Building new hospitals: a UK infection control perspective

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Summary Infection control input is vital throughout the planning, design and building stages of a new hospital project, and must continue through the commissioning (and decommissioning) process, evaluation and putting the facility into full clinical service. Many hospitals continue to experience problems months or years after occupying the new premises; some of these could have been avoided by infection control involvement earlier in the project. The importance of infection control must be recognized by the chief executive of the hospital trust and project teams overseeing the development. Clinical user groups and contractors must also be made aware of infection control issues. It is vital that good working relationships are built up between the infection control team (ICT) and all these parties. ICTs need the authority to influence the process. This may require their specific recognition by the Private Finance Initiative National Unit, the Department of Health or other relevant authorities. ICTs need training in how to read design plans, how to write effective specifications, and in other areas with which they may be unfamiliar. The importance of documentation and record keeping is paramount. External or independent validation of processes should be available, particularly in commissioning processes. Building design in relation to infection control needs stricter national regulations, allowing ICTs to focus on more local usage issues. Further research is needed to provide evidence regarding the relationship between building design and the prevalence of infection.

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Introduction and aims of the Project Group

In March 2003, a group of medical microbiologists and infection control nurses met to share their experience of infection control issues related to new hospital building projects. The Project Group members were involved in hospital developments throughout the UK and Ireland. Some projects had been completed, some were in progress, and others were just beginning. Different design teams, builders and facilitators were involved in each project. Some of the schemes were built under the Private Finance Initiative (PFI), while others used public sector monies. Although there are specific issues regarding PFI projects that need to be addressed, most of the practical experiences are applicable to all hospital building initiatives, whatever their funding source or political setting.

It is now accepted that infection control should be integral to the planning and subsequent building and operation of all healthcare premises. A recent publication by the UK National Health Service (NHS) body, NHS Estates—‘Infection control in the built environment’ (2002)—provides very helpful guidance to all professionals involved in the development of new healthcare facilities. This document had not been available to most members of the Project Group at the beginning of their projects, and much time was spent gathering information and considering problems without any relevant guidance. The Project Group does not intend the present report to duplicate material contained in that publication, but instead to complement it, distilling the practical experiences gained from a number of new hospital developments.

Some problems encountered were unique to a particular building project, but most were common to all. If these problems are recognized at an early stage, costly alterations and delays (not to mention clinical risk) could be minimized.

The aims of the Project Group were as follows.

To share and learn from experience gained from a number of new hospital building projects across the UK and Ireland.

To understand the processes involved in the planning, design, building, commissioning and operation of these new healthcare facilities.

To consider how microbiologists and infection control teams (ICTs) can best be involved in these processes.

To provide guidance for healthcare professionals and contractors faced with similar projects in the future.

To raise the profile of infection control within new hospital schemes amongst chief executives, project managers, designers, contractors and the Department of Health, so that ICTs are empowered to influence the process.

Formation of guidelines and action points

The Project Group felt that it would be most helpful to structure the guidelines chronologically, so that the key action points are identified for each stage of the developmental process. Each scheme can be subdivided into the following sections.

1. Concept and feasibility studies. Departmental and support service output specifications (i.e. details of how they will operate).
2. For PFI projects: invitation for expressions of interest by potential sponsors. Preliminary and final invitations to contract negotiation.
3. Planning and design of the project.
4. Tendering and choice of preferred bidder.
5. Building of the new development, both new sites (‘green-field sites’) and those where it will be necessary to maintain clinical services within an existing building site.
6. Commissioning of new premises and decommissioning of old premises.
7. Operational issues (equipment, facilities management, etc.).

ICTs need to be involved throughout each stage of this process.

Concept and feasibility studies. Departmental and support service output specifications

Initial planning is at a strategic level, involving negotiations between national, regional and local planners. There are often historical and local political issues to consider, in addition to the health needs of the local community. Proposed numbers of beds and the provision of clinical and support services within the new development may all differ from the current healthcare service, and may be based on completely new concepts of delivering health care. Proposed numbers of beds may make assumptions on occupancy rates, expected length of stay, the provision of community health care and social services. New strategies for clinical use of beds may be considered (e.g. ‘swing beds’—those available for use by medical, surgical or other
specialties according to demand). It is important that all clinical staff, including ICTs, are aware of the assumptions made by the new development, so that appropriate risk assessments can be used when making decisions.

Once the content of the development has been agreed, departments are asked to prepare output specifications. These define departmental functions, interactions with other departments and services, staffing, accommodation and equipment resources. Special delivery and waste disposal requirements are also detailed. Whole hospital output specifications are also drawn up, detailing issues such as patient and staff movements through the hospital, how support services interact with clinical services, etc.

Output specifications are prepared for support services such as cleaning, catering, laundry, waste disposal, pest control and utilities management. It is vital that ICTs are aware of, and are in agreement with, these specifications. Model output specifications have now been drawn up by the Department of Health, and are available on their website (www.dh.gov.uk; modified in December 2002 and in July 2003). All new-building PFI schemes are expected to use these specifications, which are then customized to the individual development. There is no requirement to use these specifications for non-PFI schemes, although they are regarded as 'best practice'. ICTs need to be particularly aware of the proposed response and rectification times within these specifications. Rectification times allow the provider to rectify a deficiency in provision within a specified period of time. In practice, this may mean that a dirty ward observed during an audit session will not incur a penalty if the situation is rectified within a certain time period (say 30 min). There is no guarantee of maintaining the specified standard of cleanliness. Clearly this has major implications for contract performance monitoring and audit activity.

**Recommended infection control action points at this stage**

Be aware of the proposed use of the new development and of any changes in the way in which health care is to be provided.

Get involved in the strategic overview of the project so that the opportunity to 'design in' good infection control is not lost—negative pressure facilities, safe pathways of waste disposal, etc.

Get involved in key departmental output specifications—pathology, isolation bed proposals within clinical specialties, theatres, central sterile supplies departments (CSSDs), etc.

Get involved in support service output specifications. Anticipate the implications of response and rectification clauses. Plan performance monitoring and audit activity. Ensure the outbreak scenario is considered. Be clear about responsibilities to avoid later disputes.

Ensure that current infection control policies and procedures are up to date, as these will be used in departmental output specifications.

Produce key specifications for infection control (flooring, surfaces, ventilation, hand hygiene, etc.). Think of the ideal rather than of current policies and procedures that may be constrained by current inadequate facilities.

**Invitation to express interest. Preliminary and final invitations to negotiate contracts (PFI-funded projects)**

Expressions of interest are invited via the *Official Journal of the European Community* (OJEC), and a number of bidders may be subsequently invited to negotiate further. Details of the information requested from bidders at the preliminary and final stages of negotiation are given on the Department of Health’s website (under 'Private finance initiative'). Bidders are asked to submit design proposals that are 'flexible enough for the trust to adapt it to alternative uses, and to extend in response to new developments in health care'. Proposals need to reflect good design practice, and details should be provided on energy consumption, minimization of waste, and compliance with existing Health Technical Memoranda, Building Notes and Health and Safety legislation.

All design proposals should be in accordance with the output specifications provided by the trust, and some bidders may choose to include services previously provided in-house, e.g. the CSSD, pathology or endoscopy, within their proposal.

The final invitation to contract negotiation is usually limited to three or fewer bidders. It is at this stage that more detailed plans are put forward, with further discussion with clinical user groups.

**Planning and design**

Clinical user groups are set up for each department and service proposed to be provided in the new development. They include staff working in, and those interacting with, the departments. Output specifications are refined, keeping flexibility and foreseeable changes in practice in mind; they are then passed on to the planning team and architects for inclusion within the design proposals. Particular
emphasis is placed on deciding which services need to be in proximity to each other, and ensuring easy access for public and staff to departments as relevant. Biosecurity requirements need to be considered for microbiology laboratories.

In practice, clinical user groups may find themselves liaising with more than one potential bidder for the project. The time for discussion is often limited, commercial confidentiality needs to be observed, and the different approaches taken by bidders may be confusing. Potential bidders may come from abroad and be unfamiliar with UK working practices, professional guidelines and legislation. Output specifications therefore must be clear and not assume any pre-existing knowledge.

The above apply to all hospital departments, but ICTs have additional concerns. Clinical user groups may not regard infection control as a core concern when considering the design of their new departments. Fundamental design proposals such as flooring may not be consistent with infection control principles, and important equipment such as hand washbasins, availability of alcohol hand rub dispensers, bedpan macerators/washers and clinical waste disposal holds may be overlooked. Flows of clean and dirty linen, the positioning of clean and dirty sluice rooms, patient treatment rooms, toilets and mechanisms of waste disposal may not have been considered. It is vital that every clinical user group includes a member of the ICT in its initial meeting, and that a defined infection control link person is then identified who can liaise further with the ICT as appropriate. Fundamental infection control principles need to be emphasized throughout the design and planning process—these will include the use of appropriate materials for flooring and for other surfaces, ventilation and water/plumbing services. Inadequate storage or waste disposal areas cannot be justified by unrealistic expectations of portering, delivery and other support services. ICTs need to be aware of whole hospital plans, including landscaping (e.g. water features), as clinical user groups may not be consulted on such issues.

The time required to participate fully in the design and planning stages is considerable. ICTs are often small and the task of overseeing such a major project, in addition to routine clinical work, surveillance and audit, can be overwhelming. Chief executives need to be made aware of the benefits of such a time investment. Time spent briefing project managers and other key individuals on the importance of infection control principles is well spent. It is vital for the strategic group to identify key quality issues that should include the standard of finish of surfaces such as floors, walls and joins.

Problems experienced in planning and design

Architects and planners may be unfamiliar with, or unaware of, UK working practices, Building Notes, Health and Safety legislation and professional guidance.

Inadequate time may be available to meet with design teams, and there may be short timescales for decision making.

Lack of awareness of infection control issues amongst clinical user groups.

Lack of experience in producing output specifications and in setting up contracts.

Infection control action points at this stage

Ensure that the trust project manager (TPM) is aware of the importance of infection control. Brief the TPM and other key individuals on fundamental infection control principles (such as those relevant to flooring, surfaces, ventilation and hand hygiene).

Attend meetings of key user groups (pathology, theatres, major clinical areas); where it is impractical for a member of the ICT to attend, ensure a designated link individual does so. Produce an ‘infection control check list’ so that clinical user groups can check that infection control requirements are incorporated in the design. This should include:
- flooring and other surfaces, doors and windows;
- flows of clean and dirty material, waste disposal, storage of clean items;
- washbasins, alcohol hand rub dispensers;
- departmental kitchen facilities, food provision to patients;
- dirty sluice and toilet facilities;
- equipment decontamination; and
- special ventilation needs (e.g. in theatres, isolation rooms and endoscopy).

Discuss areas of concern with all potential bidders for the contract.

Collate relevant Building Notes, Health and Safety legislation and professional guidance relevant to the area under discussion; ask what guidance the design teams are using.

Get external advice at an early stage of development for specialized areas.

Visit or consult with colleagues involved in similar projects.

Tendering. Choice of the preferred bidder

Once bidders have submitted their design proposals, clinical user groups and key individuals within
the trust may be invited to compare the schemes, or to comment on the designs offered if there is only one bidder. Ideally, an infection control representative should be part of this process.

Designs may be assessed using criteria that include:

- meeting clinical need;
- flexibility;
- expansion possibility;
- affordability.

It is not unusual for affordability to be the main criterion, and it is vital that any major concerns with regard to the other criteria are clearly emphasized before the final choice is made.

Once the preferred bidder has been chosen, more detailed plans are drawn up, and eventually staff will be expected to 'sign off' (i.e. agree to) plans for their own departments. Clinical staff need to familiarize themselves with design nomenclature and symbols if mistakes or future misunderstandings are to be avoided. Staff cannot be expected to be experts in this area, and they should seek clarification or training from a professional source if necessary. It is not unusual for design plans to change for reasons of affordability after the preferred bidder has been chosen. It is vital that sufficient time is allocated for scrutiny of the proposed final plans, as it may not be possible to rectify the situation later. The ICT needs to gain an overview over hospital-wide plans at an early stage of the project.

Problems experienced at the tendering stage

- Inexperience of interpreting design plans.
- Specifications and designs changed after 'sign off'.

Recommended infection control action points at this stage

- Obtain professional advice or training in interpreting design plans.
- Obtain agreement that plans cannot be changed after ‘sign off’ without proper consultation.
- Take photographs, or obtain samples, of 'mock-ups' of design and of proposed fabrics (e.g. laboratory benching, flooring materials). This is useful for future reference if it becomes necessary to demonstrate that specifications have been modified without consultation.
- Document all key decisions, detailing what was agreed, when and with whom.

Building

Different problems may be anticipated in different situations. A green-field-site development may pose fewer day-to-day problems than building on an existing site, but there may be difficulties with site access and remoteness. Maintaining clinical services within a building site poses many potential problems, and requires a risk management approach (see Appendix A for more details regarding maintaining clinical services within a building site).

Whatever the development, the ICT needs to remain in constant communication with the TPM and external design and building teams. They need to be appraised of infection control activities and concerns so that potential problems are identified at an early stage, and solutions must be found before clinical care is compromised.

In general, consideration should be given to the fact that contractors may have incomplete experience of UK healthcare services and may be unfamiliar with UK Building Notes, Health and Safety legislation or existing professional guidance. It should not be assumed that guidance discussed at the design and planning stages has been communicated to the contractors. The fabrics and materials used throughout building may have infection control implications. Furthermore, specialized clinical areas need specific input from ICTs and may require external expert advice (e.g. for the intensive care unit, theatres, isolation facilities, CSSDs and containment level 3 laboratories).

Problems experienced at the building stage

- Lack of access to the building site.
- A number of contractors may be involved, with changing personnel. This may lead to difficulties in communication and continuity.
- Guidance discussed at the design and planning stages not communicated to contractors.
- Conflicts between contractors.
- Difficulty or impossibility in rectifying problems during the later stages of development.
- Changes made to agreed plans without sufficient consultation.
- Little consideration given to pest control.
- Infection control risks of landscape features (e.g. fountains) not always considered.
- Use of inappropriate surfaces and fabrics.
- Installation of inappropriate radiators.
- Difficulty in maintaining clinical services within a building site (see Appendix A for more details).
Recommended infection control action points at this stage

Agree rights of access for the ICT to the building site and to contractors.
Establish relationships with contractors, and reinforce fundamental infection control principles with them.
Make risk assessments to minimize hazards to patients and staff (see Appendix A).

Commissioning (and decommissioning of old premises)

There are often considerable political and economic pressures to reach project completion and handover of the new development promptly. In the latter stages of the development, it is not unusual for further design and equipment modifications to be barred. The NHS trust becomes financially liable for the new development at its handover, and the responsibility for multiple sites is expensive. Therefore, the trust may wish for the new development to become operational within a time insufficient for adequate commissioning of services. Commissioning is a crucial stage that may be overlooked if it is not clear who has responsibility for commissioning. Any uncertainties about this should be clarified with the contractors and the trust project team at an early stage. Where external validation of services and equipment is necessary, adequate notice must be given to those involved, and time must be allowed to rectify any problems identified.

Examples of services and equipment requiring commissioning within a new development include:

- water and plumbing;
- ventilation—including special areas such as theatres and isolation facilities;
- decontamination equipment—including that in CSSDs, washer-disinfectors, autoclaves, and bedpan washers and macerators;
- specialist containment areas—containment level 3 laboratories and pharmacy aseptic suites;
- catering equipment.

Contractors have a responsibility to commission their services, but the extent of this commissioning may be insufficient to ensure a safe environment for a clinically vulnerable population. Evidence that such commissioning has been performed may not be forthcoming, and contractors may not accept that the ICT is entitled to request such evidence. External validation is invaluable; it provides the trust with an independent expert opinion, and supports the position of the ICT (see Appendix D for useful sources of external advice).

In addition to services requiring formal commissioning, a risk assessment must be made regarding those services that can only be tested by full clinical use and occupation. Such services include food supply, water supply and plumbing. Some problems (e.g. blockage of drainage systems with builders’ rubble) may be well known to the building industry, but would not necessarily be anticipated by healthcare staff. Staff need to be trained adequately on new techniques and equipment (e.g. bedpan washers, laboratory specimen tube delivery systems), otherwise problems will emerge as staff struggle to familiarize themselves with their new surroundings. Support services need to anticipate clinical waste requirements, with collection frequency matching waste disposal storage capacity.

Once vacated, clinical areas need decommissioning. Assurances need to be given to new occupants, or demolition workers, that buildings are clear and safe to enter. Advice may be sought from the ICT as regards decommissioning of laboratory, mortuary and other special clinical areas.

Problems experienced in commissioning and decommissioning

A lack of clarity over responsibility roles in commissioning.
Contractors may work to different standards from those required, with potential conflicts of interest.
Inadequate timescales for commissioning and rectifying problems that are encountered.
Difficulties in gaining access, and inadequate preparation, for external assessors/validators.
Commissioning performed by contractors found to be inadequate and the trust failing to recognize and document this.
ICT receiving insufficient information.
Cost of commissioning, and decommissioning, not considered by contractors and/or the trust.
Delays in equipment procurement that reduced the period available for commissioning.
Vacated buildings left in dirty and unsafe condition.
Vacated buildings subject to pests and arson.
Operating and maintenance procedures inadequate for specialist orthopaedic theatres.

Infection control action points at this stage

Meet with chief executive and TPM to determine infection control risks and responsibilities of the ICT.
Ensure that adequate time is given for commissioning. Anticipate that failure may occur in the first attempt at commissioning.
Agree with contractors who holds the responsibilities for which areas of commissioning.
Where potentially different standards could be applied, decide which to use.
Agree what information relevant to infection control will be supplied by the contractors.
Use external assessors and validation for special areas (theatres, containment level 3 laboratories, CSSDs).
Ensure that there is adequate communication with, and preparation for, external assessors.
Agree ongoing monitoring of standards wherever applicable (water, ventilation, etc.) either with the contractors or with the Estates department.
Once they have been commissioned, services need to be maintained (e.g. the flushing of water systems in unoccupied buildings).

Operational and equipment issues

Equipment may be redeployed from existing stocks, or may be newly acquired. Adequate specifications must be drawn up for all equipment, incorporating assessments for fitness for intended use, manual handling, fire, health and safety, decontamination and infection control. Users must be clear about the timeliness of providing equipment, responsibility for maintenance contracts, and procedures for decontamination.

There are great logistical difficulties in putting an empty building into full clinical use and occupation over a short period of time. Considerable organizational planning must occur, with staff clear about each other’s roles and responsibilities. Infection control staff may need to advise on the transfer of patients with infectious diseases, or those requiring special isolation facilities. When untried systems of work [catering, plumbing, information technology (IT) systems, etc.] are put into full clinical use, previously unanticipated problems may arise. Unless resolved promptly, problems may persist for months or years after occupation.

Problems experienced with operational and equipment issues

Delays in equipment purchase and delivery led to unplanned redeployment of existing equipment. There were consequent issues regarding the cleaning and assessment of whether such equipment was fit for purpose.

Untried systems failed on being put into clinical use (food supplies, water and steam supplies, drainage and sewage systems, bedpan washers, CSSD equipment).
Lack of access to pipework resulted in difficulties in resolving leaks and in floods, with consequent damage to IT systems and the fabric of the building.
Lack of access to the ventilation system ducting made it difficult or impossible to clean adequately.
Persistent problems in provision of appropriate quality water.
Inadequate portering frequency to meet clinical waste disposal needs.
Inadequate provision of storage for clinical waste.
Ventilation systems were incapable of meeting specified requirements.

Infection control action points at this stage

Ensure that full commissioning has taken place, and ongoing monitoring standards have been agreed.
If equipment fails commissioning standards because of poor quality machines, ensure that there is early replacement with alternatives which meet the relevant specifications.
Make a risk assessment of all systems before they are put into full clinical use.
Anticipate that drainage systems may become blocked.
Ensure that staff are trained adequately on new systems of work and in using new equipment.
Ensure that there is performance monitoring of contracts and audit by the ICT.
Ensure that all equipment has an infection control risk assessment, and documented procedures for decontamination.

Evaluation

Evaluation of the successes and failures of any new development should take place throughout the project, and ICTs should be active participants. Valuable lessons can be learnt and shared with others. Unfortunately, evaluation may not be given the attention and priority it deserves once a move has been achieved.
This document has been produced as a result of ICTs evaluating the projects in which they have been involved. We remain concerned that so much responsibility falls to ICTs in overseeing new hospital developments, and very much welcome
the NHS Estates’ document ‘Infection control in the built environment’ which gives national guidance on fundamental infection control principles. However, we feel that stricter national regulations in this area may provide a framework for exacting inspections with legislative support. Such regulations could be rigorously monitored within the Health and Safety at Work Act, and allow ICTs to focus on more local usage issues. Finally, we need more evidence regarding the relationship between building design and the prevalence of infection. The funding of research and development in this area would be a valuable adjunct to national building regulations that have a greater focus on infection control.

Appendix A

Maintaining clinical services within a building site

Aim

To minimize infection risk to patients, staff, visitors and contractors during building work.

During construction and refurbishment, there is also the need to monitor the progress of infection control requirements of the design and identify any problems at an early stage. Construction or refurbishment work adjacent to occupied facilities requires a risk management approach. The risk will depend upon the type of clinical activity undertaken, adjacencies, special patient risk groups and other local factors. Good design and project management should reduce the risks of infection related to the building activity.

Recommended strategy for maintaining services

Early involvement of the ICT in the planning stages.

Continued involvement of the ICT throughout the construction or refurbishment, commissioning and post-project evaluation stages.

At the planning stage, the ICT should agree work programmes and timescales with contractors. Document what advice has been given. Consider operating a ‘permit-to-work’ system requiring infection control authorization for work in sensitive areas such as those accommodating immunosuppressed patients.

Make a risk assessment of the process for anything with infection control implications.

Obtain the agreement of contractors to use infection control precautions where necessary. Educate and advise contractors and Estates workers on matters relevant to infection control. Audit compliance with the above.

Early involvement of the ICT in planning

There should be national and local acceptance of the importance of early and adequate infection control involvement in construction planning. The ICT should attend local Estates works progress meetings regularly.

Risk assessment

The following factors need to be considered.

The type and scale of activity (e.g. disruption of water supply, digging, demolition).

Patient groups at particular risk (e.g. immunocompromised patients, especially neutropenic patients, including bone marrow transplant, solid organ transplant, radiotherapy and oncology patients, and those with haematological malignancies).

Specialized areas (e.g. operating theatres, CSSDs, laundries, critical care units, high-dependency units, pharmacy clean rooms).

Potential pathogens (e.g. aspergillus, legionella).

Other factors (e.g. the nature of adjacent clinical areas, type of ventilation, siting of air intakes, patient movements, access for construction workers, their materials and waste).

A useful risk assessment model can be found in ‘Infection control in the built environment’ (see Appendix E). This grades the risk and suggests an appropriate level of precautions according to the type of construction activity planned and the infection control risk group by area or patient group.

Potential infection control precautions

The following are examples of infection control precautions that may be appropriate depending on the risk assessment for each individual project.

Barriers

Plastic sheeting. This must be fire-rated with \( \geq 0.6 \) m overlap for entry. Potential problems include flapping or torn sheets, and fire hazard (if the sheeting is not fire-rated). There should be a rigid barrier, which should be dust-proof and fire-rated.
Construct an entry vestibule for changing clothing, tool storage, etc.
Seal windows with adhesive strips.
Control dust by ‘damping down’.
Seal the doors and roof spaces.
Consider using ‘tacky mats’ (i.e. adhesive-impregnated mats that retain dust) outside the entrance to the construction area.
Be aware of potential problems with heat in summer and mould in winter.
Take care to minimize dust dispersal when dismantling barriers, and clean the area thoroughly afterwards.

Traffic control

Direct patients, staff and visitors away from construction areas. Ensure that signs are clear and visible.
Have a separate entry and exit for builders. Separate the builders’ route from those of patients, staff and visitors, including separate lifts if appropriate.
Ensure that builders avoid patient areas.
Ensure that routes for building materials and waste do not compromise infection control requirements.
Ensure that immunocompromised patients are not exposed to excess traffic.

Ventilation

Sealed construction areas are potentially hazardous for workers. It is very difficult to construct a temporary roof over outdoor construction activity, and protective barriers may be breached during the construction process.
The use of a negative pressure HEPA-filtered vacuum in the construction area, exhausted outside, has been described.
Air flow should be directed from clean to dirty areas.
Protect the ventilation units of clinical areas. This is most important for high-risk areas with immunocompromised patients or specialized units. Air intakes should be sealed. This will preclude certain clinical areas from being used. When possible, dust-generating construction activities should take place out of hours when the air-handling units are shut down. Consider the use of additional filters. These may block quickly, depending on the type of activity. Monitor filters and air flow, and change filters as required.

Water supply disruption (see also Appendix B)

Monitor water quality chemically before concluding that it is safe.
If there has been contamination, microbiological testing should be undertaken.
Potential remedial actions for contamination include:
- flushing of the system;
- chlorination;
- pasteurization of the hot water supply;
- addition of chlorine dioxide;
- addition of silver or copper ions.

Waste

Remove building waste through a designated route avoiding clinical areas as far as possible.
Remove debris in tightly sealed, lidded containers. Alternatively, cover it with a wet sheet.
Remove building waste regularly, ideally on a daily basis. Do not allow it to accumulate.
If construction activity is above ground level, remove waste via a chute through a window.
Waste chutes should be sealed when not in use. Waste chutes should be designed to empty directly into a covered skip or container, avoiding gaps.

Builders’ clothing and equipment

Construction workers and their equipment should be free of debris and dust on exiting the building area, particularly if they are passing through clinical areas. The following strategies have been used:

- vacuum cleaning of clothing and equipment;
- an airlock with a change of clothing;
- overshoes;
- overalls;
- tacky mats;
- wiping down of equipment before it leaves the area.

Cleaning

A programme of cleaning within the construction area and in adjacent clinical areas should be drawn up. Plans should also be made for additional cleaning in the event of unexpected contamination, and for a commissioning clean. The following may be useful components of the programme:

- HEPA-filtered vacuum cleaners;
- damp dusting or wet mopping;
- wet mopping outside the construction area;
- tacky mats at exits from the construction areas;
water mist to reduce dust, although this may lead to problems with mould; shampooing of carpets; clean vestibule areas at the end after the barriers have been dismantled; specify the standards of cleanliness expected for the new development upon commissioning. Consideration could be given to adapting the UK’s Patient Environment Action Team standards for this purpose.

Protection of high-risk patients

Consider deferring the admission of high-risk patients, admitting elsewhere, or deferring elective immunosuppression. Plan the movements of susceptible patients including access to hospital for immunosuppressed outpatients. The use of masks may be appropriate if patients may be exposed to dust. Prophylactic antifungals may be used in extremely vulnerable patients. If the water supply may be compromised, consider the use of sterile water for drinking and for ice making. Ensure appropriate barriers are in place. Seal windows, doors and ceilings. Solid ceilings are more suitable than false ceilings. Use HEPA-filtered air in areas accommodating immunosuppressed patients. Temporary or permanent facilities may be provided. Use a filtered air curtain over doors to units with highly susceptible patients. Ensure that the air flow is in the right direction to protect the patient, i.e. the air supply in the patient’s room must be greater than the air supply to the adjacent corridor (the air supply should be 10–20% greater than the air exhaust). Monitoring of the air may be appropriate, e.g.: - air flow; - particle counts; - air sampling.

Audit

During construction, the ICT should review its progress on a regular basis in order to identify any potential problems at an early stage. Inspection should include considerations such as: - dust and debris; - traffic control; - barriers; and - cleanliness of adjacent sites.

Certain forms of formal monitoring may be appropriate under some circumstances, e.g.: - air flow; - air sampling; - air particle counting; - microbiological water testing; - water temperature; - humidity.

A suggestion for a daily construction monitoring form, based on an article by Carter and Barr, may be found in 'Infection control in the built environment'. ICTs may prefer to design their own checklists. A thorough check should also be made at the time of commissioning. Following completion of the work, a project appraisal should be completed.

Appendix B

Development of a safe water supply and foul drainage system

Issues that need to be considered

The construction of a new hospital with a completely managed environment gives rise to major challenges in the delivery of a microbiologically safe water supply. Long runs of pipework in ducting, which also carries ventilation ducting, give great scope for heat loss or gain. Contractors may not appreciate that all clinical areas will serve vulnerable patients. Water samples taken during commissioning may be inadequate in number and distribution, and may have been taken immediately after hyperchlorination, leading to false-negative results. Subsequent regular flushing may not be carried out prior to occupation of the new premises, or may not be possible in some areas if drainage work has not been completed. The mainstay of commissioning of the water system relies on temperature monitoring and residual chlorine measurement. However, HTM 2027, ‘Hot and cold water supply, storage and mains services’, states that samples for microbiological testing should be taken from selected areas within the distribution system and that ‘the system should not be brought into service until the ICT certifies that the water is of potable quality’. Contractors may not know this or understand the need for it. The time available for testing and rectifying problems may be short, particularly because the contractor will want to keep to a minimum the period between commissioning of the premises,
and occupation when regular flushing will be needed. Planning decisions on drainage will influence the decision on whether to install macerators or bedpan washer-disinfectors. Modern designs make considerable use of single rooms with en-suite facilities and this may result in lower water throughput per outlet. The success of alcohol hand rub is likely to have reduced overall hospital water consumption.

**Recommended strategy for the design of water systems**

**Early involvement of the ICT in the planning of the water system**

Early involvement in planning enables the ICT to understand the design and capacity of the system, and to influence factors such as tank capacity and frequency of refilling with the aim that stagnation of reserves should be avoided.

**Wash handbasins**

The ICT should be involved in the following.

The decision on the type of basin to be installed, including whether plugs are required for wash basins designated for patient use, but not those for staff. It is useful to get the contractor to erect mock-ups of basins to demonstrate to users.

The decision on the type of taps for patient and staff use. If using mixer valves, consider whether a separate cold tap is needed. The choice of taps will be influenced by the need to fit thermostatic mixer valves to avoid scalding in patient areas, and also access to unblended hot water at sentinel points for monitoring purposes.

The siting and number of wash handbasins. Deciding whether basins need to be sited outside rooms; this should be decided at an early stage to ensure that sufficient space is allowed.

Mixer taps: some designs have sealed cores which mean that, in our experience, they cannot be sterilized or disinfected once contaminated with organisms such as pseudomonas.

**Showers**

The ICT should be involved in the following.

The choice of shower heads so that the risk of growth of legionella can be minimized.

The design of the shower cubicle so that the ICT can advise on suitable materials for cleaning, and on a system that will not leak and allow water to collect.

**Hot and cold water systems**

Long sections of pipework running through a building have the potential for heat loss or gain which may require a boosting of chemical disinfection to maintain adequate levels (such as chlorine dioxide or silver/copper ion treatments). A laboratory water supply should be entirely separate (including separate tank) from that of the rest of the hospital, as explained in 'Hot and cold water supply, storage and mains services' (see Appendix E).

**Foul drainage system**

The decision of whether to install bedpan washer-disinfectors or macerators will be influenced by the capacity of the foul drainage system and the load which the water company can take into the public drainage system.

The diameter of the pipework will determine the likelihood of blockage.

Builders’ rubble tipped into drains during construction can lead to major problems such as a backflow of sewage into clinical areas after occupation. It may take some time to locate and clear the blockage.

**Ornamental water features**

The ICT should discourage the use of ornamental fountains which would result in aerosol production. Such features require upkeep by intensively planned preventative maintenance to avoid the risk of disseminating *Legionella* sp., and are best avoided.

**Direct involvement of the ICT with the builders throughout the building process**

Reasonable access to the new premises is needed in order to carry out the commissioning of...
bedpan washer–disinfectors. Initial tests usually result in failure. By developing a working relationship with the contractors, the contractors should come to understand the need for the ICT to sign off the commissioning of the water system. This should enable a sufficient number of water samples from hot and cold outlets to be analysed at least 48 h after hyperchlorination of the building by a United Kingdom Accreditation Service (UKAS) (or equivalent)-accredited method.

Record keeping

Keep detailed records of meetings with contractors—these are valuable if disagreements arise between the trust and the contractors. The ICT should be provided with all relevant records including temperature and chlorine measurement results to enable them to undertake a risk assessment.

Risk assessment

Occupation of the new hospital should take place once all services are commissioned satisfactorily. However, there is often considerable economic and political pressure to achieve completion on time. In these circumstances, the ICT may need to undertake a risk assessment if the commissioning water results are less than ideal. Increased usage following occupation may reasonably be expected to reduce higher-than-expected total viable counts. The presence of coliforms would, however, suggest a more serious problem.

Monitoring following occupation

Occupation of the building will lead to changes in water use of some areas from the design as services settle into their new environment. Continuing discussions will be needed with facilities and maintenance staff to adapt the supply to these changing circumstances. A system of reporting results to the trust, which includes the ICT, should be established.

A pattern of water quality should be established taking seasonal variation into account before the frequency of testing can be reduced. Experiences gained should be evaluated and knowledge shared with others for the benefit of future building projects.

Appendix C

Development of ventilation systems

Issues that should be considered

A hospital contains numerous specialist areas, many of which have particular ventilation requirements. Architects and contractors may not be aware of relevant specialist standards and guidelines. During the planning stages, the use of areas will change. Changes needed in the ventilation specification are unlikely to be considered by the general clinical staff. Ventilation systems are almost impossible to change substantially following occupation. It is therefore critical to plan appropriately and to include some spare capacity. It is worth considering how to manage the appearance of new guidance (e.g. relating to severe acute respiratory syndrome). Builders may not recognize the commissioning requirements for some specialist areas, e.g. theatres. A last-minute failure at the independent commissioning stage can prevent occupation on time. It is extremely difficult to design a reliable fail-safe ventilation system for a laboratory containment level 3 room in a ventilated building.

Recommended strategy

There should be early involvement of the ICT in the planning stages of all parts of the hospital. Early clarification of the relevant standards to be met should be obtained from the architect and builders. The ICT should be directly involved with the contractors throughout the building project. Use of independent specialist services should be used to commission areas such as theatres and category 3 laboratories. The ICT should keep detailed records. Monitoring of the ventilation systems should be undertaken following occupation.

Early involvement of the ICT in planning

Isolation room ventilation

The size of ducting, the capacity of air-handling units, and the ability to cool as well as heat rooms need to be characterized at an early stage. The ICT needs to be involved at this stage as changes will be much more difficult later.
There is the opportunity at the planning stage to incorporate the capacity to change between positive and negative pressure for haematology single rooms, and to determine who should be able to control this. Control and fail-safe systems are simplified if the air supply and extract to particular rooms are from matched air-handling units. This should be introduced into plans at an early stage.

The ICT can comment on design issues such as shared scrub and preparation rooms which will influence pressure changes during use as doors are opened and closed.

In our experience, it is extremely difficult to design a ventilated containment level 3 room which complies with safety legislation. It is worth considering having a room which is not artificially ventilated and which can then be readily sealed in the event of a spillage.

New hospitals are likely to have more single rooms (apart from isolation rooms) than older ones. These should be designed to remain comfortable for the patient if they need to be used as isolation rooms and the door has to remain closed. Configuration of the ventilation varies between new builds; in some designs, rooms may be under positive pressure and therefore unsuitable for patients with infections that are transmitted by the airborne route. This is a particular issue in paediatrics where the number of isolation rooms is likely to be insufficient to contain all their infectious patients at all times of the year. Special care baby units need to have ventilation that does not flow from one room into the next. Rooms should not be under positive air pressure. One or more single rooms should be reliably under negative pressure in order to isolate babies with respiratory viruses.

Architects and builders are unlikely to be aware of all relevant specialist guidance. Supplying them with references for these (particularly for any recent standards) will rectify this. When planning the operating theatre suites, it is worth drawing attention to the relevant guidance documents as theatre sizes are likely to vary from the standard design. This will necessitate a change to standard air flows in order to achieve the required number of air changes per hour. Architects and builders are unlikely to have a prior understanding of this.

The ICT should check that the contractors are working to relevant standards, as information about them may not be passed on from the architect/main builder. The ICT will need to check the direction of air flows for all isolation rooms prior to occupation even if commissioning data are produced showing them to be satisfactory. What the contractor intends to be the direction of flow may not be the case in practice. If occupation follows shortly after building completion, dust will still be settling. It may be necessary to carry out testing for Aspergillus spp. in areas due to be occupied by immunocompromised patients.

A specialist should be engaged to undertake the commissioning of both theatres and containment level 3 facilities. This can be a particularly useful independent view in the event of a disagreement between the trust and their PFI partner. They will also be able to provide valuable advice in the event of a commissioning failure as to how the architect/builder should amend the design to achieve compliance with regulations.

Visible monitors above isolation room doors (e.g. magna-helix gauges) are useful for checking
room performance on a day-to-day basis. There will need to be a policy for staff education and monitoring so that fluctuations in pressure are noticed and acted upon.

The ICT should be included in regular reports made to the trust in order to assure themselves of the continuing satisfactory performance of theatre, isolation room and containment level 3 ventilation.

Appendix D
Useful sources of external validation in the UK

Hospital Infection Research Laboratory
City Hospital NHS Trust
Dudley Road
Birmingham B18 7QH, UK
Tel.: +44 121 507 4822
(Contact: Christina Bradley)

Laboratory of Health Care Associated Infection (LHCAI)
Specialist and Reference Microbiology Division
Health Protection Agency
61 Colindale Avenue
London NW9 5HT, UK
Tel.: +44 208 200 1295
(Contact: Peter Hoffman)

For containment level 3 laboratories, safety audits and advice
Biosafe Safety Services
272 London Road
Wallington SM6 7DJ, UK
Tel.: +44 208 647 4447
(Contact: John Daniels)

Appendix E
Bibliography and useful references


National Health Service Estates. *Infection control in the built environment.* London: HMSO; 2002.†


† It may be useful to note that the NHS Estates document 'Infection control in the built environment', and other useful publications such as Building Notes are listed (and many executive summaries are available free) on the NHS Estates website ([http://www.nhsestates.gov.uk/home.asp](http://www.nhsestates.gov.uk/home.asp)). NHS employees can get full-text electronic copies of many documents through the Knowledge & Information Portal [http://195.92.246.148/nhsestates/knowledge/knowledge_content/home/home.asp](http://195.92.246.148/nhsestates/knowledge/knowledge_content/home/home.asp).
Appendix F
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