NHS
National Patient Safety Agency

National Reporting and Learning Service

Lessons from high hazard industries for healthcare

SUMMARY REPORT

CONTENTS

INTRODUCTION 1
Who should read this and why? 1
Why consider human factors in design? 3
Evidence from other industries 4
Evidence from healthcare 7
Healthcare research 7

DESIGN PRINCIPLES 8
The project team 8
People and process 9
Address known problems 10
Key design considerations 10
Design evaluation 11

DESIGN PROCESS 12
Step 1: Determine the project scope 14
Step 2: Identify users and key activities 15
Step 3: Identify the safety issues 17
Step 4: Analyse and prioritise the safety issues 20
Step 5: Develop potential design options and solutions 22
Step 6: Evaluate design solutions 25
Step 7: Implement the design 27

NEXT STEPS 28

ACRONYMS 28

REFERENCES 29

INTRODUCTION

Who should read this and why?

This document summarises the information presented in the report entitled *Lessons from high hazard industries for healthcare: full report*[1], which communicates a process for incorporating 'human factors' into healthcare facility design, with the aim of improved safety and patient outcomes.

This quick guide gives an overview of the reasons for taking human factors into account during healthcare facility design, and a brief explanation of the process and methods applied in a 'user-centred' approach to design. It is intended to provide guidance for those decision-makers involved in the planning, design and development of healthcare facilities, whether new build, re-build or re-fit, and particularly:

- building consortia (whether private or publicly financed):
  - architects and designers;
  - project directors;
  - funding consultants;
  - building construction contractors;
  - healthcare planners;
  - clinicians;
  - engineers;
  - facilities managers;
  - manufacturing industries supplying the healthcare sector.
- healthcare organisations and NHS trusts:
  - project directors;
  - project teams;
  - facilities and estates directors;
  - design champions.

The full *Lessons from high hazard industries for healthcare*[1] report gives more detailed advice on how to incorporate human factors into the design process and describes some of the human factors techniques available to do this. A full list of technical references and sources of further information, including those from other industries, is also provided in the full report.

This report is one of a series on safer design, on topics such as medication packaging and the built environment, all of which are available from the NPSA website.

The approach outlined in this report should be considered alongside current national guidance on healthcare estates design and procurement processes.

'Human factors' is a discipline devoted to the inter-relationship between humans, the devices and equipment they use, and the environment in which they live and work.[2]

Human factors analysis involves the assessment of physical ergonomics (the environment, workplace layout or equipment interfaces), work processes, user needs and vulnerable groups, with the aim of understanding and identifying the factors that increase risk and lead to errors.

Human factors research indicates the importance of designing to reduce or minimise contributory factors that can impact on human error and safety, such as noise, fatigue and inadequate standardisation, and that these must be reflected in the design brief, goals and procurement process.

Why consider human factors in design?

Human factors techniques such as human error identification (HEI), task analysis (TA), or hazard and operability (HAZOP) studies can help avoid reported examples of poor design, such as:

- Hand washing gel dispensers that are the same colour as the wall, too high for wheelchair users and have no place for people to put down handbags or other items they are carrying. This means they are inaccessible to some, not seen by most and require people to pick their items up from the floor after washing their hands.
- The distribution of departments around a healthcare facility resulting in vital departments being placed long distances apart (e.g. operating theatres and recovery units on different floors, emergency units and imaging departments in different buildings), leading to unnecessary patient transfer during critical care, increased patient stress, increased chance of infection and reduced patient privacy.
- Drug preparation areas on wards that are busy, cluttered and poorly lit, leading to interruptions during complex drug calculations.
- The storage of equipment, drugs and supplies in inaccessible areas, leading to extra staff journeys, extra workload and potential shortcuts in procedures.
- A lack of consideration given to the compatibility of equipment, such that patients cannot be moved with vital monitoring equipment due to the lack of specific power supplies or space.
- Reception desks that cannot be reached by people in a wheelchair, reducing accessibility.
- Different drugs being stored next to each other in similar packaging, leading to medication selection errors.
- Inaudible patient alarms due to ambient noise or the layout of working areas.

Evidently, differences exist between healthcare and other industries. Different industries have different outputs and have different contextual issues, but the process of risk identification remains the same in any industry where risks can lead to a catastrophic loss of life.

A wealth of research and knowledge demonstrating the integration of human factors into design is available, some of which has already translated into techniques that have been successfully applied within the healthcare sector.

"Ensuring [human factors] considerations are integrated into the overall project lifecycle is fundamentally an issue of project management and systems engineering…Neglect of human factors requirements can lead to systems that cannot deliver the performance expected."

London Underground[3]

"It is useful to make effective use of the very valuable insights and lessons learned throughout the human factors case process, i.e. what worked and what didn't work. This can help prevent problems and save resources in future projects."

European Organisation for the Safety of Air Navigation[4]

Evidence from other industries

The importance of the human contribution to safety and risk has been recognised following high profile accidents (e.g. Bhopal, Chernobyl, Clapham Junction).

Experience from safety-critical industries, such as aviation and nuclear power, has shown that systems, facilities and equipment are safer if they are designed to match the abilities and behaviour of the people that use them. In particular, experience has shown that the earlier such human factors knowledge is considered in the development process, the safer the system will be.

A 'user-centred' approach to safety takes human factors into account at each stage of the design process, with positive results, such as:

- reduced incidents and accidents;
- improved usability – operators find the equipment easy to use and understand;
- improved safety for users;
- development of cost-effective design solutions;
- reduced likelihood of operator error;
- reduced risk-taking behaviour.

The following case studies demonstrate the benefits high hazard industries have seen from applying human factors in design, although specific design changes must be taken within context.

Nuclear control room redesign[5]

In a control room for a nuclear power plant, the displays and controls used by operators for emergency situations are displayed on both the front and back panels of a control unit. This configuration contributed to increased potential errors in operator actions during emergencies and hence overall risk levels for the plant.

A TA was conducted for the tasks undertaken by operators in the control room to determine in detail how the configuration of displays impacted on performance. The TA was developed by conducting interviews with operators to identify user experience and running detailed scenarios simulating a number of conditions to analyse how configurations affected task performance.

It allowed graphical representations of all operator tasks and sub-tasks in the control room to be developed. From this, the types of errors that could be caused through display configuration could be identified.

Error types identified included:

- task performance errors – configuration can impair individual task performance if displays and controls for a specific task are spread across individual panels and outside of peripheral vision;
- communication errors – configuration can make communication difficult and lead to errors;
- performance verification error – configuration can make it difficult for supervisors to verify an operator's actions.

Having identified these potential errors, recommendations were developed aimed at eliminating them, such as reducing the number of transitions between panels in order to improve performance and communication, and improving the configurations so it is easier to observe actions and understand which actions have been taken, so performance can be verified. These recommendations helped to improve operator communication and the efficiency of operator actions.

Space craft design (National Aeronautics and Space Administration [NASA])[6]

Due to the complexity of space crafts and the potentially catastrophic consequences of human error, in terms of loss of life, cost and media coverage, NASA have developed a specific set of design principles that underlie their design process.

These design principles aim to increase usability and reduce mental workload, risk of potential for errors, and mission cost. Examples include:

- design should consider methods to reduce operational complexity and interdependencies;
- design should consider accommodation of early in-flight demonstrations of spacecraft functional capability to identify potential flight/ground system shortfalls;
- design for operability, in terms of reducing the number of tasks and the sequence complexity of tasks.

Oil platform re-design[7]

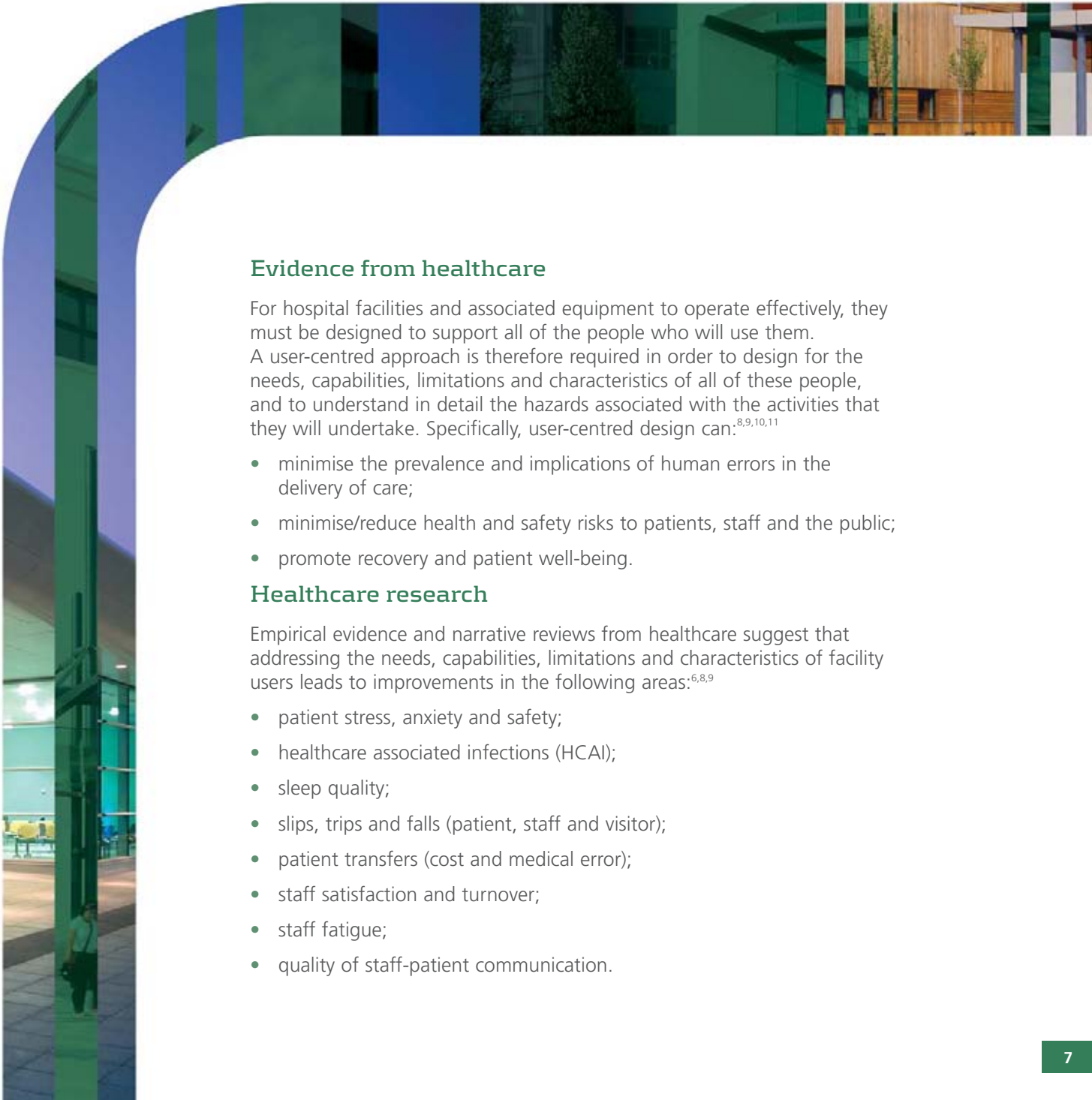
A study was undertaken to examine the effects of introducing drilling to an offshore platform that had only ever been used for production. A HAZOP study had identified communication between the drilling crew and production crew as a key potential contributor to increased errors and risks. To help identify where communication errors may occur between the two teams and how these potential errors could be avoided, a TA and communications analysis were conducted based on informal interviews with personnel on the platform.

The TA detailed tasks undertaken by operators, information available to decide the correct course of action, and the type of feedback provided from this action. The communication analysis recorded who was communicating, their locations, the facilities available to aid communication and any other factors that would affect performance.

The results of the TA and communication analysis revealed that levels of noise made public address systems ineffective, pagers were made ineffective through background noise and the production control room is visually isolated from the rest of the platform. The findings led to a number of recommendations:

- the public address system should have an automatic volume so it does not become ineffective when background noise increases;
- telephone pagers should have a visual display to avoid reliance on audio alerts;
- closed circuit television (CCTV) should be used to ensure that the production control room can observe what is happening on the platforms.

These recommendations led to a number of potential safety benefits, such as quick and effective responses to emergencies/abnormal conditions and a reduction in the likelihood of operator error, operator downtime, and accidents.



Evidence from healthcare

For hospital facilities and associated equipment to operate effectively, they must be designed to support all of the people who will use them. A user-centred approach is therefore required in order to design for the needs, capabilities, limitations and characteristics of all of these people, and to understand in detail the hazards associated with the activities that they will undertake. Specifically, user-centred design can:[8,9,10,11]

- minimise the prevalence and implications of human errors in the delivery of care;
- minimise/reduce health and safety risks to patients, staff and the public;
- promote recovery and patient well-being.

Healthcare research

Empirical evidence and narrative reviews from healthcare suggest that addressing the needs, capabilities, limitations and characteristics of facility users leads to improvements in the following areas:[6,8,9]

- patient stress, anxiety and safety;
- healthcare associated infections (HCAI);
- sleep quality;
- slips, trips and falls (patient, staff and visitor);
- patient transfers (cost and medical error);
- staff satisfaction and turnover;
- staff fatigue;
- quality of staff-patient communication.

DESIGN PRINCIPLES

A summary of design principles found in other industries is presented below (see references for sources of these principles).

The project team

The design team should utilise the skills and perspectives of a number of different experts, such as human factors and risk specialists, as well as involving stakeholders and key facility users.

Consistent and effective leadership is then needed to implement and drive the design process and ensure that safety-oriented design is an ongoing priority.

Involving staff (clinical and non-clinical), the public and patients at all stages in the design process ensures that the facility will support the people who use it and enhance safety. Similarly, stakeholder representatives for families, patients, staff, regulators, professional bodies, designers and community bodies should be engaged throughout the design process.

- Use multi-disciplinary teams including human factors and risk specialists.[12,13,14,15]
- Adopt consistent and effective leadership.[13,16,17]
- Involve users early and throughout the design process.[13,16,18]
- Engage all stakeholders.[13,16,19]

"Best practice in human factors integration (HFI) is to appoint a human factors manager who is responsible for planning, monitoring and coordinating HFI activities. For large projects it is recommended that the human factors manager is a dedicated role, staffed by specialists."

Health and Safety Executive[20]

People and process

Facilities should be designed around major organisational processes, defined and documented at an early stage to identify key operational needs and highlight major areas for hazard identification and solution development.

The needs and requirements of vulnerable patients and activities also need to be addressed at an early stage in order to avoid potentially costly changes later on.

Developing an understanding of the experiences of facility users and the journeys they make within the hospital will help to ensure that their operational needs and associated hazards are addressed.

- Design around major organisational processes.[13,16,21]
- Design around the key vulnerable populations.[12,22,23]
- Understand the user experiences and journeys.[22,23,24]
- Mock-up and evaluate concepts at every stage.[16,17,24]

"The mix of knowledge and experience will lead to a broader, more comprehensive and balanced consideration of human factors issues."

European Organisation for the Safety of Air Navigation[4]

"The equipment will need to be designed to match specific characteristics and requirements of the people and processes."

London Underground[3]

Address known problems

The design of the facility must tackle the known hazards relating to patients, staff and visitors that have been identified and documented within the healthcare field. A number of information sources can be used to help identify and understand these hazards and to develop design solutions (e.g. analysis of current facility designs, incident data and reports from other healthcare or safety critical organisations).

Contributory factors and latent conditions that contribute to an active failure, as well as any new risks that design solutions introduce, should also be determined and tackled by the design team (see Step 4, page 20).

- Address known hazards to patient, staff and visitor safety in the physical environment.[17,19,21]
- Use/assess existing designs and incident data for common problems.[16,21,23]
- Identify contributory factors and latent conditions.[17,19,23]
- Identify and mitigate any new risks that may be introduced.[13,21,23]

"Important lessons can be learned from existing working environments. Aspects will have been optimised during use of existing systems or modifications made to remove problems… Aspects should be captured to avoid repeating existing mistakes."

London Underground[3]

Key design considerations

Standardisation has many benefits for patients, staff and visitors, and should be maximised in the hospital infrastructure (technology, equipment, computer systems, electrical equipment layouts, interfaces, room design, storage and navigation, systems and processes).

Designing for usability ensures that the facility and its equipment are easy to learn, effective, efficient and satisfying to use. In addition, designing for functionality helps to ensure that the facility design supports work process and workflow, whilst also being flexible in order to accommodate ongoing change.

Simplicity is another important design consideration – the simpler a facility, the easier it is to understand and use. The lean manufacturing philosophy is a useful approach to help simplify processes and reduce waste, therefore speeding up production and reducing error and inefficiencies.

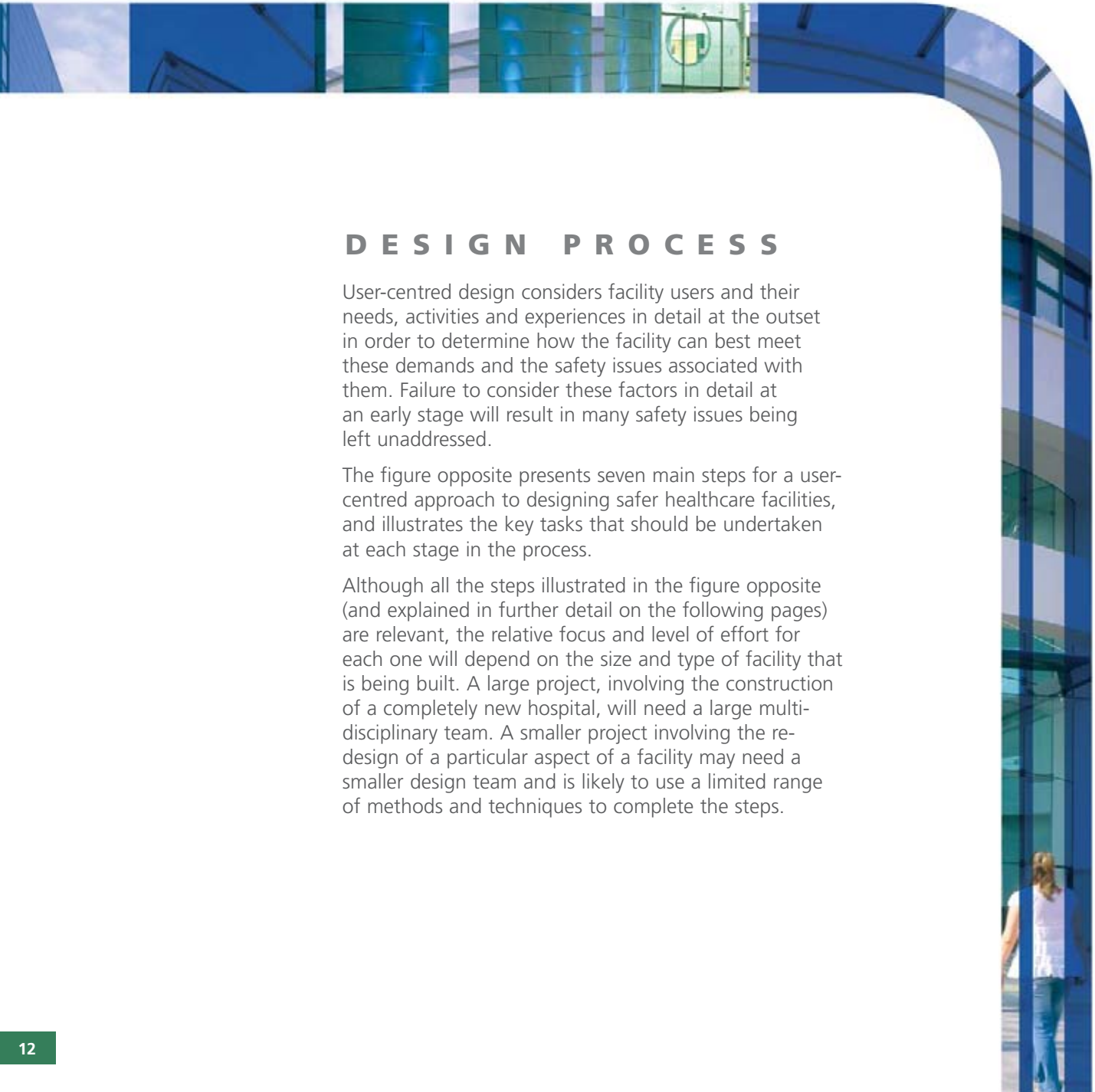
- Design for standardisation.[12,16,24]
- Design for usability, functionality and flexibility.[16,18,19]
- Focus on simplicity.[16,18,22]
- Focus on systems, not just individual elements.[13,14,22]
- Design for visibility.[12,25]
- Design for workflow.[12,25]

Design evaluation

Design solutions should be evaluated using actual potential users of the facility. This will not only help to ensure that the design of the facility meets the requirements of all users, but that any potential new risks related to the design solution can be identified and tackled.

The design process should be iterative, with findings from each stage fed back to earlier stages. It is important to ensure that evaluation results are communicated to everyone involved.

- Evaluate design with real users.[16,18,21]
- Ensure that the design process is iterative.[13,14,23]
- Feed back evaluation results and learn from the process.[12,16,22]
- Disseminate results nationally.[12,14,22]



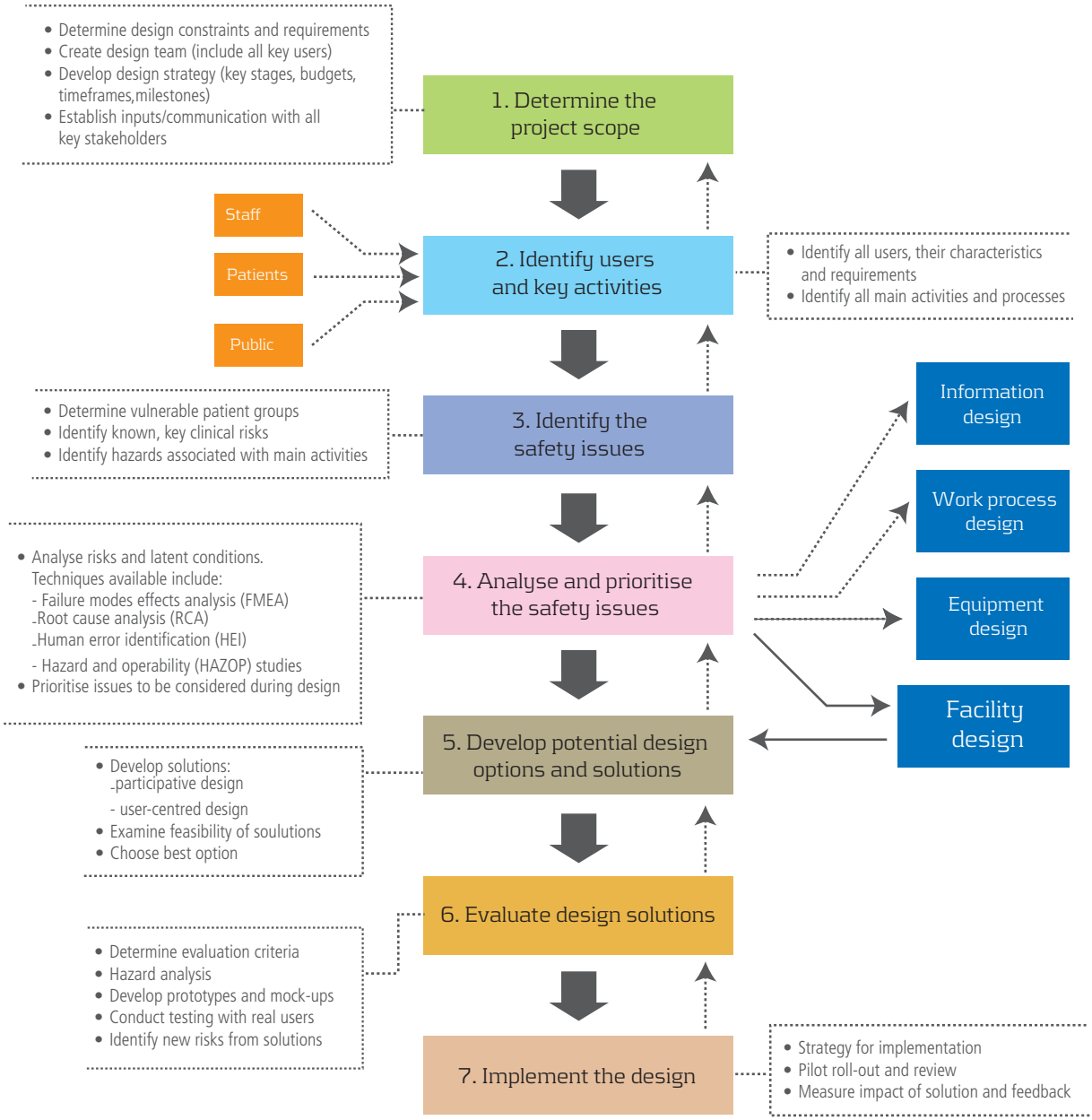
DESIGN PROCESS

User-centred design considers facility users and their needs, activities and experiences in detail at the outset in order to determine how the facility can best meet these demands and the safety issues associated with them. Failure to consider these factors in detail at an early stage will result in many safety issues being left unaddressed.

The figure opposite presents seven main steps for a user-centred approach to designing safer healthcare facilities, and illustrates the key tasks that should be undertaken at each stage in the process.

Although all the steps illustrated in the figure opposite (and explained in further detail on the following pages) are relevant, the relative focus and level of effort for each one will depend on the size and type of facility that is being built. A large project, involving the construction of a completely new hospital, will need a large multi-disciplinary team. A smaller project involving the re-design of a particular aspect of a facility may need a smaller design team and is likely to use a limited range of methods and techniques to complete the steps.

Designing for patient safety



The key aims, considerations and activities for the seven main steps for a user-centred approach to designing safer healthcare facilities are summarised below.

Step 1: Determine the project scope

1.1 Determine the design scope, constraints and requirements

The initial project scope needs to be clearly defined by considering:

- end-users, e.g. the population serviced by the facility and the type of patient that will use the facility, based on services provided;
- services that the facility will provide;
- constraints, e.g. resources, the degree of flexibility required from the design, stakeholder interests;
- requirements, e.g. staff numbers, occupancy rates, number of beds, percentage of single-bed and multi-bed wards.

1.2 Create the design team

A multi-disciplinary design team (including representative key users and experts, e.g. human factors and risk experts, individuals with healthcare associated infection (HCAI) knowledge) is required, and appropriate consultation and communication needs to be established with key stakeholders.
In order to work effectively, the design team should have a clear leader and create defined roles and responsibilities for designers, stakeholders and expert consultants.

1.3 Develop the user-centred design strategy

A user-centred design strategy should take into account all the activities required during the design, development and implementation of the facility that will address user requirements, risks, hazards, safety issues and usability issues. It should also include users in the design process and consider normal, abnormal, degraded and emergency operating conditions.

In order to achieve these objectives, a user-centred design strategy should:

- provide a strategic framework so that all user requirements, risks, hazards and usability/safety related issues will be addressed throughout the design process;
- provide clear indicators as to what are considered to be acceptable and unacceptable levels of patient safety risks;
- have a process to record, track and eliminate or mitigate identified risks, hazards and usability/safety related issues;
- set out responsibilities of all external contractors and internal personnel with respect to implementing and managing the user-centred design process;
- anticipate potential barriers.

"It is critical that those end-users involved in informing and evaluating the design are representative of the eventual end-users."
London Underground[3]

1.4 Establish inputs/communication with all key stakeholders

In order to ensure their effective engagement, the expectations, requirements, conflicts of interest and strengths of the following key stakeholders should be identified:

- representatives of all clinical and non-clinical staff, patients and the public;
- regulators and industry representatives;
- designers, builders, architects, engineers, equipment representatives, private finance initiative consortiums (PFIs) and the trust executive team;
- human factors and risk management experts.

Those stakeholders to be actively involved with the design team should be identified, as well as how best to communicate with those that are not actively involved.

A responsible, accountable, supportive, consulted and informed (RASCI) chart can be a useful tool to help identify and determine who should be in the design team, the roles and responsibilities of team members, and at which points within the design process to communicate with different stakeholders.

Step 2: Identify users and key activities

The second step in the design process is to obtain a thorough understanding of the facility users, their experiences and how the facility promotes positive patient outcomes and minimises risks to all users.

2.1 Identify all users, their characteristics and requirements

Identifying all potential users of the facility, their characteristics (e.g. age, language ability, mobility and experience using the facility) and their requirements is an essential part of user-centred design.

A 'user group matrix' can be used to systematically identify users and determine their level of vulnerability, characteristics and needs, and any associated safety and design implications (see full report[1] for details).

2.2 Identify all main activities and processes

Understanding the user experience for each specific user group enables the design team to gain an early understanding of the key organisational processes to design around. The following activities can help:

- elicit information regarding processes and activities from real users of similar facilities through observations, interviews, surveys and workshops;
- create a model of workflow that considers the services provided and the goals, major tasks and sub-tasks for each of these, and the relationships and interaction between services;
- use participative workshops with real users to confirm the accuracy of this workflow model;
- review policies and procedures within the organisation or wider in order to understand the existing recommended working practices;
- be aware of differences between recommended and realistic working practices.

Relevant characteristics of the physical and social environment, including the materials and equipment people use, characteristics of the workspace, temperature, humidity, noise and work practices, should also be considered.

'Lean manufacturing' approaches are helpful when designing around core processes, while observation, interviews, questionnaires, surveys, participative workshops, scenarios and walk/talk-throughs can be used to identify users, requirements and key activities (more details on these techniques can be found in the full report[1]).

"Analysis should be carried out of the tasks that will be involved in performing safety functions to determine the demands on personnel in terms of perception, decision making and action."

Nuclear Installations Inspectorate[23]

Step 3: Identify the safety issues

Step three identifies safety issues associated with the facilities, its processes and users.

3.1 Determine vulnerable patient groups and vulnerable activities

It is important to design around vulnerable populations and vulnerable activities (treatments that leave individuals who are not within vulnerable populations at risk) as they are likely to be the most susceptible to risks and provide the greatest challenges for the design.

Vulnerable activities include surgery, anaesthetisia, recovery from surgery and transfers, while vulnerable patients can be considered as people:

- who are more susceptible to errors and hazards (e.g. patients suffering from complex conditions, those needing multiple or emergency interventions);
- who are more fragile than the average patient;
- for whom the outcome of incidents would be more serious (e.g. falls in the elderly);
- with whom communication may be difficult (e.g. due to language difficulties, hearing problems, unconsciousness, confusion);
- who bring additional hazards into the facility (e.g. infection, emotional needs and behaviours);
- who are categorised as having special needs (e.g. physical, mental and/or emotional).

The range of services to be provided, as well as the community and target population served, will determine the vulnerable patient groups and activities for a facility. Once these have been identified, it is essential to recognise and understand in detail the relevant needs, requirements and characteristics. Understanding the activities undertaken, treatments, equipment, devices and medicines used, and the characteristics of the environment for all of these, will help to identify the requirements and potential hazards associated with them.

Observations, workshops, surveys and formal studies (such as HAZOP studies) can be undertaken to assess needs and requirements, although these approaches may need to be adapted to accommodate certain vulnerable patient groups (see full report[1] for details of methods).

"When making design choices, the solution should work for the most vulnerable patients."

Center for the Study of Healthcare Management[19]

3.2 Identify known, key clinical risks

In order to improve patient safety, facility design must tackle known clinical risks areas (e.g. risks known to be associated with the delivery of healthcare in a facility/hospital, for example the spread of infection, treatment errors, delays in emergency care, slips, trips and falls, and injuries through manual handling).

The benefits of doing this have been highlighted in healthcare research[9,10,24] and include, for example, increased hand washing, reduced cross-infection and lower levels of surface bacterial contamination.

3.3 Identify hazards associated with main activities

Hazards and risks associated with the main functions and activities of the facility should be proactively identified (e.g. by using hazards checklists). These could include:

- very frequent or practised activities that are subject to slips in human performance, accepted violations or established work-arounds;
- rare or exceptional activities that staff may have little opportunity to practice;
- locations that have specific functions, e.g. operating rooms, reception areas;
- locations that may have safety implications for many activities, e.g. stores, blood banks.

This task will also help to identify key areas for mock-ups and user testing in the next stage of the design process. A number of methods, such as HAZOP studies and RCA, can be used to identify hazards. It is important that all risks are recorded (even those not selected for further evaluation) and addressed in the design solution and evaluation stages.

FMEA, HAZOP studies, TA, HEI techniques, heuristic evaluation, user trials and mock-ups are all methods that can be used to prioritise specific risks. More information on these techniques can be found in the full report[1].

Potential facility area for consideration	Examples of risks to consider
Operating theatres	Infection; medication errors
Recovery units	Poor staff visibility of patients
Patient wards (single-bed, multi-bay)	Infection spread; patient stress
Reception areas	Slips, trips and falls; violence to staff

Potential facility activities for consideration	Examples of risks to consider
Resuscitation	Equipment not maintained on resuscitation trolleys; items not replaced
Clinical handover	Access to information systems such as whiteboards and records; areas for staff meetings; visibility of patients
Bedside checking and prescribing	Provision of working areas; lighting; access to patients, devices and equipment

Step 4. Analyse and prioritise the safety issues

The aim of the fourth step in the design process is to analyse and prioritise the safety issues identified in step three and identify those that need to be addressed by facility design solutions.

These techniques will help to describe hazards in more detail to determine where in a sequence of actions these hazards and usability/safety related issues will occur, as well as their severity and likelihood of occurring. This will give a clear indication of which issues require design solutions, and therefore where time and resources should be focused.

Finally, the depth of knowledge obtained from this analysis will allow for the development of more effective and practical design solutions.

4.1 Analyse risks and latent conditions

Some hazards, referred to as latent conditions or factors, can lie dormant for long periods of time and may only bring about adverse consequences when they combine with other factors.

For example, lack of sound-proofing/damping to minimise ambient noise is a latent condition that may mask auditory alarms on equipment or make communication between staff difficult. This could lead to poor monitoring of patient status, stress (for patients and staff) and miscommunication between staff resulting in errors in diagnosis, medication and treatment.

Latent conditions relating to inadequate standardisation (e.g. of interfaces, equipment, working procedures and prescribing systems) could cause procedures to be carried out differently, introducing errors in treatment, medication and communication (e.g. due to lack of familiarity with equipment, incorrect assumptions regarding patient information and test results).

"The need to identify hazards, assess risks and select, implement and monitor preventive actions is an essential foundation of safety management – the avoidance of latent failures."

Advisory Committee on the Safety of Nuclear Installations[24]

4.2 Prioritise which safety issues can be addressed by facility design

Not all risks and hazards can be addressed by facility design; some issues will be better addressed through the design of equipment, information or work processes.

Those that can, should be prioritised in terms of perceived severity or consequence for patients, staff and the public, and perceived likelihood of occurrence. The likelihood needs to consider both the probability per activity and the frequency of the activity.

A risk matrix such as the one opposite indicates which combinations of severity and likelihood should be considered for detailed examination. All risks and hazards above 'moderate' should be examined in more detail in the next stage of the design process.

Risk matrix

Consequence	Likelihood 1 Rare	2 Unlikely	3 Possible	4 Likely	5 Almost certain
5 Catastrophic	5	10	15	20	25
4 Major	4	8	12	16	20
3 Moderate	3	6	9	12	15
2 Minor	2	4	6	8	10
1 Negligible	1	2	3	4	5

For grading risk, the scores obtained from the risk are assigned grades as follows:

1-3 Low risk | 4-6 Moderate risk | 8-12 High risk | 15-25 Extreme risk

After screening, specific risks, hazards, latent conditions, usability problems and other safety related issues should be prioritised. Which of these risks will have design solutions developed, and which can be considered acceptable or highly unlikely and therefore addressed at a later date or not at all, can then be determined.

FMEA, HAZOP studies, TA, HEI, heuristic evaluation, user trials and mock-ups can be used to analyse how people use facilities and to identify risks, hazards and problems with usability that may lead to safety issues (although not all the methods will assist in the prioritisation of risks, for example, in terms of frequency and severity).

Step 5: Develop potential design options and solutions

The aim of step five is to develop potential design options to reduce risk and meet user requirements.

5.1 Develop solutions

Design solutions should reduce the potential for human error (especially in the delivery of care) and incorporate features that will promote positive patient outcomes and well-being (particularly for patients and staff).

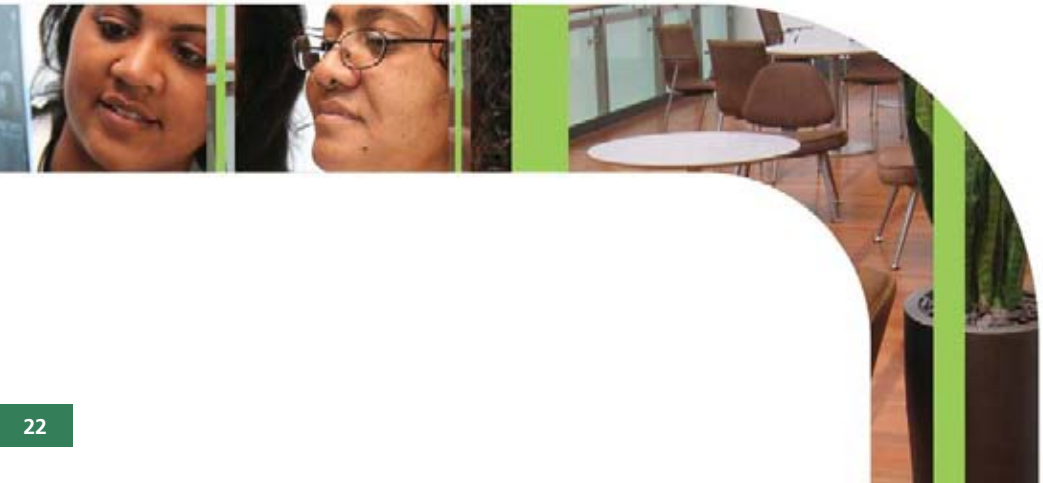
User-centred design ensures that the user is directly involved with the design process (i.e. designers consult them to establish their needs and requirements), but they are not always involved in the development of design solutions. Participative design goes further; actively involving users in the development of solutions and decision making processes regarding prioritisation and selection.

This approach is advantageous in that it utilises the operational knowledge of end-users to ensure design solutions are better received and used by end-users.

Methods to use include focus groups, workshops, individual interviews, questionnaires and surveys.

"Accident rates tend to be lower when participative relations exist…That is, all members of staff help identify hazards and suggest remedies."

Advisory Committee on the Safety of Nuclear Installations[24]



5.2 Examine feasibility of solutions

It is likely that several potential design solutions will be generated.

Assessing feasibility will include considering:

- the basic feasibility;
- the creation of any new risks or safety issues from the option;
- the likely cost-benefits of the option.

Cost-benefit analysis identifies the potential costs of implementing the design solution and compares them with the potential benefits by giving them a monetary value. This allows a business case for implementing a particular solution to be built, which is further enhanced by the inclusion of benefits that cannot be given a monetary value, such as patient or staff satisfaction.

Cost considerations can include:	Benefits can include:
• available budgets; • time; • labour or expertise required; • materials; • maintenance and testing costs; • frequency of use; • replacement costs (lifecycle); • disruption; • training.	• safety improvements (accident/incident rates); • reliability of facility; • maintainability of facility; • efficiency benefits (reduced length of patient stay, increase in number of patients that can be treated); • patient, staff and public satisfaction; • quality of relationship between staff and patient; • cost savings and/or increased revenues.

5.3 Choose the best options

Choosing the best design options (i.e. those to take forward for detailed evaluation), should consider:

- improvements in patient safety and usability;
- reliability – is the solution going to be reliable?
- maintainability – can the solution be maintained over a long period of time and can the facility afford to maintain the solution?
- affordability – can the solution be built and implemented?
- flexibility and adaptability – how easily will the option accommodate future changes in demand or use?
- time – how quickly can the option be implemented?
- disruption – how much disruption is caused by the potential option?

Methods that can be used to develop design solutions include FMEA, RCA, HAZOP studies, TA, HEI, user trials, mock-ups, participative workshops, interviews and computer aided design (see full report[1]).

Step 6. Evaluate design solutions

The sixth step in the design process is to evaluate and evolve a design solution so that it is fit for implementation.

6.1 Determine evaluation criteria

Design solutions should be evaluated against a clear set of performance criteria (specifications or indicators that must be met). These should consider overall cost-benefits and determine to what extent the design eliminates or reduces identified risks/hazards, meets user requirements, avoids the introduction of additional significant risks or safety issues, and allows the incorporation of positive features.

6.2 Hazard analysis

Hazard analysis can be conducted at any stage of the detailed design development. When there is no prototype or mock-up available, scenarios and participative workshops can be used. In all cases, a form of HAZOP study can be used to identify sequences of activities and the extent to which hazards are eliminated, as well as where new hazards may occur and their consequences.

6.3 Develop prototypes and mock-ups

When the design has reached an appropriate point, the evaluation should include real-life conditions through the use of mock-ups and/or prototypes. Parts of the design that can be mocked-up during the early stage of the design process (when development of a full prototype is not possible) include:

- dimensions;
- dynamics between the users and parts of the facility;
- surfaces and moving parts;
- position and orientation of a part of the facility (e.g. bed, bathroom, cupboard, reception desk) in relation to the user and/or other parts of the facility;
- information (signage, labelling, instructions, icons and symbols).

6.4 Conduct testing with real users

User testing involves the observation of a representative sample of intended users using the facility or mock-up, or carrying out a specific task or activity. It is particularly important to ensure that key groups of users are represented according to criteria such as range of skills, training, experience and vulnerability, and testing should simulate:

- different users and their characteristics;
- different tasks and activities;
- different characteristics and parts of the facility;
- different environmental characteristics (e.g. noise, temperature and interactions with other parts of the facility);
- unusual circumstances (e.g. power outage or break in other essential utility).

> *"Always make sure that any alterations are evaluated by the people who do the job and take care that a change introduced to solve one problem does not cause difficulties somewhere else."*
>
> Health and Safety Executive[14]

6.5 Identify new risks from solutions

It is important to appreciate that new risks can occur because of new or changed design, and to use the available methods to identify new potential risks.

Step 7: Implement the design

The final step in the design process is to develop a robust and successful implementation strategy and ensure that early feedback on facility use is obtained in order to enable further learning and improvement.

7.1 Strategy for implementation

Design implementation is frequently where many projects fail. Designs can be degraded due to inadequate implementation, and issues can arise from a lack of resources, late and inadequately considered amendments, and failure to build to the required standards and quality. Compromises made in order to meet programme timescales or cost requirements, poor change management and cultural barriers (beliefs, different working styles etc) can also create problems.

The development of an implementation strategy should involve all key stakeholder groups who will influence, and have a vested interest in, the facility. The implementation strategy should consider the leadership, logistics, resources, timescales and key stages for the implementation, as well as the key roles and responsibilities of the design team, delivery team and other stakeholder groups.

7.2 Pilot roll-out and review

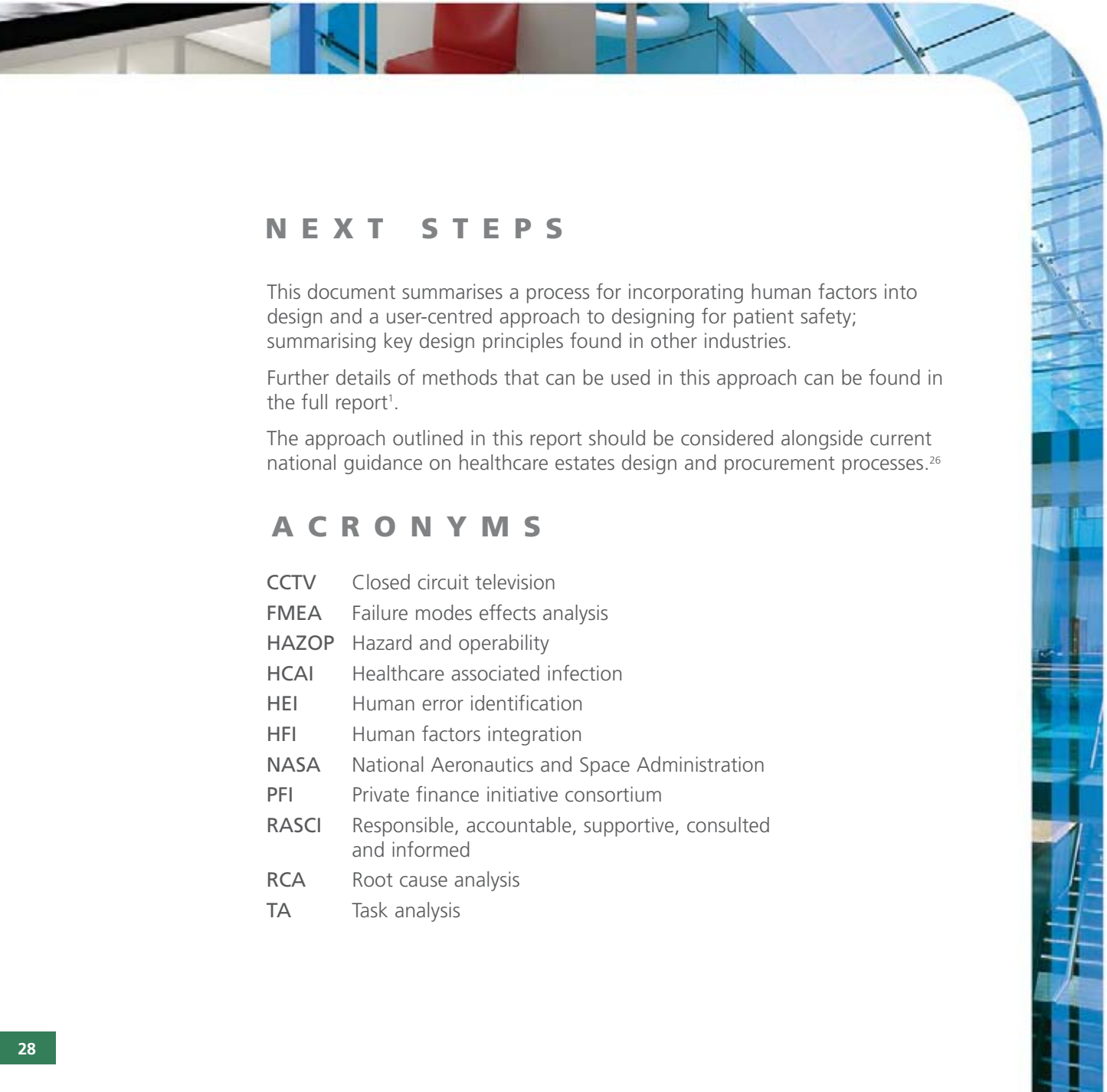
Pilot roll-out and review creates an evidence base that can help further evaluate the facility design and feed into other similar designs. It also allows staff, patients and the public to use the facility, which helps them to understand how it operates and what the design is trying to achieve, while also giving them the opportunity to identify any problems with facility design that may have an impact on safety.

7.3 Measure impact of solution and feedback

Surveys and questionnaires should be used to get user feedback, and field studies should be conducted to obtain information about actual use and arising issues, including the impact of the solution and any risks introduced. Quality checks should be maintained in order to ensure that the review process is meeting its objectives.

"Many human factors issues can only be addressed by attending to several areas of design…Best practice is achieved only when human factors are integrated into the mainstream of systems development."

Health and Safety Executive[14]



NEXT STEPS

This document summarises a process for incorporating human factors into design and a user-centred approach to designing for patient safety; summarising key design principles found in other industries.

Further details of methods that can be used in this approach can be found in the full report[1].

The approach outlined in this report should be considered alongside current national guidance on healthcare estates design and procurement processes.[26]

ACRONYMS

CCTV	Closed circuit television
FMEA	Failure modes effects analysis
HAZOP	Hazard and operability
HCAI	Healthcare associated infection
HEI	Human error identification
HFI	Human factors integration
NASA	National Aeronautics and Space Administration
PFI	Private finance initiative consortium
RASCI	Responsible, accountable, supportive, consulted and informed
RCA	Root cause analysis
TA	Task analysis

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Further reading is included in the full report, available at www.npsa.nhs.uk/nrls/improvingpatientsafety

Photographs courtesy of: MAAP Architects, Nightingale Associates, Nick Barbair/BDP, Nick Gutteridge (pages 5,14,15,25,27,28 and front cover)

The National Reporting and Learning Service (NRLS) aims to identify and reduce risks to patients receiving NHS care and leads on national initiatives to improve patient safety.

Through its national reporting system, the NRLS collects confidential reports of patient safety incidents from healthcare staff across England and Wales. Clinicians and safety experts help analyse these reports to identify common risks and opportunities to improve patient safety.

Feedback and guidance are provided to healthcare organisations to improve patient safety. These include alerts to address specific safety risks, tools to build a strong safety culture and national initiatives in specific areas such as hand hygiene, surgical safety, design, nutrition and cleaning.

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This publication is also available online at: **www.npsa.nhs.uk/nrls/improvingpatientsafety**

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