Empirical review of NHS estates ergonomic drawings

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Empirical Review of NHS Estates
Ergonomic Drawings

By
Jun Lu

A Doctoral Thesis
Submitted in partial fulfilment of the requirements
for the award of
Doctor of Philosophy of Loughborough University
April 2008

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ABSTRACT

In the late 1970s and the early 1980s the Department of Health developed an ergonomic database, in the form of ergonomic drawings, to act as guidance for the design of new hospitals and the adaptation of old buildings. But there is very little peer-reviewed empirical evidence published to support the recommended drawings.

The project used ergonomic methodologies to review the ergonomic drawings of single bed spaces and toilet / shower facilities on adult acute wards and intensive care units (ICUs) in terms of nursing staff carrying out specific clinical tasks. The objectives were to (1) review the complex interfaces using ergonomic task analysis methods from other industries, (2) to provide up-to-date ergonomic information to designers (architects) and planners on spatial requirements for the above units, and (3) provide recommendations for the development of future guidance on functional space requirements.

Five PFI hospitals were visited to capture a range of 'actual' space dimensions in the forms of coded AutoCAD drawings and relevant photos for the application of building the mock-ups for the Functional Space Experiments (FSEs). The field observations were conducted over 5 weeks at two local hospitals. A total of 100 nursing tasks with 74 nurses were recorded and analysed by using Hierarchical Task Analysis (HTA) and Link Analysis (LA). FSEs were conducted with 36 nurses for the ICU, adult acute ward and toilet/shower mock-ups resulting in 190 composite link analysis diagrams.

The results from the FSEs were described as an 'ergonomic envelope', the incompressible functional space required for clinical tasks in these areas. The average spatial requirement of ward bed space envelope was 11.14m² (average width of 3.21m, length of 3.47m). The average spatial requirement of toilet / shower envelope was 5.43m² (average width 2.08m, length of 2.61m). The average spatial requirement of ICU bed space envelope was 23.47m² (average width of 4.96m, length of 4.80m). It was recommended that both the width and the length should be given together with the area
for an envelope, and hospital planners and architects should regard ergonomic envelope as a "core space" in the hospital development.

Finally a 4-step protocol for future development, revision and testing of ergonomic drawings were presented, and the potential further study areas were suggested.
**TABLE OF CONTENTS**

<table>
<thead>
<tr>
<th>Section</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>vii</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>ix</td>
</tr>
<tr>
<td>List of Figures</td>
<td>xi</td>
</tr>
<tr>
<td>List of Tables</td>
<td>xv</td>
</tr>
<tr>
<td>Chapter 1. INTRODUCTION</td>
<td></td>
</tr>
<tr>
<td>1.1 Background</td>
<td></td>
</tr>
<tr>
<td>1.1.1 The development of NHS Hospital design guidance and ergonomic drawings</td>
<td></td>
</tr>
<tr>
<td>1.1.2 Problems</td>
<td></td>
</tr>
<tr>
<td>1.2 Aims of this project</td>
<td></td>
</tr>
<tr>
<td>1.3 Outline of the thesis</td>
<td></td>
</tr>
<tr>
<td>Chapter 2. LITERATURE REVIEW</td>
<td></td>
</tr>
<tr>
<td>2.1 The development of the hospital accommodation in the UK</td>
<td></td>
</tr>
<tr>
<td>2.1.1 Nightingale's principle</td>
<td></td>
</tr>
<tr>
<td>2.1.2 Modern hospital design</td>
<td></td>
</tr>
<tr>
<td>2.1.3 Recent ideas on patient room</td>
<td></td>
</tr>
<tr>
<td>2.2 Hospital design guidance or recommendations on patient room</td>
<td></td>
</tr>
<tr>
<td>2.2.1 Acute ward bedroom / bed space</td>
<td></td>
</tr>
<tr>
<td>2.2.2 ICU bedroom / bed space</td>
<td></td>
</tr>
<tr>
<td>2.2.3 Toilet and shower room/bath room</td>
<td></td>
</tr>
<tr>
<td>2.3 Summary</td>
<td></td>
</tr>
</tbody>
</table>
## Table of Contents

### Chapter 3. METHODOLOGY

3.1 Research design

3.1.1 Assumptions and research questions

3.1.1.1 Assumptions

3.1.1.2 Research questions

3.1.2 Research objectives and methodological framework

3.1.3 Research methods

3.2 Literature review

3.2.1 Objectives

3.2.2 Search strategy

3.3 Scoping site visits

3.3.1 Objective

3.3.2 Ethical consideration and participating site recruitment

3.3.2.1 Ethical consideration

3.3.2.2 Recruitment of participating sites

3.3.3 Conducting the site visits

3.4 Observations

3.4.1 Objectives

3.4.2 Ethical consideration and subject recruitment

3.4.2.1 Ethical consideration

3.4.2.2 Subjects and recruitment

3.4.3 Pilot study

3.4.4 Conducting the observations

3.5 Functional Space Experiments (FSEs)

3.5.1 Objectives

3.5.2 Ethical consideration and subject recruitment

3.5.2.1 Ethical consideration

3.5.2.2 Subjects and recruitment

3.5.3 Building the full size mock-ups

3.5.4 Pilot study
## Table of Contents

### Chapter 6. FUNCTIONAL SPACE EXPERIMENT (FSE)

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1</td>
<td>122</td>
</tr>
<tr>
<td>Data collection</td>
<td></td>
</tr>
<tr>
<td>6.1.1</td>
<td>122</td>
</tr>
<tr>
<td>FSEs for bed spaces and en-suite toilets / shower rooms in acute wards</td>
<td></td>
</tr>
<tr>
<td>6.1.1.1</td>
<td>122</td>
</tr>
<tr>
<td>Mock-ups</td>
<td></td>
</tr>
<tr>
<td>6.1.1.2</td>
<td>126</td>
</tr>
<tr>
<td>Subjects</td>
<td></td>
</tr>
<tr>
<td>6.1.1.3</td>
<td>126</td>
</tr>
<tr>
<td>Simulation scenarios</td>
<td></td>
</tr>
<tr>
<td>6.1.2</td>
<td>131</td>
</tr>
<tr>
<td>FSEs for room and cubicle bed spaces in ICUs</td>
<td></td>
</tr>
<tr>
<td>6.1.2.1</td>
<td>131</td>
</tr>
<tr>
<td>Mock-ups</td>
<td></td>
</tr>
<tr>
<td>6.1.2.2</td>
<td>133</td>
</tr>
<tr>
<td>Subjects</td>
<td></td>
</tr>
<tr>
<td>6.1.2.3</td>
<td>133</td>
</tr>
<tr>
<td>Simulation scenarios</td>
<td></td>
</tr>
<tr>
<td>6.2</td>
<td>136</td>
</tr>
<tr>
<td>Data analysis and results</td>
<td></td>
</tr>
<tr>
<td>6.2.1</td>
<td>136</td>
</tr>
<tr>
<td>Room / cubicle bed spaces and en-suite toilets / shower rooms in acute wards</td>
<td></td>
</tr>
<tr>
<td>6.2.1.1</td>
<td>136</td>
</tr>
<tr>
<td>Analysis and results of room / cubicle bed space in acute wards</td>
<td></td>
</tr>
<tr>
<td>6.2.1.2</td>
<td>145</td>
</tr>
<tr>
<td>Analysis and results of en-suite toilet / shower room in acute wards</td>
<td></td>
</tr>
<tr>
<td>6.2.2</td>
<td>150</td>
</tr>
<tr>
<td>Room / cubicle bed spaces in ICUs</td>
<td></td>
</tr>
<tr>
<td>6.3</td>
<td>157</td>
</tr>
<tr>
<td>Summary</td>
<td></td>
</tr>
</tbody>
</table>

### Chapter 7. DISCUSSION

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.1</td>
<td>158</td>
</tr>
<tr>
<td>Design guidance and information for design</td>
<td></td>
</tr>
<tr>
<td>7.1.1</td>
<td>159</td>
</tr>
<tr>
<td>Design guidance</td>
<td></td>
</tr>
<tr>
<td>7.1.2</td>
<td>162</td>
</tr>
<tr>
<td>Credible research as design information</td>
<td></td>
</tr>
<tr>
<td>7.1.2.1</td>
<td>163</td>
</tr>
<tr>
<td>Evidence-based design</td>
<td></td>
</tr>
<tr>
<td>7.1.2.2</td>
<td>164</td>
</tr>
<tr>
<td>What is the evidence for architect’s evidence-based design?</td>
<td></td>
</tr>
</tbody>
</table>
Table of Contents

7.2 Special information used in hospital development: ergonomic knowledge

7.2.1 Participatory ergonomics

7.3 Standardisation

7.4 Functional space experiments (FSEs)

7.4.1 Why FSEs?

7.4.2 Ergonomic envelope

7.4.3 FSEs results

7.4.4 Limitations

7.4.4.1 Mock-up

7.4.4.2 Participant

7.4.4.3 Dealing with observational information

7.5 Some suggestions

7.5.1 Ethics issue

Chapter 8. CONCLUSION AND RECOMMENDATION

8.1 Review of the researcher questions with the outputs

8.2 Protocol for future development, revision and testing of ergonomic drawings

8.3 Future research works

References

Appendices

- Appendix A: Information sheets
- Appendix B: Consent forms
- Appendix C: Observation data collection sheets
- Appendix D: Data from 5 site visits
- Appendix E: Observational data analysis – HTA
| Appendix F: Standard instructions for the tasks to be simulated in FSEs | 253 |
| Appendix G: FSEs data analysis – LA | 261 |
| Appendix H: Expert interview schedule | 267 |
ABSTRACT

In the late 1970s and the early 1980s the Department of Health developed an ergonomic database, in the form of ergonomic drawings, to act as guidance for the design of new hospitals and the adaptation of old buildings. But there is very little peer-reviewed empirical evidence published to support the recommended drawings.

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Finally a 4-step protocol for future development, revision and testing of ergonomic drawings were presented, and the potential further study areas were suggested.
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After completing my PhD, I have now the opportunity to express my gratitude to a number of people who contributed in some way to this thesis.

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# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Figure Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter 1</td>
<td>Core bed space — elevation view and plan view</td>
<td>3</td>
</tr>
<tr>
<td>Chapter 2</td>
<td>A Nightingale ward</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>The ward plans: from Nightingale to cruciform and sub-divided</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>The racetrack plan and the Falkirk plan</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>A 4-bed bay in the experimental ward at Larkfield Hospital, Greenock</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>“Nucleus” wards 1990 — a six-bed room and a single-bed room</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>The universal patient room</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>AEDET</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Acute ward bed space</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Five activity zones within a bedroom</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>ICU bed space</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>En-suite toilet</td>
<td>39</td>
</tr>
<tr>
<td>Chapter 3</td>
<td>Methodological framework</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>Project overview</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Sample of HTA</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>Example of HTA of transferring a patient from bed to wheelchair</td>
<td>69</td>
</tr>
</tbody>
</table>
### Chapter 4

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>The hospitals visited</td>
<td>73</td>
</tr>
<tr>
<td>4.2</td>
<td>Sample of sketches of ward bed spaces</td>
<td>76</td>
</tr>
<tr>
<td>4.3</td>
<td>Sample of sketches of ICU bed spaces</td>
<td>77</td>
</tr>
<tr>
<td>4.4</td>
<td>Sample of sketches of en-suite toilet</td>
<td>78</td>
</tr>
<tr>
<td>4.5</td>
<td>Plans of the ward rooms and cubicles measured</td>
<td>81</td>
</tr>
<tr>
<td>4.6</td>
<td>Plans of the ICU rooms and cubicles measured</td>
<td>83</td>
</tr>
<tr>
<td>4.7</td>
<td>Plans of the toilets measured</td>
<td>84</td>
</tr>
<tr>
<td>4.8</td>
<td>Widths and lengths of room bed spaces measured on acute wards</td>
<td>85</td>
</tr>
<tr>
<td>4.9</td>
<td>Widths and lengths of cubicle bed spaces measured on acute wards</td>
<td>86</td>
</tr>
<tr>
<td>4.10</td>
<td>Areas of room and cubicle bed spaces measured on acute wards</td>
<td>86</td>
</tr>
<tr>
<td>4.11</td>
<td>Widths and length of room and cubicle bed spaces measured on ICU</td>
<td>87</td>
</tr>
<tr>
<td>4.12</td>
<td>Areas of room and cubicle bed spaces measured on ICU</td>
<td>88</td>
</tr>
<tr>
<td>4.13</td>
<td>En-suite toilet / shower room in HBN 40</td>
<td>89</td>
</tr>
<tr>
<td>4.14</td>
<td>Areas of en-suite toilets on acute ward and ICU</td>
<td>89</td>
</tr>
</tbody>
</table>

### Chapter 5

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>Layout of single bed room</td>
<td>92</td>
</tr>
<tr>
<td>5.2</td>
<td>Layout of 4 bed room</td>
<td>93</td>
</tr>
<tr>
<td>5.3</td>
<td>Layout of 6 bed room</td>
<td>93</td>
</tr>
<tr>
<td>5.4</td>
<td>Layout of day surgery ward</td>
<td>94</td>
</tr>
<tr>
<td>5.5</td>
<td>Layout of one toilet</td>
<td>94</td>
</tr>
<tr>
<td>5.6</td>
<td>Sample of data sheet</td>
<td>96</td>
</tr>
<tr>
<td>5.7</td>
<td>Layout of ICU bed space</td>
<td>103</td>
</tr>
<tr>
<td>5.8</td>
<td>Layout of ICU single room</td>
<td>104</td>
</tr>
<tr>
<td>5.9</td>
<td>Analysis of task frequency on ward</td>
<td>111</td>
</tr>
<tr>
<td>5.10</td>
<td>Sample of Link analysis of transferring a patient from bed to wheelchair</td>
<td>112</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td>5.11</td>
<td>Sample of HTA to describe the task process of transferring a patient from bed to wheelchair in a ward bed space</td>
<td></td>
</tr>
<tr>
<td>5.12</td>
<td>Analysis of task frequency on ICU</td>
<td></td>
</tr>
<tr>
<td>5.13</td>
<td>Sample of link analysis of washing a patient and changing bed sheets</td>
<td></td>
</tr>
<tr>
<td>5.14</td>
<td>Sample of HTA to describe the task process of transferring a patient from bed-to-bed in an ICU bed space</td>
<td></td>
</tr>
<tr>
<td>5.15</td>
<td>Analysis of task frequency in en-suite toilet</td>
<td></td>
</tr>
<tr>
<td>5.16</td>
<td>Sample of link analysis of assisting a patient in wash</td>
<td></td>
</tr>
<tr>
<td>5.17</td>
<td>Sample of HTA to describe the task process of toileting a patient in a ward en-suite toilet</td>
<td></td>
</tr>
</tbody>
</table>

**Chapter 6**

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1</td>
<td>Mock-ups of bed space layouts of acute wards</td>
</tr>
<tr>
<td>6.2</td>
<td>Mock-ups of en-suite toilets / shower rooms of acute wards</td>
</tr>
<tr>
<td>6.3</td>
<td>Lines representing the boundary and exact space required</td>
</tr>
<tr>
<td>6.4</td>
<td>Sample of standard instruction for the task of bed wash and getting a patient up from bed to chair or wheelchair by a hoist in the ward bed space</td>
</tr>
<tr>
<td>6.5</td>
<td>Sample of standard instruction for the task of providing an emergency assistance when a patient slipped on the floor and fell in the toilet</td>
</tr>
<tr>
<td>6.6</td>
<td>Participating nurses undertaking a bed wash task in an acute ward bed space</td>
</tr>
<tr>
<td>6.7</td>
<td>Mock-ups of bed space layouts of ICUs</td>
</tr>
<tr>
<td>6.8</td>
<td>Sample of standard instruction for the task of transferring a patient from bed to bed in ICU bed spaces</td>
</tr>
<tr>
<td>6.9</td>
<td>Participating nurses undertaking a bed wash task in an ICU bed space</td>
</tr>
<tr>
<td>6.10</td>
<td>Sample of Link Analysis for 3 simulating tasks in a ward bed space FSEs</td>
</tr>
<tr>
<td>6.11</td>
<td>Ward bed space dimension: area (m²)</td>
</tr>
<tr>
<td>6.12</td>
<td>Ward bed space dimension: width (m)</td>
</tr>
</tbody>
</table>
List of Figures

6.13 Ward bed space dimension: length (m) 144
6.14 Ward en-suite toilet / shower room dimension: area (m²) 149
6.15 Ward en-suite toilet / shower room dimension: width (m) 149
6.16 Ward en-suite toilet / shower room dimension: depth (m) 150
6.17 ICU bed space dimension: area (m²) 154
6.18 ICU bed space dimension: width (m) 155
6.19 ICU bed space dimension: length (m) 155

Chapter 7

7.1 Participatory ergonomics in hospital development 171
7.2 User-centred design 175
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Table Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter 1</td>
<td>1.1 Dimensions of bed spaces recommended in different HBNs</td>
<td>5</td>
</tr>
<tr>
<td>Chapter 2</td>
<td>2.1 Benchmark of practice of single patient room</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>2.2 Modules of accommodation in a ward</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>2.3 Activities in / around a bed space of acute ward</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>2.4 Acute ward bed space dimensions from archival documents</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>2.5 ICU bed space dimensions from archival documents</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>2.6 Activities in an en-suite toilet / shower room</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>2.7 En-suite toilet / shower room dimensions from archival documents</td>
<td>40</td>
</tr>
<tr>
<td>Chapter 4</td>
<td>4.1 Rooms visited</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>4.2 Room and bed space coding</td>
<td>79</td>
</tr>
<tr>
<td>Chapter 5</td>
<td>5.1 Overall data presentation of observations on general wards</td>
<td>99</td>
</tr>
<tr>
<td></td>
<td>5.2 Equipment and furniture used during general ward observations</td>
<td>101</td>
</tr>
<tr>
<td></td>
<td>5.3 Overall data presentation of observations on ICUs</td>
<td>107</td>
</tr>
<tr>
<td></td>
<td>5.4 Equipment and furniture used during ICU observations</td>
<td>109</td>
</tr>
</tbody>
</table>
List of Tables

Chapter 6

6.1 Ward bed space templates 123
6.2 Ward en-suite templates 123
6.3 ICU Bed space templates 132
6.4 LA data of bed wash + bed-to-wheelchair by a hoist in ward bed spaces 139
6.5 LA data of transferring a patient from trolley to bed in ward bed spaces 140
6.6 LA data of resuscitating a patient in ward bed spaces 141
6.7 LA data of providing an emergency assistance in ward en-suite toilets / shower rooms 146
6.8 LA data of showering a patient in ward en-suite toilets / shower rooms 147
6.9 LA data of bed wash + bed-to-wheelchair by a hoist in ICU bed spaces 151
6.10 LA data of transferring a patient from bed to bed in ICU bed spaces 152
6.11 LA data of resuscitating a patient in ICU bed spaces 153
6.12 Spatial requirements of ergonomic envelopes 157

Chapter 7

7.1 Samples of hard evidence and soft evidence 166
7.2 Optimal and minimal requirements of ergonomic envelopes 180
7.3 Comparison between a mock-up and a room / space in hospital 182
Chapter 1 Introduction

This chapter introduces Health Building Notes (HBNs) and NHS Estates Ergonomic Drawings and their development during approx. 25 years, summarises the problems on updating and using HBNs and drawings, describes the purpose of this PhD project, and outlines the structure of the thesis.

1.1 Background

The NHS Plan (2000) pointed out that the NHS must be prepared to change and focus on the things that really matter to patients. Hospital design teams and estates and facilities managers must therefore take steps to satisfy and reflect the requirements of patients and their families in hospitals of the future and in those undergoing comprehensive development programmes, and create a safe, efficient, patient-centred environment.

There is no doubt that creating a decent healthcare environment should not be able to just rely on personal opinion or experience. Since the late 1940s, different kinds of policy and guidance have been produced to help people involved in hospital development generate a good design solution for such a complex healthcare delivery system.

1.1.1 The development of NHS Hospital design guidance and ergonomic drawings

The history of the development of officially produced guidance can be traced back to 1948 when the NHS was established. The Ministry of Health had to address how to promote hospital developments, how to set the standards for design, how to achieve equity of provision, and how to monitor progress of developments (Francis, et al, 1999). The appearance of the Hospital Building Notes in 1961 signalled the beginning of a new
era for hospital planners in the UK (Moss, 1977). They informed and set standards for all NHS hospital developments.

In the early 1970s, the DHSS in collaboration with the Regional Hospital Boards developed a systematic approach to hospital design, and adopted a standard method for recording information required to design and equip healthcare buildings. As part of this information system, individual room considerations, including the identification of activity units and the items of fixed or mobile equipment required within these activity spaces, became the Activity Data Base (ADB) providing design guidance.

By the late 1970s or the early 1980s, this ergonomic data base had been developed to comprise Component-User data sheets that illustrated components (i.e. equipment, furniture and fittings) and the space required for activities around them, room layouts and work flow diagrams (Hilliar, 1981; Stanton, 1983). The main function of the data sheets was to ensure the application of adequate space standards in hospital design.

According to Hilliar (1981) and Stanton (1983), full-scale mock-ups were used to obtain ergonomic information and to test other aspects of room and component design during the development of component-user data, but not with user trials (Stanton, 1983).

The data sheets were in the form of drawings, which could visually “give the space requirements for activities and other ergonomic information relating to the use of spaces within hospital and health buildings” (Hilliar, 1981). Since then, some of the drawings have been published in the Health Building Notes (HBNs) series for complementing the notes and acting as guidance for the design of new hospitals and the adaptation or extension of old buildings. They also encouraged those involved in hospital design and planning to think in terms of the relationship between a user (patient or clinical staff) and a particular component and other components located within a defined area to produce a more efficient planning of space. This is one of the ergonomic contributions to the healthcare architecture.
The Figure 1.1 is an example of the ergonomic drawings of a core bed space adapted from HBN 04 (NHS Estates, 1997), with recommended dimensions of equipment, furniture, and space used around the bed etc.

Figure 1.1 Core bed space – elevation view and plan view
(Adapted from HBN 04, NHS Estates, 1997; Reproduced with permission of NHS Estates)
1.1.2 Problems

Since the ergonomic drawings were developed (approximately 25 years ago) there have been considerable changes in both medical technology and clinical practice which both impact on the space requirements for clinical tasks, for example day case and keyhole surgery, diagnostic equipment (CAT, NMR), electric ward beds etc.. The agenda for change in health care has been underpinned by Clinical Governance, which reinforces the need for decisions affecting clinical practice to be supported by robust evidence (Department of Health, 1998). To supplement this there are also national initiatives on patient safety (Department of Health, 2000) and standards for care (Essence of Care). These strategic and professional initiatives set the scene for current clinical practice. Therefore there is an urgent need to understand how the context for provision of healthcare has changed, what the scope is for future technology, who are the stakeholders for the ergonomic drawings, and how architects/project managers are using current drawings, so as to find out whether the drawings have been updated to reflect such changes in clinical practice and medical technology.

Currently, the model of the NHS hospital development is that most new hospitals are designed, built, even owned and run by a private sector consortium or grouping of companies under the Private Finance Initiative (PFI) for at least 25 years, which means the NHS plan aiming at creating such a safe, efficient, patient-centred environment will be delivered with the cooperation of the others, the PFI consortium.

In the hospital development phase, theoretically the architects commissioned by the PFI have to comply with relevant legislation, guidance and should have used HBNs and the existing ergonomics drawings. As it normally takes 10 years or more for a hospital from a very first stage through to design, construction, and being in use, it is likely that the guidance used in the design process will be the version that was available when the design started. However, it is also likely that there will be improvements in clinical practice and medical technology made during the years when the hospital was being
developed. So have the PFI and architects been updating the design to account for the new changes? Would the hospital built under the guidance of “that time” when the design process started be able to accommodate the changes of “this time” when the building was complete?

The Table 1.1 briefly summarised the evolution of some space standards for hospital bed spaces in single bedrooms and multi-bed rooms respectively, it can be seen that the updating has been carried out at “appropriate” intervals of time since 1961 in different individual guidance, in terms of hospital patient bed space design.

<table>
<thead>
<tr>
<th>Guidance</th>
<th>Year</th>
<th>Dimension of bed space in single bed room</th>
<th>Dimension of bed space in multi-bed room/bay</th>
</tr>
</thead>
<tbody>
<tr>
<td>HFN 30 – Infection Control in the Built Environment</td>
<td>2002</td>
<td>Bed centres at least 3.6m apart for infection control</td>
<td></td>
</tr>
<tr>
<td>HBN 04, Vol. 1 – In-patient Accommodation</td>
<td>1997</td>
<td>3.7m x 4.9m (pg.65)</td>
<td>No less than 2.9m x 2.9m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.9m x 2.7m (double room – pg. 67)</td>
</tr>
<tr>
<td>HBN 40, Vol. 2 – Treatment Areas</td>
<td>1995</td>
<td>3.7m - 3.8m in length</td>
<td>2.9m x 2.7m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.1 m - 3.6m in width</td>
<td>(called &quot;core bed space&quot;)</td>
</tr>
<tr>
<td>HBN 4 – Adult Acute Wards</td>
<td>1990</td>
<td>3.9m (3.7m - restricted minimum) in length</td>
<td>No less than 2.9m x 2.5m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.3m (3.1m - restricted minimum) in width</td>
<td></td>
</tr>
<tr>
<td>HBN 40, Common Activity Spaces Vol. 1 – Example layouts; Common components</td>
<td>1986</td>
<td>3.7m - 3.8m in length</td>
<td>2.9m x 2.5m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.8m - 3.6m in width</td>
<td>(called &quot;core bed space&quot;)</td>
</tr>
<tr>
<td>HBN 4 – Ward Units</td>
<td>1961</td>
<td>120 - 140 sq. ft (i.e. approx. 3.6m along the bed axis, 3.3m in width)</td>
<td>8 feet - bed centres apart (approx. 2.4m)</td>
</tr>
</tbody>
</table>

Table 1.1 Dimensions of bed spaces recommended in different HBNs
From the pre-literature review, there are some specific problems in the development, updating and use of the HBNs and the ergonomic drawings:

- There was little literature about architects using ergonomic drawings, so it is difficult to determine whether the drawings work or if there are problems in patient rooms in terms of using them.

- In the HBNs, it did not explain the "ergonomic" reasons behind the drawings very well, which may have led the architects to ignore or misuse them. Moreover, some architects may have produced their own guidance by misusing them.

- Although NHS Estates have been regularly updating the HBNs, including the relevant ergonomic drawings, very little evidence was found to provide a rationale for the changes in the recommended dimensions. According to Table 1.1, for example, the dimensions of single bedroom recommended in HBN 04 of 1997 are 3.7m in length with 3.4m in width, while the dimensions of single bedroom in HBN 04 of 1961 are approximate 3.6m in length with 3.3m in width. The dimensions both of length and width have increased just 0.1m over a period of 36 years, so the question of how the dimensions increased to reflect changes in technology and clinical practice over 36 years is raised. There has been an absence of a research background.

- Some of guidance is dated although they had been updated already. So far there have been 22 existing HBNs including 34 volumes, in which 14 volumes were already over ten years old (Department of Health, 2007). For example, HBN 04 Vol.1 – In-patient Accommodation (NHS Estates, 1997) is the most recent guidance on designing hospital in-patient accommodation. However the recommended dimensions in it do not meet the size of patient bed space

---

1 The update of HBN 04 is in the progress.
recommended in HFN 30 on Infection Control (NHS Estates, 2002). This has already produced controversy with a judicial review into bed space design at University College Hospital (Hawkes, 2004).

1.2 Aim of this project

As the largest repeating unit in a hospital, the inpatient bed space and the en-suite toilet / shower room are configured from multi-bed bays to single rooms and occupied by different users (patients, clinicians, support staff, visitors etc.). There are a wide range of clinical activities performed in / around the bed space and in the toilet. This is a real challenge to the architects who are intending to design a good space for all the users, as it is hard for them to achieve understanding of functionality and usability of the space in terms of complex clinical activities. Hence good ergonomic drawings of the bed space and en-suite toilet could help architects make up for their lack of knowledge of clinical practice.

According to the NHS Plan (2000), hospitals should provide the patients with safe and efficient care as the focus centre for the service provision. To achieve this goal, a safe and efficient working environment is needed for the caregivers, i.e. nursing staff, who spend most time with the patients in the bed space, and use the hospital for much longer periods than patients. If nursing staff’s workplace cannot be ensured to be safe and efficient, the staff may leave due to the different reasons caused by bad functionality and usability, which might lead to the lack of good care for patients. The hospitals will fail to provide safe and quality care and treatment to patients and satisfy their requirements that the hospitals aim for. The hospital will therefore lose the money they try to save.

Based on the above two reasons, this project aims to review the existing ergonomic drawings by looking at the single bed space, and the en-suite toilet/shower room in single rooms and multi-bed bays on adult acute wards and intensive care units (ICU) in
terms of nursing staff carrying out 4 key clinical activities: manual handling, resuscitation, disability access, and infection control, which are frequent tasks and/or have a high injury risk.

The major benefit will be to ensure a safe clinical environment that has been designed with input from patient/carers as well as healthcare staff and other professionals. From a financial perspective the use of generic ‘ergonomic envelopes’ as the framework for key clinical areas may reduce design costs.

1.3 Outline of the thesis

Chapter 1 Introduction: introduces Health Building Notes (HBNs) and NHS Estates Ergonomic Drawings and their development during approx. 25 years, summarises the problems on updating and using HBNs and drawings, describes the purpose of this PhD project, and outlines the structure of the thesis.

Chapter 2 Literature Review: describes the development of hospital accommodation in the past, today and future, reviews the spatial requirements or recommendations of the ward and ICU bed spaces and the en-suite toilet / shower room from the different design guidance or published research, summarises the specific spatial issues for 4 clinical activities to be looked at within a bed room / space or an en-suite toilet / shower room respectively.

Chapter 3 Methodology: describes the research questions, the methodological framework based on those questions, and the methods to be used in the project. Some special issues such as ethic considerations, the subject recruitment are stated as part of methodological work for the NHS-involved research.
Chapter 1 Introduction

Chapter 4 Scoping Site Visit: describes the data collection and analysis of site visits at five PFI hospitals, and presents the data in comparison with the HBN recommendations, also in the forms of coded AutoCAD drawings and relevant photos for the application of deciding the simulation templates in Functional Space Experiments (FSEs).

Chapter 5 Observation: describes the data collection and analysis of observations at two local hospitals, which resulted in: 1.) where the area with the higher density of activities were; 2.) which task occupied more space; 3.) what the generic task components were in a certain task and 4.) the frequency of the nursing tasks, etc..

Chapter 6 Functional Space Experiment: describes the data collection and analysis of FSEs in the mock-ups, which resulted in a total of 60 sets of dimensions of ICU FSEs, 90 sets of ward FSEs and 40 sets of en-suit FSEs. The chapter also describes the further analysis undertaken by comparing the FSE results with the site visit data and the existing HBN recommendations.

Chapter 7 Discussion: summarises the following key considerations to discuss: 1.) design guidance and evidence-based design, how the ergonomic knowledge was used in this project and will be used to support the evidence-based design, 2.) standardisation: some thoughts raised from this project, e.g. why the standardisation was important and what standardisation effort was and will be, relating to the physical environment, 3.) the FSEs result, 4.) some limitations of the project.

Chapter 8 Conclusion and Recommendation: reviews the research questions, presents the protocol for the future development, revision and testing of ergonomic drawings, and suggests the potential further study areas.
Chapter 2 Literature Review

This chapter describes the development of hospital accommodation in the past, today and future; reviews the spatial requirements or recommendations of the ward and ICU bed spaces and the en-suite toilet / shower room from the different design guidance or published research; summarises the specific spatial issues for 4 clinical activities to be looked at within a bed room / space or an en-suite toilet / shower room respectively.

2.1 The development of the hospital accommodation in the UK

Healthcare buildings range from a very small medical centre with less than 10 beds to a very large district general hospital with over 1500 beds. They contain spaces with very complex and intense demands for control of the physical environment.

In HBN 04 Adult Acute Ward (Department of Health and the Welsh Office, 1990) the term “ward” meant the accommodation (bedrooms, day spaces, services space) for a group of patients normally the responsibility of a named sister / charge nurse. This is further defined in HFN30 (NHS Estates, 2002), the following terminology was used:

- **Single room**: a room with space for one patient and usually contains as a minimum: a bed; locker/wardrobe; and clinical hand-wash basin plus a small cupboard with worktop.
- **En-suite single room**: as above but with any combination of en-suite facility, that is, shower, shower and toilet, bath and toilet or just toilet etc.
- **Bay**: any room that contains more than one bed (i.e. two-bedded bay; three-bedded bay; four-bedded bay; six-bedded bay, etc.), which may or may not have en-suite facility.

Cox and Groves (1990) said that a general hospital would usually have the following wards: adult acute, adult surgical, old people’s or geriatric, children’s or paediatric, maternity, orthopaedic, psychiatric, and intensive care ward, as an independent
department. Sometimes there are isolation wards for patients carrying an infection or who need to be nursed in a bacteria-free environment.

As stated in "the Design of Acute Wards (1991)" by the NHS Estates, "experience of the previous designs, combined with a desire to improve patient care and efficient staff use, led to the development of a ward with multi-bed bays and single bed rooms." Meanwhile, architecture and medical technology combined in the design of the hospital mutually shape each other. Medical technology innovations and clinical practice progresses have created a need for hospital space design.

2.1.1 Nightingale's principle

The history of hospital developments can be dated back to the healing practice of ancient Egyptians. The first truly modernist hospital planning principles were introduced through the work of Florence Nightingale following her "Notes on Hospitals" in 1859 (Verderber and Fine, 2000; Miller and Swensson, 2002).

To achieve cross-ventilation and nurse efficiency, Nightingale recommended the construction of a larger ward as a long open space for approximately thirty patient beds with sanitary areas, store rooms and services at either end. This ward was known as "the Nightingale ward" (Figure 2.1). It was approached from one end, lit and ventilated from both sides, and had two rows of beds arranged to face one another, with bed head against the window walls. Day space for patients who could get out of bed, were islands in the central passage between the feet of the beds. A single entrance was adjacent to the nurse's station, from which the ward was observed and controlled (Cox and Groves, 1990; NHS Estates, 1997; Verderber and Fine, 2000). However, patient privacy was compromised by the nursing efficiency and the ability to regulate entry to and exit from the ward (Miller and Swensson, 2002).
Florence Nightingale emphasised the room function. Her principles for hospital design, concerning the aspects such as the maximum allowable width and length of a ward, the size of windows, their placement in relation to the bed, etc. were unprecedented and became the dominant spatial organisation of hospitals for over a hundred years in many countries in Europe and in the US (NHS Estates, 1997; Verderber and Fine, 2000).

The variations on the Nightingale ward, the cruciform and the sub-divided wards were developed respectively at around the end of the 19th century and the early 20th century (Figure 2.2) (Cox and Groves, 1990; NHS Estates, 1997).

With the cruciform plan, the overall length was shortened by the transepts, which humanised the scale of the ward and provided the opportunity to change the location of the nurse station, ancillary rooms, toilet facilities etc. at either end of the ward (Cox and Groves, 1990; NHS Estates, 1997). The sub-divided ward improved the living
standards, in which the long space was wider and subdivided by screens into bays on both sides. Each bay contained three or four beds arranged two deep and parallel to the external walls; patients no longer faced the light from the windows opposite. Sometimes the bays were enclosed as a multi-bed room to give the patients more privacy. The nurse station, which was opposite a single bedroom in the centre, could segregate the sexes. The toilet facilities and the other ancillary rooms were located at the two ends of the block (Cox and Groves, 1990).

Figure 2.2 The ward plans: from Nightingale to cruciform and sub-divided
(Source: Cox and Groves, 1990: 69, 70)
2.1.2 Modern hospital design

The principles and concepts behind hospital design changed since World War II (Francis et al., 1999). The main evolution relating to the hospital ward and patient room were as follows:

1.) Racetrack concept

The “racetrack” concept was introduced after 1945. The hospital wards were planned with multi-bed bays and ancillary grouped around a central core of utilities and circulation due to the small urban sites leading to the development of high hospital buildings. This layout enabled the patient beds to occupy the whole frontage, shortened its length, and provided mixed sex wards with multi-bed bays for use either by female or male patients (Figure 2.3) (Cox and Groves, 1990; NHS Estates, 1997). As a variation on the racetrack plan, the 1960s Falkirk layout had a strong core of facilities with dispersed nurse stations from which nurses could manage a number of bed bays and/or single-bed rooms flexibly in accordance with variations of workload (NHS Estates, 1997).

![Racetrack and Falkirk ward layout](image)

Figure 2.3 The racetrack plan and the Falkirk plan
(Source: NHS Estates, 1997: 34, 35)
2.) Nuffield experimental ward

In 1949 the Nuffield Provincial Hospitals Trust began a study on aspects of the hospital, which significantly influenced hospital ward design. Their report "Investigation into the Functions and Design of Hospitals (1955)" was the only historical document to provide empirical research to support their recommendations. Their work on wards was based on a functional investigation of what the nursing methods were, what was going on in a specific area, and the spatial requirements for the staff to perform their tasks efficiently, etc.. They used work-study techniques and cinematographic data collection to measure the space required for nursing activities such as: bed making, pressure care, manual handling (bed-wheelchair and bed-trolley), giving an intravenous infusion, arranging an oxygen tent over the bed, and taking an X-ray from the front and side (Hignett, et al, 2007).

In the experimental wards at Larkfield Hospital, the smaller 4-bed bays and some of the single rooms had a lavatory immediately adjacent (Figure 2.4) (Hughes, 2000). As many beds as possible were capable of being observed not only from the nurses’ station but also by nurses as they went about the ward on their routine duties (Cox and Groves, 1990).

---

1 A similar procedure was used to compare the space required to move a patient from chair to bed and floor to bed in a bed space, and explore the spatial requirements to transfer a patient from wheelchair to toilet in an en-suite toilet respectively (Hignett and Keen, 2005; Hignett and Evans, 2006).
3.) New NHS hospitals under guidance

As mentioned in the previous chapter, to meet the need for disseminating information, controlling standards, establishing need for capital investment and monitor project developments, a series of Hospital Building Notes (HBNs) were published from the early 1960s. Following the recognition of energy demands, a modular design concept was developed based on principles that aimed to control energy consumption by maximising the external wall area available for windows, limiting the number of floors and standardising the services (NHS Estates, 1997).

Francis et al. (1999) identified a number of initiatives implementing HBNs on these principles. The first generation was “Best Buy” developed in 1960s, “a low, compact, economic plan with highly serviced departments of diagnostic and treatment in a central core separated by a ‘ring main’ corridor from the wards” At the end of 1960s the second initiative (Harness) was developed with “all departments ... assembled round a main
corridor, known as the Harness zone, through which people, supplies and energy pass.” (Francis, 1998).

The ultimate design using these principles became known as the Nucleus hospital, the third generation with a standard cross-shaped “template” of approximately 1000 m². Ward designs for acute, elderly, psychiatric, children and maternity facilities were created. The solutions included six-bedded bays and single rooms, some with en-suite facilities (Figure 2.5). Since the prototype Nucleus adult acute ward was opened in 1980 at Pinderfields General Hospital, Wakefield, hospitals have largely used the model with variations suggested in HBNs between 1985 and 1990 (NHS Estates, 1997).

To summarise, as the changes in medical technology and clinical practice impacted on healthcare facilities, requiring substantial re-developments or upgrades in hospital designs, hospital accommodation in the UK has changed considerably in design from Nightingale’s time.

Figure 2.5 “Nucleus” wards 1990 – a six-bed room and a single-bed room
(Source: NHS Estates, 1997: 37)
2.1.3 Recent ideas on patient room

1.) Single-bed rooms or multi-bed rooms

Over time, healthcare has become more specialized and ward design has developed towards smaller multi-bed bays and single bed rooms, as stated previously. In the United States single rooms have become the industry standard in new construction of acute care facilities (Chaudhury, et al., 2003), whilst in the UK, the optimal number of beds per room in a ward is still an open question with the different bed cluster modules recommended in the guidance (NHS Estates, 1997, 2001, and 2003).

The significant change in society today is increased public expectation about the quality of delivery of service. Expectations of the health services include: higher standards of care; improved services; and to be afforded privacy and dignity during their time in the hospital (Woogara, 2004; Chaudhury, et al, 2003). Single rooms (with en-suite facilities) address the key issues of privacy and dignity in ward accommodation.

There have been a number of studies, looking at the issue of single and multiple occupancy rooms in terms of the following issues (Table 2.1) (Kirk, 2002; Phiri, 2003; Chaudhury, et al., 2003, 2005; Lawson and Phiri, 2004):
### Benchmark of practice of single room

<table>
<thead>
<tr>
<th>Issues</th>
<th>Benchmark of practice of single room</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infection transmission</td>
<td>Lower healthcare-acquired infection (HCA) rates</td>
</tr>
<tr>
<td>Noise</td>
<td>Patients have better quality of sleep, (less stressful)</td>
</tr>
<tr>
<td>Patient safety</td>
<td>Reduced injuries from falls</td>
</tr>
<tr>
<td>Patient preference</td>
<td>Greater dignity and privacy</td>
</tr>
<tr>
<td>Room flexibility</td>
<td>Patients experience less transfer.</td>
</tr>
<tr>
<td>Isolation</td>
<td>Patients feel lonely to some extent.</td>
</tr>
<tr>
<td>Nursing management</td>
<td>Poor nursing observation associated to adverse events</td>
</tr>
</tbody>
</table>

Table 2.1 Benchmark of practice of single patient room

2.) Standardisation, flexibility and the acuity adaptable (universal) room

There are two important future proposals with respect to hospital space design: standardisation and flexibility.

Reiling et al. (2003) set out the need for a ‘truly standardized room’ with specific requirements developed through a Failure Modes Effect Analysis (FMEA). The standardised room locates equipment, supplies and furniture in the same place in every room to promote efficiency in care delivery, reduce the medical errors and improve patient and staff satisfaction (Reiling et al., 2004; Scalise et al., 2004). A further discussion on standardisation can be seen in the section 7.3.
The increasing use of bedside technologies and treatment means that patient rooms must accommodate more bedside equipment, e.g. monitors, computers, pumps and other apparatus, as well as providing more space for clinical staff and family members. For instance, as families are encouraged to be involved in the care, the amenities provided become more important, and the rooms will be designed to contain refrigerators, microwave ovens and other amenities (Glodsmith and Miller, 1990; Cahnman, 2006; Knowles, 1997; Scalise, et al., 2004) Meanwhile, some patients may require walking frames, wheelchair or assistance to move or use the toilet, shower room, which requires more rooms to comply with disability access codes. As a result, a larger, more flexible patient room is explored to be equipped to respond to changes in function, equipment, medical technology and clinical practice (Glodsmith and Miller, 1990; Knowles, 1997; Hamilton, 2003a). The dimensions and configuration of the room include a patient area, family area (including recliner bed etc.), caregiver area and hygiene area (Jastremski and Harvey, 1998; Hamilton, 1999).

Berry et al. (2004) describe acuity adaptable (universal) rooms as standardised rooms with the space, dimensions and features to accommodate a wide variety of patient conditions, needs, equipment and staffing during changing stages of illness and recovery. Despite greater capital costs, it is suggested that increased flexibility and adaptability are likely to produce substantial revenue savings even in the short term.

The only published examples of acuity adaptable rooms are for intensive care facilities (Figure 2.6) (Berry et al., 2004; Hendrich et al., 2004). There was also a study carried out by the NHS Estates to look at how much space was needed around the acute ward bed space for various tasks such as using a trolley, using a hoist, transferring a patient from bed to chair, using resuscitation procedures etc. (NHS Estates, 2005b). The spatial requirement of the above rooms described in the section 2.2.2.
3.) Impact of bedside technology on the ward and patient room

The introduction to the concept of “patient-centred care” at hospitals is changing the traditional ward organisation (Knowles, 1997). Hand-held computing and wireless hand-held communication systems, as one of the biggest trends of bedside technology, encourage and support patient safety efforts and provide clinicians with great mobility; allowing clinical and other patient information to be entered and queried and schedules tracked from remote locations or at the bedside. The caregivers are no longer bound to a central nurse station where information is controlled and managed (Knowles, 1997; Scalise et al., 2004). Their workplace is therefore decentralised and moved closer to patient rooms to encourage more bedside time with patients (Buenning and Shepler, 2006).
Two other trends of patient room technology are point-of-care testing at the bedside and hand-held imaging devices, particularly portable ultrasounds (Scalise, 2004). As mentioned earlier, the increase of the use of portable equipment requires more space in the patient room.

4.) Achieving Excellence Design Evaluation Toolkit (AEDET)

A more recent piece of design support / guidance is the Achieving Excellence Design Evaluation Toolkit (AEDET) (NHS Estates, 2001b). This is recommended to assess new healthcare buildings with three main headings, functionality (user, space, and access), impact (character and innovation) and build standard (performance, engineering, construction) (Figure 2.7). It is not promoted as a universally applicable tool, but as criteria which may be adapted and incorporated into “specifications of design vision, philosophy and quality” (NHS Estates, 2001b).

The usability of AEDET has been questioned by Gesler et al. (2004). The tool focuses more on physical spaces than social or symbolic design, so expecting participants (stakeholders) to translate quite complex qualitative judgements about several discrete questions into single scores in AEDET may, in practice, be quite difficult to achieve.

To summarise, the rapid technological development and the constant organisational decomposition in more and more sub-specialities have made hospital planning and design an increasingly complicated task. The introduction of new diagnostic and treatment techniques is constantly changing the conditions for design. Obsolescence in hospitals is an unavoidable problem, which requires extensive renovations and updates to respond to the emerging needs.
5.) A Staff and Patient Environment Calibration Tool (ASPECT)

ASPECT is a tool for evaluating the quality of design of staff and patient environments in healthcare buildings. It is based on a database of over 600 pieces of research, and delivers a profile that indicates the strengths and weaknesses of a design or an existing building (NHS Estates, 2005a). ASPECT is set out under 8 sections: privacy, company and dignity; views; nature and outdoors; comfort and control; legibility of place; interior appearance; facilities; and staff. Each of 8 sections summarises how well a healthcare building complies with best practice to score that section.

As ASPECT is a tool specifically directed towards achieving excellence in design rather than ensuring compliance with legislation, regulation and guidance. It has been suggested that ‘high scores in ASPECT do not therefore necessarily guarantee compliance (with legislation, regulation and guidance)’ (NHS Estates, 2005a). This may indicate that ASPECT can just be considered as a design or evaluation support, rather than guidance.
2.2 Hospital design guidance or recommendations on patient room

According to HBN 04 Vol. 1 (NHS Estates, 1997) and Vol. 2 (NHS Estates, 1998), there are five modules of accommodation in a ward. This is grouped as a core set of rooms as patient, clinical and support areas (Table 2.2). Some hospital wards also have dedicated accommodation for visitors, doctors on call, and/or rehabilitation services.

In the critical care unit, the model is similar, but there are different considerations for the support facilities for the patient’s family and friends (NHS Estates, 2003a).

<table>
<thead>
<tr>
<th>Modules of accommodation</th>
<th>Core set of rooms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.) Bed and sanitary facilities</td>
<td>Patient areas – bedrooms, sanitary facilities and day spaces</td>
</tr>
<tr>
<td>2.) Patient support facilities</td>
<td>Clinical facilities – treatment room, utility room and storage</td>
</tr>
<tr>
<td>3.) Storage spaces</td>
<td>Support and administrative areas – nurse station, office, staff restrooms</td>
</tr>
<tr>
<td>4.) Utilities</td>
<td></td>
</tr>
<tr>
<td>5.) Staff facilities, Administration areas</td>
<td></td>
</tr>
</tbody>
</table>

Table 2.2 Modules of accommodation in a ward
2.2.1 Acute ward bedroom / bed space

The bed space is the largest repeating design unit in hospitals (Hignett et al., 2007). This space presents a complex design challenge due to the different people who will occupy the space (patients, clinicians, support staff, visitors etc.) and the wide range of task activities (Lu and Hignett, 2005). For patients, it is used as their bedroom, living room, dining room, doctor's office, and even their bathroom.

In 1863 in her “Notes on Hospitals” (Cited by Nuffield Provincial Hospitals Trust, 1955), Florence Nightingale suggested that for a bed space “there should be space sufficient between the sides of adjacent beds to avoid stagnation of air altogether. There should also be room for free movement of three or four persons, for the use of a night-chair, without annoyance to the next patient, and also for a portable bath, when required...” More than one century later, Carpman and Grant. (1993) suggested that general acute care rooms should provide circulation space for clinical teams and equipment to easily gain access to the patient, sufficient space for a wardrobe/bedside locker, overbed table, patient chair, and visitor chair, in addition to patient bed, and an unobstructed circulation area to ensure access for wheelchairs, mobile hoist, walking frames, and even another patient bed or trolley for transferring, and sufficient space to accommodate family and friends’ visits. In multi-bed rooms, additional clearance is needed for manoeuvring one bed past another. There should be sufficient space between other curtained areas to allow trolleys and beds to pass by without being a hazard (NHS Estates, 1997). Under-dimensioned rooms make it more difficult to carry out the intended functions and activities (Teikari, 1995). An ergonomic drawing of the core bed space was presented as Figure 1.1 in the introduction chapter. Figure 2.8 shows a typical bed space in an acute ward.
Similar to Carpman and Grant's suggestion, HBN 04 Vol. 1 (NHS Estates, 1997) required that a single- or multi-bed room, all bed spaces of acute wards to be provided with:

- a variable-height bed;
- a bedside locker (or locker wardrobe);
- an overbed table;
- an easy chair and space for additional stacking chair;
- a bedhead luminaire;
- a bedhead services panel incorporating;
- a patient handset control unit incorporating;
- oxygen and vacuum outlets;
- personal storage;
- a work station with a computer terminal;
- storage for a day’s supply of linen and surgical goods/supplies.
These provisions are necessary as the basis of a desirable environment in a static bed space. Meanwhile, the bed space in the ward was designed as a dynamic space to satisfactorily accommodate the diverse activities. There were three distinct categories of direct activities that occur around patient bed as shown in the Table 2.3 (NHS Estates, 1997).

<table>
<thead>
<tr>
<th>Clinical treatment and care</th>
<th>Activities in / around a bed space</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Admission, with the intimate discussion of personal matters</td>
</tr>
<tr>
<td></td>
<td>Specific medical and nursing interventions and observation</td>
</tr>
<tr>
<td></td>
<td>Rehabilitation</td>
</tr>
<tr>
<td></td>
<td>Teaching and training the patient and relatives</td>
</tr>
<tr>
<td></td>
<td>Informing, discussing, listening, and advising</td>
</tr>
<tr>
<td>Personal care and maintenance</td>
<td>Eating, drinking, washing, and toileting</td>
</tr>
<tr>
<td></td>
<td>Entertainment/diversion, reading, watching TV</td>
</tr>
<tr>
<td></td>
<td>Socializing</td>
</tr>
<tr>
<td></td>
<td>Receiving visitors</td>
</tr>
<tr>
<td>Support activities</td>
<td>Preparation of clinical procedures</td>
</tr>
<tr>
<td></td>
<td>Maintaining records</td>
</tr>
<tr>
<td></td>
<td>Holding stores</td>
</tr>
<tr>
<td></td>
<td>Communicating</td>
</tr>
<tr>
<td></td>
<td>Developing staff skills</td>
</tr>
</tbody>
</table>

Table 2.3 Activities in / around a bed space of acute ward
The Figure 2.9 adapted from HBN 04 Vol.1 (NHS Estates, 1997) is an example, showing the zones to enable the activities to take place around a bed space in a single-bed room.

![Diagram of five activity zones within a bedroom](image)

**Figure 2.9 Five activity zones within a bedroom**

(Source: NHS Estates, 1997: 12)

The optimal size of patient room is a topic of great controversy and is frequently debated by medical and nursing staff, by hospital planners, and by designers. In fact, patient room sizes or the sizes of bed space vary widely according to government or local building codes, health and safety requirements, and furniture and equipment standards. Many guidance publications, including health and safety, hospital design and...
clinical guidance, are available to assist the architects in planning and design the hospital spaces. Literature was retrieved to plot the evolution of the recommended dimensions (width and length) from the archival documents for bed space dimensions in single bedrooms and multi-bed bay cubicles (Table 2.4)\(^2\). It can be seen that NHS Estates have regularly been updating their recommendations but very little evidence was found to support these changes.

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Bed space width (m)</th>
<th>Bed space length (m)</th>
<th>Bed space area (m(^2))</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006: American Institute of Architects (room)(^3)</td>
<td>-</td>
<td>-</td>
<td>11.15</td>
</tr>
<tr>
<td>2006: American Institute of Architects (cubicle)</td>
<td>-</td>
<td>-</td>
<td>9.29</td>
</tr>
<tr>
<td>2005b: NHS Estates (room and cubicle)</td>
<td>3.60</td>
<td>3.70</td>
<td>13.32</td>
</tr>
<tr>
<td>2005: Hignett &amp; Keen (room and cubicle)</td>
<td>3.60</td>
<td>4.70</td>
<td>16.92</td>
</tr>
<tr>
<td>2004: Villeneuve, Canada</td>
<td>4.00</td>
<td>3.50</td>
<td>14.00</td>
</tr>
<tr>
<td>2004: WorkCover, Australia (room)</td>
<td>2.75</td>
<td>3.30</td>
<td>9.10</td>
</tr>
<tr>
<td>2004: WorkCover, Australia (cubicle)</td>
<td>2.60</td>
<td>3.50</td>
<td>9.10</td>
</tr>
<tr>
<td>2003: Reiling et al. USA (room)</td>
<td>3.80</td>
<td>4.70</td>
<td>17.86</td>
</tr>
<tr>
<td>2003: ACC, NZ (room)</td>
<td>2.90</td>
<td>3.50</td>
<td>10.15</td>
</tr>
<tr>
<td>2003: ACC, NZ (cubicle)</td>
<td>2.40</td>
<td>2.85</td>
<td>6.84</td>
</tr>
<tr>
<td>2002: HFN 30 – Infection Control in the Built Environment (cubicle)</td>
<td>3.60</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2001: American Institute of Architects (room)</td>
<td>-</td>
<td>-</td>
<td>11.15</td>
</tr>
</tbody>
</table>

\(^2\) The Table 2.4 was adapted from the paper “Questioning the Use of NHS Estates Ergonomic Drawings (Lu and Hignett, 2005) and the report “Empirical Review of NHS Estates Ergonomics Drawings” (Hignett et al., 2007a).

\(^3\) The AIA Guidelines of both 2001 and 2006 also suggest that single patient rooms should be at least 3.66m wide by 3.96m long. This would be approximately 14.86m\(^2\), exclusive of toilet rooms, closets, lockers, wardrobes, alcoves, or vestibules, but should accommodate comfortable furniture for family members (one or two) without blocking staff access to patients.
<table>
<thead>
<tr>
<th>Year</th>
<th>Source</th>
<th>Room Dimensions</th>
<th>Cubicle Dimensions</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>American Institute of Architects (cubicle)</td>
<td>-</td>
<td>-</td>
<td>9.29</td>
</tr>
<tr>
<td>1999</td>
<td>Adler. Metric Handbook (room)</td>
<td>3.10</td>
<td>3.30</td>
<td>10.23</td>
</tr>
<tr>
<td>1999</td>
<td>Adler. Metric Handbook (cubicle)</td>
<td>2.90</td>
<td>2.50</td>
<td>7.25</td>
</tr>
<tr>
<td>1997</td>
<td>HBN 04, Vol. 1 – In-patient Accommodation (room)</td>
<td>4.90</td>
<td>3.70</td>
<td>18.13</td>
</tr>
<tr>
<td>1997</td>
<td>HBN 04, Vol. 1 – In-patient Accommodation (cubicle)</td>
<td>2.90</td>
<td>2.90</td>
<td>8.41</td>
</tr>
<tr>
<td>1997</td>
<td>HBN 40, Vol. 2 – Treatment Areas (cubicle)</td>
<td>2.70</td>
<td>2.90</td>
<td>7.83</td>
</tr>
<tr>
<td>1990</td>
<td>HBN 4 – Adult Acute Wards (room)</td>
<td>3.10 – 3.30</td>
<td>3.70 – 3.90</td>
<td>11.47 – 12.87</td>
</tr>
<tr>
<td>1990</td>
<td>HBN 4 – Adult Acute Wards (cubicle)</td>
<td>2.50</td>
<td>2.90</td>
<td>7.25</td>
</tr>
<tr>
<td>1986</td>
<td>HBN 40, Common Activity Spaces Vol. 1 – Example layouts; Common components (room)</td>
<td>2.80 – 3.60</td>
<td>3.70 – 3.80</td>
<td>10.36 – 13.68</td>
</tr>
<tr>
<td>1986</td>
<td>HBN 40, Common Activity Spaces Vol. 1 – Example layouts; Common components (cubicle)</td>
<td>2.50</td>
<td>2.90</td>
<td>7.25</td>
</tr>
<tr>
<td>1961</td>
<td>HBN 4 – Ward Units (room)</td>
<td>3.30</td>
<td>Approx 3.60</td>
<td>11.15 – 13.00</td>
</tr>
<tr>
<td>1961</td>
<td>HBN 4 – Ward Units (cubicle)</td>
<td>2.40</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1955</td>
<td>The Nuffield Provincial Hospitals Trust</td>
<td>2.13</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1951</td>
<td>Medical Research Council</td>
<td>2.43</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1946</td>
<td>General Nursing Council of England and Wales</td>
<td>3.05</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1937</td>
<td>Departmental Committee</td>
<td>2.44</td>
<td>-</td>
<td>9.29</td>
</tr>
<tr>
<td>1928</td>
<td>Voluntary Hospitals Commission</td>
<td>2.44</td>
<td>-</td>
<td>9.29</td>
</tr>
<tr>
<td>1866 – 7</td>
<td>Poor Law Board</td>
<td>1.83</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1863</td>
<td>Florence Nightingale</td>
<td>-</td>
<td>-</td>
<td>9.29</td>
</tr>
</tbody>
</table>

Table 2.4 Acute ward bed space dimensions from archival documents
Data were found on bed space width from 1866 to 2005. The Nuffield Provincial Hospitals Trust (1955) cited/reported seven dimensions, with the earliest being a recommendation from Nightingale’s considerations in 1863 that “In round numbers, the superficial area per bed should be not less than 100 square feet”.

The second was from the Poor Law Board (1866-1867) recommending that “6 feet (1.83m) was sufficient spacing for the ordinary sick” (Poor Law Board, 1867, cited in Nuffield Provincial Hospitals Trust, 1955). The third and the fourth were from the Voluntary Hospitals Commission in 1928 and the Departmental Committee (1937) appointed by the Minister of Health respectively (Ministry of Health, 1937, cited in Nuffield Provincial Hospitals Trust, 1955). The latter adopted 8 feet between bed centres as their standards, as recommended by the former. During this time a minimum of 100 square feet per bed was accepted.

The fifth was from the General Nursing Council of England and Wales in 1946 who advocated that “the distance between the bed centres should not be less than 10 feet (3.05m) as an absolute minimum”, and the sixth in 1951 was from Medical Research Council with a memorandum on The Control of Cross Infection in Hospitals recommending only a minimum of 8 feet (2.43m) between bed centres (Medical Research Council, 1951, cited in Nuffield Provincial Hospitals Trust, 1955). The seventh dimension was derived from research carried out by The Nuffield Provincial Hospitals Trust concluding that “to satisfy the needs of nursing a 4-foot square space between beds (that is, bed centres at 7 feet (2.13m) is adequate” (1955: 13) and therefore to achieve great compactness bed centres at 6 feet (1.83m) or 6 feet 6 inches (1.98m) could be arranged” (1955: 22).
The recommendations for bed space/patient room have increased gradually. There are fewer data available for bed space length. Little empirical evidence has been published to support the recommended dimensions. As mentioned earlier, the Nuffield Provincial Hospitals Trust (1955) was the only historical document to provide empirical research to support their recommendations.

It is found that different documents and publications have different "voices". For example, when architects design a hospital, they should refer to the guidance of NHS Estates which could be HBN 04 (NHS Estates, 1997) giving the size of 2.9m x 2.9m for a cubicle, whereas the architect's handbook, The Metric Handbook (Adler, 2004) gives the sizes of 2.9m x 2.5m for a cubicle in a 6-bed bay. The two recommendations conflict and may have led to confusion for architects.

In HBN 04 Vol. 1 (NHS Estates, 1997), there are also conflicts. On the page 13, a core bed space was introduced with 3.4m as the minimum width requirement and 3.7m in length but without clarifying if it would be applicable in a single room or a multi-bed room. Furthermore it recommended that each bed space should not be less than 2.9m x 2.9m (page 14), but also recommended the size of 2.7m in width and 2.9m in length in the section 9.0 the Evidence Base (page 67).

In the most recent publication from NHS Estates (2005b), it recommended that there is a need to provide a minimum clear space of 3.6m x 3.7m around beds in both single and 4-bed rooms. It also gave the different dimensions to accommodate the different tasks, like using a hoist, using a trolley, using resuscitation procedures etc. Some of those dimensions are larger than the minimum clear space, some smaller, however, there was no clarification on how the clear space was concluded relating to those dimensions.

Additionally, sufficient space is essential to safe and efficient care and treatment. However as Stanton (1983) said, "badly positioned equipment in theoretically adequate overall space would prevent the room from being used as intended", the configuration
of a room is more important than its overall size. It is determined by a number of functional requirements, for example space around the bed for nursing, the intensity of care, and patient privacy.

Although a large room will offer more space, a smaller but well planned room might meet the functional requirements just as easily. The decision should be reached by studying specific tasks and activities, and establishing routine arrangements within the smaller spaces where it could be demonstrated that it was possible to do them adequately. So architects need to know in detail what happens in a bed space or patient room and how tasks are carried out before they design the space.

2.2.2 ICU bedroom / bed space

Patients admitted to an ICU are experiencing a life-threatening illness that needs the use of specialised medical technologies. An ICU patient room or bed space is often filled with tubes, wires, monitoring equipment, bright lights, respirators, and other pieces of machinery. According to HBN 57 (NHS Estates, 2003a), the layout should achieve a balance between providing privacy for patients, in both single-bed rooms and multi-bed areas, and providing unobstructed observation of patients by staff. Requirements for services to bed space and for equipment around the bed also have an effect on space provision and layout. In order to provide an efficient working environment for staff, the layout should take account of key functional relationships between activity spaces, such as bed areas and utilities, and staff areas and bed areas.

The bed area, containing most of the outlets and services to the patient’s equipment, accommodates most of the activity (Figure 2.10). Whether in a single room or multi-bed area, all bed areas in an ICU require the following equipment located within a medical supply unit adjacent to the bed-head (NHS Estates, 2003a):
• an electric bed
• 28 single power-points and connection to the UPS system
• multi-parameter monitoring
• ventilation and humidification equipment
• infusion pumps and syringe pumps
• low-pressure vacuum points and high-pressure vacuum points
• an examination lamp
• oxygen outlets, 4-bar air outlets and one 7-bar air outlets for surgical equipment connection
• a nitrous oxide point
• a feeding pump
• a blood warmer
• drugs storage space

Figure 2.10 ICU bed space
(Source: scoping site visit)
HBN 57 (NHS Estates, 2003a) states that the size of each patient bed area should be not less than 26 m² in order to accommodate the essential requirements:

- Staff access to the patient from all sides of the bed;
- Enable staff to manoeuvre the patient, themselves and equipment safely;
- Accommodate all clinical equipment permanently located around the bed;
- Additional space to accommodate any mobile equipment that may be required (the variety and number of clinical interventions that take place within a CCA is increasing, e.g. minor surgical interventions, imaging services by the computed radiography);
- Enable a minimum of five members of staff to attend to the patient in an emergency situation;
- Enable some investigation and treatment to be undertaken, e.g. minor surgical interventions, diagnostic imaging with mobile X-ray machine;
- Protect the patient’s visual and auditory privacy and dignity (Space between beds);
- Accommodate the patient’s chair;
- Enable at least two visitors to sit at the patient’s bedside comfortably, even when clinical interventions are being carried out.

Literature was retrieved to plot the evolution of the recommended dimensions from the archival documents for bed space dimensions in single bedrooms and multi-bed bay cubicles (Table 2.5). It can be seen that NHS Estates have regularly been updating their recommendations but very little evidence was found to support these changes.
<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Bed space area (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006 Buenning</td>
<td>29.26</td>
</tr>
<tr>
<td>2006 AIA: room/cubicle</td>
<td>18.58</td>
</tr>
<tr>
<td>2004 Takrouli: room with storage</td>
<td>40.00</td>
</tr>
<tr>
<td>2004 Takrouli: cubicle</td>
<td>30.00</td>
</tr>
<tr>
<td>2004 Hendrich: room without family space</td>
<td>22.50</td>
</tr>
<tr>
<td>2004 Hendrich: room</td>
<td>36.00</td>
</tr>
<tr>
<td>2003 Sponsler: room</td>
<td>37.16</td>
</tr>
<tr>
<td>2003 Held: cubicle</td>
<td>18.00</td>
</tr>
<tr>
<td>2003a HBN 57: room/cubicle</td>
<td>26.00</td>
</tr>
<tr>
<td>2001 Stiechler: room</td>
<td>39.48</td>
</tr>
<tr>
<td>2001 Hamilton: room</td>
<td>33.00</td>
</tr>
<tr>
<td>2001 Gallant &amp; Lanning: room</td>
<td>25.08</td>
</tr>
<tr>
<td>2001 AIA: room/cubicle</td>
<td>18.58</td>
</tr>
<tr>
<td>1999 HermanMiller for Healthcare: room</td>
<td>23.23</td>
</tr>
<tr>
<td>1998 Koay: room</td>
<td>15.75</td>
</tr>
<tr>
<td>1997 Intensive Care Society: room</td>
<td>25.50</td>
</tr>
<tr>
<td>1997 Intensive Care Society: cubicle</td>
<td>20.00</td>
</tr>
<tr>
<td>1996 AIA: room</td>
<td>13.94</td>
</tr>
<tr>
<td>1995 Wedel et al: room</td>
<td>25.00</td>
</tr>
<tr>
<td>1995 Wedel et al: cubicle</td>
<td>20.00</td>
</tr>
<tr>
<td>1993 Marans: room</td>
<td>12.00</td>
</tr>
<tr>
<td>1992 HBN 27: cubicle</td>
<td>20.25</td>
</tr>
</tbody>
</table>

Table 2.5 ICU bed space dimensions from archival documents
The first ICUs were built in the early to mid 1950s, with open wards and no partitions except curtains/screens. The second and third generation ICUs (1970s and 1980s) had individual rooms, moving from walled cubicles to folding/sliding doors with increased level of control. (Fontaine et al., 2001). There are fewer documents providing detailed recommendations (i.e. both width and length) of ICU bed space than acute ward bed space.

In HBN 57 (NHS Estates, 2003a) being the most recent publication from NHS Estates, the detailed dimensions of the ICU bed space is recommended as 4.6m in width and 5.5m in length; and the detailed dimensions of the ICU single bedroom is recommended as 4.8m in width and 5.45m in length excluding the anteroom. The recommended space has increased from 20.25m² (cubicle, NHS Estates, 1992) in 1992 to around 26m² (room/cubicle, NHS Estates, 2003a) in 2003.

As mentioned earlier, in the US there have been recommendations to decrease patient transfers with the use of adaptable acuity design (Hamilton, 1999; Hendrich et al., 2004). The critical case bed space needs to have working space for staff, the appropriate clinical equipment and furniture, and movement space for both routine and emergency care (Hamilton, 1999). In the US the recommended space envelope has increased from 13.94m² (room, AIA, 1996) in 1996 to 16.72m² (room/cubicle, AIA, 2001) in 2001 and 36m² for the universal (acuity adaptable) room (Hendrich et al., 2004).

Again, there was no empirical research located to support the recommendations shown in Table 2.5.

2.2.3 Toilet and shower room/bath room

As required by the HBN 04 Vol.1 (NHS Estates, 1997), all single-bed rooms and multi-bed rooms should have en-suite toilet. A large proportion of patients may use a wheelchair or require assistance with hygiene during their stay. Easy access, convenient
location and good design of sanitary facilities are of great importance to patients. In each single-bed room there should be a toilet and a shower/bathroom (as well as a wash basin for use by staff as well as patients). In all single-bed room or in 4-bed bay, one assisted toilet and one assisted bathing/shower room, should be designed so that nursing staff can assist the patient.

Patients using an assisted bathroom or shower room may arrive in a wheelchair or on a mobile hoist. Staff assist the patient in showering / bathing and associated activities, and may also give treatments. The space must be sufficient to accommodate three staff, and permit the manoeuvring of support equipment such as a wheelchair, a shower chair, and/or a hoist.

There are three distinct categories of direct activities that occur around en-suite toilet (Table 2.6; Figure 2.11). The configurations of patient toilet and bathroom/shower are determined not only by the circulation system, size of unit and overall form of the building, but also by the position of sanitary facilities.

<table>
<thead>
<tr>
<th>Activities in an en-suite toilet / shower room</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wash basin area</strong></td>
</tr>
<tr>
<td>Washing and dressing</td>
</tr>
<tr>
<td>Shaving</td>
</tr>
<tr>
<td>Combing hair</td>
</tr>
<tr>
<td>Putting on makeup</td>
</tr>
<tr>
<td>Minor treatment</td>
</tr>
<tr>
<td><strong>Shower/bath area</strong></td>
</tr>
<tr>
<td>Taking a bath or shower</td>
</tr>
<tr>
<td>Dressing</td>
</tr>
<tr>
<td>Minor treatment</td>
</tr>
<tr>
<td><strong>Toilet area</strong></td>
</tr>
<tr>
<td>Toileting</td>
</tr>
<tr>
<td>Using the wash basin while sitting on the toilet (optional)</td>
</tr>
</tbody>
</table>

Table 2.6 Activities in an en-suite toilet / shower room
Literature was retrieved to plot the evolution of the recommended dimensions from the archival documents (Table 2.7). Compared to bed spaces, the en-suite toilet / shower room dimensions have not been updated regularly. In the HBNs, there is little discussion about the exact dimension or size of these facilities apart from their location in the unit layout. Only in HBN 40 of 1986, 1989 and 1995 (NHS Estates, 1986, 1989 and 1995b), the recommended space of en-suite toilet / shower room was kept with around 2.7m both in width and length.

Hignett and Evans (2006) looked at two of the toilet layouts in more detail to include a wheelchair as part of the equipment rather than a walking frame (Figure 10). They found that the room sizes would need to increase to 6.5 m² - 6.8m² to accommodate a mobile hoist to transfer a patient from a wheelchair to the toilet. However, if the rooms...
were designed for independent wheelchair users then additional space would be needed as a turning circle (2.25m²).

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Width (m)</th>
<th>Depth (m)⁴</th>
<th>Area (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006: the Department of Finance and Personnel</td>
<td>2.40</td>
<td>2.50</td>
<td>6.00</td>
</tr>
<tr>
<td>2006: Hignett and Evans</td>
<td>-</td>
<td>-</td>
<td>6.50 - 6.80</td>
</tr>
<tr>
<td>2005: NHS Estates</td>
<td>-</td>
<td>-</td>
<td>4.50</td>
</tr>
<tr>
<td>2004: Goldsmith_1</td>
<td>2.23</td>
<td>1.68</td>
<td>3.75</td>
</tr>
<tr>
<td>2004: Goldsmith_2</td>
<td>1.44</td>
<td>2.10</td>
<td>3.00</td>
</tr>
<tr>
<td>2003: ACC_1</td>
<td>2.60</td>
<td>2.20</td>
<td>5.72</td>
</tr>
<tr>
<td>2003: ACC_2</td>
<td>3.25</td>
<td>2.20</td>
<td>7.15</td>
</tr>
<tr>
<td>2001: BS 8300:2001</td>
<td>2.40</td>
<td>2.50</td>
<td>6.00</td>
</tr>
<tr>
<td>2001: Workcover – single en-suite_1</td>
<td>2.15 + width of a toilet bowl</td>
<td>1.50 + depth of a toilet bowl</td>
<td>-</td>
</tr>
<tr>
<td>2001: Workcover – single en-suite_2</td>
<td>1.50 + depth of a toilet bowl</td>
<td>2.10 + widths of both a basin and a toilet bowl</td>
<td>-</td>
</tr>
<tr>
<td>2001: Workcover – single or shared en-suite_3</td>
<td>3.04</td>
<td>1.50 + depth of a toilet bowl</td>
<td>-</td>
</tr>
<tr>
<td>1995: NHS Estates – HBN 40 Vol. 2</td>
<td>2.70</td>
<td>2.70</td>
<td>7.29</td>
</tr>
<tr>
<td>1989: NHS Estates – HBN 40 Vol. 4</td>
<td>2.70</td>
<td>2.75</td>
<td>7.43</td>
</tr>
<tr>
<td>1986: NHS Estates – HBN 40 Vol. 1</td>
<td>2.70</td>
<td>2.70</td>
<td>7.29</td>
</tr>
</tbody>
</table>

Table 2.7 En-suite toilet / shower room dimensions from archival documents

⁴ The term “depth” was used to describe the dimension of the en-suite toilet / shower room along the doorway.
2.3 Summary

1.) **Current publication**: There is a lot of published literature concerning hospital development or specific department / area design, but little focusing on the configuration / layout of patient's bed space or toilet/shower room. In particular there was little literature looking at the spatial issues in terms of specific clinical activities.

2.) **Ergonomic knowledge**: Most of the literature on hospital space design did not address the ergonomic factors. There was no evidence that architects had enough knowledge about clinical activities. Held (2003) found that architects made some serious errors in the room layout of the planned ICU due to lack of detailed knowledge of work procedures in the hospital. The contribution of ergonomics is "both poorly understood and underestimated" (Villeneuve, 2000).

3.) **Design guidance**: In terms of the development, updating and use of the HBNs and the ergonomic drawings, the following points were summarised as mentioned in the first chapter:

- There was little literature investigating whether architects use the HBNs or ergonomic drawings in their design.
- The HBNs did not explain the "ergonomic" rationale behind the drawings very well, and very little empirical research evidence was found to provide a rationale for the changes in the recommended dimensions, although the HBNs have been regularly updated.
- Some of guidance on building design and planning is dated although updating has been going on at some intervals of times.
- In terms of bed space, different documents and publications made different recommendations in the HBNs which may have led to confusion for architects.
4.) **ADB**: As mentioned in Chapter one, ADB is a computerised package to assist healthcare planners, architects, and teams involved in the briefing, design and equipping of healthcare environments. It was developed in consultation with representatives drawn from the Royal Colleges, professionals involved in the provision of the environment, for example architects, engineers and facilities managers, who are also involved in the consultation process for development of the guidance itself (NHS Estates, 2003b). However, there was little information on how the ADB were developed, what evidence it was based on. Additionally, NHS Estates states that ADB is produced concurrently with the development of guidance and standards and contains accurate and detailed data drawn directly from the HBNs (NHS Estates, 2003b). However, if viewing the website of the NHS Estates (currently called the DH Knowledge & Information Portal; http://195.92.246.148/nhsestates/knowledge/knowledge_content/home/home.asp), it can be found that the latest version of ADB was issued in mid-August 2007 when many of HBNs stayed still over ten years old including the very important HBN 04 Vol.1 – In-patient Accommodation (NHS Estates, 1997) (See the section 1.1.2 for the relevant description). The question was how ADB was updated concurrently with the development of the HBNs?

5.) Further to the above issues, additional points were summarised from an HD/MARU Forum entitled ‘Information for Health Design: What should the Future Hold?’ at the end of 2005, where 15 expert practitioners got together to discuss industry’s needs in terms of the design guidance and suggest how they could be improved (Hospital Development, 2005):
• The guidance has been embedded in policy, and is too prescriptive to be fully understood and interpreted by architects.

• The guidance does not encourage innovation in the design process; only a mandatory requirement is provided but without non-mandatory recommendations.

• The guidance lacks a cost framework and staffing resources framework to support best practice.
Chapter 3 Methodology

This chapter describes the research questions, the methodological framework based on those questions, and the methods to be used in the project. Some special issues such as ethical considerations, the subject recruitment are stated as part of methodological work for the NHS-involved research.

Healthcare is a relatively new area of practice for ergonomics (Hignett and Wilson, 2002), so it is proposed that there are methodologies from other safety critical environments that have been developed in the last 20 years and could be used for the evaluation of existing ergonomic drawings as well as the development of new ‘ergonomic envelopes’. Ergonomics is already being used to analyse and design interfaces and interactions to contribute to the overall goals of improved safety and efficiency in the clinical environment. As mentioned earlier, the benefits to stakeholders such as staff, patients, and the other users will be realised through the provision of clinical environments that will be designed with up-to-date ergonomic information based on current clinical practice.

3.1 Research design

3.1.1 Assumptions and research questions

The assumptions and research questions were generated based on literature review at the very early stage of the study in terms of the research aim stated in chapter one, to review the existing ergonomic drawings by looking at the single bed space, and the en-suite toilet/shower room in single rooms and multi-bed bays on adult acute wards and ICUs.
3.1.1.1 Assumptions

1.) The majority of NHS Estates ergonomic drawings may have been updated over last 20 years, but it is doubtful that they were able to reflect the changes in clinical practice and medical technology. This may have led those involved in the development of hospitals to use invalid ergonomic information in their decision-making.

2.) The existing hospitals are constructed from architects' applications and interpretations of design guidance, i.e. health building notes, which consist of ergonomic drawings.

3.) A protocol for the development, revision and testing of ergonomic drawings is needed and can be worked out by using a series of ergonomic methods.

3.1.1.2 Research questions

1.) Have the ergonomic drawings been updated to reflect changes in clinical practice and medical technology?
   - How has the context for provision of healthcare changed?
   - How were the existing ergonomic drawings developed in the early 1980s?
   - How have the drawings changed in the last 20 years? Are they capable of reflecting changes in clinical practice and medical technology

2.) Are the drawings used by the architects during the development/redevelopment of hospitals?
   - What are the most important issues for the architects in dealing with the hospital spaces within the design?
   - How do architects deal with the user needs through the design?
   - What do architects think about the relationship between ergonomic drawings and building design?
3.1.2 Research objectives and methodological framework

In terms of reviewing the ergonomic drawings of the single bed space, the en-suite toilet/shower room on adult acute wards and ICUs the research objectives are:

- To explore the complex interfaces between clinical staff, the equipment used and the environment in which care and treatment are provided.
- To provide up-to-date ergonomic information for architects and project managers based on current clinical practice.
- To facilitate and support inclusive design based on up-to-date ergonomic data.

1 The consequential sub-questions of question 2 are mainly about a separate, parallel study of interviewing experts on hospital development, of which I was partly involved in the data collection phase. It seems that simply comparing the existing hospitals with the relevant drawings may be able to answer the question 2. However, to answer four sub-questions will firmly support the methodological framework (Figure 3.1.) to explore question 1 and question 3 logically. So the interview data were used in this thesis with the permission of the chief investigator of the study.
Accordingly, the outputs include:

- Ergonomic envelope\(^2\) for revision of ergonomic drawings based on task analysis methodologies for key areas of clinical activity.
- Validation for the transfer of task analysis methodologies from other safety critical service industries for use in the healthcare industry.
- A protocol for the future development, revision and testing of NHS Estates ergonomic drawings.

Based on the assumptions and research questions, a methodological framework was structured to identify the ways to carry out the project (Figure 3.1).

\(^2\) The incompressible functional space or area within which the clinical tasks can be performed safely and efficiently is defined by the ergonomic envelope, which is a working envelope without consideration for activities within family, hygiene and in-room storage areas. The detailed description can be seen in the discussion chapter.
3.1.3 Research methods

The project has been conducted through a number of research stages: literature review, scoping site visit, observation, and functional space experiment (for simulation trials).

- The literature review was concerned with the development and use of ergonomic drawings in healthcare in the context of changes in clinical practice over the last 20 years.
- Scoping site visits were used to collect data on the dimensions and layouts of single bedrooms, multi-bed bays, en-suite toilets and shower rooms in the areas...
of ICUs and adult acute wards at different hospitals built within the last 10 years. These data, representing architects' interpretations of HBNs as hospital design recommendations, were then used as the templates to set up the full-size mock-ups for functional space experiments at HEPSU laboratory of the university.

- Observations were undertaken in single patient room, multi-bed bay and en-suite toilets/shower rooms in the areas of ICUs and adult acute wards at local hospitals to find out what is exactly going on in a defined space when a nursing task is performed by using Hierarchical Task Analysis (HTA) and Link Analysis (LA). The simulation scenarios were developed based on the observational data for the FSEs. Additionally, the further qualitative data from the comments of the nursing staff and the observation dairy of the researcher were reported to illustrate the problems and issues confronted by nursing staff in undertaking their tasks.

- Functional space experiments (FSEs) for simulating nursing tasks for different layouts taken from the site visits were carried out in hospital mock-ups at the laboratory at Loughborough University by using LA. The ergonomic envelopes were produced as the recommendations to revise the ergonomic drawings.

As mentioned earlier, expert interviews were carried out in a parallel study, which elicited the views of architects, healthcare planners, and facilities managers etc. about the use of ergonomic drawings and patient rooms\(^3\). The interview data were also to be used in the final data analysis to bring together the scoping visits visit and task analysis data in a comparative review and produce recommendations for revised and new ergonomic drawings.

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\(^3\) 19 experts were interviewed between September 2004 and November 2005, including 10 Architects, 4 Healthcare Planners and 2 Facilities Managers. The ethical approval of interviewing experts was granted by Loughborough University. The interview schedule can be seen in Appendix H. The detailed results can be seen in the Final Report of 'Empirical Review of NHS Estates Ergonomics Drawings' for DH Estates and Facilities Division (Hignett, et al, 2007a).
The overview of the project is showing in Figure 3.2; a timeline for work progress was developed to ensure the completion of the study in time as proposed.
3.2 Literature review

3.2.1 Objectives

The literature review was conducted in two phases. The first phase as mentioned previously, was completed at a very early stage of the project to help define the research questions based on the research purpose. The second phase was guided by the research questions and conducted in terms of research objectives and methods to identify the gaps in the development/updating of the drawings and the use of the drawings. All the relevant review was presented in part of the previous chapter – chapter two to give a detailed background information.

3.2.2 Search strategy

The literature searches covered NHS and NHS Estates online and offline (the NHS Estates Library) resources to identify and retrieve archival documents mainly about the historical development of bed space guidance. The searches also covered the relevant references in the Loughborough University Library, Clinical Sciences Library at University of Leicester, Nottingham Medical School Library, and more general and specific internet resources (e.g. PubMed, ProQuest, Medline, Science Direct, etc.). The key keyword searches linked aspects of nursing activities in specified areas, hospital ward design, bed space design, toilet design, shower room / bathroom design, and task analysis in/of the environments.

The main areas covered by the literature searched are as follows:

- Health Building Notes (HBNs) and Health Facility Notes (HFNs) – guidance for designers, architects, facilities managers, planners for new buildings and refurbishment healthcare facilities;
Chapter 3 Methodology

- Relevant research reports from the online Knowledge Information Portal (KIP) of the NHS Estates;
- Building standards, codes, and regulations;
- Patient room design (bedroom, toilet / shower room);
- Bed space design;
- Nursing activities and nursing staff needs;
- Patient safety;
- Infection control;
- Disability access/accessibility design;
- Ergonomics methodologies

It was decided to mainly retrieve the references dated 1980 and afterwards, relating to empirical evidence (presenting data and findings) and non-empirical information (providing general descriptions). However, relevant literature published before 1980, but dealing with hospital design guidance, patient room design, were also searched.

3.3 Scoping site visits

The site visits were a scoping activity designed to capture a range of ‘actual’ room / space dimensions for use in the Functional Space Experiments. Hospitals with building projects for adult acute ward and ICU accommodations since 1993 were identified by NHS Estates.

3.3.1 Objective

To investigate the use of the HBNs, each site was visited in the areas of ICUs and adult acute wards and a selection of empty bed spaces (rooms and cubicles) and toilets / shower rooms. The spaces were measured and photographed. These data, representing architects’ interpretations of HBNs as hospital design recommendations, were then used to set up the full-size mock-ups for FSEs at the laboratory to simulate nursing tasks.
The purpose of the site visits was to:

- Collect current information on site physical conditions, e.g. layout, dimension, equipment, devices and furniture used, etc.;
- Collect additional information on site situations, e.g. single room or multi-bed bay, which department it was, staffs' informal comments on the sites, etc.;
- Try to get the information on the hospital development, e.g. who designed, the years when planned and built / renovated.

3.3.2 Ethical consideration and participating site recruitment

3.3.2.1 Ethical consideration

As the study took place in the NHS trusts, the ethics approval was granted from the Multi-centre Research Ethics Committee (MREC) (Wales) 04/MRE09/31, with additional individual site approval (ethical and research governance). The submitted documents included the completed application forms, the research proposal, participant information, consent forms (See Appendix A for all the information sheets and Appendix B for all the consent forms), and other supportive documents, e.g. C.V. for investigator, letter from funder, statement of indemnity arrangements, etc.

3.3.2.2 Recruitment of participating sites

A list of hospitals, which have been built since 1993, was provided by the NHS Estates. The director of facilities and/or the project manager at each site were contacted by an invitation letter to provide information about the project and ask if they would be interested in participating. A follow-up letter was sent after 1 month in case the first letter had not arrived. The hospitals declining to participate were excluded from the research.
When the ethics application was approved, a copy of all the approval documents were sent to the participating hospitals. Then the dates of the visit were decided by mutual convenience in advance as well.

During the visits, the director of facilities or a project manager was first met up with and given the information sheet and consent forms again. Then he or she was asked to sign the consent form and the photographic consent form on behalf of the NHS Trust, to give permission for access to the premises for data collection and for the physical information and the photographs of the rooms visited to be used in the research.

During the visit, there was no patient contact, and staff were only required to escort the researcher to the location. The researcher only measured, sketched and photographed the empty bed spaces and en-suite facilities to record the layouts with essential elements e.g. furniture, equipment.

When the visits were complete, the researcher sent the image data (photographs) to the participating hospitals for confidentiality and accuracy checking. On the acceptance of the data, the researcher then analysed and displayed the data for setting up the mock-ups of the laboratory-based FSEs.

The researchers (JL with two assistants for measurement) would withdraw immediately and seek to recruit an alternative site if anyone objected to the data collection when the researchers were on-site.

3.3.3 Conducting the site visits

A pre-site visit was conducted to a local hospital at a very early stage of the study as a pilot to develop and test the site visit plan. Then the researcher and two assistants carried out 5 site visits with anthropometric benchmarking to collect data. Each visit lasted 3-4 hours.
Chapter 3 Methodology

The procedure was developed as follows:

1. To contact the director of facilities and/or the project manager to set up the work plan on-site to confirm the time, duration, and which rooms/departments would be available to be measured and photographed ahead of the date when visited;

2. To prepare essential materials and tools, e.g. different colour pens, notebook, blank A4 paper, camera, 5-metre measuring tape, and relevant ethical documents, etc.;

3. To meet the director of facilities and/or the project manager and further explain the aims of the research project. Providing the information sheet and asking them to sign the consent form on behalf of the hospital; at the same time the researcher also signed the form to recorded the process. Both parties kept a signed copy;

4. To collect some background information on the hospital from the director of the facilities and/or the project manager, e.g. the plans of the hospital, the concise history of planning and construction of the hospital, success stories or problems in the accommodation to be visited in terms of functionality and usability;

5. To discuss the detailed visit plan, e.g. departments to be visited, who would escort the researchers;

6. To undertake the visit to the accommodation by measuring the dimensions of the rooms and spaces, sketching and taking photographs the rooms and spaces layouts, etc.;

7. To meet the director of facilities and/or the project manager again to conclude the whole visit when the visit was complete. Further involvement was discussed, including the review of the data collected on site and a workshop providing early access to the research findings.
3.4 Observations

Observation is useful for recording physical task interactions between people, machine and their workplace (Stanton and Young, 1999). It is suggested that there are five different types of information that can be elicited from observations. They are activity sequence, activity frequency, duration of activities, fraction of time spent in states, and spatial movement (Stanton, et al., 2005).

3.4.1 Objectives

Observations were carried out in an acute hospital and a community hospital for one week and four weeks respectively to understand how nursing activities are carried out in the patient bed space, and toilet / shower room and develop the simulation scenarios based on the observational data.

The participating hospitals were chosen based on NHS Estates’ recommendation and the easy access.

The objectives were as follows:

- To get an understanding of the nursing activities in patient bed space and toilet / shower room;
- To record and analyze data about nursing activities;
- To develop simulation scenarios of FSEs to test the different layouts for manual handling, resuscitation, infection control and disability access;
- To identify problems during the nursing tasks related to space and layout issues.
As the nursing tasks to be observed and the environments within were always complicated and there were no guidelines for such observations, the following steps were used to develop the observation methodology:

Step 1. Develop initial observation protocol (pre-pilot study);
Step 2. Testing initial observation protocol (pilot study);
Step 3. Revise observation protocol;
Step 4. Carry out observations according to the revised protocol to collect data;
Step 5. Analyse data.

3.4.2 Ethical consideration and subject recruitment

3.4.2.1 Ethical consideration

As mentioned earlier, all research in the NHS is reviewed and approved by the ethics and research governance committees for the review of the project and for the permission to access the hospitals respectively. The approval letter for the submission of the research at local NHS Trusts to undertake observations and FSEs for simulation trials was granted. The submitted documents included the completed application forms, the research protocol, different participant information sheets (for nurses in observations and FSEs respectively and patients in observations – See the Appendix A), consent forms (for nurses and patients in observations respectively and nurses’ general form and photographic form in FSEs – See the Appendix B), and other supportive documents, e.g. C.V. for investigator, letter from funder, statement of indemnity arrangements, etc.

The honorary contracts were applied and held by the researcher for working at both hospitals.

The purpose of the different information sheets was to provide participants with information about the project, what they would be invited to do, and what their rights
were, etc. Both nursing staff and patients involved in the observation of nursing tasks were given different information sheets and asked to sign different consent forms respectively.

Patients were only observed while receiving care or treatment if they had already been recruited on to the project. No patients were approached unless the nursing staff indicated that it was appropriate to approach them. This minimised the risk of inappropriate research invitations and potential distress (and invasion of privacy) for patients.

3.4.2.2 Subjects and recruitment

The subjects were nursing staff working at the observed clinical settings, and patients who were provided with care and treatment by participating nursing staff.

Preliminary discussions about nurse recruitment were first held with people in charge of nursing staff from both hospitals. A copy of the information sheet about the project was then taken to the identified wards at each hospital. Posters for recruiting participants were displayed on the ward notice board for at least one week before the start of the observations. The nursing staff were approached on each shift and invited to participate in the project. All the nurses were given the information sheet and asked to sign the consent form. If they declined or did not respond they were excluded from the study.

Patients on each of the wards were approached (under the guidance of the nursing staff) on the first day of the observation period. They were given another information sheet and had an opportunity to discuss the project with the researcher. It was explained that the research was about bed space and nursing tasks and that their permission was needed by the researcher so that she could observe the nurses when they were providing treatment and care to the patients. If a patient declined to participate the researcher stopped the observations when the shadowed nurse was attending to them and would
restart the observations when the nurse went to a participating patient. Patients who were admitted during the observation period were invited to participate when the nursing staff advised that it was appropriate to approach them. If they declined or were unable to consent they were excluded from the study.

3.4.3 Pilot study

A pre-pilot and a pilot were undertaken on two days respectively at the beginning of the observations both at the CICU of one hospital and four acute wards of another hospital to:

- test and develop the initial observation protocol and data collection sheets;
- practise observations of nursing tasks;
- become familiar with the unit and nurses;
- get a general perspective of nursing tasks and the equipment used;
- determine the duration of the observations in a day.

As there were nursing staff and patients involved (observed) during the pilots, the consent form was signed by the participating nurses and the researcher; and another consent form was signed by the participating patients and the researcher. Both parties kept a signed copy.

3.4.4 Conducting the observations

The observation procedure was then developed based on the two pilots as follows:

1. Meet with ward / unit manager to set up the observation timetable;
2. Confirm the time, duration, and which nurse(s) would be available to be shadowed with the charge nursing staff in advance;
3. Prepare observation materials, e.g. different colour pens, notebook, data collection sheet (See Appendix C), relevant ethical documents, etc.;
4. Go to the observation site one day before the observations to approach and recruit patients under the guidance of nursing staff. Potential participants would have opportunity to discuss the project with the researcher and be provided with the information sheet. If they agree to take part in the observations, they would then be asked to sign the consent form. At the same time the researcher would also sign the form to record the process. Both parties kept a signed copy;

5. Arrive at the observation site 30 minutes before the shift / session starting on the observation day, and meet with charge nursing staff;

6. Explain to nurses the aims of the research project with providing information sheet, and ask them to sign the consent form if they agree to participate. At the same time the researcher also signed the form to record the process. Both parties kept a signed copy;

7. Position the researcher to obtain the best view of the observation field for the tasks occurring in the bed space or toilet, whilst maximising the patient’s dignity;

8. Observe the tasks performed by the participating nursing staff and patients;

9. Enter data on the data collection sheets during the actual observation, and immediately after the observation;

10. Meet with ward / unit manager again when the field data collection was complete, to confirm the further involvement within the FSEs for simulation trials.

The observations would terminate when it was unlikely that there would be any new significant information generated. The observational data would then be reviewed with the help of nursing staff, to find out if there were any tasks or important details overlooked.

LA and HTA were used to record and analyse the data. The details were described in sections 3.6.1 and 3.6.2.
3.5 Functional Space Experiments (FSEs)

Simulation trial is a method to “observe operator activity and record performance” (Kirwan and Ainsworth, 1992) and “demonstrate a concept in order to collect human preference and performance data” (Nemeth, 2004) in a replication of the real world setting to model the environment, resources needed, and people involved.

As stated by Marans and Stokols (1993), simulations can be undertaken for many purposes, including 1.) the training of students and professionals; 2.) the assessment of people’s preferences, behaviour patterns and health when exposed to alternative environmental arrangements; 3.) the visualization of complex settings prior to the design and construction; and 4.) the incorporation of the observers’ evaluations of simulated settings into the planning and design of new environments or the renovation of existing ones.

As mentioned earlier, in this project, the review of ergonomic drawings included the evaluation of the designs of the existing patient spaces / rooms at some hospitals, in which architects had interpreted the ergonomic drawings. An optimally sized and configured patient room or space is critically important for reasons of both health and efficiency. To achieve this purpose, it would be effective to run simulation exercises in a full scale mock-up with hospital users, evaluate the results, and revise the drawings for the future designs accordingly.

Additionally, because this sort of patient spaces / rooms are repeated hundreds of times in a healthcare facility and there may be a significant difference between the amount of space estimated to accommodate clinical activities and equipment / furniture and the actual amount needed, the simulation exercises could result in significant savings in both design cost and space allocation in the hospital development / redevelopment.
3.5.1 Objectives

Functional space experiments (FSEs) were developed to test the space required for the tasks identified in the observation phase. The simulations were designed to test the different layouts of the bed space and toilet / shower room measured at hospitals during the site visits. Due to the time limitation, 4 – 6 layout templates for each of three areas, i.e. ward bed space, ICU bed space and en-suite toilet / shower room, were chosen to simulate 2 – 3 frequent tasks or safety critical tasks relating to manual handling, resuscitation, disability access or infection control. The details can be seen in the FSE chapter.

The simulation trials were undertaken in full-scale mock-ups built at Healthcare Ergonomics and Patient Safety research Unit (HEPSU) laboratory of Loughborough University. As the laboratory was unable to accommodate all the sets of FSEs simultaneously, the FSEs of ICU bed space layouts were undertaken separately form the FSEs of the layouts of acute ward bed space and toilet / shower room. The objectives were:

- To identify the interaction between nursing staff, equipment / furniture, and the environment when an activity was occurring in patient bed space and toilet / shower room;
- To record video data for further analysis.
The following steps were used to develop the FSE methodology:

Step 1. Develop initial FSE plan (Pre-pilot study);
Step 2. Set up the room mock-ups to be tested;
Step 3. Test initial FSE plan and mock-ups (pilot study);
Step 4. Revise FSE plan and improve mock-ups;
Step 5. Carry out FSEs according to collect data
Step 6. Analyse data

3.5.2 Ethical consideration and subject recruitment

3.5.2.1 Ethical consideration

As mentioned in observation section, the ethical application for undertaking the FSEs was approved by the local LREC and the research governance committee.

3.5.2.2 Subjects and recruitment

The subjects were nursing staff from the same hospitals as the observation phase. Preliminary discussions about nurse recruitment were first held with managers in charge of nursing staff from both hospitals. A copy of the information sheet about the project was then taken to the identified wards at each hospital. A poster about nurse recruitment was displayed on the ward notice board a few weeks before the start of the FSEs. The researcher also had informal conversations with nurses about the FSEs during the observation phase and gave a verbal invitation to them to participate. They were given the FSE information sheet explaining what the project was about, what they would be invited to do, and what their own rights were, etc. The participating nursing staff were asked to sign the consent form along with an additional photographic consent form on the day of FSEs. If they declined they were excluded from the study.
3.5.3 Building the full size mock-ups

The researchers built the bed space and toilet / shower room mock-ups using the same layout and same size as those measured at the site visits. Different coloured tapes were used to mark the floor to represent the boundaries of the different bed spaces. The ICU bed space mock-ups, ward bed space mock-ups and toilet / shower room mock-ups can be seen in the chapter of FSEs.

4-way directional video taping was used to record the participant’s movements between equipment, furniture and the simulation mannequin (patient) for further analysis.

The equipment and furniture were borrowed from manufacturers or made of cardboard to full size dimensions. The model of patient was a full size articulated mannequin weighing 17kg.

3.5.4 Pilot study

A pre-pilot and a pilot were undertaken at HEPSU laboratory with the help of nursing staff from two observed hospitals.

The objectives of the pre-pilot study were:

- to review the observational data,
- to provide additional essential clinical information which the researcher was not able to access during the observations, e.g. the resuscitation task;
- to discuss and determine what tasks would be simulated;
- to make a list of equipment, furniture and devices to be used in the FSEs.
At the pilot study, the following issues were discussed with nursing staff:

1. Scenario. The description of the task process for the simulation scenarios, which was produced by researchers based on the observational data, were reviewed and developed. (See section 3.5.5)
2. Participants. How many participants would be needed for a task;
3. Mock-up. The researcher described the construction and the purpose of the mock-ups, and then received advice on improving them from the nurses;
4. Equipment and furniture. Nursing staff reviewed and tested the simulated equipment and furniture, and gave advice on improving the equipment made out of cardboard;
5. Video camera. The researcher set up and tested the video cameras at four corners with nurses performing the tasks within the simulated areas;
6. Walkthrough. The researcher and nursing staff determined what and how the participants were going to perform, how many simulation sessions to be run and how many participants for each session would be required.

Although the pilots were not the formal FSEs, the consent forms (general and photographic) were signed by the participating nurses and the researcher due to the ethical requirement for the NHS staff involvement. Both parties kept a signed copy of the forms.
3.5.5 Simulation scenario development

With the help of the nursing staff in the pilot, the scenarios were developed as a detailed instruction based on observational data. The following information was given:

1. What task would be simulated?
2. Who were the participants?
3. How many participating nursing staff were required to perform the task?
4. The patient’s condition and situation during the task.
5. The list of equipment, furniture and devices required during the task.
6. The start point and the end point of the task.
7. The description of the task process.
8. The diagram of the space layout in which the simulated task would occur.

The item 7 – the description of the task process was produced mainly based on the HTA results of observations. The details were described in section 3.6.1.

3.5.6 Conducting the FSEs

The proposed simulation procedure has been developed based on the pre-pilot study, the pilot study and literature as follows:

1. To contact ward / unit manager from the same hospital as with observation phase to set up the simulation timetable;
2. To ensure that mock-ups, equipment/furniture, video cameras were ready;
3. To confirm the session, timetable, and the number of participating nursing staff with the charge nursing staff the day before the session would occur;
4. To prepare experiment materials, e.g. different coloured tapes, pen & notebook, videotapes, scenario sheets, relevant ethical documents, etc.;
5. To meet the participating nursing staff, explain the aims of the research project (information sheet), and ask them to sign the general consent form and the photographic consent form. At the same time the researcher also signed the form to recorded the process. Both parties kept a signed copy;

6. To give the participating nurses 30 minutes before starting the FSEs, to familiarise them with the mock-ups and scenarios;

7. To conduct the FSEs according to a standardised task scenario / procedure with video recording.

8. To record additional data during the simulation trials, and after completing the trials.

3.5.7 The number of the trials for each mock-up layout

There were some methods available for estimating / calculating sample size in formal experiments (Jekel, et al., 2007; Maisel and Persell, 1996), which resulted in estimates of participant number being very large (McClelland and Suri, 2005). However, there were a number of papers discussing the participant number in an investigation (Faulkner, 2003; Virzi, 1992; McClelland and Suri, 2005).

For the user trials, Virzi (1992) concluded that approximately 80% of usability problems could be identified by 5 participants, and fewer new insights were revealed as the number increased. McClelland and Suri (2005) suggested that small numbers were often sufficient to guide the design team, and in practice, involvement of 4 – 6 participants selected to represent a good range of characteristics and contexts could provide significant information and evidence of issues that had not appeared before.

The FSEs of this project recruited nursing staff (rather than various users or testers in the usability testing) to simulate the clinical tasks. Each of the tasks were simulated by experienced participants following a standardised task procedure / scenario. As the participants simulated what they normally did in their workplace, the results would be
less affected by their individual characteristics and interests than by inexperienced participants. So it was decided that the number of the trials for each ‘product’ (i.e. mock-up) would be 4 – 6 times, which meant 4 – 6 groups of participating nursing staff would simulate each of the chosen tasks in each mock-up layout.

3.6 Methods used for data collection and analysis

3.6.1 Hierarchical task analysis (HTA)

As mentioned earlier in this chapter, the researcher used HTA for the data analysis and further scenario development. HTA is a technique to analyse data by breaking a task down into sub-tasks until a stopping point is reached when the task cannot be further broken/described (Shepherd, 2001). It was used to re-describe the recorded data to arrive at a detailed understanding of what nursing staff were required to do and how they accomplished their tasks (Figure 3.3). During the observations, the data collected showed the individual variance in a specified task by different nursing staff. With HTA, the generic task components, which would be used to help in developing the simulation scenarios, were then identified from these data. During the FSEs, the participants simulated the tasks according to the scenarios. The standardised processes were analysed and compared.

The software called “TaskArchitect” was used to assist in HTA outputs (Figure 3.4).
Figure 3.3 Sample of HTA

Figure 3.4 Example of HTA of transferring a patient from bed to wheelchair
3.6.2 Link analysis (LA)

LA relies on observation or a walk-through to establish links between components in the system, then uses spatial diagrams to analyse movements between these components (Stanton and Young, 1999, Baber and Stanton, 1996). It was used to look at spatial relationships within a defined area in the collection and analysis of the observational data and in the analysis of the FSEs to determine the optimal layout, accurate size of the area / space, and improve design.

In the observation phase, LA was used to:

1. look at spatial relationships by recording and analysing movements between components, i.e. nursing staff, equipment/device and furniture within a bed space, and
2. identify which task occupied more space, and the areas with the higher density of activities (See Figures 5.9, 5.12 and 5.15), to help decide which tasks to simulate.

In the FSE phase, LA was used to record and analyse:

1. the movements of components, i.e. nursing staff, equipment/device and furniture; and
2. participants’ (nursing staff) movements among equipment/device, furniture and the simulation mannequin (patient).

AutoCAD was used to draw the link diagrams as output to convey spatial information and analyse the result of each layout.

LA could be also considered to be a flow analysis, because the purpose of using LA in the FSEs was to show the “the physical setting in which functions are carried out” (Nemeth, 2004), besides the movements of the components or between the components.
Figure 6.10 in the FSEs chapter shows the LA result of a bed space for the tasks of bed wash, transferring a patient and resuscitation, which looks like a “flow diagram” rather than a typical link diagram as shown in Figures 5.9, 5.12 or 5.15.
Chapter 4 Scoping Site Visit

This chapter describes the data collection and analysis of site visits at five PFI hospitals, and presents the data in comparison with the HBN recommendations, also in the forms of coded Auto CAD drawings and relevant photos for the application of deciding the simulation templates in Functional Space Experiments (FSEs).

Twenty-five hospitals in the UK with building projects in the last ten years were approached. Five agreed to participate, resulting in a small convenience sample. All of five hospitals are the 1st wave PFI hospitals. Each site was visited and a selection of empty bed spaces (rooms and cubicles) and toilets/shower rooms in adult acute medical/surgical wards and intensive care units were measured and photographed.

4.1 Site information

As stated in the methodology chapter, a pre-site visit was conducted to a local hospital at a very early stage of the study as a pilot to develop and test the site visit plan. During October to December 2004, the researcher and two assistants carried out 5 site visits with anthropometric benchmarking to collect data (Figure 4.1). Each visit lasted 3-4 hours.

The general information about five hospitals is as follows:

- Hospital A: Opened in 1993 for phase one and 2003 for phase two, has 323 beds for specialities such as, general medicine, surgery, orthopaedics, day surgery, maternity and gynaecology, outpatient and therapies.
- Hospital B: Opened in 2001, has 521 beds and provides a wide range of inpatient, outpatient and day care services.
- Hospital C: Opened in 2002, has more than 600 beds and provides emergency care, surgery, diagnostics, paediatrics, maternity, outpatient and day case services.
Hospital D: Opened in 2002, has about 800 beds and provides a wide range of health services including general medical, surgical, maternity and emergency services.

Hospital E: Opened in 2001, has around 450 beds and is split into four divisions such as, children and women services, medicine and elderly, surgery and anaesthetics, diagnostic and therapeutic services.

Figure 4.1 The hospitals visited
4.2 Data collection

On the arrival of the site, the researcher met up with the director of facilities or a project manager and provided them with the information sheet and consent forms (general and photographic). Both parties signed the consent forms for access to the premises for data collection.

After confirming the detailed the visit plan, the director of facilities or the project manager escorted the researcher to the location to measure, sketch and photograph the 'empty' bed spaces¹ and en-suite facilities to record the layouts with essential elements e.g. furniture, equipment.

There was informal communication between the researcher and the clinical staff, for example, briefly explaining to the staff what the project was about, the purpose of visit, asking them questions when a certain equipment or furniture was in use, and also answering any of their questions relating to the project. However, there was no patient contact due to the strict ethic requirement.

The different colour pens, notebook, blank A4 paper, camera, 5-meter measuring tape to be used to collect the data including:

- Photographs of empty rooms and bed spaces;
- Notes recording additional information on the type of rooms and departments (Table 4.1), the years of planned and built / renovation;
- Sketches and diagrams of the rooms showing layout and configuration (Figures 4.2, 4.3 and 4.4);
- The exact dimensions of the rooms collected by the measuring tape;
- The list of all equipment, devices and furniture used in the rooms and bed spaces.

¹ There were the equipment and furniture placed in the normal positions, but just no patient in there.
The Figures 4.2, 4.3, and 4.4 show a sample of sketches and photos of typical bed spaces in adult acute wards and in ICUs, as well as a typical en-suite toilet from the visits.

After the site visits were complete, all the sketches were transferred into AutoCAD drawings for further analysis.

<table>
<thead>
<tr>
<th>Hospital visited</th>
<th>Adult acute ward</th>
<th>ICU</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single room</td>
<td>En-suite toilet</td>
</tr>
<tr>
<td>A</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>B</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>C</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>D</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>E</td>
<td>√</td>
<td>√</td>
</tr>
</tbody>
</table>

Table 4.1 Rooms visited
Figure 4.2 Sample of sketches of ward bed spaces
Figure 4.3 Sample of sketches of ICU bed spaces
Figure 4.4 Sample of sketches of en-suite toilet

4.3 Data analysis

After confidentiality checking by the participating hospitals, some of the photographs have been omitted because they were not approved. The researcher then analysed and displayed the data to set up the mock-ups for the Functional Space Experiments. Rooms, cubicles, en-suite toilets / shower rooms that were measured and photographed at five sites were coded (Table 4.2) and interpreted into AutoCAD drawings (See Appendix D for the data of 5 sites displayed with photos and CAD drawings).
From Figures 4.5 and 4.6, it can be seen that the rooms and the cubicle bed spaces visited and measured on acute wards and ICUs had the similar space configuration, although they had different room /space sizes and shapes. Normally in a ward bed space, there was a patient bed, a chair, a bedside table (locker), a wash hand basin (not available in cubicle) a bed head service on the wall and, whilst in an ICU bed space, there was a patient bed, a nurse table (for charting) and a chair, a nurse trolley, a bin, a wash hand basin (not available in cubicle as well) and a gantry (modular rail) or pendent (power column) bed head service. As all the bed spaces were not in use at the time.
when the visits were undertaken, some equipment or furniture needed for the care and treatment of the patient may not be present. This issue was addressed in the observation phase when the clinical tasks were observed in a ward or an ICU bed space.

However, the items of equipment/furniture in the en-suite toilets / shower rooms visited and measured at 5 sites were placed in very different positions (Figure 4.7). It was also found that there were fewer en-suite toilets / shower rooms in intensive care units than on the adult acute wards at the 5 hospitals, because the ICU patient are too vulnerable and dependent to use the toilet or shower room, their washing and toileting had to be done in bed.
### Figure 4.5 Plans of the ward rooms and cubicles measured

Note: 1 = bed, 2 = chair, 3 = locker
Chapter 4 Scoping Site Visit

Figure 4.6 Plans of the ICU rooms and cubicles measured

Note: 1 = bed, 2 = bedhead service, 3 = nurse trolley, 4 = nurse desk
4.3.1 Dimension of acute ward single room and cubicle bed spaces

The dimensions of single rooms on acute wards, excluding the en-suite sanitary spaces, were found to be between 2.93m and 3.75m in length, and 2.71m and 3.68m in width. According to HBN 4 (NHS Estates, 1990), which should have been used in the design of the five hospitals visited before the updating version HBN 04 in 1997, only the length of the room of Hospital C exceeded the recommended length of 3.70m, but most
of the rooms were wider than the recommendation of 3.10m in width, with the exception of Hospital E (Figure 4.8). In terms of room area, one of rooms of Hospital B, and the rooms of Hospital C and D were larger than the recommended dimension of 11.47m² (Figure 4.10), which resulted in 50% of single rooms measured on acute wards being larger than the HBN recommendation.

The dimensions of bed spaces in multi-bed bays on the wards were found to be between 2.60m and 2.90m in length, and 2.30m and 2.70m in width. The rooms of Hospitals A and B were smaller than the HBN recommendation of 2.90m in length and 2.50m in width, while the rooms of Hospitals C and D were a similar size, a bit larger than the recommended dimension of 7.25m² (NHS Estates, 1990) (Figures 4.9 and 4.10).

Figure 4.8 Widths and lengths of room bed spaces measured on acute wards.
Figure 4.9 Widths and lengths of cubicle bed spaces measured on acute wards

Figure 4.10 Areas of room and cubicle bed spaces measured on acute wards
4.3.2 Dimension of ICU single room and cubicle bed spaces

The dimensions of single rooms and cubicle bed space measured on intensive care units, excluding the en-suite sanitary spaces, were found to be between 4.00m and 5.35m in length, and 3.30m and 6.12m in width (Figure 4.11). The relevant Guidance HBN 27 (NHS Estates, 1992), just provides recommended bed space dimensions of 4.5m in both width and length. From Figures 4.11, it was found that only the width of the room of Hospital C and the length of the room of Hospital E were less than the recommended 4.5m. In terms of room area, all the rooms were larger than the recommendation – 20.25m². However, the width and the length of most of the cubicle bed spaces were not more than 4.5m, except the length from Hospitals D and E. Therefore, only the ICU bed space measured from Hospital D was larger than 20.25m² (Figure 4.12).

Figure 4.11 Widths and length of room and cubicle bed spaces measured on ICU
4.3.3 Dimension of en-suite toilet and shower rooms

Due to the variety of configurations of toilet / shower rooms, any minimum length or width of the room without a specific configuration cannot be given in design guidance. As mentioned earlier, the en-suite toilets and shower rooms measured at five hospitals were configured in very different ways; it was not possible to compare them.

HBN 40 Vol. 1 (NHS Estates, 1986) and Vol. 4 (NHS Estates, 1989), as the guidance at the time when the hospitals were designed, had the very similar recommendations for the layout (Figure 4.13) and the size (Figure 4.14). It was found that the en-suite toilet C-AWCT was larger than both recommended sizes 7.29m² and 7.43m² in two volumes of HBN 40, and the other en-suite toilets were smaller than the recommended sizes (Figure 4.14).
Figure 4.13 En-suite toilet / shower room in HBN 40

Figure 4.14 Areas of en-suite toilets on acute ward and ICU
All the coded AutoCAD drawings of the rooms or spaces measured were displayed along with the relevant photos in the Appendix D, which were used to choose the templates for the simulation trials in the Functional Space Experiments (FSEs).
Chapter 5 Observation

This chapter describes the data collection and analysis of observations at two local hospitals, from which result in where the area with the higher density of activities were, which task occupied more space, what the generic task components were in a certain task and the frequency of the nursing tasks, etc.

5.1 Observations at the hospitals

Observations were carried out in a community hospital and an acute hospital for four weeks and one week respectively, in order to understanding how nursing activities are carried out in the patient bed space, and toilet / shower room and developing the simulation scenarios.

5.1.1 Hospital one: acute wards

The observation areas were sited on 3 medical wards and a day surgery unit at a 95-bed community hospital, which provided a range of in-patient, day case, outpatient services, and therapy services. There are 22 – 24 beds on each medical ward with standard single bed rooms, 4 bed rooms, and six bed rooms being observed (Figures 5.1, 5.2, and 5.3). The day surgery ward is an open ward with 11 beds (Figure 5.4). The toilets observed were not standardised with differences in shape and size. The Figure 5.5 shows the layout of one toilet observed frequently.

5.1.1.1 Subjects

The subjects were nursing staff and patients on the wards. Patients were approached (under the guidance of nursing staff) on the day before the observations and provided with an information sheet to explain the project, what they would be invited to do, and what their own rights were, etc. If they agreed to permit the observation of nursing
tasks, they were asked to sign a consent form. The nurses were approached, given a different information sheet and asked to sign the consent form on the observation day.

As mentioned in the methodology chapter, the researcher also signed the forms for the participating patients and nurses to record the consenting process.

Figure 5.1 Layout of single bed room
Figure 5.2 Layout of 4 bed room

Figure 5.3 Layout of 6 bed room
Figure 5.4 Layout of day surgery ward

Figure 5.5 Layout of one toilet
A one-day pilot and a one-week observation were then carried out on each ward with a total of 4 days of pilot and 4 weeks of observations. It was decided that data collection on each day would be undertaken during the early shift from 0730 when the shift handover was normally complete till 1500 when the early shift ended, because both the staff's experience and the result of the pilot suggested that the frequent nursing tasks occur during this period.

The researcher positioned herself near the nurse station where the patient rooms were in sight so that the researcher could be aware of what tasks might occur in a certain bed space. Meanwhile, the nurses who were caring for a participating patient were advised in advance on what kind of tasks the researcher would like to watch so that they could give notice before they started the relevant tasks in order to alert the researcher.

The observations were recorded by taking notes manually without any image recording due to the ethical requirements. As well as literal descriptions of the process of the task, the recorded data also included in the data sheets (Figure 5.6):

- the purpose of the task;
- the clinical area under observation;
- start and finish time of the task;
- where the observer was positioned while observing;
- all the participants;
- the sketch of the layout recording other details of observed area, such as the position of equipment, furniture, devices;
- lines drawn on the layout sketch briefly recording movements of components or elements of the observed area.
An observation diary was kept to record general information and additional data not recorded on the data sheets.

![Sample of data sheet](image)

Figure 5.6 Sample of data sheet
Although the researcher and nurses tried to ensure that the researcher recorded as many tasks as possible, some tasks were still missed, for example, concurrent tasks where the researcher had to choose one to observe and “abandon” another one. An order of priority was established for: new tasks, different nurse(s), and more vulnerable patients (because less vulnerable patients were more independent, requiring less assistance of nursing staff or equipment). However some of the participating patients felt too uncomfortable (physically or psychologically) to let the researcher stay round the bed space to watch, sometimes the nursing staff who were performing the task felt it was inappropriate for the other people (i.e. the researcher) being present due to patient’s dignity or their own comfort. In this situation the researcher stopped the observation when the shadowed nursing staff was attending to them and restarted the observations when the nurse indicated that it was appropriate to approach them or when the nurse went to another participating patient. There were just two tasks in which the patients withdrew during the whole observation phase.

By the end of one week of observations for each ward, it was found that there was no significant new information generated, the observations therefore ended. After 4 week of observations, a total of 69 nursing tasks were recorded with 46 nurses providing care and treatment to 54 patients involved (Table 5.1). The use of equipment and furniture was summarised in the Table 5.2.

1 Note: As the hoist is one of the most common equipment used to move a patient and requiring more space than the other equipment for assistance in moving like a walking frame, the project focuses on the hoist regarding the equipment assisting in a moving task.

Table 5.1 describes the tasks of moving with or without a hoist so as to make the further analysis simpler and clearer. Without a hoist may mean with or without nursing staff or equipment assistance in moving, but just without a hoist (See Table 5.2).
Chapter 5 Observation

After the observations on each ward, there was a brief review of the observational data with the ward manager, and there was a further review of the data with the nursing staff from the observation fields at the pilot of FSEs (See the section 6.1.1.3). It was found from both reviews that the activities observed were representative of the daily work in the observation fields (i.e. bed spaces and toilets) and no major activities were overlooked during the observations. Therefore it was considered that the data collected were reliable and applicable for the subsequent FSEs.

<table>
<thead>
<tr>
<th>Tasks observed</th>
<th>Number of times tasks observed</th>
<th>Duration (mins)</th>
<th>No. of nurses involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Getting a patient up from bed to chair or wheelchair without a hoist</td>
<td>7</td>
<td>10</td>
<td>1–2</td>
</tr>
<tr>
<td>2. Getting a patient up from bed to chair or wheelchair with a hoist</td>
<td>17</td>
<td>15–30</td>
<td>2–4</td>
</tr>
<tr>
<td>3. Moving a patient from chair to chair/wheelchair without a hoist</td>
<td>1</td>
<td>3–5</td>
<td>1–2</td>
</tr>
<tr>
<td>4. Moving a patient from chair to bed without a hoist</td>
<td>1</td>
<td>5</td>
<td>1–2</td>
</tr>
<tr>
<td>5. Moving a patient from chair to bed with a hoist</td>
<td>1</td>
<td>10–15</td>
<td>2</td>
</tr>
<tr>
<td>6. Bathing a patient without assistance of equipment</td>
<td>4</td>
<td>15–20</td>
<td>1–2</td>
</tr>
<tr>
<td>7. Bathing a patient with assistance of equipment</td>
<td>2</td>
<td>20–30</td>
<td>1–3</td>
</tr>
<tr>
<td>8. Getting a patient up and then moving them out of the room without a hoist</td>
<td>4</td>
<td>10–20</td>
<td>1–3</td>
</tr>
<tr>
<td>9. Getting a patient up and then moving them out of the room with a hoist</td>
<td>1</td>
<td>10–20</td>
<td>2–3</td>
</tr>
<tr>
<td>10. Transferring a patient from trolley to bed without a hoist</td>
<td>17</td>
<td>5–10</td>
<td>3–5</td>
</tr>
</tbody>
</table>
## Table 5.1. Overall data presentation of observations on general wards

<table>
<thead>
<tr>
<th></th>
<th>Activity</th>
<th>Time (min)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Toileting a patient in bed without a hoist</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>12</td>
<td>Weighing a patient</td>
<td>1</td>
<td>3 – 5</td>
</tr>
<tr>
<td>13</td>
<td>Getting a patient up and toileting in bed with a hoist</td>
<td>2</td>
<td>20 – 30</td>
</tr>
<tr>
<td>14</td>
<td>Getting up a patient in bed without a hoist</td>
<td>3</td>
<td>10 – 15</td>
</tr>
<tr>
<td>15</td>
<td>Washing a patient in the toilet without a hoist</td>
<td>2</td>
<td>5 – 10</td>
</tr>
<tr>
<td>16</td>
<td>Toileting a patient in the toilet without a hoist</td>
<td>1</td>
<td>5 – 10</td>
</tr>
<tr>
<td>17</td>
<td>Toileting a patient in the toilet with a hoist</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>18</td>
<td>Washing a patient in the chair</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Tasks observed on general wards</td>
<td>Equipment used or involved (besides patient bed)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Getting a patient up from bed to chair or wheelchair without a hoist</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Getting a patient up from bed to chair or wheelchair with a hoist</td>
<td>✔ ✔ ✔ ? ✔ ✔ ? ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moving a patient from chair to chair/wheelchair without a hoist</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moving a patient from chair to bed without a hoist</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moving a patient from chair to bed with a hoist</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bathing a patient without assistance of equipment</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bathing a patient with assistance of equipment</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Getting a patient up and then moving them out of the room without a hoist</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Getting a patient up and then moving them out of the room with a hoist</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Toileting a patient in bed without a hoist</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Getting a patient up and toileting them in bed with a hoist</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Getting a patient up from the bed without a hoist</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Washing a patient in the toilet without a hoist</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Toileting a patient in the toilet without a hoist</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Toileting a patient in the toilet with a hoist</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Washing a patient in the chair</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Providing resuscitation in a bed space</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Table 5.2 Equipment and furniture used during general ward observations (✓ = used or involved; ? = depending on patient’s condition)
### Equipment and furniture list:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Patient overbed table</td>
<td>10. Mobile hoist</td>
</tr>
<tr>
<td>2</td>
<td>Locker / bedside table</td>
<td>11. Patient chair</td>
</tr>
<tr>
<td>3</td>
<td>Bin</td>
<td>12. Patient wheelchair</td>
</tr>
<tr>
<td>4</td>
<td>Drip stand(s)</td>
<td>13. Commode chair</td>
</tr>
<tr>
<td>5</td>
<td>Bedhead service</td>
<td>14. Shower chair</td>
</tr>
<tr>
<td>6</td>
<td>Walking frame</td>
<td>15. Oxygen</td>
</tr>
<tr>
<td>7</td>
<td>Banana board</td>
<td>16. Pat slide</td>
</tr>
<tr>
<td>8</td>
<td>Bath scale</td>
<td>17. Resuscitation trolley</td>
</tr>
<tr>
<td>9</td>
<td>weighing scale</td>
<td>18. Patient trolley</td>
</tr>
</tbody>
</table>
5.1.2 Hospital two: cardiac intensive care unit

The observation areas were sited on the cardiac intensive care unit (CICU) at an acute hospital of around 520 beds, which provided a range of in-patient, day case and outpatient services. There are 16 beds on the unit including one in the isolation room.

![Diagram of ICU bed space]

Figure 5.7 Layout of ICU bed space

5.1.2.1 Subjects

The subjects were nursing staff and post-op patients on the unit. As patients on the unit were very vulnerable and most of them were unconscious in the first 2 – 3 hours after they were brought from the operating theatre, they were approached (under the guidance of nursing staff) on the day before their operation and provided with an information sheet to explain the project, what they would be invited to do, and what their own rights were, etc. If they agreed to permit the observation of nursing tasks, they were asked to
sign a consent form. The nurses were approached, given a different information sheet and asked to sign the consent form on the observation day.

Figure 5.8 Layout of ICU single room

5.1.2.2 Data collection

A two-day pilot and a one-week observation were carried out based on the initial and revised protocols respectively. Data collection on each day was undertaken during the morning shift from 0800 when the shift handover was normally complete till 1900 when the next shift handover started. The researcher positioned herself at the end of the corridor of the unit where the bed spaces on both sides of the corridor were in sight so that she could be aware of what tasks might occur in a certain bed space. As with the observations on the general wards, the nurses who were caring for a participating patient were advised in advance on the kind of tasks the researcher would like to watch
so that they could give notice before they started the relevant tasks in order to alert the researcher.

Also as with the observations on the general wards, data were recorded by taking notes manually without any image recording due to the ethical requirements. As well as literal descriptions of the process of the task, the recorded data also included:

- the purpose of the task;
- the clinical area under observation;
- start and finish time of the task;
- where the observer was positioned while observing;
- all the participants;
- the sketch of the layout recording other details of observed area, such as the position of equipment, furniture, devices;
- lines drawn on the layout sketch briefly recording movements of components or elements of the observed area.

An observation diary was kept to record general information and additional data not recorded on the data sheets.

Although the researcher and nurses tried to ensure that the researcher recorded as many tasks as possible, some concurrent tasks were still missed due to the similar reasons to the ward observations. An order of priority to choose one to observe was established for: new tasks, different nurse(s), and female patients (since fewer female patients were available). There were two participating patients who felt unhappy or uncomfortable (physically or psychologically) to let the researcher stay round them when they received a bed wash. There were also two nurses stopping the researcher’s observations as one nurse wanted to protect her patient’s dignity and the other one indicated it wasn’t worth watching her because she would only give a very quick performance.
Chapter 5 Observation

As the patients on the units had just had an operation with the urine bag attached and were all very vulnerable and dependent, there were no tasks of toileting or washing occurring in a toilet. This fitted with what had been found during the site visits that there were fewer en-suite toilets / shower rooms on intensive care units than on the adult acute wards at the five hospitals.

By the end of one week of observations, it was found that there was no significant new information generated, the observations therefore ended. Except for five withdrawn cases, a total of 31 nursing tasks were recorded with 28 nurses providing care and treatment to 25 patients involved (Table 5.3). The use of equipment and furniture was summarised in the Table 5.4.

Again, the similar reviews of the observational data to the ward observations showed that the activities observed were representative of the daily work in the bed spaces and there were no major activities being overlooked during the observations. Therefore the data collected were reliable and applicable for the subsequent FSEs.
## Table 5.3. Overall data presentation of observations on ICUs

<table>
<thead>
<tr>
<th>Tasks observed</th>
<th>Number of times tasks observed</th>
<th>Duration (mins)</th>
<th>No. of nurses involved</th>
<th>Patient’s condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Washing, shaving a patient, changing bed sheets</td>
<td>1</td>
<td>40</td>
<td>2 – 3</td>
<td>Awake, dependent</td>
</tr>
<tr>
<td>• Washing a patient, changing bed sheets</td>
<td>14</td>
<td>30 – 40</td>
<td>2 – 3</td>
<td>Asleep/awake, dependent</td>
</tr>
<tr>
<td>• Checking a patient’s rectum / anus</td>
<td>1</td>
<td>5 – 10</td>
<td>1 – 2</td>
<td>Asleep</td>
</tr>
<tr>
<td>• Repositioning (moving / sliding) a patient on the bed</td>
<td>5</td>
<td>5</td>
<td>2 – 3</td>
<td>asleep/awake, dependent</td>
</tr>
<tr>
<td>• Washing, dressing, and moving a patient from bed to chair or wheelchair without a hoist</td>
<td>3</td>
<td>20 – 40</td>
<td>2 – 3</td>
<td>Awake, less dependent</td>
</tr>
<tr>
<td>• Dressing and moving a patient from bed to chair or wheelchair without a hoist</td>
<td>4</td>
<td>20 – 30</td>
<td>2 – 3</td>
<td>Awake, less dependent</td>
</tr>
<tr>
<td>• Moving a patient from chair to wheelchair</td>
<td>1</td>
<td>5</td>
<td>1 – 2</td>
<td>Awake, less dependent</td>
</tr>
<tr>
<td>• Transferring a patient from bed to bed</td>
<td>1</td>
<td>10</td>
<td>2 – 3</td>
<td>Awake, dependent</td>
</tr>
<tr>
<td>• Front chest X-ray with mobile X-ray machine</td>
<td>1</td>
<td>10 – 15</td>
<td>2 – 3</td>
<td>Asleep/awake, dependent</td>
</tr>
<tr>
<td>Tasks observed in ICU cubicles</td>
<td>Equipment used or involved (besides patient bed and overhead gantry)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Washing, shaving a patient, changing bed sheets</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>• Washing a patient, changing bed sheets</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>• Checking a patient’s rectum / anus</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>• Repositioning (moving / sliding) a patient on the bed</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>• Washing, dressing, and moving a patient from bed to chair or wheelchair using a hoist</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>• Washing, dressing, and moving a patient from bed to chair or wheelchair without a hoist</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>• Dressing and moving a patient from bed to chair or wheelchair using a hoist</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>• Dressing and moving a patient from bed to chair or wheelchair without a hoist</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>• Moving a patient from chair to wheelchair</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>Task</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>Transferring a patient from bed to bed</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Transferring a patient from bed to chair, from chair to bed by a hoist</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Providing resuscitation in a bed space</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Front chest X-ray with mobile X-ray machine</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Table 5.4 Equipment and furniture used during ICU observations (✓ – used or involved; ? – depending on patient’s condition)

**Equipment and furniture list**

1. Nurse trolley + desk + chair
2. Bed head service
3. Pat slide
4. Bin
5. Drip stand(s)
6. Ventilator
7. Filter
8. Chest drain
9. Warming machine
10. Dirty linen bin
11. Hoist
12. Patient chair
13. Patient wheelchair
14. Another patient bed
15. Resuscitation trolley
16. Infusions trolley
17. Intubation trolley
5.2 Data analysis and results

5.2.1 Acute ward: single room, cubicle bed space

During the field data collections, the task of getting a patient up from bed to chair or wheelchair with a hoist and the task of transferring a patient from trolley to bed without a hoist were the most frequently observed, followed by the task of getting a patient up from bed to chair or wheelchair without a hoist (Figure 5.9). The hoist was used quite frequently to move patients on the participating wards.

No tasks of resuscitation occurred during the observations, which was anticipated at the beginning. However, this kind of task was a safety critical task for which the spatial requirement was very essential. The researcher therefore attended training sessions for basic / advanced life support and conducted a very early pilot with experts in resuscitation to obtain first impressions and essential knowledge of resuscitation.\(^2\)

The issues of infection control and disability access were analysed as sub-tasks, e.g. hand hygiene during clinical tasks.

\(^2\) As the resuscitation task will definitely be simulated in the consequent FSEs due to the indication of the project aim, the researcher developed and added a resuscitation task into the Table 5.2 to inform the simulation exercise basically. (The detailed scenario will be developed with the help of nursing staff from the hospital in FSEs.)
As described earlier, the researcher sketched the layout of the observed area to record the position of the equipment, furniture, and drew lines to record the movements of components in the area. Based on these sketches and the literal descriptions of the task processes, a further link analysis of each task was carried out as shown in Figure 5.10. It was found that the side where patient’s locker was located was the area most occupied if nursing staff only needed to give a wash or move a patient up in bed. The side where the patient’s chair was located was the area most occupied when nursing staff moved a patient from bed to chair or wheelchair regardless of whether they used equipment like a hoist during the tasks.

For most of the observed tasks, the foot of the bed was the area occupied least during the tasks. The items of equipment/furniture within a bed space on the observation site were found to be placed in similar positions to the sites visited.
During the observations, it was also found no matter what tasks the staff were undertaking, two situations normally happened. One was that the curtained space was cramped with the movements of staff, equipment and furniture pushing the curtain outwards. In this situation, 1.) there were more movements the staff had to have; 2.) the patient's privacy and dignity was poor when the curtain was open unconsciously by being pushed too far; 3.) the two adjacent bed spaces could 'fight' with each other when the morning bed wash was given simultaneously. Another situation was that the staff moved the equipment and furniture, which were not used in the tasks, out of the space before they started the tasks. Both situations led to the poor staff efficiency.

It seemed that the space around the patient bed was never sufficient for use, which fitted with what the staff commented on to the researcher. There were no considerations for a family area or a storage area in the bed spaces observed.

Figure 5.10 Sample of Link analysis of transferring a patient from bed to wheelchair
Before the task started, clean water was prepared in a bowl put on the over bed table.

1 Preparation phase

1.1 Nurse 1 at patient's right side to uncover the patient

1.2 Nurse 1 lowered the bed

2 Washing, dressing and moving the patient

2.1 Nurse 1 at right side washed the patient's legs with a wipe twice.

2.2 Nurse 1 dried the patient's body.

2.3 Nurse 1 washed the patient's bottom

2.3.1 Nurse 1 asked the patient to roll himself to the left side.

2.3.2 Nurse 1 washed the patient's bottom with another clean wipe, and then dried his bottom.

2.4. Nurse 1 helped the patient put on his clothes

2.4.1 Nurse 1 helped the patient put on his underwear.

2.4.2 Nurse 1 moved the over bed trolley to the bed foot.

2.4.3 Nurse 1 walked to the locker to get patient's clothes.

2.4.4 Nurse 1 back to the patient to help him wear his shorts and shoes while the patient was lying on the bed.

2.5 Nurse 1 left to find a helper.

2.6 Nurse 1 walked back to the patient's right side.

2.7 Nurse 2 came in with a wheelchair

2.7.1 Nurse 2 placed the wheelchair at the right side of the bed end.

2.7.2 Nurse 2 walked to the right side of the patient along with nurse 1.

2.8 Two nurses moved the patient from bed to wheelchair.

2.8.1 Two nurses made the patient move to the bed edge.

2.8.2 Two nurses help the patient stand up by the bed.

2.8.3 Nurse 2 passed the walking frame to the patient.

2.8.4 Two nurses helped the patient walk to the wheelchair by using the walking frame.

2.8.5 Two nurses helped the patient sit down into the wheelchair.

3 Tidying up phase

3.1 Nurse 2 returned the walking frame to the bed foot, and then left.

3.2 Nurse 1 helped the patient tidy himself a bit.

3.3 Nurse 1 tidied up the bed.

---

Figure 5.11 Sample of HTA to describe the task process of transferring a patient from bed to wheelchair in a ward bed space
As stated in the methodology chapter, the researcher used Hierarchical Task Analysis (HTA) to analyse the data according to the literal descriptions of the process of the task, so identified the generic task components to develop the simulation scenarios for the functional space experiments (Figure 5.11). The HTA output can be seen in Appendix E.

5.2.2 ICU: Single room and cubicle bed space

During the field data collections, the task of washing a patient and then changing the bed sheets was the most frequently observed, followed by the task of repositioning (moving / sliding) a patient on the bed, and the task of dressing and moving a patient from bed to chair or wheelchair (Figure 5.12).

The issues of infection control and disability access were analysed as sub-tasks, e.g. hand hygiene during clinical tasks.

![Figure 5.12 Analysis of task frequency on ICU](image-url)
Again no there were no tasks of resuscitation occurring during the observations. For the same reason mentioned in the section 5.2.1, the researcher added the information on resuscitation into the Table 5.4 to inform the simulation scenario.

Although no observations of nursing staff using a hoist were made, the researcher noted and was advised by the nursing staff that the mobile hoist was also used frequently to move patients on the unit. It would be more critical in safety with using a hoist to undertake a task, for instance, moving a patient from bed to chair, than without using a hoist. The researcher attended a training session for manual handling and conducted an early pilot with relevant experts to obtain the essential knowledge of using a hoist in the nursing tasks and add hoist tasks into the Table 5.4 to inform the potential simulation exercises basically.

Additionally, no observations were made of nursing staff toileting a patient either in bed or in the toilet as the patients on the unit were too vulnerable to move. Normally an urine bag was attached to the patient for urine discharge. This result was consistent with what was found in the site visit phase that there were few en-suite toilets / shower rooms on intensive care units.

Based on the sketches and the literal descriptions of the task processes, a further link analysis of each task was carried out as shown in Figure 5.13. It was found, for most of the observed tasks, the bed head was the area occupied least, while the side of the left hand shelf, i.e. the patient’s right side, where the bin and the nurse trolley were located, was the area most occupied during the tasks.

In addition, the items of equipment/furniture within a bed space on the observation site were found to be placed in similar positions to the sites visited. However, the room or cubicle bed spaces sometimes revealed a 'potpourri' of different equipment and furniture. For example, there were both new purchased ventilators and very old ones being used on the unit. This might lead to the inefficient work processes of nursing
tasks if the users were not familiar with either of them. Unfortunately there was no chance to take any photos on the observation sites to show this kind of situations due to the ethical requirements.

In terms of the size of the bed space observed, a few nursing staff commented that it was big enough for use comparing with the acute ward. However, the researcher still observed that the curtains were pushed outwards when some tasks were being undertaken, especially at the foot end of the patient beds. It was also observed that the nursing staff would like to move the chair(s) for the family visit out of the bed space before a task started, which meant there was no family or storage space being considered for the bed spaces observed.

The height of the gantry hoist may be a problem as the outlets mounted on it were so high that some staff found it hard to reach them during the tasks.

Figure 5.13 Sample of link analysis of washing a patient and changing bed sheets
HTAs were used to identify individual variance and generic task components to develop the simulation scenarios for the ICU FSEs (Figure 5.14)

1. Preparation phase
   1.1 Nurse 1 at the bed head to adjust the bed for the task
   1.2 Nurse 2 at the left side of the patient, nurse 3 at the right side,
   1.3 Nurse 4 brought another bed into the cubicle at the patient’s right side, then stood with nurse 2

2. Transferring the patient from bed to bed by sliding
   2.1 Nurse 1, 2 & 4 rolled the patient to the left side with the bed sheet wrapping the patient’s body
   2.2 Nurse 3 put a pat slide under the patient’s body
   2.3 Nurse 1, 2 & 4 rolled the patient back onto their back
   2.4 Nurse 2 put the two beds side-by-side
   2.5 Nurse 4 walked to the foot of the bed
   2.6 All four nurses pulled the bed sheet to slide the patient across to the second bed

3. Tidying up
   3.1 Nurse 1 & 3 moved the bed with the patient on
   3.2 Nurse 1 removed the pat slide
   3.3 Nurse 3 tidied up the patient’s bed
   3.3 Nurse 2 & 4 tidied up the original bed, and unplugged it

Figure 5.14 Sample of HTA to describe the task process of transferring a patient from bed-to-bed in an ICU bed space

5.2.3 En-suite toilet / shower room

It was seen that there were 11 tasks recorded in the toilet (Table 5.1), which were almost a quarter of the tasks observed during the field data collection. A lot of the frequent tasks were very similar although they were performed by different nursing staff, for example, the task of toileting a patient without a hoist as shown in the Figure 5.17. Therefore this kind of tasks was not recorded repeatedly, and the task of bathing a
patient without using equipment became the most frequently task being recorded (Figure 5.15).

From the Figure 5.15, it was seen that the task of washing a patient without a hoist, the task of toileting a patient with a hoist and the task of bathing a patient with assistance of equipment were the second most frequent tasks being recorded. Actually, only the task of washing a patient without a hoist plus the task of toileting a patient without a hoist, which was mentioned at the beginning of this section, were the two most frequent tasks occurring during the data collection. These two kind of tasks raised few problems about the spatial issues due to fewer people and equipment involved.

Equipment to assist in moving a patient, for instance, a hoist, walking frame and wheelchair were used frequently in the task of toileting a patient, but only the wheelchair was observed to be used for the task of giving a wash in the toilet / shower room.

Most of the en-suite toilet observed had both shower and bath facilities, however, there were no tasks of showering a patient being observed. The researcher was advised that the shower were always out of order and the bath seemed easier to be handled, although the shower was better than the bath in terms of hygiene and infection control.

Based on these sketches and the literal descriptions of the task processes, a further link analysis of each task was carried out as shown in the Figure 5.16.

It was found, for most of the observed tasks, that the toilet had cramped conditions around the doorway, even though only one nurse was assisting within. There was no room for turning around a hoist if it had been used to bring a patient in. The only way to bring it along with the patient out was to move it backwards. Due to this kind of awkward working position and inefficiency in manual handling, some staff gave up using the hoist in the toilets, which may lead to an unexpected injury.
Chapter 5 Observation

Figure 5.15 Analysis of task frequency in en-suite toilet

Figure 5.16 Sample of link analysis of assisting a patient to wash
Some staff mentioned that it was a disaster when a patient collapsed in the toilet. The emergency assistance was provided by a number of the staff struggling with getting in and out of the toilet to perform the different sub-tasks. In this situation, the use of a hoist was completely impossible.

During the tasks of having a wash by the basin, the patient’s property such as clothes, toiletries, etc. were sometimes placed on the top of the toilet lid, which meant there was no space for holding the necessary items in the toilets observed.

Again HTAs were used to identify individual variance and generic task components to develop the simulation scenarios for the FSEs (Figure 5.17)

<table>
<thead>
<tr>
<th>The patient walked to the toilet herself with a walking frame while a nurse escorted her.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Before toileting</strong></td>
</tr>
<tr>
<td>1.1 Nurse 1 stood by the left side of the patient to help her sit down onto the toilet bowl.</td>
</tr>
<tr>
<td>1.2 Nurse 1 moved the walking frame away from the patient.</td>
</tr>
<tr>
<td>1.3 Nurse 1 asked the patient to call her using the bell when finished.</td>
</tr>
<tr>
<td>1.4 Nurse 1 left.</td>
</tr>
<tr>
<td><strong>2. After toileting</strong></td>
</tr>
<tr>
<td>2.1 The patient called the nurse.</td>
</tr>
<tr>
<td>2.2 Nurse 1 was back to help the patient stand up.</td>
</tr>
<tr>
<td>2.3 Nurse 1 helped the patient put on pants and skirt.</td>
</tr>
<tr>
<td>2.4 Nurse 1 passed the walking frame to the patient.</td>
</tr>
<tr>
<td>2.5 The patient walked out of the toilet with nurse 1’s escort.</td>
</tr>
</tbody>
</table>

Figure 5.17 Sample of HTA to describe the task process of toileting a patient in a ward en-suite toilet
Generally to summarise the problems from the observations in bed spaces of acute wards and the CICU and the toilets of acute wards, the following was found:

- Cramped working space, which would lead to the staff inefficiency;
- Awkward working positions, which may cause the staff inefficiency and injury;
- Lack of the considerations for a family space in a bed space;
- Lack of the considerations for a storage space in a bed space.
- Loss of patient dignity when the curtains were moved.
Chapter 6 Functional Space Experiment (FSE)

This chapter describes the data collection and analysis of FSEs in the mock-ups, which resulted in a total of 60 sets of dimensions of ICU FSEs, 90 sets of ward FSEs and 40 sets of en-suite FSEs. The chapter also describes the further analysis undertaken by comparing the FSE results with the site visit data and the existing HBN recommendations.

6.1 Data collection

Testing the different bed space layouts and dimensions measured at hospitals during site visits, FSEs of room and cubicle bed spaces in acute wards and intensive care units, and en-suite toilet / shower rooms were undertaken in full-scale mock-ups built at Healthcare Ergonomics and Patient Safety research Unit (HEPSU) laboratory of Loughborough University respectively.

6.1.1 FSEs for bed spaces and en-suite toilets / shower rooms in acute wards

6.1.1.1 Mock-ups

Six layouts of room or cubicle bed space were selected based on the priorities such as templates with different sizes and shapes, templates from different sites, templates including layouts of both room and cubicle bed spaces (Table 6.1). Four layouts of en-suite toilets / shower rooms were selected based on the similar priorities (Table 6.2). The detailed layouts also can be seen in the Appendix D following a layout code.
### Table 6.1 Ward bed space templates

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<th>Layout</th>
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<th>Width (m)</th>
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### Table 6.2 Ward en-suite templates

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1 The term of ‘length’ was used to describe the dimension of a patient room or a cubicle along the axis of the patient’s bed, and ‘width’ described the dimension of a patient room or a cubicle perpendicular to the axis of the patient’s bed.

2 The term of ‘depth’ was used to describe the dimension of a toilet along the doorway, and ‘width’ described the dimension of a toilet perpendicular to the doorway.
As mentioned in early chapters, the mock-up layouts were set up the same as the actual examples collected in the site visit scoping exercises (Figures 6.1 and 6.2). Different coloured tapes were used to mark the floor to represent the boundaries of the different bed space layouts. The researchers marked additional parallel lines at 20cm intervals on both sides of a boundary line to record and measure the exact space required for nursing tasks (Figure 6.3).

Figure 6.1 Mock-ups of bed space layouts of acute wards
Figure 6.2 Mock-ups of en-suite toilets / shower rooms of acute wards

Figure 6.3 Lines representing the boundary and exact space required
The equipment and furniture were borrowed from manufacturers or made of cardboard to full size dimensions. The patient was a full size articulated mannequin\(^3\) (weight = 17kg).

4-way directional video taping was used to record the participant’s movements between equipment, furniture and the simulation mannequin (patient) for further analysis.

6.1.1.2 Subjects

The participants were the nursing staff from the same site as the observation phase, who were first invited verbally and given the information sheet during the observations. On the day of the experiments, the participating nurses were given the same information sheet again and asked to sign the consent forms (general and photographic). As mentioned in the methodology chapter, the researcher also signed the forms for the participating nurses to record the consenting process.

6.1.1.3 Simulation scenarios

As with the observational phase, a pre-pilot and a pilot were undertaken at the laboratory respectively with the help of nursing staff from the hospital of acute ward observations to review the observational data; provide essential clinical information which the researcher was unable to access during the observations; and discuss what and how many tasks would be simulated based on the frequency issue and safety critical issue.

According to the observation result (Figure 5.8), washing and getting a patient up from bed to chair or wheelchair by a hoist; transferring a patient from trolley to bed were the most two frequent tasks observed. The pilot participating nurses agreed to this result.

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\(^3\) The task of showering a patient used a live patient (a participating nurse acted voluntarily) instead of the mannequin because the patient needed to handle the wheelchair.
and added that these two tasks might show spatial issues due to big equipment involved, i.e. hoist and patient trolley. Additionally, although there were no tasks of resuscitation occurring during the observations, this kind of infrequent tasks was a safety critical task for which the spatial requirement was very essential. Bearing in mind that the project aim was to review the ergonomic drawings of bed spaces (and en-suite toilets / shower rooms) in terms of 4 key clinical activities: manual handling, resuscitation, disability access, and infection control, the researcher and the participating nursing staff chose the following three tasks to be simulated in the bed space (room or cubicle) mock-ups:

1) Washing and getting a patient up from bed to wheelchair by a hoist;
2) Resuscitating a patient in the bed space; and
3) Transferring a patient from trolley to bed.

There was a slight challenging procedure in choosing nursing tasks for simulation trials in en-suite toilet / shower room mock-ups. As the project aim focused on reviewing the ergonomic drawings of en-suite toilet and shower rooms, the tasks of bathing a patient were excluded from the FSEs. As the task of washing a patient without a hoist and the task of toileting a patient without a hoist, the most two frequent tasks occurring during the observational data collection, raised few problems about the spatial issues due to fewer people and equipment involved, these two tasks were excluded from the FSEs as well.

Considering frequent tasks and safety critical tasks with likely spatial issues, the researcher chose the tasks of showering a patient (frequent task) and providing an emergency assistance (safety critical task) to be simulated with the help of participating nurses. A wheelchair was introduced into the former task to give an even worse scenario on spatial requirement. Based on the following two reasons, a overhead (gantry) hoist was chosen in the latter task: 1.) Hignett and Evans (2005) pointed out that the mobile hoist exposed the handlers to higher postal risks than the overhead hoist, and 2.) It
would be hard to move a mobile hoist into a toilet during a real emergency assistance task if the doorway was blocked by the patient's body.

In summary, the following two tasks were chosen to be simulated in en-suite toilet / shower room mock-ups:

1) Providing an emergency assistance using an overhead hoist when a patient slipped on the floor and fell in the en-suite toilet;
2) Showering a wheelchair patient.

The simulation exercises of infection control were undertaken as sub-tasks in the above five tasks.

After choosing the simulating tasks, the participating nurses then helped the researcher review the description of the task process produced and develop a standard instruction for undertaking each of simulating tasks. For example, the number of nurses to be involved in each task, the equipment and furniture to be used and located in each task, the patient's condition and situation during the task, the start point and the end point of the task (Figures 6.4 and 6.5). All the other instructions were displayed in Appendix F, which the participating nurses would have to follow in the FSEs.
Female patient 82 years old, Clostridium difficile infection, admitted with urine infections and falls, asking for toilet a lot, starts having diarrhoea, specimen sent off.
- Very large bowel movement, incontinent of faeces in the bed and the only sensible way to manage hygiene needs is to bathe.

**Start point** – patient in the bed to be washed
**End point** – Outside room on hoist

**Equipment to be used:** Patient bed, Over bed table, Locker, Patient chair, Bin, Wash basin (in some single rooms), Visitor chair (in single rooms), Dressing trolley (Extra gloves and aprons outside the bed space), Hoist/sling, Drip stand (PAC), Commode chair (in single rooms), Patient property bag, Wash bowl, Walking frame.

Figure 6.4 Sample of standard instruction for the task of bed wash and getting a patient up from bed to chair or wheelchair by a hoist in the ward bed space

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Elderly, Female patient, 90 years old, pre-op (cataract operation)
- Advised not to go to toilet on own but was desperate and a bit confused,
- Heard shouting shortly after,
- Found in toilet, pants around knees and head between toilet and wall

**Start point** – patient shouting
**End point** – back on wheelchair in room by the gantry

**Equipment to be used:** Wash basin, Toilet, Toilet chair/shower chair, Bin, Overhead lift, Walking frame.

Figure 6.5 Sample of standard instruction for the task of providing an emergency assistance when a patient slipped on the floor and fell in the toilet
For those tasks that the researcher did not have a chance to observe during the observation phase, such as the resuscitation task, two tasks to be simulated in the en-suite toilets/shower rooms, the nursing staff helped the researcher develop the detailed simulation scenarios, i.e. the description of the task process, the standard instruction for undertaking each of the tasks, then provided a walkthrough to test and revise the simulation scenarios.

Finally, the researcher and nursing staff ran another round of the walkthrough for each of five chosen tasks to determine what and how the participants were going to perform, how many simulation sessions to be run and how many participants for each session would be required.

After the pilots, five sessions were run with 18 participating nurses (Figure 6.6). Each session had a group of nurses testing the layouts by repeatedly performing the three tasks. A total of 90 tasks simulating in the room or cubicle bed spaces and 40 tasks in the en-suite/shower rooms were recorded by multi-direction cameras for further analysis.

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4 As mentioned in the observation chapter, the researcher attended training sessions for basic/advanced life support and conducted a very early pilot with experts in resuscitation to obtain the first impressions and the essential knowledge of resuscitation. When analysing the observational data, the researcher produced a very brief description for a resuscitation task, for instance, the equipment to be used, the staff to be involved etc. which gave a start point to develop the simulation scenario.
6.1.2 FSEs for room and cubicle bed spaces in ICUs

6.1.2.1 Mock-ups

Four layouts were selected also based on the priorities such as templates with different sizes and shapes, templates from all of five sites visited, templates including layouts of both room and cubicle bed spaces (Table 6.3). The detailed layouts can be seen in the Appendix D according to the layout code.

The mock-up layouts were set up as the same to the actual examples collected in the site visit scoping exercises (Figure 6.7). Again, different coloured tapes were used to mark the floor to represent the boundaries of the different bed space layouts. The additional parallel lines at 20cm intervals on both sides of a boundary line were marked to record and measure the exact space required for nursing tasks.
### Table 6.3 ICU Bed space templates

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</table>

Table 6.3 ICU Bed space templates

![Mock-ups of bed space layouts of ICUs](image-url)

Figure 6.7 Mock-ups of bed space layouts of ICUs
The equipment and furniture were borrowed from manufacturers or made of cardboard to full size dimensions. The patient was also the full size articulated mannequin with the weight of 17kg.

Again, 4-way directional video taping was used to record the participant's movements between equipment, furniture and the simulation mannequin (patient) for further analysis.

6.1.2.2 Subjects

The participants were the nursing staff from the same site as the observation phase. They were given the information sheet for FSEs and asked to sign the consent forms on the day of FSEs. Again, the researcher also signed the forms for the participating nurses to record the consenting process.

6.1.2.3 Simulation scenarios

With the same pilot protocol as the FSEs of ward bed spaces, the nursing staff reviewed the observational data; provided essential clinical information which the researcher was unable to access during the observations; and discussed what and how many tasks would be simulated based on the frequency issue and safety critical issue.

As mentioned earlier a mobile hoist was also used frequently to move patients on the unit which would be more critical in safety issue than without using it, the task of washing and dressing a patient, and then moving them from bed-to-wheelchair using a hoist was developed for the FSEs of ICU bed spaces by integrating the four most frequent tasks shown in the Figure 5.11 (in the observation chapter) into one.
Additionally, although the task of transferring a patient from bed-to-bed was observed infrequently, the nursing staff suggested that this task would show spatial issues due to one more piece of large equipment involved in an area already containing some big equipment like the original patient bed, the ventilator, the bed head service, and a lot of lines and tubes. So the task of transferring a patient from bed-to-bed was chosen in terms of safety and efficiency considerations.

Besides these two tasks, the task of resuscitating a patient was chosen as a safety critical task again.

Finally, the tasks for the FSEs of ICU bed spaces were summarised as follows:

1) Washing and dressing a patient, and then moving them from bed to wheelchair by a hoist;
2) Resuscitating a patient; and
3) Transferring a patient from bed to another bed.

The simulation exercises of infection control were undertaken as sub-tasks in above three tasks.

There were no simulation trials of ICU en-suite toilets / shower rooms because the fact found in both site visit phase and observation phase was that these kind of rooms were very few and hardly in use due to the patients being too vulnerable to move.

After choosing the simulating tasks, the participating nurses then helped the researcher review the description of the task process produced and develop a standard instruction for undertaking each of simulating tasks, for example, the number of nurses to be involved in each task, the equipment and furniture to be used and located in each task, the patient’s condition and situation during the task, the start point and the end point of
the task (Figure 6.8). All the instructions for 3 tasks were displayed in the Appendix F, which the participating nurses would have to follow in the FSEs.

Again, as the researcher was not able to observe the resuscitation task during the observation phase, the nursing staff helped the researcher develop the detailed simulation scenario, i.e. the description of the task process, the standard instruction for undertaking the task, then provided a walkthrough to test and revise the simulation scenario. Additionally, although the researcher did not observe any tasks using a hoist, she attended a training session for manual handling and conducted an early pilot with relevant experts to obtain the essential knowledge of using a hoist. This gave the researcher an easy access whilst developing the simulation scenario for the task of bed wash plus bed-to wheelchair using a hoist.

Finally, the researcher and nursing staff also ran another round of the walkthrough for each of three chosen tasks to determine what and how the participants were going to perform, how many simulation sessions to be run and how many participants for each session would be required.

Routine task of transferring a patient from bed to bed.
Patient post-surgery and unable to assist. No infection control problems.

Start point – Patient in the first bed
End point – Patient in the second bed

Equipment to be used: Two patient beds, Charting table, Stool, Gantry (bed head), Two drip stands, Pat slide, Ventilator, Chest drain, Urine bag, Dressing trolley, Bin.

Figure 6.8 Sample of standard instruction for the task of transferring a patient from bed to bed in ICU bed spaces
After the pilots, three sessions were run with 18 participating nurses (Figure 6.9). Each session had two groups of nurses, giving a total of six groups testing the layouts by repeatedly performing the three tasks. A total of 60 tasks were video recorded for further analysis.

Figure 6.9 Participating nurses undertaking a bed wash task in an ICU bed space

6.2 Data analysis and results

6.2.1 Room / cubicle bed spaces and en-suite toilets / shower rooms in acute wards

6.2.1.1 Analysis and results of room / cubicle bed space in acute wards

As stated earlier, 4 room and 2 cubicle bed spaces were chosen to be templates for the FSEs. The multi-directional video data (from 4 cameras) were analysed frame by frame using Link Analysis (LA). The movement of each participating nurse, equipment, and furniture during a task was plotted individually and then overlaid with each other for each task and template to give 90 data sets of the composite link analyses as shown in
Figures 6.10 a (bed wash + bed-to-wheelchair by a hoist), 6.10 b (trolley-to-bed transfer) and 6.10 c (resuscitation). The overlaid diagrams are very detailed but give a true reflection of the complexity of the working activities.

The whole process of LA for 90 tasks consumed around 200 hours with each task costing 2 – 3 hours. The empirical data for each task is given in Tables 6.4, 6.5 and 6.6. The LA were displayed in the Appendix G.
Figure 6.10 Sample of Link Analysis for 3 simulating tasks in a ward bed space FSEs
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Table 6.4 LA data of bed wash + bed-to-wheelchair by a hoist in ward bed spaces
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Table 6.5 LA data of transferring a patient from trolley to bed in ward bed spaces
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Table 6.6 LA data of resuscitating a patient in ward bed spaces
The average space occupied for each task was calculated as shown in Figures 6.11, 6.12 and 6.13 in terms of area, width and length respectively.

It was found that the trolley-to-bed transferring task occupied the most space with an average area of 10.94m², followed by the resuscitation task with an average area of 10.93m² and the bed wash task with 10.65m² (Figure 6.11). This result is larger than the HBN04 (NHS Estates, 1990) recommendation of a minimum cubicle bed space of 7.25m², and also larger than HBN40 (NHS Estates, 1995b) and HBN04 (NHS Estates, 1997) recommendations for cubicle bed spaces of 7.83m², 8.41m² respectively, but smaller than all recommendations of single room from HBN04 (NHS Estates, 1990) with 12.87m², HBN40 (NHS Estates, 1995b) with 11.32m², and HBN04 (NHS Estates, 1997) with 16.88m².

With respect to the average area, it was found that the templates of B-AWR2 and D-AWR could accommodate the average requirement and all the trials carried out within them. The templates of B-AWC, D-AWC, and E-AWR were exceeded for the average requirement and accommodating the trials within them. The average width and length of the templates was also calculated for the further analysis (Figures 6.12 and 6.13).
Chapter 6 Functional Space Experiment

Figure 6.11 Ward bed space dimension: area (m$^2$)

Figure 6.12 Ward bed space dimension: width (m)
Chapter 6 Functional Space Experiment

Figure 6.13 Ward bed space dimension: length (m)

From the width analysis, all the results are between 2.74m and 3.56m. It was found that the bed wash task required an average of 3.21m, followed by the trolley-to-bed transferring task with 3.18m and the resuscitation task with 3.14m. The result of 3.21m is more than the HBN04 (NHS Estates, 1990) of 2.50m, HBN40 (NHS Estates, 1995b) of 2.70m and HBN04 (NHS Estates, 1997) of 2.90m on the minimum width of cubicle bed space, even wider than the recommendation of the width of single room with 3.06m in HBN40 (NHS Estates, 1995b), but less than the recommendations on the width of single bed room in HBN04 (NHS Estates, 1990) of 3.30m and HBN04 (NHS Estates, 1997) of 4.90m.

All the results of length analysis are between 3.20m and 3.65m. It was found that the resuscitation task required an average of 3.47m, followed by the trolley-to-bed transfer task with 3.44m and the bed wash task with 3.32m. The result of 3.47m is more than the HBN04 (NHS Estates, 1990), HBN40 (NHS Estates, 1995b) and even HBN04 (NHS Estates, 1997) of 3.06m.
Estates, 1997) recommendations on the length of cubicle bed space with minimum of 2.90m, but less than all the recommendations on the length of single bed room in above three guidance with 3.90m, 3.70m and 3.70m respectively (NHS Estates, 1990, 1995 and 1997).

The trolley-to-bed transfer task and the resuscitation task required similar size and shape.

With respect to the bed space envelope, the bed wash task required the largest average width to accommodate the access/egress of the hoist and meet the challenges of the frequent tasks, and the resuscitation task required the greatest average length to accommodate the increased number of staff as well as the equipment and circulatory space around the bed and meet the safety critical challenges. These two dimensions were used in the bed space envelope that can accommodate all of three tasks, i.e. 3.21m (width) x 3.47m (length) = 11.14m²

6.2.1.2 Analysis and results of en-suite toilet / shower room in acute wards

As stated earlier, 4 en-suite toilets / shower rooms from acute adult wards were chosen to be templates for the FSEs. The multi-directional video data (from 4 cameras) were analysed frame by frame using Link Analysis. The movement of each participating nurse, equipment, and furniture during a task was plotted individually and then overlaid with each other for each task and template to give 40 data sets of the composite link analyses as an AutoCAD.

The whole process of LA for 40 tasks consumed around 80 hours with each task lasting around 2 hours. The empirical data for each task is generated as shown in Tables 6.7 and 6.8. The LA were displayed in the Appendix G.
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Table 6.7 LA data of providing an emergency assistance in ward en-suite toilets / shower rooms
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Table 6.8. LA data of showering a patient in ward en-suite toilets / shower rooms
The average space occupied for each task was calculated as shown in Figures 6.14, 6.15 and 6.16 in terms of area, width and depth respectively.

It was found that the emergency assistance task occupied the most space with an average area of 5.04m², slightly more than the showering task with an average area of 5.02m² (Figure 6.14). This result is smaller than the recommendations of HBN40 (NHS Estates, 1986) with the dimension of 7.29m² and HBN4 (NHS Estates, 1990) with the dimension of 5.27m² (page 35), but larger than the sample of en-suite toilet of a single bed room in HBN4 (NHS Estates, 1990) with the dimension of 3.30m² (page 36). Compared with the most recent recommendations in HBN40 (NHS Estates, 1995b) with the dimension of 7.29m², the result is smaller.

As described earlier, due to the variety of configurations of toilet / shower rooms, any minimum length or width of the room without a specific configuration cannot be given in design guidance. The comparison between different depths or widths is not necessary.

With similar reasoning to the ward bed space envelope for both the challenges of frequent task (showering a patient) and safety critical task (emergency assistance), the average spatial requirement of en-suite toilet/shower envelope was concluded to be 5.43m² with the width of 2.08m and the length of 2.61m.
Figure 6.14 Ward en-suite toilet / shower room dimension: area (m²)

Figure 6.15 Ward en-suite toilet / shower room dimension: width (m)
6.2.2 Room / cubicle bed spaces in ICUs

As stated earlier, three single rooms and one cubicle bed space were chosen to be templates for the FSEs. The multi-directional video data (from 4 cameras) were analysed frame by frame using Link Analysis. The movement of each participating nurse, equipment, and furniture during a task was plotted individually and then overlaid with each other for each task and template to give 60 data sets of the composite link analyses as an AutoCAD drawing.

The whole process of LA for 60 tasks consumed around 180 hours with each task lasting around 3 hours. The empirical data for each task is generated as shown in Tables 6.9, 6.10 and 6.11. The LA were displayed in the Appendix G.
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Table 6.9 LA data of bed wash + bed-to-wheelchair by a hoist in ICU bed spaces
<table>
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<th>Area (m²)</th>
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<tr>
<td>178</td>
<td>C-ICR</td>
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<td>4.37</td>
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</table>

Table 6.10 LA data of transferring a patient from bed to bed in ICU bed spaces
Table 6.11 LA data of resuscitating a patient in ICU bed spaces

<table>
<thead>
<tr>
<th>Site/layout ID</th>
<th>Length (m)</th>
<th>Width (m)</th>
<th>Area (m²)</th>
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<tbody>
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<tr>
<td>190</td>
<td>5.10</td>
<td>4.77</td>
<td>24.33</td>
</tr>
</tbody>
</table>

The average space occupied for each task was calculated as shown in Figures 6.17, 6.18 and 6.19 in terms of area, width and length respectively.

It was found that the bed-to-bed transferring task occupied the most space with an average area of 23.26m², followed by the resuscitation task with an average area of 22.87m² and the bed wash task with 22.36m² (Figure 6.17). This result is larger than the HBN recommendation of 1992 with minimum of 20.25m², but smaller than the most recent recommendations both of 25.30m² for a cubicle bed space and of 26.16m² for a single room (NHS Estates, 1992 and 2003a).
With respect to the average area, it was found that the templates D-ICR and E-ICR could accommodate the average requirement and all the trials carried out within them. Both the templates of B-ICC and C-ICR were exceeded for the average requirement and accommodating the trials within them. The average width and length of the templates was also calculated for the further analysis (Figures 6.18 and 6.19).

Figure 6.17 ICU bed space dimension: area (m²)
Figure 6.18 ICU bed space dimension: width (m)

Figure 6.19 ICU bed space dimension: length (m)
From the width analysis, all the results are between 4.19m and 5.93m. It was found that the resuscitation task required an average of 4.89m, followed by the bed-to-bed transfer task with 4.87m and the bed wash task with 4.81m. This result is not only wider than the HBN recommendation of 1992 with minimum of 4.50m, but also wider than the most recent recommendations of both 4.60m for a cubicle bed space and 4.80m for a single room (NHS Estates, 1992 and 2003a).

All the results of length analysis are between 4.36m and 5.09m. It was found that the bed-to-bed transfer task required an average of 4.80m, followed by the resuscitation task with 4.67m and the bed wash task with 4.66m. This result is longer than the HBN recommendation of 1992 with minimum of 4.50m, but shorter than the most recent recommendations of both 5.50m for a cubicle bed space and 5.45m for a single room (NHS Estates, 1992 and 2003a).

Most of the resulting dimensions resembled square shapes.

With similar reasoning to the ward bed space envelope for both the challenges of frequent task (bed-to-bed transfer) and safety critical task (resuscitation), the average spatial requirement of the ICU bed space envelope was concluded in 23.47m² the width of 4.89m and the length of 4.80m.
6.3 Summary

The ergonomic envelopes for ward bed space, en-suite toilet / shower room and ICU bed space are shown as Table 6.12. The spatial requirements were based on the specific tasks (which were simulated in the FSEs) under a defined situation (simulation scenario) as stated in the previous sections and chapters. It is recommended that both the width and the length should be given together with the area for an envelope.  

<table>
<thead>
<tr>
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<tr>
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<td>Ward bed space</td>
<td>11.14</td>
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<tr>
<td>En-suite toilet / shower room</td>
<td>5.43</td>
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<tr>
<td>ICU bed space</td>
<td>23.47</td>
</tr>
</tbody>
</table>

Table 6.12 Spatial requirements of ergonomic envelopes

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5 The discussions on the ergonomic envelopes and their spatial requirements were in the sections 7.4.2 and 7.4.3 in Chapter 7.
Chapter 8 Conclusion and Recommendation

The chapter reviews the research questions, presents the protocol for the future development, revision and testing of ergonomic drawings, and suggests the potential further study areas.

Based on the discussion in the section 7.4.3, it is concluded that the dimension of the acute ward bed space envelope was 11.14m² with the width of 3.21m and the length of 3.47m; the dimension of the ICU bed space envelope was 23.47m² with the width of 4.89m and the length of 4.80m; and the dimensions of the en-suite toilet/shower room envelope was 5.43m² with the width of 2.08m and the depth of 2.61m.

As mentioned previously, the envelopes should be an incompressible functional space, and the dimensions above had to be described as (spatial) requirements rather than recommendations, although they were just based on a few safety critical or frequent tasks tested under a defined situation (simulation scenario). It is suggested that the envelopes should be presented with the dimensions on the premise of clarifying the specific situations, of which the producers of design guidance, the architects, the healthcare planners, and even the project manager will be informed.

8.1 Review of the researcher questions with the outputs

- Research question 1: Have the ergonomic drawings been updated to reflect changes in clinical practice and medical technology?

The literature review has looked at the development of hospital in the past and today, and the existing ergonomic drawings, and sought evidence for the recommendations and subsequent changes. The change in guidance has been mapped both nationally and internationally, which resulted in the affirmation

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1 As there will exist a need to consider more tasks / situations in the further development of the envelopes for the thorough review of the ergonomic drawings, the four step protocol stated in the section 8.2 can be used for this purpose.
Chapter 8 Conclusion and Recommendation

that the drawings have been updated. However, there were no studies reporting evaluations of the use of the guidance (ergonomic drawings), so no answers have been found to the research question ‘whether the ergonomic drawings were capable of reflecting changes in clinical practice and medical technology’ in literature review.

Bringing together the data from the scoping site visit phase and FSE phase, it was concluded that the ergonomic drawings have not been capable of reflecting changes in clinical practice and medical technology.

- Research question 2: Are the drawings used by the architects during the development/redevelopment of hospitals?

Although it is showed that the dimensions of patient bed spaces and en-suite toilets were different between the scoping visited sites and the HBN recommendations (ergonomic drawings), the question whether the drawings have been used could not be simply answered based on the result from just five site visits. Much bigger scoping with more sites may be needed to draw the final conclusion.

From the parallel interview study, it was found that the drawings were used by the architects when developing new hospitals, but in a variety of ways from being taken literally through to use as a reference but ignoring detail, as the lack of supporting evidence for the ergonomic drawings was felt to detract from their potential impact (Hignett, et al., 2007).

It is pointed out that the ergonomic drawings need to be based on research evidence. A range of ergonomic methods can be used to provide a detailed knowledge of work processes within a defined space or area as supporting evidence in review and revision of the drawings.
Research question 3: Do the drawings work with respect to the functionality and usability of the recommended space and layouts?

The results of the FSEs, giving average dimensions for ergonomic envelopes, are one of the first sources of empirical evidence for the HBNs. It was found that the more recent guidance for ICU would accommodate the ergonomic envelope (NHS Estates, 2003), as would the ward bed space (NHS Estates, 2005), but that the recommendations for toilet/shower provision were still inadequate (NHS Estates, 2005). It was concluded that some of the drawings would work with respect to the functionality and usability (only because they were recommended to be big enough with unknown reason).

The FSEs have resulted in three recommended ergonomic envelopes based on task analysis for ICU and ward bed spaces and en-suite toilet/shower rooms.

The project has demonstrated the effectiveness of transferring two ergonomic task analysis methods (Hierarchical Task Analysis and Link Analysis) into healthcare. Link analysis was found to be very effective for plotting the movements of the nurses and accounting for the complexity of the tasks. This method, in combination with HTA, provided a simple but effective way of determining the functional space requirements for nursing activities.

8.2 Protocol for future development, revision and testing of ergonomic drawings

There is an urgent need to provide the people involved in the healthcare development with high quality evidence so that the development will respond to the rapid changes in clinical practice and medical technology, and create a safer and more efficient clinical environment.
Chapter 8 Conclusion and Recommendation

It is proposed that the 4-step protocol should be used for future development, revision and testing of ergonomic drawings (guidance). This protocol will also be applicable to the healthcare development as described as follows:

- **Step 1:** Define an example to test or build to produce a layout from ‘real life’.

  This can include current guidance/recommendations, a room or a specific area from an existing facility or a new built to be.

- **Step 2:** Observe task activities using HTA and LA in the defined area (or the area with the same functionality to the new build in the existing facility) to develop a simulation scenario based on the frequency and criticality of activities, or any special functions/activities which are required to be addressed by the entrusting party.

  The observation is carried out for frequently conducted and safety critical nursing tasks.

  LA is used to look at spatial relationships within the defined area in the collection and analysis of the observational data. HTA is used for the data analysis to identify individual variance and generic task components to develop the simulation scenarios for the FSEs.

- **Step 3:** Conduct FSEs with the simulation scenario to determine the spatial requirements for ergonomic envelope.

  FSEs is developed to test the space required for the tasks identified in the field observations. The simulations is designed to test the sample layouts and dimensions using simulation scenarios. LA is used in the analysis of the FSEs to
determine the optimal layout and improve design, according to the multi-directional video data.

- **Step 4: Take additional information into account to finalise the dimensions of the sample based on the ergonomic drawings.**

This is referring to some other functions / activities which have not been required to simulate but will have influence on the functionality of the simulated area as a whole, for example, the storage or circulation space.

This step needs to be carried out by the building designer in consultation with the ergonomics advisor.

A good pilot is an essential factor to ensure a smooth and success process both of the observations and FSEs.

As Hamilton (2005) suggested, most architects will act as users of research findings, and it is likely that the above four step protocol would be mainly used by the producers of design guidance, researchers or even healthcare planners rather than architects. However, this protocol may give architects the evidence-based understanding of the research information that can lead to success in evidence-based design.

**8.3 Future research works**

There may be some potential studies that could be inspired by this project.

1. Follow-up studies in the same areas or new areas:

   - The project looked at a few nursing tasks to review the ergonomic drawings. It is suggested that more safety critical or frequent tasks could be considered to
review the drawing thoroughly. For example, such tasks as providing an emergency operation around a bed space, or using the large portable equipment such as X-Ray machine, ultrasound machine.

- Regarding the resulting ergonomic envelopes from this project, the further studies on detailed spatial requirements can be carried out. For example, it was observed that in a ward bed space, the area on the side of the patient chair was occupied more frequently and physically than the side of the locker. The studies could look at the exact spatial requirement of each side of the patient bed, and even of the area of the foot of the bed so that the layout will be highly improved.

It was also observed that the doorway parallel to the long axis of the patient bed made bringing in / out the equipment easier than the doorway perpendicular to the long axis of the bed. The detailed study could look at the impact of the door position on the efficiency and safety of the tasks.

Similarly, another potential study could look at the impact of the position of en-suite toilet / shower room on the efficiency and safety of the tasks.

- The study also could look at the ergonomic envelopes of some new clinical areas such as the theatres, nurse stations, storage space / room etc. under the 4 - step protocol developed from this project.

- To reflect the changes in medical technology and clinical practice, it is suggested that the potential study should look at new ergonomic envelopes under the protocol. For example, combining with the current trend of a universal room, the study could look at a larger, more functional and flexible patient room with the ergonomic envelope as an incompressible core space.

2. Review of the ergonomic envelope:
• The study could look at the measurable improvement after using the recommendations (ergonomic envelopes) from this project. The parameters could be the cost, the staff efficiency and satisfaction, etc.

3. Wider works to use the protocol in:

• the pre-construction phase of the hospital development / redevelopment to create a safety and efficient clinical environment;
• the evaluation of the completed hospital to look at the nurses work conditions and facilitating nurses involvement.
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A


B


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V


W


Appendix A: Information sheets

Review of NHS Estates Ergonomics Drawings

(Scoping Site Visit)

The majority of the ergonomic drawings were produced over 20 years ago and have not been updated to reflect changes in clinical practice and medical technology.

Aim

The aim of this project is to review the functionality of NHS Estates ergonomic drawings with respect to key clinical issues of manual handling, infection control, resuscitation and disability access for:

- Acute adult wards (multi-bed bays and single rooms).
- Intensive care facilities.

Methods

The project will take a four stage approach as shown in the diagram on the next page.

Outputs

The outputs will include

1. Recommendations for revised ergonomic drawings.
2. A protocol for the future revision and testing of NHS Estates ergonomic drawings.
Overview of project and methods

Current Ergonomic

How are the current drawings used?

How has the context for provision of health care changed?

What is the scope for future

Data collection

Who are the stakeholders?
- Clinical staff
- Support staff (e.g.

1) Individual expert interviews
   Architects, Ergonomists and Project Managers

2) Dimensions and layout examples
   Recently built in-patient facilities

3) Observations for Task Analysis
   Manual handling, resuscitation, disability access

4) Simulation exercises in hospital room mock-up at Loughborough University with:
   1. Experts in manual handling, infection control, resuscitation and disability access
   2. Nursing staff
   To include task analysis and focus groups

NB. Patient views are being researched in a separate project.

We have a full size hospital room mock-up which can be reconfigured to allow analysis of different dimensions and layouts. It is fitted with multi-directional CCTVs to allow analysis of working activities from 4 directions.
Participant (nurse) information sheet (observation)

Better design of patient bed space, toilets and bathrooms:
Review of NHS Estates ergonomic drawings

Invitation to participate
You are being invited to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

Thank you for reading this.

What is the purpose of study?
This study looks at single patient rooms, 4-bed bays, toilets/bathrooms in adult acute wards and critical care units. The aims are to review the existing ergonomic drawings in above areas, and to produce a recommendation to improve the healthcare environments. The following clinical tasks will be considered in the study: manual handling, resuscitation, infection control, and disability access.

We are currently collecting data from observations in XXX Hospital, CNWL PCT and YYY Hospital, UHL.

Who is doing this research?
This research is funded by the NHS Estates. The researchers are from Loughborough University (Dr. Sue Hignett and Miss Jun Lu).

Do I have to take part?
No. It is up to you to decide whether or not to take part. If you do decide to take part you will be given a consent form to sign. If you decide to take part you are still free to withdraw at any time without giving a reason.

What will happen to me if I agree to take part?
You will be asked to assist in data collection by allowing the researcher (Jun Lu) observing your nursing tasks in wards at XXX Hospital or in CICU at YYY Hospital, and will be kept informed of the project results. It will take approximately 1/2 day per participant.

What will happen to me if I decide to withdraw from the project?
There will be no effect on your employment status. The data already collected will be used for analysis unless you specially request it to be withdrawn and destroyed.

What do I have to do?
You will need to allow Jun Lu to observe your nursing tasks in the ward so that we can make detailed data recordings.
You will be asked to describe situations where safely critical incidents occurred which were related to the bed space layout.

What are the possible advantages/disadvantages of taking part?
The research will produce a more efficient design of the bed space, toilet/bathroom, which may help to provide better workplaces to nursing staff in the future.

What happens if something goes wrong?
We will follow the incident report procedure at XXX Hospital / YYY Hospital and Loughborough concurrently. If you are harmed by taking part in this research project, there are no special compensation arrangements. If you are harmed due to someone’s negligence, then you may have grounds for a legal action but you may have to pay for it. Regardless of this, if you wish to complain about any aspect of the way you have been approached or treated during
the course of this project the normal National Health Service (or University) mechanisms may be available to you.

**Will my taking part in this study be kept confidential?**
If you take part in this study all information collected about you during the course of the research will be kept strictly confidential. All references to participants in the report will be anonymous. The information will be kept in secure location, accessible only to researchers. All of the data will remain the property of the Loughborough University and will be destroyed 5 years after publication.

**What will happen to the results of the research study?**
The results will be coded (for anonymity) and analysed by the research team before being reported. The results may also be presented in appropriate scientific journals and conferences. If you take part in this research, you can obtain copies of these publications from the research team. The data will be stored by the Chief Investigator (Sue Hignett, Data Controller) at Loughborough University under conditions specified by the Departmental Data Protection Advisor.

**Who is funding the research?**
The research is funded by the NHS Estates.

**Who has reviewed the study?**
The Local Research Ethics Committee of Leicestershire (for CNWL PCT and UHL) has reviewed the study.

**Who do I contact for more information?**
You can ask: Dr. Sue Hignett – S.M.Hignett@lboro.ac.uk, Tel. 01509 223003; Miss Jun Lu – J.Lu@lboro.ac.uk, Tel. 01509 228479

**What if I have any concerns?**
If you have any concerns about this study or the way it has been carried out, you should contact the researchers (Sue Hignett, Jun Lu).
Participant (nurse) information sheet (simulation trial)

Better design of patient bed space, toilets and bathrooms:
Review of NHS Estates ergonomic drawings

Invitation to participate
You are being invited to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.
Thank you for reading this.

What is the purpose of study?
This study looks at single patient rooms, 4-bed bays, toilets/bathrooms in adult acute wards and critical care units. The aims are to review the existing ergonomic drawings in above areas, and to produce a recommendation to improve the healthcare environments. The following clinical tasks will be considered in the study: manual handling, resuscitation, infection control, and disability access.
We are collecting data from simulations for 5 different layouts in the hospital room mock-up at Loughborough University.

Who is doing this research?
This research is funded by the NHS Estates. The researchers are from Loughborough University (Dr. Sue Hignett and Miss Jun Lu).

Do I have to take part?
No. It is up to you to decide whether or not to take part. If you do decide to take part you will be given a consent form to sign. If you decide to take part you are still free to withdraw at any time without giving a reason.

What will happen to me if I agree to take part?
You will be asked to assist in data collection by simulating nursing tasks in the mock-up at Loughborough University, and will be kept informed of the project results. It will take 1 – 2 hours for each of 5 visits.

What will happen to me if I decide to withdraw from the project?
There will be no effect on your employment status. The data already collected will be used for analysis unless you specially request it to be withdrawn and destroyed.

What do I have to do?
We will ask you to take part in simulations of nursing tasks in the mock-up at Loughborough University so that we can make detailed data recordings.
The tasks will be videoed so that link analysis of spatial relationship can be carried out later.
We will ask you to describe situations where safely critical incidents occurred which were related to the bed space layout.

What are the possible advantages/disadvantages of taking part?
The research will produce a more efficient design of the bed space, toilet/bathroom, which may help to provide better workplaces to nursing staff in the future.

What happens if something goes wrong?
We will follow the incident report procedure at XXX Hospital / YYY Hospital and Loughborough University concurrently. If you are harmed by taking part in this research project, there are no special compensation arrangements. If you are harmed due to someone’s negligence, then you may have grounds for a legal action but you may have to pay for it.
Regardless of this, if you wish to complain about any aspect of the way you have been approached or treated during the course of this project the normal National Health Service (or University) mechanisms may be available to you.

Will my taking part in this study be kept confidential?
If you take part in this study all information collected about you during the course of the research will be kept strictly confidential. All references to participants in the report will be anonymous. The information will be kept in secure location, accessible only to researchers. All of the data will remain the property of the Loughborough University and will be destroyed 5 years after publication.

What will happen to the results of the research study?
The results will be coded (for anonymity) and analysed by the research team before being reported. The results may also be presented in appropriate scientific journals and conferences. If you take part in this research, you can obtain copies of these publications from the research team. The data will be stored by the Chief Investigator (Sue Hignett, Data Controller) at Loughborough University under conditions specified by the Departmental Data Protection Advisor.

Who is funding the research?
The research is funded by the NHS Estates.

Who has reviewed the study?
The Local Research Ethics Committee of Leicestershire has reviewed the study.

Who do I contact for more information?
You can ask: Dr. Sue Hignett – S.M.Hignett@lboro.ac.uk, Tel. 01509 223003; Miss Jun Lu – J.Lu@lboro.ac.uk, Tel. 01509 228479

What if I have any concerns?
If you have any concerns about this study or the way it has been carried out, you should contact the researchers (Sue Hignett, Jun Lu).
Participant (patient) information sheet (observation)

Better design of patient bed space, toilets and bathrooms:
Review of NHS Estates ergonomic drawings

Invitation to participate
You are being invited to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this.

What is the purpose of study?
This study looks at single patient rooms, 4-bed bays, toilets/bathrooms in adult acute wards and critical care units. The aims are to review the existing ergonomic drawings in above areas, and to produce a recommendation to improve the healthcare environment. The following clinical tasks will be considered in the study: manual handling, resuscitation, infection control, and disability access.
We are currently collecting data from observations in XXX Hospital and YYY Hospital.

Who is doing this research?
This research is funded by the NHS Estates. The researchers are from Loughborough University (Dr. Sue Hignett and Miss Jun Lu).
Do I have to take part?
No. It is up to you to decide whether or not to take part. If you do decide to take part you will be given a consent form to sign. If you decide to take part you are still free to withdraw at any time without giving a reason.

What will happen to me if I agree to take part?
You will be asked to assist in data collection by allowing the researcher (Jun Lu) to observe nurses providing treatment and care for you.

What will happen to me if I decide to withdraw from the project?
The researcher will stop observing all nursing activities involving you immediately. The data already collected will be used for analysis unless you specially request it to be withdrawn and destroyed.

What do I have to do?
You will only need to sign the consent form, and then allow Jun Lu to observe nurses providing treatment and care for you.

What are the possible advantages/disadvantages of taking part?
The research will produce a more efficient design of bed spaces, toilets and bathrooms, which may help to provide better and safer environments for patients, clinical staff, visitors, and public in the future.

What happens if something goes wrong?
We will follow the incident report procedure at XXX Hospital / YYY Hospital and Loughborough University concurrently. If you are harmed by taking part in this research project, there are no special compensation arrangements. If you are harmed due to someone's negligence, then you may have grounds for a legal action but you may have to pay for it. Regardless of this, if you wish to complain about any aspect of the way you have been approached or treated during the course of this project the normal National Health Service (or University) mechanisms may be available to you.
Will my taking part in this study be kept confidential?
If you take part in this study all information collected about you during the course of the research will be kept strictly confidential. All references to participants in the report will be anonymous. The information will be kept in secure location, accessible only to researchers. All of the data will remain the property of the Loughborough University and will be destroyed 5 years after publication.

What will happen to the results of the research study?
The results will be coded (for anonymity) and analysed by the research team before being reported. The results may also be presented in appropriate scientific journals and conferences. If you take part in this research, you can obtain copies of these publications from the research team. The data will be stored by the Chief Investigator (Sue Hignett, Data Controller) at Loughborough University under conditions specified by the Departmental Data Protection Advisor.

Who is funding the research?
The research is funded by the NHS Estates.

Who has reviewed the study?
The Local Research Ethics Committee of Leicestershire (for CNWLPC and UIIL) has reviewed the study.

Who do I contact for more information?
You can ask: Dr. Sue Hignett – S.M.Hignett@lboro.ac.uk, Tel. 01509 223003; Miss Jun Lu – J.Lu@lboro.ac.uk, Tel. 01509 228479

What if I have any concerns?
If you have any concerns about this study or the way it has been carried out, you should contact the researchers (Sue Hignett, Jun Lu).
Appendix B: Consent forms

Consent Form (Scoping site visit)

Title: Empirical Review of NHS Estates Ergonomic Drawings

Investigators: Sue Hignett, Jun Lu

Site: (Name of NHS Trust)

Have you read and understood the information sheet? YES/NO

Have you had opportunities to ask questions and discuss the study? YES/NO

Have all your questions been answered satisfactorily? YES/NO

Have you received enough information about this study? YES/NO

Who have you spoken to? Dr/Mr/Ms ..............................................................

Do you understand that you are free to withdraw from this study

• At any time? YES/NO
• Without having to give a reason? YES/NO

Do you agree to take part in the study? YES/NO

Do you understand that the data (including video recordings and stills) will not be available to you after the study? YES/NO

Signature ........................................

Date ........................................
I have explained the study to the above participant and they have indicated their willingness to take part.

Signature
(Researcher)

Date

NAME (BLOCK CAPITALS)
Consent Form (Observation, for nursing staff)

Title: Empirical Review of NHS Estates Ergonomic Drawings

Investigators: Sue Hignett, Jun Lu

Site: (Name of the hospital)

Have you read and understood the information sheet? YES/NO

Have you had opportunities to ask questions and discuss the study? YES/NO

Have all your questions been answered satisfactorily? YES/NO

Have you received enough information about this study? YES/NO

Who have you spoken to? Dr/Mr/Ms........................................................................................

Do you understand that you are free to withdraw from this study

- At any time? YES/NO
- Without having to give a reason? YES/NO

Do you agree to take part in the study? YES/NO

Do you understand that the data (including video recordings and stills) will not be available to you after the study? YES/NO

Signature (Participant)..............................................................................................................

NAME (BLOCK CAPITALS)....................................................................................................

Date................................
I have explained the study to the above participant and they have indicated their willingness to take part.

Signature (Researcher) .................................................................

Date.................................

NAME (BLOCK CAPITALS) ..........................................................
Consent Form (Simulation trial, for nursing staff)

Title: Empirical Review of NHS Estates Ergonomic Drawings

Investigators: Sue Hignett, Jun Lu

Site: Loughborough University

Have you read and understood the information sheet? YES/NO

Have you had opportunities to ask questions and discuss the study? YES/NO

Have all your questions been answered satisfactorily? YES/NO

Have you received enough information about this study? YES/NO

Who have you spoken to? Dr/Mr/Ms .................................................................

Do you understand that you are free to withdraw from this study
  • At any time? YES/NO
  • Without having to give a reason? YES/NO

Do you agree to take part in the study? YES/NO

Do you understand that the data (including video recordings and stills) will not be available to you after the study? YES/NO

Signature .................................................................

Date.................................
(Participant)...........................................................................................................
NAME (BLOCK CAPITALS)......................................................................................

I have explained the study to the above participant and they have indicated their willingness to take part

Signature ............................................. Date..............................
(Researcher)........................................................................................................
NAME (BLOCK CAPITALS)....................................................................................
Consent Form (Observation, for patients)

Title: Empirical Review of NHS Estates Ergonomic Drawings

Investigators: Sue Hignett, Jun Lu
Site: (Name of the hospital)

Have you read and understood the information sheet?

Yes/No

Have you had opportunities to ask questions and discuss the study?

Yes/No

Have all your questions been answered satisfactorily?

Yes/No

Have you received enough information about this study?

Yes/No

Who have you spoken to? Dr/Mr/Ms.............................................................

Do you understand that you are free to withdraw from this study

• At any time?

Yes/No

• Without having to give a reason?

Yes/No

Do you agree to take part in the study?

Yes/No

Do you understand that the data (including video recordings and stills) will not be available to you after the study?

Yes/No

Signature (Participant)........................................................................

Date........................................
NAME (BLOCK CAPITALS)..............................................................................................

I have explained the study to the above participant and they have indicated their willingness to take part

Signature
(Researcher)........................................................................................................

NAME (BLOCK CAPITALS)............................................................................................

Date..........................
CONSENT FOR THE PUBLICATION OF MEDICAL PHOTOGRAPHS

Copyright of all images remains with Loughborough University

Consent is given only for use in the publication(s) detailed below; images may not be used for any other purpose.

The photographs shown above this statement have been taken with my permission as part of my participation in the following project. I have also agreed that they may be used for teaching professional staff.

Project title: Empirical Review of NHS Estates Ergonomic Drawings

Following discussion/correspondence with the researcher (Name.............................. Dept..............................), I understand that it may be helpful for these photographs to be published.

Publication media:  
- Book  
- Journal (print and electronic)  
- Poster  
- Hospital publication  
- Electronic  
- Other

Name of publication ...................................................... Publisher....................................

Electronic publications may be available worldwide on the internet. As a result, I understand that the material may be seen by the general public. My name and details will remain confidential but I understand that I might be recognised from the material so full confidentiality is not guaranteed.

In view of the explanations given to me by the researcher, I give consent for these pictures to be published in this form only. I have crossed through any pictures that I do not wish to be published and I accept the assurances given that these will not be used.

I understand that no pictures will be submitted for publication within the next 14 days and that during this time, this consent may be withdrawn by writing to the researcher. However should I wish to withdraw consent once photographs have been submitted for publication / published it may not be possible to withdraw them.

Signed: .......................................................... Participant  
Date:...........................................

Please complete x2 forms: Copies to (1) Publishers, (2) Principal Investigator (researcher)  
Dept of Human Sciences, Loughborough University, Loughborough, Leics. LE11 3TU
Appendices

Appendix C: Observation data collection sheets

Observation data collection sheet

<table>
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<th>Task:</th>
<th>Time: start –</th>
<th>Finish –</th>
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Site description:

General description

Participants description

Nurse(s): Sketch

Patient:

Layout notes

Equipment description

Additional notes
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Appendix D: Data from 5 site visits

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Appendices

A-AWCT2

A-AWR
B-ICC

No photograph

B-ICR

B-AWRT
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</table>
Appendices

E-AWR, E-AWT

E-ICC

E-ICR
Appendix E: Observational data analysis – HTA (selected)

Task No. 1: Washing a patient, changing bed sheets

1 Preparation phase
1.1 Nurse 1 prepared clean bed sheets
1.2 Nurse 1 prepares the basin with some clean water and put it on the trolley
1.3 Nurse 1 prepared some clean wipes
1.4 Nurse 1 wore gloves and apron
1.5 Nurse 1 moved the warming machine out of the bed space
1.6 Nurse 1 curtained off the bed space
1.7 Nurse 1 prepared for washing the patient
   1.7.1 Nurse 1 moved the basin with the trolley closer to the patient bed at patient’s right side
   1.7.2 Nurse 1 put some clean wipes into basin
   1.7.3 Nurse 1 talked to the patient
   1.7.4 Nurse 1 uncovered the blanket on the patient body

2 Washing the patient
2.1 Nurse 1 washed at the right side of the patient
   2.1.1 Washing the patient’s right leg
      2.1.1.1 got a clean wipe from the basin
      2.1.1.2 washed the patient’s right leg
      2.1.1.3 fetched a clean towel from the nurse chair to dry the leg
      2.1.1.4 put the dirty wipe on the bed edge
   2.1.2 Washing the patient’s right upper body
      2.1.2.1 got a clean wipe from the basin
      2.1.2.2 washed the patient’s right upper body for three times
      2.1.2.3 put the dirty wipe at the edge of the bed
   2.2 Nurse 1 removed the bed sheets on patient’s right side to pushed them under patient’s body
   2.3 Nurse 1 moved the basin with the trolley to the left side of the patient
   2.4 Nurse 1 washed at the left side of the patient
2.4.1 Washing the patient’s left leg
2.4.1.1 fetched a clean wipe from the basin
2.4.1.2 put some blue skin cleanser onto the wipe
2.4.1.3 washed the patient’s left leg
2.4.1.4 put the dirty wipe at the edge of the bed
2.4.1.5 fetched another clean wipe from the basin
2.4.1.6 washed the left leg again
2.4.1.7 put the dirty wipe at the edge of bed

2.4.2 Washing the patient’s left upper body
2.4.2.1 fetched another clean wipe from the basin
2.4.2.2 put some blue skin cleanser onto the wipe
2.4.2.3 washed the patient’s left upper body
2.4.2.4 put the dirty wipe at the edge of the bed
2.4.2.5 fetched another clean wipe from the basin
2.4.2.6 washed the left upper body again
2.4.2.7 put the dirty wipe at the edge of bed

2.4.3 Nurse 1 fetched another clean towel from the chair to clean and dry the patient’s left body

2.5 Nurse 2 came into the cubicle
2.5.1 wore the apron
2.5.2 stood by the right side of patient and waited

2.6 Nurse 1 finished the washing

3 Changing bed sheets
3.1 preparation phase
3.1.1 Nurse 1 went outside to ask the third nurse to assist
3.1.2 Nurse 3 came in
3.1.2.1 fetched the gloves and apron and wore them at the right side of patient
3.1.2.2 walked to the left side of patient
3.1.2 Nurse 1 went to the right side and lifted up the bed a bit using the control panel
3.1.3 Nurse 2 went to the left side of the patient along with nurse 3

3.2 Moving the patient and changing bed sheets
3.2.1 Nurse 1, 2 & 3 rolled the patient onto the patient's left hand side

3.2.2 Nurse 2 and 3 held the patient on their side while nurse 1 washed patient's back body
   3.2.2.1 Nurse 1 got a clean wipe from the basin to wash patient's bottom, then dried with a clean towel
   3.2.2.2 Nurse 1 repeated the above washing and drying twice
   3.2.2.3 Nurse 1 checked patient's rectum/anus
   3.2.2.4 Nurse 1 disposed the gloves, then wore a new pair
   3.2.2.5 Nurse 1 got a clean bed sheet from the nurse chair to put it at right side of the bed
   3.2.2.6 Nurse 1 got another clean bed sheet to put it together with the first one at the right side of the bed

3.2.3 Nurse 1, 2 & 3 let patient lie flat

3.2.4 Nurse 1 walked to patient's left side, nurse 2 & 3 walked to patient's right side

3.2.5 Nurse 1, 2 & 3 rolled the patient onto the patient's right hand side

3.2.6 Nurse 2 and 3 held the patient on their side while nurse 1 removed the dirty bed sheet
   3.2.6.1 Nurse 1 put the dirty sheets into the dirty linen bin
   3.2.6.2 Nurse 1 pulled the clean sheets over the left side of the bed under the patient's body
   3.2.6.3 Nurse 1 took off gloves and tidied up the bed

3.2.7 Three nurses put the patient flat
   3.2.7.1 Nurse 1 pulled off the dirty pillow and put a clean one (previously prepared) under the patient's head
   3.2.7.2 Nurse 1 changed the pillowcase for the dirty pillow
   3.2.7.3 Nurse 2 walked to the patient's left side
   3.2.7.4 Nurse 1 & 2 rolled the patient to their side by pulling the upper bed sheet
   3.2.7.5 Nurse 3 put the clean pillow under patient's right body
   3.2.7.6 Nurse 2 returned to the patient's right side

3.2.8 Three nurses slid the patient to a proper position
   3.2.8.1 Nurse 1 at bed head, nurse 2 at the patient's right side, and nurse 3 at the left pulled the upper bed sheet up to the bed head to slide the patient
   3.2.8.2 Three nurses tidied up the bed, covered the patient with a clean blanket
   3.2.8.3 Nurse 1 adjusted the bed to make patient comfortable
3.2.9 Nurse 2 and nurse 3 disposed the gloves and aprons into the bin and left the bed space
3.2.10 Nurse 1 opened the curtains and tidied up

Task No. 3: Washing, dressing and moving a patient from bed to chair without a hoist

1 Washing and dressing the patient
1.1 Nurse 1 at patient's left side, nurse 2 at patient's right side
1.2 Nurse 1 uncovered the patient
1.3 Nurse 1 brought a wipe to the patient to ask him to wash his mouth
1.4 Nurse 1 washed the patient's face
1.5 Nurse 2 washed patient's right leg
1.6 Nurse 1 left
1.7 Nurse 2 got a towel from the trolley to dry patient's right leg
1.8 Nurse 1 back with a clean blouse to put it on the trolley
1.9 Washing patient's left leg
    1.9.1 Nurse 1 want back to the patient's left side
    1.9.2 Nurse 2 went to the bed foot
    1.9.3 Nurse 1 unwrapped the patient's left leg
    1.9.4 Two nurses washed the left leg with wipes
    1.9.5 Nurse 2 got a clean towel to dry the left leg
1.10 Dressing the patient with the blouse
    1.10.1 Nurse 2 returned to the right side
    1.10.2 Two nurses made the patient sit straight
    1.10.3 Nurse 1 washed patient's back body with a wipe
    1.10.4 Nurse 1 got the blouse from the trolley
    1.10.5 Nurse 2 moved the basin stand close to the wall
    1.10.6 Nurse 2 got a clean bed sheet from the trolley and put it on the chair at the right side of the bed
    1.10.7 Two nurses wore the blouse for the patient

2 Preparing for moving
Appendices

2.1 Nurse 1 went to the right side of the patient to unconnected the tubes, wires with the patient (for a while)

2.2 Nurse 2 wore the pants for the patient
   2.2.1 Nurse 2 got patient’s pants from the trolley and walked to the left side
   2.2.2 Nurse 2 wore the pants for the patient

2.3 Nurse 2 went to the left side to make to bed lower down

2.4 Nurse 2 went to the right side to pull the chair closer to the bed

2.5 Nurse 2 sorted out the urine bag
   2.5.1 Nurse 2 fetched the urine bag from left side and back to the right again
   2.5.2 Nurse 2 hanged the urine bag at the right side of the bed

2.6 Nurse 2 sorted out the green-cap bottle
   2.6.1 Nurse 2 fetched the green-cap bottle from the left side and back to the right at the third time
   2.6.2 Nurse 2 hanged the bottle at the right side of the bed

3 Moving the patient from bed to chair

3.1 Nurse 1 went to the right side of the patient, nurse 2 to the left

3.2 Two nurses helped the patient sit straight and move to the bed right edge

3.3 Nurse 2 went to the right side of the bed to stand facing the patient

3.4 Nurse 1 went to the patient’s left side to wear the pants well for the patient

3.5 Nurse 1 pushed the bed away a bit to get more room

3.6 Nurse 2 faced the patient, nurse 1 at patient’s left to walk the patient slowly to the chair

3.7 Nurse 2 to the patient’s right side, nurse 1 walked to face the patient

3.8 Two nurses helped the patient sit down

4 Tidying up

4.1 Nurse 1 sorted out the machines/equipment

4.2 Nurse 2 covered patient’s legs with a blanket, and put a pillow under patient’s feet

4.3 Nurse 2 took the dirty linens and the bed away
Task No. 10 Repositioning a patient on the bed

1 Preparation phase
   1.1 Nurse 1 stood at patient’s right side
   1.2 Nurse 2 at patient’s left side
   1.3 Nurse 1 lowered the bed to make the patient lie flat

2 Moving the patient
   2.1 Two nurses pulled the upper bed sheet to slide the patient to the bed head a bit
   2.2 Nurse 1 adjusted the bed to make the patient lie comfortably
   2.3 Nurse 1 got a clean pillow from the nurse desk
   2.4 Nurse 2 held the patient’s head
   2.5 Nurse 1 put the pillow together with the original one under patient’s head

3 After the moving
   3.1 Nurse 2 left
   3.2 Nurse 1 tidied up the bed and covered the patient well
Task No. 11: Checking a patient's rectum/anus

1 Preparation

1.1 Nurse 1 and nurse 2 wore gloves and aprons
1.2 Nurse 2 at the right side of the patient to pulled out the pillow under the patient's right back
1.3 Nurse 1 at patient's left side to lower the bed a bit and make it flat

2 Checking the rectum

2.1 Nurse 2 rolled the patient to the patient's right hand side and held the body
2.2 Nurse 1 tested the rectum twice
2.3 Nurse 1 wrapped the dirty things into a wipe and put them on the bed edge
2.4 Nurse 1 put a pillow under patient's left body
2.5 Nurse 2 let the patient lie flat

3 Tidying up

3.1 Nurse 2 left
3.2 Nurse 1 tidied up the bed
3.3 Nurse 1 adjusted the bed to make the patient comfortable
3.4 Nurse 1 gathered all the dirty things together and threw them into the bin along with the dirty gloves
Appendices

Task No.12: Transferring a patient from bed to bed

1 Preparation phase
1.1 Nurse 1 at the bed head to adjust the bed for the task
1.2 Nurse 2 at the left side of the patient, nurse 3 at the right side,
1.3 Nurse 4 brought another bed into the cubicle at the patient’s right side, then
stood with nurse 2

2 Transferring the patient from bed to bed by sliding
2.1 Nurse 1, 2 & 4 rolled the patient to the left side with the bed sheet wrapping
the patient’s body
2.2 Nurse 3 put a slide under the patient body
2.3 Nurse 1, 2 & 4 let the patient lie flat
2.4 Nurse 2 made two beds side-by-side
2.5 Nurse 4 walked to the bed foot
2.6 Four nurses pulled the bed sheet to slide the patient to another bed

3 Tidying up
3.1 Nurse 1 & 3 move the bed where the patient was lying a bit
3.2 Nurse 1 took the slide away
3.3 Nurse 3 tidied up the patient’s bed
3.3 Nurse 2 & 4 tidied up the original bed, and unplugged it
Task No. 17 Moving a patient from chair to wheelchair

1 Before moving
1.1 Nurse 1 stood by patient's right side while the patient sitting on the unmovable chair
1.2 Nurse 2 at patient's left side by holding the urine bag

2 Moving the patient
2.1 Two nurses held patient's arms and body to stand up him
2.2 The patient walked to the wheelchair and then sat down with 2 nurses assists
2.3 Nurse 2 hung the urine bag at the right side of the wheelchair and then left
2.4 Nurse 1 fetched the patient's bag from the shelf and put it on the patient's knees
Task No. 23: Front chest X-ray with mobile X-ray machine

1. Before X-ray
   Nurse 1 stood at patient’s left side
   The X-ray staff at patient’s right side with holding the red board
   Nurse 1 and X-ray staff both pulled the upper bed sheet under patient’s body
   The X-ray staff put the red board under patient’s body
   Nurse 1 left
   The X-ray staff walked around the bed from right side to the left, then back to the right to adjust the red board under patient’s body

2. Taking the X-ray
   The X-ray staff fetched the X-ray machine from the outside to push it into the cubicle at patient’s left side
   The X-ray staff operated the machine to make ready
   The X-ray staff stepped out of the cubicle and informed the others to be aware of the X-ray
   Taking the X-ray

3. After X-ray
   3.1 The X-ray staff walked back to the patient’s left side
   3.2 Pulled out the red board under patient’s body
   3.3 Tidied up the bed a bit
   3.4 Pushed the machine out of the cubicle
Appendices

Task No. 28: Washing + shaving a patient, changing bed sheets

1 Preparation phase
1.1 Nurse 1 prepared clean linens to put on the chair before starting the task
1.2 Nurse 1 prepares moveable basin on the trolley before starting the task
1.3 Nurse 1 prepared for washing the patient
   1.3.1 Nurse 1 moved the basin + trolley closer to the patient bed at patient’s right side
   1.3.2 Nurse 1 put some clean wipes into basin

2 Washing + shaving the patient
2.1 Nurse 1 washed at the right side of the patient
   2.1.1 Washing the patient’s face
      2.1.1.1 Nurse 1 washed the patient’s face and shaved carefully
      2.1.1.2 Nurse 1 washed the face again
      2.1.1.3 Nurse 1 dried the patient’s face with the towel on patient’s chest
   2.1.2 Nurse 1 changed the water, and back in with clean water still at patient’s right side
   2.1.3 Washing the patient’s right hand and right arm
      2.1.3.1 Nurse 1 got a clean wipe from the basin
      2.1.3.2 Nurse 1 washed right hand and arm twice
      2.1.3.3 Nurse 1 dried the hand and arm with the same towel
   2.1.4 Washing the patient’s right leg
      2.1.4.1 Nurse 1 uncovered the patient’s right leg
      2.1.4.2 Nurse 1 put the towel of 2.1.3.3 under the leg
      2.1.4.3 Nurse 1 got a clean wipe from the basin to wash the patient’s right leg
      2.1.4.4 Nurse 1 fetched a clean towel from the chair to dry the patient’s right leg
      2.1.4.5 Nurse 1 pull out the towel under patient’s right leg
      2.1.4.6 Nurse 1 put the towel on patient’s left side
      2.1.4.7 Nurse 1 covered the patient’s right leg
   2.2 Nurse 1 recorded something at the desk near the balloon pump at the bed foot
2.3 Nurse 1 moved the trolley with basin to the left side of the patient

2.4 Nurse 1 washed at the left side of the patient

  2.4.1 Washing the patient’s left body
  2.4.1.1 fetched a clean wipe from the basin
  2.4.1.2 washed the patient’s left upper body and left hand
  2.4.1.3 dried the body and hand with a clean towel
  2.4.1.4 put a towel under patient’s left leg
  2.4.1.5 washed the left leg and foot twice

  2.4.2 Washing the patient’s bottom and dried

2.5 Nurse 1 moved the trolley closer to the wall, and then left for asking a hand

2.6 Another nurse (nurse 2) came into the cubicle 20 minutes later

  2.6.1 Nurse 2 wore the apron
  2.6.2 Nurse 2 stood by the right side of the patient

3 Changing bed sheets

  3.1 Changing bed sheets
  3.1.1 Nurse 1 at patient’s left side to pushed the dirty bed sheet under patient’s body to nurse 2’s side
  3.1.2 Nurse 1 got a clean sheet from the chair to put it on the left side of patient
  3.2.2 Nurse 1 got another clean bed sheet to put it together with the first one at the left side of the bed

  3.2.3 Two nurses rolled the patient to the right
  3.2.3.1 Nurse 2 held the patient
  3.2.3.2 Nurse 1 checked the patient’s sacrum then disposed the gloves
  3.2.3.3 Nurse 1 washed the patient’s back body and back bottom
  3.2.3.4 Nurse 1 dried the patient’s body
  3.2.3.5 Nurse 1 pushed the clean sheets to nurse 2’s side
  3.2.3.6 Nurse 1 walked to patient’s right side
  3.2.3.7 Nurse 2 walked to patient’s left side

  3.2.4 Two nurses rolled patient to the left
  3.2.4.1 Nurse 2 held the patient
  3.2.4.2 Nurse 1 pulled out the dirty sheets and threw them into the dirty linen bag
3.2.4.3 Nurse 1 pulled 2 clean sheets to herself side
3.2.4 Two nurses tidied up the sheets on the bed
3.2.5 Nurse 1 got a clean sheet to cover the patient and pulled off dirty blanket to put it onto the nurse chair
3.2.6 Two nurses changed the pillowcase
  3.2.6.1 Nurse 1 pulled off one pillow under patient’s head
  3.2.6.2 Nurse 1 changed the pillowcase
  3.2.6.3 Two nurses lifted patient’s head a bit
  3.2.6.4 Nurse 1 put the pillow back under the patient’s head
Appendix F: Standard instructions for the tasks to be simulated in FSEs

1.) Standard instructions for the tasks to be simulated in FSEs of adult acute wards and en-suite toilets

Task 1. Providing resuscitation in the bed space (with 4 nurses)

Male patient, 75 years old,
• who is CCF (congestive cardiac failure) at 3am in the morning.
• and is admitted with shortness of breath (SOB), and then became more breathless.
• The patient in the next bed notified nurses, who then checked the patient.

Start point – the patient lost consciousness

End point – after a couple of CPR + defibrillation attempts

Equipment to be used:
• Patient bed
• Over bed table
• Locker
• Patient chair
• Bin
• Wash basin (in some single rooms)
• Visitor chair (in single rooms)
• Crash trolley
• Drip stand
• G-size O2 cylinder
• Suction
• Walking frame
Task 2. Bed wash + getting up a patient from bed to chair or wheelchair by a hoist (with 2 – 3 nurses)

Female patient 82 years old,
- Clostridium difficile infection,
- is admitted with urine infections and falls, asking for toilet a lot,
- starts having diarrhoea, specimen sent off,
- very large bowel movement + incontinent of faeces in the bed + only sensible way to manage hygiene needs is to bath.

Start point – patient in the bed to be washed
End point – Outside room on hoist

Equipment to be used:
- Patient bed
- Over bed table
- Locker
- Patient chair
- Bin
- Wash basin (in some single rooms)
- Visitor chair (in single rooms)
- Dressing trolley (Extra gloves + aprons, outside the bed space)
- Hoist + sling
- Drip stand (PAC)
- Commode chair (in single rooms)
- Patient property bag
- Bowl
- Walking frame
Appendices

Task 3. Transferring a patient from trolley to bed (with 3 – 4 nurses)

Male patient, 30 years,
- post inguinal hernia with drain and drip,
- just coming out of anaesthetic, returning from recovery area to the ward,
- in too much pain to slide himself across onto bed and suffering with neck problems, so decide to lateral transfer

Start – outside room
End – on bed

Equipment used:
- Patient bed
- Over bed table
- Locker
- Patient chair
- Bin
- Wash basin (in some single rooms)
- Visitor chair (in single rooms)
- Patient (theatre) trolley (with a bed sheet on it)
- Drip stand
- Pat slide
Task 4. Providing an emergency assistance when a patient slipped on the floor and fell in the toilet (with 2 – 3 nurses)

Elderly, Female patient, 90 years old,

- pre-op (cataract operation),
- is advised not to toilet on own but was desperate + a bit confused,
- is heard shouting shortly after,
- is found in toilet, pants around knees + head between toilet and wall

Start – patient shouting

End – back on wheelchair in room by the gantry

Equipment to be used:

- Wash basin
- Toilet
- Toilet chair/shower chair
- Bin
- Overhead lift
- Walking frame
- Mobile hoist
Task 5. Showering a patient in en-suite toilet (with 1 nurse)

Male patient, 42 years old,
- bilateral amputee (AKA + BKA),
- MRSA in wounds,
- self caring,
- wheelchair into shower room to transfer onto shower chair,
- is able to self propel in wheelchair + self transfer
- the nurse to be supervisory role + handing towel, and to make sure the wheelchair stays dry

Start point – in the wheelchair outside the shower area
End – outside the shower room

Equipment to be used:
- Wash basin
- Toilet
- Bin
- Shower chair
- Wheelchair
2.) Standard instructions for the tasks to be simulated in FSEs of ICUs

Task 1. Washing a patient, changing bed sheets, dressing and moving a patient, transferring a patient from bed to wheelchair using a hoist (with 3 nurses)

Routine task of giving a bed wash
Patient post-surgery and unable to assist. No infection control problems

Start point – patient in the bed to be washed
End point – patient sitting in the chair

Equipment to be used:
- Patient bed
- Patient chair
- Hoist + sling
- Bowl stand
- Charting table
- Stool
- Gantry (bed head service)
- Two drip stands
- Chest drain
- Urine bag
- Nursing trolley
- Dirty linen bin
- Bin
Task 2. Horizontally transferring patient from bed 1 to bed 2 using a pat slide (with 3 – 4 nurses)

Routine task of transferring a patient from bed to bed
Patient post-surgery and unable to assist. No infection control problems.

Start point – Patient in the first bed

End point – Patient in the second bed

Equipment to be used:

- Two patient beds
- Charting table
- Stool
- Gantry (bed head service)
- Two drip stands
- Pat slide
- Ventilator
- Chest drain
- Urine bag
- Nursing trolley
- Bin
Task 3. Resuscitation (with 5 – 6 nurses)

Patient post-surgery, unable to assist, admitted with shortness of breath (SOB), and then became more breathless.

Start point – the patient lost consciousness

End point – after a couple of CPR + defibrillation attempts

Equipment to be used:

- Patient bed
- Crash trolley
- Intubation trolley
- Infusion trolley
- Charting table
- Stool
- Nursing trolley
- Gantry (bed head service)
- Two drip stands
- Ventilator
- Chest drain
- Urine bag
- Bin
Appendices

Appendix G: FSEs data analysis – LA (selected)

Bed wash + bed-to-wheelchair by a hoist

Black layout bed wash - Session 1

Bed wash + bed-to-wheelchair by a hoist

Black layout bed wash - Session 2
Appendices

Bed wash + bed-to-wheelchair by a hoist

Black layout bed wash - Session 3

Bed wash + bed-to-wheelchair by a hoist

Black layout bed wash - Session 4
Appendices

Transferring a patient from trolley to bed

Black layout trolley 2 bed - Session 1

Transferring a patient from trolley to bed

Black layout trolley 2 bed - Session 2
Transferring a patient from trolley to bed

Black layout trolley 2 bed - Session 3

Transferring a patient from trolley to bed

Black layout trolley 2 bed - Session 4
# Appendix H: Expert Interview Schedule

<table>
<thead>
<tr>
<th>Topic area</th>
<th>Questions</th>
<th>Prompts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Use of drawings</td>
<td>Please describe your experience in using HBNs in the design of bed spaces (cubicles and rooms) and ensuite areas?</td>
<td>Previous projects, Interactions with project managers</td>
</tr>
<tr>
<td>2. Space priority</td>
<td>What do you think the HBNs bring to the design process?</td>
<td>Setting minimum standards, Highlighting relationships between components, Schedules of accommodation, Patient Safety</td>
</tr>
<tr>
<td>3. Impact of drawings on design</td>
<td>How were the drawings used in the design process?</td>
<td>Initial ideas, Framework for clinicians, Testing alternative proposals, Reviewing/evaluating final design</td>
</tr>
<tr>
<td>4. Stakeholders</td>
<td>Who do you think the stakeholders are for HBNs?</td>
<td>Architects, Clinicians, Specialist clinicians (e.g. infection control, disability access, manual handling), Hospital managers, Estates, Patients/public</td>
</tr>
<tr>
<td>5. Staff working space</td>
<td>In your experience how did the HBNs assist in ensuring good working environments?</td>
<td>Staff involvement, Participatory design, Task analysis</td>
</tr>
<tr>
<td>6. Changes</td>
<td>How have the HBNS changes in the last 20 years?</td>
<td>Medical technology, Government legislation</td>
</tr>
<tr>
<td></td>
<td>What will drive change in the next 20 years?</td>
<td></td>
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</tbody>
</table>

- 267 -