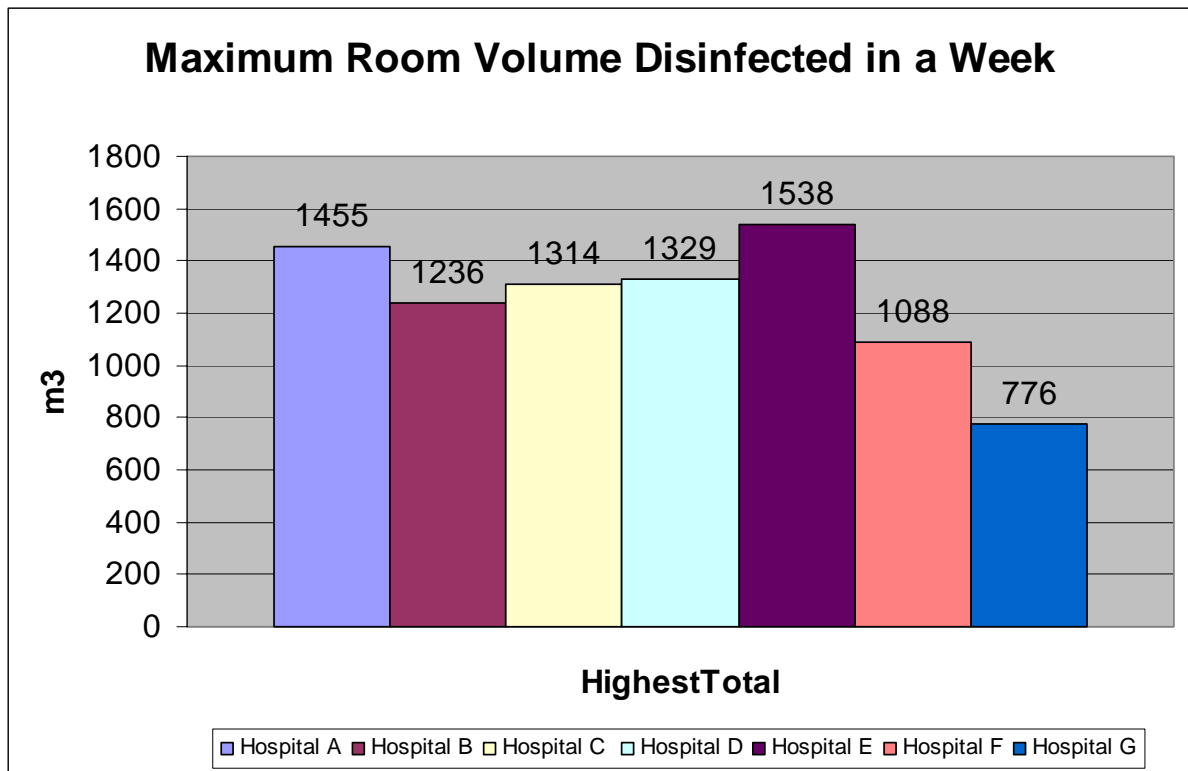


Figure 2: Maximum room volume disinfected in a week

Figure 3 shows the percentage of the maximum room volume represented by the average room volume disinfected in a week.

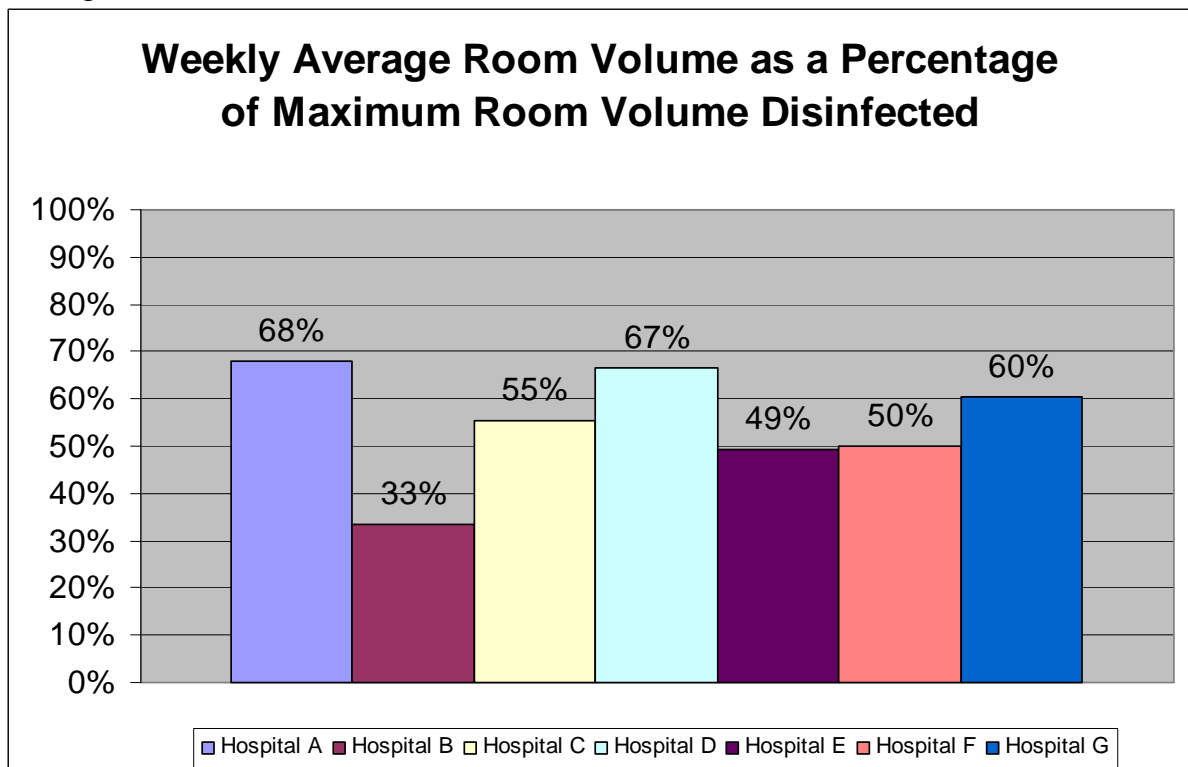


Figure 3: Weekly Average Room Volume as a Percentage of Maximum Room Volume Disinfected

Figure 4 shows the percentages of the average room volume accounted for by single rooms, rooms with more than 1 bed, and rooms with no bed at all (for example, bathrooms, treatment rooms).

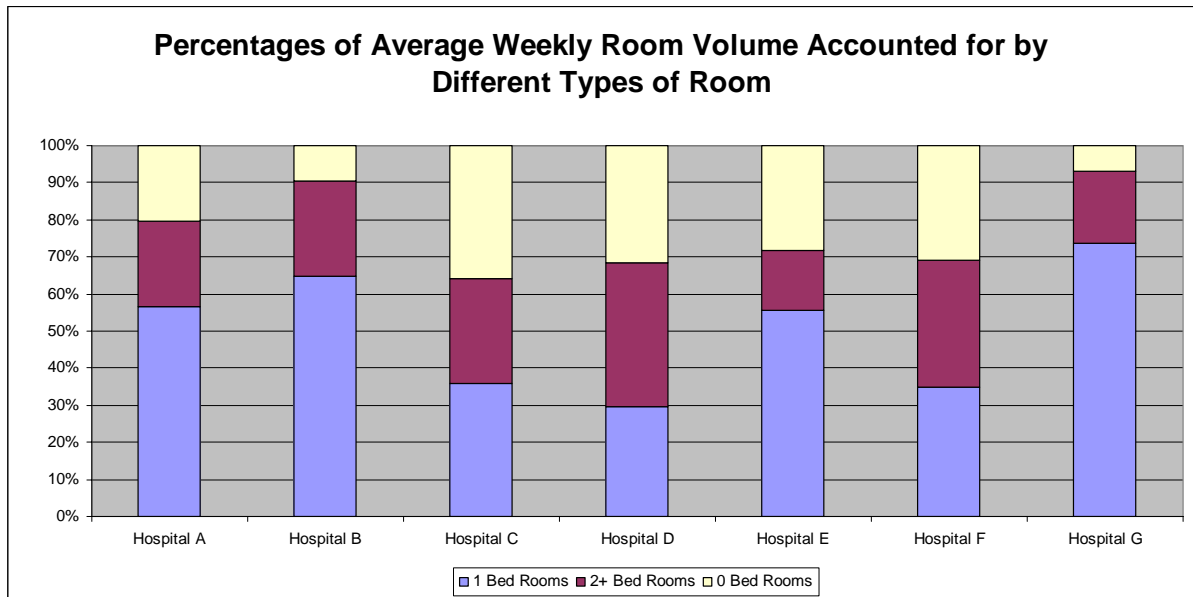


Figure 4: Percentages of Average Weekly Room Volume Accounted for by Different Types of Room

Figure 5 shows the total room volume disinfected each week in each of the Showcase Hospitals.

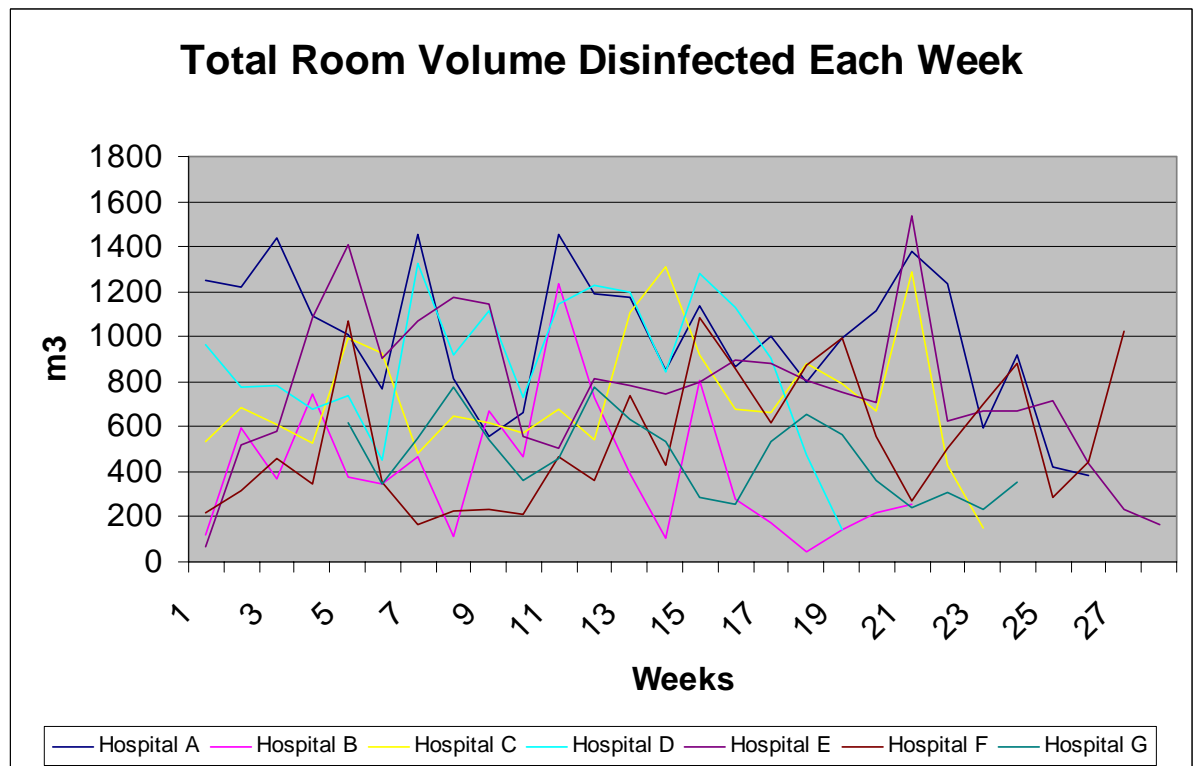


Figure 5: Total Room Volume Disinfected Each Week in Each Showcase Hospital

Figure 6 shows the total number of rooms disinfected each week in each Showcase Hospital.

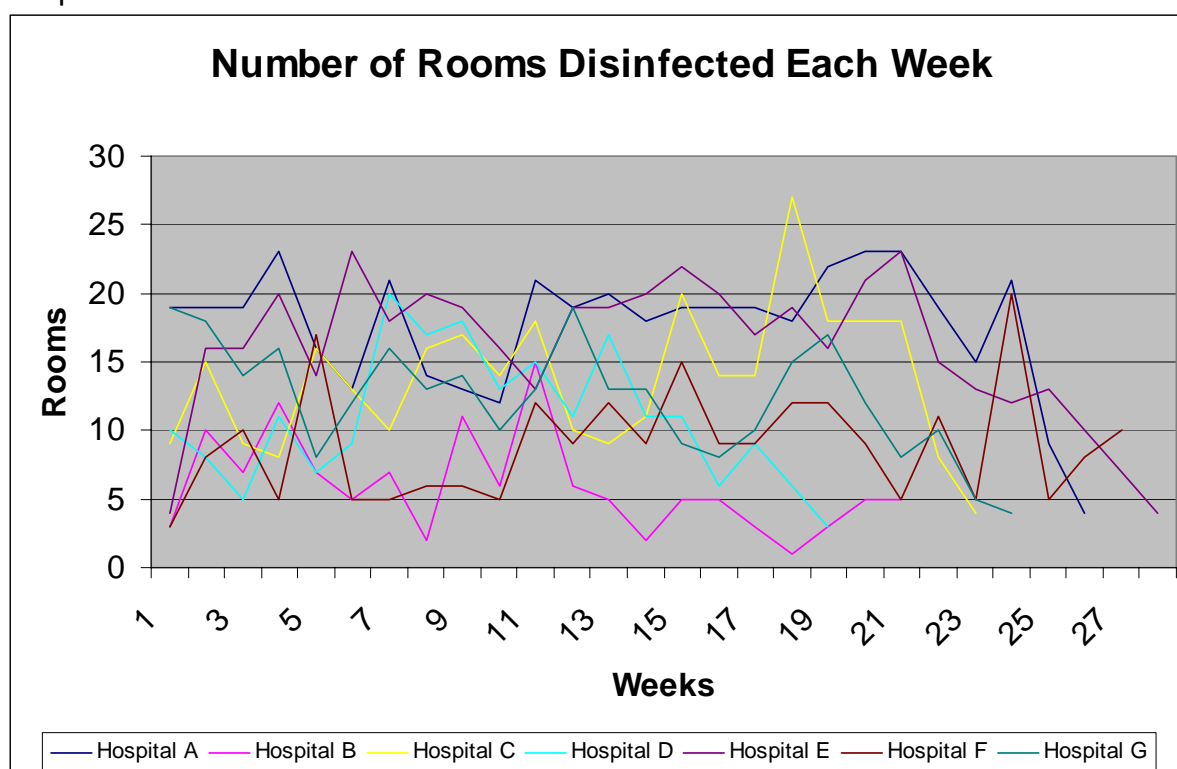


Figure 6: Number of Rooms Disinfected Each Week in Each Showcase Hospital

All these variations are clearly significant in terms of the cost effectiveness of the disinfection programme. In this evaluation, the cost of the Bioquell service was a fixed rate for the hours of service set out above. Under this form of contract, payment is unaffected by the proportion of idle time during which Bioquell staff are not actively engaged in disinfecting rooms. The greater the number of rooms and/or the greater the room volume disinfected each week, the more cost effective the service will be. For example

- The highest number of rooms disinfected in a week was 27, at a cost of £138.58 per room. The lowest was 1, at a cost of £3741.75
- The highest room volume disinfected in a week was 1,538 m³ at a cost of £2.43 per cubic metre. The lowest was 44 m³ at a cost of £78.90 per cubic metre.

The Showcase Hospitals were asked for their comments on these variations. The main issue was the difficulty in matching availability of rooms with the hours of work of Bioquell staff, with rooms becoming available late in the day when patients were discharged, when Bioquell staff were finishing for the day. High bed occupancy levels added to these difficulties.

Among the explanations proffered for higher volumes were

- Making an effort to keep Bioquell staff busy by finding areas for them to disinfect
- Decontamination of a ward being recommissioned and other pre-booked activity
- Decontamination of a ward following an outbreak of infection

- Out of hours working by Bioquell staff

Among the explanations proffered for low volumes were

- The Christmas period
- Absence of key hospital staff
- Difficulties in isolating alarms
- The engineering staff of one trust requiring 24-48 hours notice of decontamination

Were rooms “missed”?

Each hospital undertook a missed rooms audit as part of the evaluation. These audits took place over varying lengths of time ranging from a few weeks to several months. These audits looked at why rooms were not disinfected when they were available to be. In 40% of the audited cases, this was because the room was only available for disinfection too late in the day, during the night or at weekends, when the Bioquell service was not available. In a further 18% of audited cases the Bioquell staff and/or equipment were committed elsewhere in the hospital. In around a quarter of cases there was not enough time to use the system before a new patient was admitted. At other times bed managers were not informed a room was available until after it had been reoccupied, which could be the result of bed pressures or simple lapses in communication.

How responsive was the service?

Staff recorded details of the Bioquell response time. In 56% of cases disinfection was started within one hour of the request being made, with a further 32% being started within 3 hours.

How long did it take?

Staff also recorded details of the time areas were out of use. In 64% of cases this was less than four hours.

Did the system delay discharges and admissions?

Staff recorded details of any delays to patient movement. 83% indicated that the Bioquell process caused no delay to discharges or admissions.

Was it disruptive?

Staff were asked to record whether there had been any disruption caused by the use of Bioquell. 70% indicated that there was no disruption at all. This was often due to organising disinfection for times when rooms were less busy. Reasons for disruption included relocation of patients, emptying of bays, delays in admissions and inability to use facilities such as toilets or sluice rooms whilst the process was taking place.

What issues arose in relation to implementation and adoption?

There was overwhelming support for the use of the Bioquell system. 99% of staff said that they would recommend it to colleagues. 94% of patients were not inconvenienced – indeed 74% were not aware that disinfection was taking place. The issues which arose should be seen in this context.

In some hospitals there were some problems **storing** the equipment and **accommodating** the Bioquell team, though it was generally believed that storage and housing of staff would not be major concerns if hospitals were to make planned purchases of the Bioquell system.

Several hospitals had problems with **fire detection systems**. It is possible for the high-speed circulation of air during disinfection to trigger alarms. To prevent false alarms, Bioquell advises hospitals to isolate rooms from the fire alarm system during disinfection, but this may not be acceptable. Covering smoke detectors temporarily during treatment may be a more acceptable option, but this can cause delays if it is not done by Bioquell or ward staff. Fire officers need to agree local policies to ensure that hospital safety concerns are met.

At one site there were issues in dealing with two separate **facilities management and health and safety teams**. This may be an issue for other trusts where there is more than one facilities manager responsible for maintenance and for health and safety.

There was a problem with the design of **integrated bays** in one hospital, but by custom-building separate barriers the Bioquell engineers could ensure a proper seal, allowing them to use the HPV generators in most areas.

At several sites Bioquell provided only two HPV generators instead of three. This reduced capacity was made even worse in one case as a result of a **breakdown** which left just one generator operational.

The lack of clarity over **what can be disinfected** led to some concerns. For example, in one hospital it was not clearly communicated to staff that HPV can be used to disinfect complex electrical equipment which led to confusion.

At one site, there was an issue around **communication with staff** in relation to when it was safe to enter a room after the disinfection process had been completed.

Two cases of **possible adverse effects** were reported, but in neither case was it clear that Bioquell was responsible. In one case a member of the nursing staff complained of eye irritation after Bioquell treatment of a bay. She was found to have minor corneal abrasions which required treatment with eye drops. No other members of staff present at the same time suffered any similar problems, and the cause remains unclear. The second case was one of paint bubbling in a theatre which had been repainted. This was investigated by Bioquell through repeated application of HPV to similar painted surfaces. No bubbling occurred, so it is unlikely that Bioquell was responsible.

What did staff think of the product?

Staff were asked to give Bioquell a score out of 10 for 31 different factors. Figure 7 shows the scores. High scores are always good (e.g. a high score for “Errors” means that errors were thought unlikely). Thirty-two people took part in the survey and each red bar on the graph represents the average rating for a particular factor.

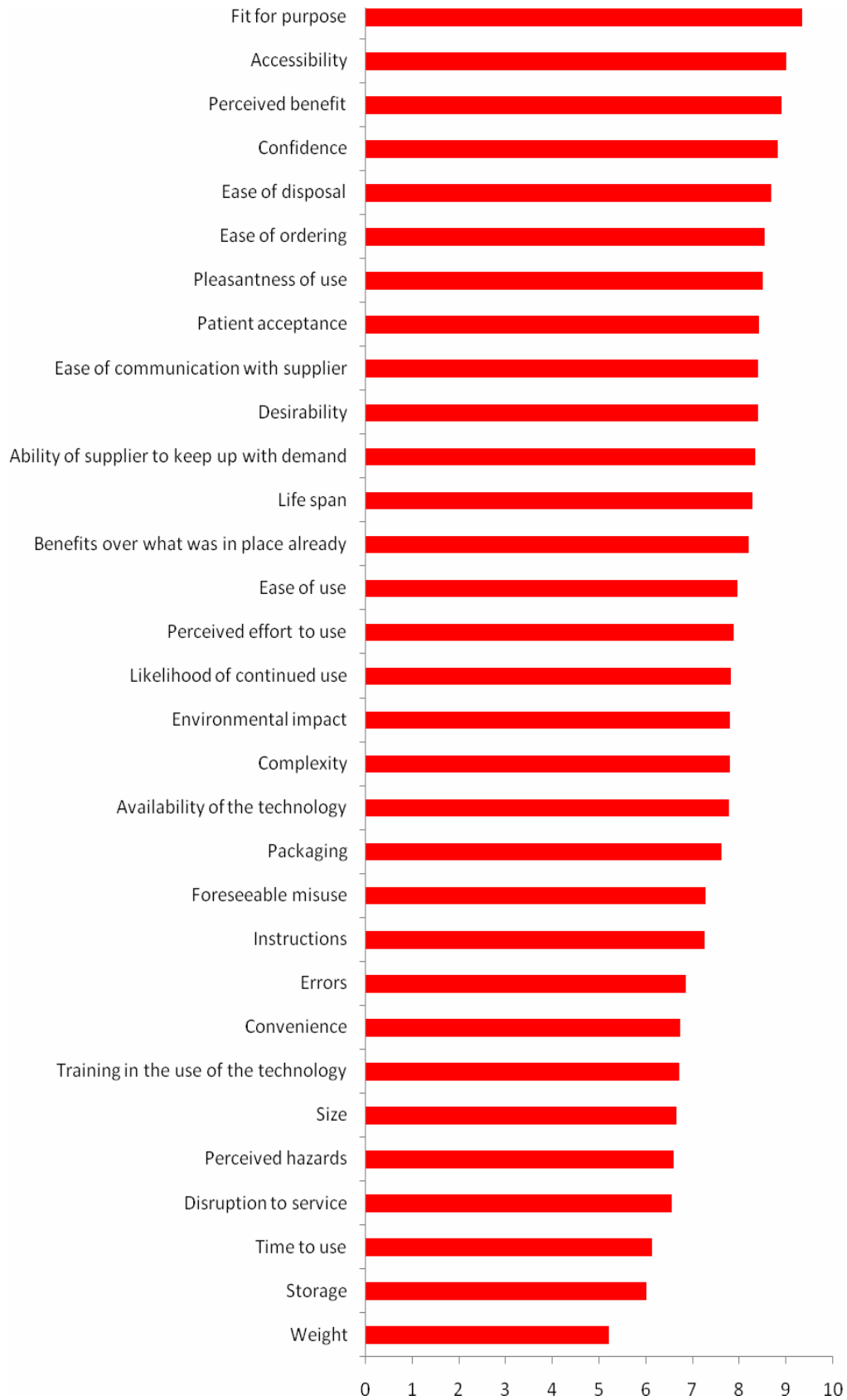


Figure 7: Bioquell scores, grouped in order of perceived importance

Advice and tools for trusts considering introducing the Bioquell system

Important Points to Consider

Two key messages emerge clearly from this evaluation.

First, the Bioquell system – which is known to be an effective way of disinfecting rooms and equipment - can be used without undue disruption to staff or patients⁵. Indeed it had overwhelming support from staff in the Showcase Hospitals.

Second, it is particularly important for a hospital to consider how and when it wishes to use the Bioquell system. The ability of the Showcase Hospitals to make effective use of the Bioquell system varied considerably both between the hospitals and from week to week within them. The main stated reason for this, borne out in the audit of missed rooms, was the unavailability of the Bioquell team at the times when the rooms were available for disinfection – often out of hours or at weekends. Even where greater use was made of the system, there were times when this was because considerable efforts were made to find rooms which could be disinfected. This must raise questions as to whether rooms were selected on the basis of a priority need, or simply because of their availability during the daytime. The audit also showed that rooms were missed because the Bioquell team were busy elsewhere in the hospital. On the other hand, advance planning was possible in some cases - for example in connection with recommissioning or following outbreaks of infection. All this suggests strongly that every effort should be made to match the availability of the service with the times when it is most likely to be needed, for example when rooms are likely to become vacant, and that continuous planning and organisation is required in order to ensure a cost effective use of the service.

It is vital to engage with bed managers in order to identify which rooms would be suitable/available for disinfection using the Bioquell system. Trusts may wish to prioritise use of the system, for example by reference to whether a patient with a nosocomial pathogen has been discharged from the room, or for widespread disinfection in the event of an outbreak. Weekend working may be helpful where bed pressures during the week may affect uptake.

Although this evaluation used the Bioquell managed HPV disinfection service (which included equipment, personnel and consumables), an alternative would be to choose the manufacturer's equipment-only option, which would require the trust to train or recruit staff to undertake the disinfection process, and to pay for the consumables; or to purchase equipment and deploy Bioquell's service personnel.

⁵ It should be noted that, in this evaluation, no assessment has been made of whether there would be greater disruption to patients (for example, from noise and other disturbance) were the service to be used out of hours.

Best value can be derived from the Bioquell system by placing items of equipment which have been identified as needing disinfection, such as electronic equipment, drip stands, commodes and wheelchairs, in rooms which need to be disinfected.

Figure 8 gives an example of a flow chart of the disinfection process.

Bioquell Scheduled Decontamination Process

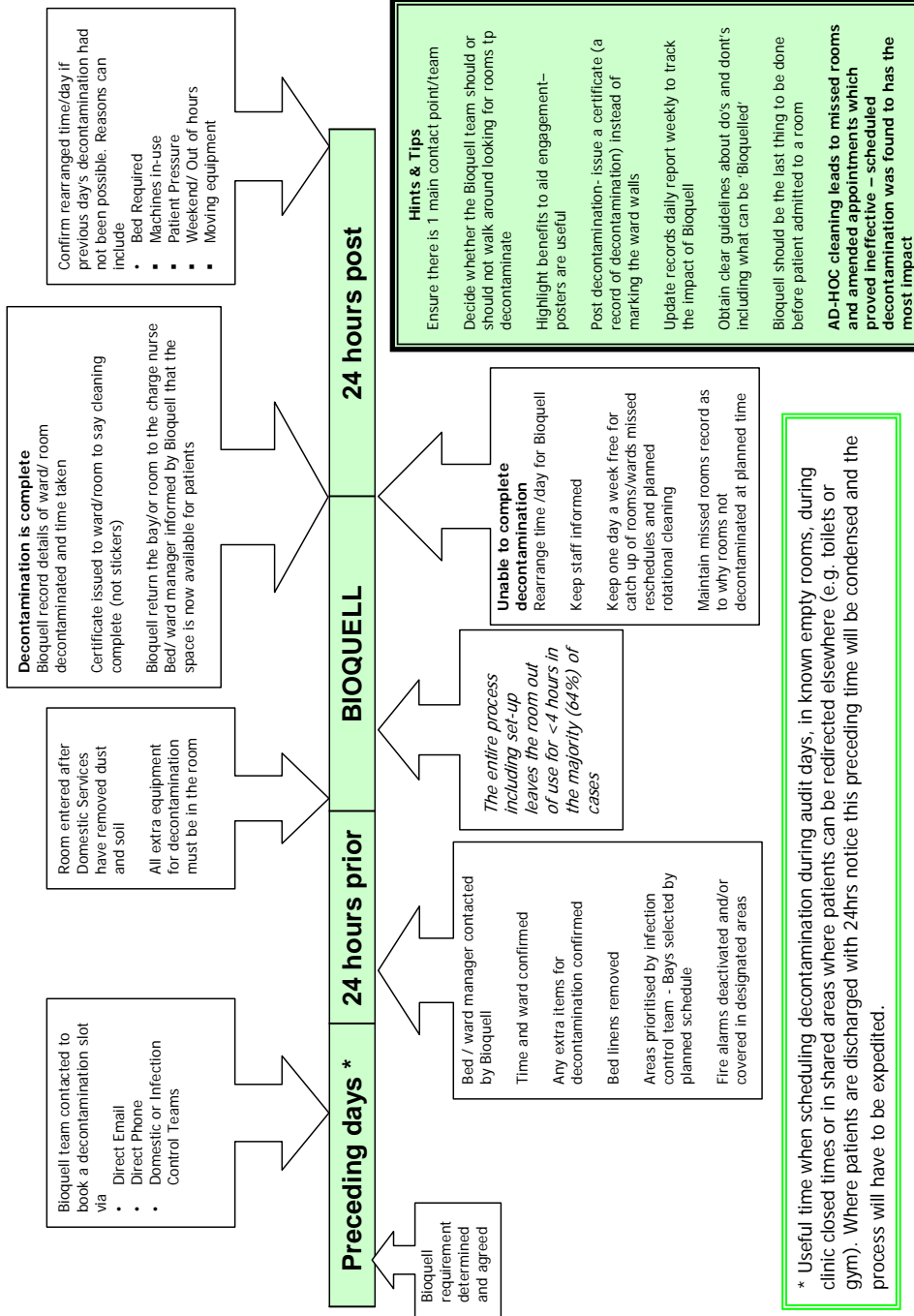


Figure 8 – Bioquell Flow Chart

'Buy-in' from key-personnel is essential for optimal adoption. Relevant stakeholders in the trust should be identified at the outset and kept informed throughout. The system requires a multi-disciplinary approach, with the co-operation of nurses, bed managers, infection control teams, facilities and estates management and the manufacturer's team. It is essential to ensure that all those who could in effect veto or disrupt the efficient use of the system have had their concerns met before the system is introduced.

Health and safety issues need to be addressed before the system is introduced. These include health and safety training for the technicians and issues around access to buildings and fire detection systems. The manufacturer's method statement and risk assessment should be assessed locally by occupational health and safety, risk management, and facilities and estates departments. Where arrangements or management differ within or across sites, these issues will need to be addressed with all the teams involved.

Storage facilities will need to be arranged for the equipment and an on-site base for the engineers operating the equipment set up. Communications (e.g. telephones, email and pager) are also essential, to ensure that trust staff can stay in close contact with the engineers.

Through leaflets, posters and local training, the manufacturer can help the trust increase awareness of the technology and its benefits and answer concerns about the suitability of the system for particular equipment.

When the system is introduced:

- patients should be informed of the process
- communication and co-operation between stakeholders should be maximised to reduce idle time and the number of 'missed beds'
- equipment requiring disinfection such as commodes, drip stands, monitoring equipment etc should be placed in the room prior to treatment so they can be disinfected simultaneously
- the performance of the system and rates of HCAI should be audited.

Costs and Benefits

Bioquell HPV disinfection is not a substitute for traditional cleaning, so the costs of the system will be additional to standard cleaning costs. It is not possible to make a direct connection between the use of Bioquell and cost savings. There is no clear evidence linking reduced levels of environmental contamination to lower levels of infection, though it is a reasonable expectation that there should be some effect, and there is some limited evidence, particularly in relation to *C. difficile*, that HPV disinfection, through elimination of the spores, may lower subsequent incidence of disease. What is clear is that patients expect hospitals to be clean, and that, in the Showcase Hospitals, patients, visitors and staff felt reassured that rooms had been disinfected – a reaction that is likely to enhance the trust's reputation.

As noted above, there are two ways in which the system can be introduced

- as a managed service, using Bioquell equipment and engineers
- by purchasing HPV generators and either employing staff (trained by the manufacturer); or using the manufacturer's engineers to deploy the equipment.

Typical costs for a managed service (two on-site Bioquell engineers, three HPV generators and consumables) are £15,000/month.

Bioquell equipment (suitable for up to 250m³) can be purchased for £33,000.

The analysis below is based on the pricing of the managed service.

Assuming an 'equivalent bed space' equal to 30 m³, the manufacturer predicts that a two-man team using three HPV generators could disinfect about 25 'equivalent bed spaces' per week. This equates to a cost of about £130 per bed space for the Bioquell service. The average achieved in the Showcase Hospitals was around 23 'equivalent bed spaces' per week, at a cost of £152 per 'equivalent bed space' but, as Figure 1 shows, this varied from 14 'equivalent bed spaces' in Hospital B (at a cost of £242 per 'equivalent bed space') to 33 'equivalent bed spaces' in Hospital A (at a cost of £105 per 'equivalent bed space'). The highest achieved in any week was 51 'equivalent bed spaces' at a cost of £68 per 'equivalent bed space'.

As figure 2 shows, not all the rooms which were disinfected in the Showcase Hospitals actually had beds. Assuming that cost can be apportioned between the different types of room according to the volume in cubic metres, the average cost of disinfecting a single room was £270 (ranging from £210 at Hospital E to £570 at Hospital B), and the average cost of disinfecting a bed space in a room with more than one bed was £131 (ranging from £85 at Hospital A to £168 at Hospital B).⁶

⁶ The average volume per bed in a single room was 45m³ (ranging from 27 m³ at Hospital G to 59 m³ at Hospitals A and D). The average volume per bed in a room with more than one bed was 30 m³ (ranging from 23 m³ at Hospital G to 36 m³ at Hospital B)

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