HEALTH BUILDING NOTE 4

In-patient accommodation
Volume 2: European case studies
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European case studies

Health Building Note 4 Volume 2

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About this series

The Health Building Note series is intended to give advice on the briefing and design implications of Departmental policy.

These Notes are prepared in consultation with representatives of the National Health Service and appropriate professional bodies.

Health Building Notes are aimed at multidisciplinary teams engaged in:

- designing new buildings;
- adapting or extending existing buildings.

Throughout the series, particular attention is paid to the relationship between the design of a given department and its subsequent management. Since this equation will have important implications for capital and running costs, alternative solutions are sometimes proposed. The intention is to give the reader informed guidance on which to base design decisions.
Acknowledgements

NHS Estates gratefully acknowledges the input to this document from a number of contributors, with particular thanks to the hospitals, architects and organisations who so willingly provided us with information as a basis for the case studies, all of whom are listed in Appendix 4.

We have made every effort to contact all copyright holders of illustrative material. If any have been inadvertently omitted, we would be glad to hear from them so that we may acknowledge them in future editions.

Architectural research was undertaken by:

Mungo Smith
Medical Architecture and Art Projects Limited
Executive summary

This document is the second volume of Health Building Note 4: In-patient accommodation. Through a series of case studies it aims to:

- extend the guidance given in HBN 4 Volume 1 by examining recent thinking on ward design in selected countries in Europe;
- illustrate good ideas in practice.

Looking at 16 hospitals in eight European countries, it compares and contrasts:

- physical organisation and planning;
- space requirements and dimensions;
- environmental quality issues;
- alternative spatial arrangements.

A profile of each country is included, which gives national healthcare statistics, background information on organisation of the healthcare system, funding, service trends, procurement processes, and in certain countries, design guidance.

The case studies contain a profile of each hospital along with a commentary that includes background information, site and location, the planning programme, the brief, building organisation, and details of the in-patient accommodation. This information is supported by photographs, site plans, ward plans and room plans.

A summary organises the findings of the study into six areas for analysis and discussion:

- schedules of accommodation;
- ward shape;
- bed distribution;
- floor areas;
- bedroom sizes and configurations;
- bathrooms.

The document concludes that one of the most important factors emerging from the case studies is the objective common to all projects to improve environmental quality. There is no single approach on how that quality can be achieved, but hospitals and designers have adopted various strategies.

Eleven of the hospitals in the study were commissioned following architectural competitions. The wide range of designs reflects the diversity of the authorities responsible for commissioning these buildings and the meticulous briefing procedures.

Architecture can play a significant role in projecting positive images of healthcare, and inspiration for new hospital environments is coming increasingly from the leisure and retail sector. Recent developments in medical technology have relatively little effect on the structure and shape of hospitals. The drive to make hospitals more compact may become less important as integrated communication and information systems are developed. This may allow architects the opportunity to design hospitals that are more humane, energy-efficient and easier to adapt and change.
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Introduction

Extensive research has already been carried out into the design of in-patient accommodation. The main motivation has been to find the most cost-effective layout, as in-patient wards have represented the largest and most costly volume of space in a hospital. The pressure to control costs has led to an emphasis on minimum space standards, efficient circulation patterns and the standardisation of construction; few building studies have investigated the impact on patient care of environmental factors such as lighting, heating and visual stimuli.

The future development of acute hospitals

The adoption and imitation of international trends and models, and the marketing of technology and equipment, have determined the function, layout and appearance of many European hospital buildings. These trends are expected to continue as member states become increasingly integrated.

In the future, it is predicted that hospitals will take care of only the most acutely ill, injured, or those requiring special procedures and technology. It is likely that hospitals will offer more centralised specialised services. These may include:

- transplant surgeries;
- endoscopic surgical techniques;
- more sophisticated laboratory procedures;
- new imaging technologies;
- information technologies.

The increased use of automation and robotics in services will influence the layout of future hospitals. Lengths of stay for In-patients may be further reduced, with hospital wards serving only a subsidiary role, and diagnostic and treatment facilities constituting the core services. The use of patient hotels and step-down facilities is likely to increase.

Aim of this document

Volume 1 of this HBN looked at the design of in-patient accommodation in the United Kingdom. This document, Volume 2, extends the guidance by examining recent thinking on ward design in selected countries in Europe.

Through a series of case studies, the document aims to illustrate good ideas in practice. Looking at 16 hospitals in eight European countries, it compares and contrasts:

- physical organisation and planning;
- space requirements and dimensions;
- environmental quality issues;
- alternative spatial arrangements.

This document focuses on the physical nature of facilities; it is not intended to be a comprehensive evaluation of in-patient accommodation.
The case studies

The case studies have been selected to illustrate a variety of design approaches. The majority of the hospitals featured are recently completed, but some unbuilt projects have been included where they are considered to be representative of the latest thinking in their respective countries.

Groningen University Hospital follows in the tradition of the large urban block hospitals in the Netherlands. It is the largest hospital featured in this document, yet it is closer in proximity and conception to its city centre than any of the other projects.

Antonius Hospital in the Netherlands develops a modular approach to bedroom design, and de Blijtjes Hospital in Belgium illustrates an in-patient environment specially designed for people who spend most of their time in wheelchairs.

The new hospital in Nuremberg, Germany, which was completed in 1995, provides clues as to how a “people-centred” environment might be created in a “high-tech” hospital.

In Spain, projects in Madrid, Huelva and Mallorca were suggested by Insalud, the National Health Institute, although it is possible that more extensive enquiries to the autonomous regions, which have well-established health services, might have identified alternative examples.

Denmark features hospitals designed by the same architectural practice, a low-rise horizontal design on a greenfield site contrasting with a 1950s block refurbishment.

Finland has produced older, more traditional ward designs, which perhaps serve more as a benchmark for comparison than as examples of radical or innovative ideas.

In both Norway and Sweden, projects of similar size and complexity were chosen. The planned reprovisions of two university hospitals in Trondheim and Oslo make an interesting comparison. In contrast, Sweden offers relatively small-scale and recently completed nursing units in Visby and Norrtälje (both designed by the same architect), and the remarkable Vidarkliniken in Järna that, although completed some 12 years ago, is worthy of special consideration.

The design of the Rikshospital in Oslo, currently under construction, has been considerably influenced by the development of the Nörrkoping Hospital in Sweden over a period of 30 years. Conceived originally as a block design, it eventually transformed into a small-scale town. Such buildings of more humane proportions have become considered more appropriate as therapeutic environments.

The most favoured approach today is derivative of the pavilion hospital: the low-rise free-form “village” type with separate buildings, horizontal open-ended and undetermined layouts, suitable for unpredictable growth and continuous change. These free dendritic building forms are more suitable for the smaller hospitals such as those found at Antonius and Norrtälje. More compact grid-like structures with closed and open inner courtyards are also used but are easier to accommodate on large greenfield sites, as for example at Aarhus.

In the future, the desire to retain hospitals close to the populations they serve will require solutions more integrated with the existing urban fabric. As a consequence, a new generation of hospital designs will be required, utilising a combination of approaches. The metamorphosis of Groningen University Hospital in the Netherlands over 20 years and the “organic” solution for the new hospital at Manacor, Spain illustrate just two of these approaches.

Methodology

Initial enquiries were made to Health Ministries of each of the 15 member states of the European Union. Very little information is held centrally, which made it difficult to establish who is responsible for co-ordinating capital programmes for hospitals and health buildings. A great deal of the decision-making has been delegated to a regional level through county councils or regional authorities.

When suitable projects had been identified, enquiries were made to the architect responsible for the project and the hospital manager. The initial research attempted to establish whether there are norms or standards for hospitals in European Union countries. From the responses received between 1995 and 1997 it is clear that, other than statutory requirements for building construction, fire protection, and health and safety, there is little evidence of published design guidance in any country other than the United Kingdom, the Netherlands or Germany. Norway and Sweden have not updated their information relating to hospital design for a number of years.
The impression is that design consultants are even more specialised in this field than in the United Kingdom, and that considerable knowledge is vested in these firms and the project teams that are assembled for the projects.

The involvement of commercial equipment manufacturers in the design process has not been investigated, although there is no doubt that they have a significant part to play in establishing spatial requirements for new clinical procedures and medical techniques. For example, the necessity to accommodate large static items has changed; more portable equipment has been developed for diagnostic and non-invasive surgical procedures.

Each of the hospitals featured has been presented in the following way:

- whole hospital floor plans are shown together with points of access, vertical service cores, horizontal circulation, identifying all the main departments. This provides a “snapshot” of the hospital and locates the in-patient accommodation, illustrating the key departmental relationships;
- ward plans are keyed to show the distribution of room functions. For the purpose of comparison, generic room names are used. These names were arrived at by identifying the equivalent activity and its UK name;
- the distribution of floor area has been analysed and compared in tables and charts. The degree of accuracy is sufficient to enable broad conclusions to be drawn. Individual bedrooms have all been redrawn for this publication and are dimensioned to the nearest 50 mm, which is sufficient for making general comparisons;
- all rooms are drawn to the same scale and furnished typically with standard furniture. Beds vary in size but generally conform to a standard pattern. In the Netherlands the point was made that the population was increasing in average height and therefore a new hospital bed standard size was being adopted.

The OECD data contained in the profile of each country is for 1994 because, at the time of writing, the most comprehensive data is available for that year. Apart from this, obtaining statistical information has been difficult, and actual sources were not confirmed in the initial collation of data; thus the status of the information cannot be fully verified.
The 16 case studies are from eight different countries, as follows:

De Bijtjes Hospital, Brussels, Belgium (Ziekenhuis “De Bijtjes”)
Antonius Hospital, Sneek, The Netherlands (Antonius Ziekenhuis)
Groningen University Hospital, The Netherlands (Academisch Ziekenhuis Groningen (AZG))
Nuremberg South Hospital, Nuremberg, Germany (Klinikum II Nürnberg-Sud)
Alcorcón Hospital, Madrid, Spain (Hospital de Alcorcón)
Manacor Hospital, Mallorca, Spain (Hospital de Manacor)
Huelva Hospital, Huelva, Spain (Hospital de Huelva “Juan Ramón Jiménez”)
Aarhus University Hospital, Skejby, Denmark (Skejby Sygehus)

Vejle Hospital, Vejle, Denmark (Vejle Sygehus)
Kuopio University Central Hospital, Kuopio, Finland (Kuopion yliopistollinen)
Lapland Hospital, Rovaniemi, Finland (Lapin Keskussairaala)
Norrtälje Hospital, Norrtälje, Sweden (Norrtälje sjukhus)
Vidarkliniken, Järna, Sweden (Vidarkliniken Järna)
Visby Hospital, Gotland, Sweden (Visby Lasarett)
The National Hospital, University of Oslo, Norway (Rikshospitalet)
Trondheim Regional Hospital (RiT 2000), Trondheim, Norway (Regionsykehuset i Trondheim)
Belgium

National healthcare statistics

<table>
<thead>
<tr>
<th>Metric</th>
<th>1994</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-patient care hospitals – Beds per 1000 population</td>
<td>7.6</td>
</tr>
<tr>
<td>In-patient bed days – Number of days/person</td>
<td>2.4</td>
</tr>
<tr>
<td>In-patient occupancy – % available beds</td>
<td>n/a</td>
</tr>
<tr>
<td>Total expenditure on health – Millions ecus</td>
<td>15,749</td>
</tr>
<tr>
<td>Total expenditure on health – % of GDP</td>
<td>8.1</td>
</tr>
<tr>
<td>Total expenditure: in-patient – Millions ecus</td>
<td>5666</td>
</tr>
<tr>
<td>Total expenditure: in-patient – % of GDP</td>
<td>2.9</td>
</tr>
<tr>
<td>Social protection: in-patient care – Coverage/total population</td>
<td>99.0</td>
</tr>
<tr>
<td>Length of stay-in patient – Mean length of stay</td>
<td>11.7</td>
</tr>
<tr>
<td>Total population – Thousand persons</td>
<td>10,116</td>
</tr>
</tbody>
</table>

(Source: OECD Health Data)

Organisation

Healthcare in Belgium is provided by both the public and the private sectors. General practitioners, dentists and specialists have their own private practices. Medical specialists focus their activities on both in-patient and out-patient services. In the hospital sector almost 40% of facilities are public, while 61% are owned by the private “not for profit” sector.

Public authorities organise and finance a number of preventive and curative services such as: out-patient pre-natal healthcare, out-patient mental healthcare, school medicine, occupational medicine and care for the disabled.

Patients have the freedom to choose their sickness insurance company, general practitioner, specialist and hospital.

Funding

Payment of healthcare expenses in Belgium is mainly on a “fee-for-service” basis and largely financed through compulsory health insurance – based upon a reimbursement system for ambulatory care and a third-party payment system for in-patient services and technical services. Patient payment varies from 10% to 25% of the costs.

Since the 1980s, Government reforms to control costs have resulted in a reduction in the number of hospital beds (by 14% between 1982 and 1989), together with the closure and merger of small hospitals and the substitution of beds in rest and nursing homes for acute beds.

Service trends

In a move towards more ambulatory care and primary care – including a shift to more minimally invasive therapy such as laser treatments, laparoscopy or cholecystectomy – day care facilities will replace hospital beds. Hospitals will see greater specialisation in areas requiring higher levels of technology and greater intensity of care. This will require extensive IT support to aid clinical and administrative decisions. There will also be a development in holistic approaches to treating patients and improving communication between primary care services and the local community.

Procurement process

Hospitals belong to either the private sector (mostly non-profit) or the public sector (social assistance centres run by the communes). Hospitals receive investment subsidies within a set of planned guidelines. They have to be accredited and, therefore, have to conform to standards, which are administered centrally through the Ministry of Health.

Following the procurement process established by the de Bijtjes project (described below), it is now a legal requirement to establish a ten-year masterplan before any major hospital project can be commenced.
The masterplan

Executing this stage of a project takes about six months and involves three phases:

1. analysis of existing situation;
2. development of strategy and programme;
3. initial design, costs and phasing.

Following hospital board approval, the masterplan is used in applications to the Ministry of Health for funds; it also serves as a guideline for the further development of the design.

Design guidance

The country is divided into four regions, which in turn are divided into sub-regions. The Programmation Law determines the number of beds for a region, and the statistics are published by the National Programmation Commission; for example, a total of 5000 beds are required in Belgium for rehabilitation services.

The gross floor area allowances for in-patient accommodation in Belgium are:

- general acute, rehabilitation and psychiatric 80 m²/bed;
- teaching 120 m²/bed.
De Bijtjes Hospital, Brussels (Ziekenhuis “De Bijtjes”)

Hospital profile

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date completed</td>
<td>1996</td>
</tr>
<tr>
<td>Total number of beds</td>
<td>148</td>
</tr>
<tr>
<td>Overall floor area m²</td>
<td>15,245</td>
</tr>
<tr>
<td>Gross area/bed m²</td>
<td>103.0</td>
</tr>
</tbody>
</table>

Introduction

“De Bijtjes” is a 150 bed hospital for the treatment of children and young adults with locomotive and neurological disorders. The hospital treats four kinds of specialty: neurology, orthopaedics, muscular disorders, and paediatrics, together with coma and post-coma patients. In addition to the specialised care nursing units, a centre for functional rehabilitation provides treatment for physical and neurological disorders and various therapies such as kinestherapy, occupational therapy, speech therapy, psychotherapy and sensory stimulation. Specialised educational facilities for in-patients and out-patients are provided in a recently refurbished wing of the original building. The existing buildings required a phased programme of refurbishment, adaptation and extension.

Site and location

The hospital stands in the grounds of the former castle of Inkendael to the south-west of Brussels, which includes a landscape of ponds and high-stemmed vegetation and offers great potential for active and passive recreation.

View across the lake to the new wards and castle (right)
Planning programme

A multidisciplinary steering group developed a detailed design brief that established the strategic approach and by 1991 had developed a masterplan for the site. In this case the process took two years instead of the usual five from first discussions to starting work on the site.

As the hospital had to continue operating normally throughout the construction stage, the redevelopment was carried out in phases. The first new building for 60 beds was completed in 1994, and the second phase – the rehabilitation department and the polyclinic, including 88 beds – was finished at the end of October 1996.

The brief

As most of the patients are young and treatment is long-term, their living, medical, recreational and educational environment is of vital importance for the most favourable development of their condition. The brief called for the integration of the functional and architectural elements with the natural environment.

Some concepts considered by the client and the design team were:

- a “village” concept – with living and nursing areas open to the outside environment as much as possible, including shopping and entertainment facilities;
- a “home” concept – with individual living spaces within the wards and communal daytime spaces outside the ward;
- a “wheelchair-friendly” traffic system – using ramps as a means of bridging height differences. Glass walls and non-uniform corridors break the monotony of straight corridors, and provide informal meeting points;
- a “stimulating” environment – using durable yet attractive and lively materials.

Building organisation

The project includes three new wings for specialised care including accommodation, therapy and medical facilities; the existing castle building was retained for administration facilities, restaurant area, staff-related functions, trainees and visitors, while the annexes have been converted into a school and residential accommodation for day attendees. The total floor area involved is 10,500 m² for the new buildings and 3,900 m² for the renovated areas.

A circular “street”, which functions as an internal “road”, connects the different nursing units, the castle and the school. At the centre of the composition is an atrium around which rises a ramp enabling (motorised) wheelchair users to move independently from one floor to another without having to use a lift.

The wheelchair patients can be evacuated from all floors via external ramps that lead onto the perimeter fire road; this, combined with footpaths, also offers therapeutic and recreational opportunities.
Ward plan

1. single-bed room
2. two-bed room
3. three-bed room
4. four-bed room
5. en-suite WC
6. en-suite shower
7. smoking room
8. day room
9. dining room
10. kitchen
11. staff base
12. office/multipurpose
13. staff rest room
14. staff changing room
15. treatment/examination room
16. dirty utility
17. clean utility
18. bulk store
19. doctor on-call suite
20. waiting area
21. store
22. switchroom
23. cleaners room
24. linen cupboard
25. WC
26. assisted WC
27. staff WC
28. shower
29. assisted bath
30. trolley bay
31. disposal
32. equipment
33. wheelchair park
34. bed maintenance
35. bed bay
36. meeting room
37. rehabilitation
Wheelchair-dependent patients make special demands on the building. Barrier-free access for wheelchair users has determined the dimensions of rooms, bathrooms and en-suite facilities. Areas with dense wheelchair traffic – including the entrances to the patients’ rooms – are as free as possible from sharp edges. The siting of ramps was determined by fire safety considerations but has been exploited for therapeutic and recreational activities.

**In-patient accommodation**

The in-patient accommodation is divided into separate “nursing villas” or wards, each having a distinct architectural expression. Large windows and glass screens ensure a transparent internal environment, blurring the distinction between inside and outside. The external facade is characterised by yellow/pink brick masonry, combined with blue ashlar, azella wood and tin roofs.

Villa A is arranged in a “clover-leaf” shape, with each lobe forming a small living unit for ten patients, which provides a domestic character to the environment. Each living unit is further sub-divided into two four-bed rooms, two single rooms or one two-bed room, and a living room with patio or balcony. Villa B comprises six single and twelve 2-bed rooms with dedicated or shared en-suite bathrooms. A further four 2-bed rooms are used for single persons. As in villa A, rooms are grouped in three clusters of ten and 14 beds together with large social spaces, which give direct access to the garden. All bedrooms have their own en-suite WC and washbasin and are specially designed for wheelchair users. At the intersection of the corridor there is a nursing station from which the whole unit and the utilities can be supervised.

Between the nursing station and the large therapeutic circuit the corridor widens and a wheelchair park and battery recharging zone is located. On opposite sides of the corridor are the staff rooms and the dining room for the patients.
The interior of this special hospital has been designed and detailed with great care and consideration for its users. Particular attention has been paid to the selection of materials that accentuate the feeling of being inside or “in the street”. Floor finishes highlight a journey round the building, from ceramic tiles in the entrance hall to linoleum in corridors or on ramps, a combination of rough and polished granite in the atrium, and vinyl and tiles in ward areas. Walls are finished in painted plaster and natural brick accentuated by up/downlighters.

Summary

The finished scheme is notable for its atrium and its superb natural setting. The architects made the argument that to create a covered open space, which allowed access to a covered area in bad weather, would be cost-effective and could be achieved with the acceptable net-to-gross floor area ratio. Because the cruciform plan of the building forms dead ends, the fire escape regulations were negotiated to allow ramps instead of stairs. These serve a dual function, enabling patients to access the garden and explore the site – a form of alternative rehabilitation.
The Netherlands

National healthcare statistics

<table>
<thead>
<tr>
<th>Category</th>
<th>1994</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-patient care hospitals – Beds per 1000 population</td>
<td>11.3</td>
</tr>
<tr>
<td>In-patient bed days – Number of days/person</td>
<td>3.7</td>
</tr>
<tr>
<td>In-patient occupancy – % available beds</td>
<td>88.6</td>
</tr>
<tr>
<td>Total expenditure on health – Millions ecus</td>
<td>24,929</td>
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<td>Total expenditure on health – % of GDP</td>
<td>8.8</td>
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<td>Total expenditure: in-patient – Millions ecus</td>
<td>13,047</td>
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<td>Total expenditure: in-patient – % of GDP</td>
<td>4.6</td>
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<tr>
<td>Social protection: in-patient care – Coverage/total population</td>
<td>73.8</td>
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<tr>
<td>Length of stay-in patient – Mean length of stay</td>
<td>32.7</td>
</tr>
<tr>
<td>Total population – Thousand persons</td>
<td>15,382</td>
</tr>
</tbody>
</table>

(Source: OECD Health Data)

Organisation

The Dutch system of healthcare consists of first-line care (family doctors, home care, city health departments and infant welfare centres), second-line care (hospital and medical specialists) and third-line care (nursing homes, rehabilitation space etc).

Funding

The Dutch healthcare insurance system provides coverage for 100% of the population and is funded from sickness funds and private insurance companies. The contribution to sickness funds is income related except for certain treatments such as stays in a nursing home, home care, psychiatric stays and drug prescriptions, which are provided through basic insurance coverage. Everyone contributes equally to this fund (the AWBZ) regardless of income.

Service trends

Most hospitals are private, not-for-profit organisations with budgets fixed by the federal government to ensure compliance with the goals of government.

The nine university teaching hospitals are owned by the national government and some municipalities own the local hospitals. The government plans the capacity and distribution of in-patient care facilities through regional planning. Plans for hospitals have to be submitted to the Health Ministry for approval.

It is anticipated that the use of information technology, if it can be financed, will increase the quality of care. In the past, the focus of information technology in healthcare has been on infrastructure (personnel, distribution, finance etc). The focus in the coming years will be on the care process, including gathering information in electronic medical files, quality measurement and education.

The fundamental changes that are taking place in healthcare are having a marked influence on space needs and the siting of facilities for the extensive range of elements that make up the healthcare system.

Design guidance

There are standards for the design of hospital buildings in the Netherlands, which is one of the few countries in Europe where official guidance on space standards exists.

These centrally registered standards are called “bouwstenen”, published by the College van Ziekenhuisvoorzieningen (CvZ) in Utrecht, which also advises the Ministry of Health. Special space standards apply to teaching hospitals. On the whole, university hospitals are provided with 25% more space than general hospitals.

Some of the national standards for design are set out below:

- There is one national standard for all medical and surgical in-patient ward areas: 17 to 18.5 m²/bed (net area including support space but excluding circulation areas). There are specific national standards for specialties, for example coronary care and high dependency beds: 33 to 37 m²/bed.
The average gross area per bed = 27 m². The average for the support area is 140 m²/40 beds = 3.5 m²/bed. The allowance for circulation, construction and technical means within an in-patient area is 1.45 (that is, 45%). The ratio of fully assisted bathrooms is one per 40 beds.

The number of single rooms in the standard ward (CvZ) is four single rooms per 20 beds (25%). The in-patient areas are separated by sex and type of treatment. Medical and surgical beds are not mixed.

Room sizes are based on the following:
- four single-bed rooms @ 14 m²;
- four two-bed rooms @ 21 m²;
- two four-bed rooms @ 42 m² for a ward of 20 beds.

Three (nurse) teams × 12 beds is a CvZ standard nursing unit of 36 beds.

Single rooms are multi-functional. The clear area around the bed as a minimum for carrying out clinical activities is 1.10–1.30 m. The minimum width for doors into bedrooms is 1.18 m. The minimum width allowed for corridors within the in-patient areas is 2.15 m (between the handrails).

### Stichting Architektenonderzoek Gebouwen Gezondheidszorg (STAGG)

In the Netherlands during the 1960s and early 1970s a group of architects working in the specific fields of healthcare buildings found it increasingly necessary to keep abreast of new developments in healthcare and to exchange views and experiences. This led to the establishment in 1972 of STAGG, a foundation of architects concerned with the design of buildings for healthcare.

An independent research organisation, STAGG organises focused studies in plenary seminars or small work-groups that convene regularly, sometimes over a period of years.

In its ten years of studies and dialogue the group has issued nine publications. In 1995 it produced a detailed research study on the use of space around a bed in single, double and four-bed rooms. STAGG concludes that the following minimum clear areas are required:

<table>
<thead>
<tr>
<th>Dimensions (m²)</th>
<th>Area (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single room</td>
<td>4.40 × 3.50</td>
</tr>
<tr>
<td>Double room</td>
<td>6.70 × 3.70</td>
</tr>
<tr>
<td>Four bed room</td>
<td>6.70 × 6.70</td>
</tr>
</tbody>
</table>

Minimum clear dimension either side of a bed should be 1.30 m. The minimum clear dimension between the end of the bed and wall should be 1.10 m. The minimum dimension between bed curtains should be 0.9 m.

STAGG investigated the relationship between the clear corridor width and width of door opening into a room. They optimised the relationship on the basis of a 2.15 m wide corridor and a 1.43 m wide door opening. This relationship is based on a detailed survey of bed suppliers and a study of the height of patients (95th percentile), which shows that they are getting taller.

Currently, floor plans need to accommodate a bed of 950 × 2200 mm, and, in the future, this will increase to 980 × 2400 mm.

The proportions of a single room should be 3.500 × 4.400 mm = 15.4 m². The minimal width of the door should be 1.33 m. The minimal width of the corridor can remain 2.15 m between handrails where there is enough extra space for carts and trolleys.
Antonîus Hospital, Sneek (Antonîus Ziekenhuis)

Hospital profile

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Date completed</td>
<td>1994</td>
</tr>
<tr>
<td>Total number of beds</td>
<td>294</td>
</tr>
<tr>
<td>Overall floor area m²</td>
<td>29,000</td>
</tr>
<tr>
<td>Gross area/bed m²</td>
<td>98.6</td>
</tr>
<tr>
<td>Average length of stay (days)</td>
<td>7.8</td>
</tr>
<tr>
<td>Bed utilisation</td>
<td>80%</td>
</tr>
<tr>
<td>Annual patient throughput</td>
<td>9949</td>
</tr>
<tr>
<td>Annual throughput per bed</td>
<td>33.84</td>
</tr>
</tbody>
</table>

Background

In 1985, the Healthcare Innovation Project (IPG) established a new project in south-west Friesland, combining all care sectors from primary to tertiary. The project focused on the 90-year-old Saint Antonius Hospital, which was in urgent need of renovation or replacement.

Programme

The programme originally began in 1988 when a proposal was considered for funding. Three years were spent planning and a further three years constructing the hospital, which opened in 1995. The close co-operation between commissioning client, consultant and evaluators produced a time saving of about two years. The “budget method” was used as a form of cost control, whereby the commissioning client shoulders the risk of amounts in excess of, or below, the agreed budget.
General description

The hospital serves a catchment area of 100,000 people. The number increases in the summer months with a large influx of people who attend the annual sailing regattas, including 1000 competitors. Sailing and skating injuries are frequent.

The extensive use of home treatment teams has effectively reduced the standard provision of three beds per 1000 population. However, an arrangement with the Department of Health to retain the overall floor area allocation of 80 m² per bed, has resulted in a net increase in floor area per bed within the ward areas.

The average length of stay has reduced from 9–10 days to 7–9 days and a further reduction to 5–6 days is anticipated. In 1998 16 beds will be used as a polyclinic. Ten beds in a local nursing home allow earlier discharges for some patients.

Site and location

The hospital is situated on the outskirts of Sneek close to the A7 motorway. The shape of the site determined the structure and design of the new hospital. The hospital is accessible from the mini-roundabout on the Bolswarderbaan road and a bus stop has been constructed nearby.

It is a principle that an ambulance should arrive with the patient within 15 minutes of an emergency call, but the many lakes and canals in the area seriously affect access and plans are in hand to establish a helicopter service in this part of the Netherlands.

Brief

Key design principles were:

1. The patient was to be the central focus of the design.
2. One building was to be provided for each main function, with possibilities for expansion of each function (open-end solutions).
3. The building was to be “low-rise”, with plenty of room for expansion.
4. Multi-bed patient rooms were to be provided, which allow for partitioning into single rooms if required.
5. Where possible, universal room dimensions were to be used, allowing for multi-purpose use.
6. Services building was to be located separately, allowing it to serve more than this hospital site.

Building organisation

The separate buildings required for the various core functions of the hospital made a low-rise building a natural choice. The main departments radiate from a central space of approximately 25 m × 25 m, which includes the main entrance, patient service centre and restaurant. All hospital services are more or less directly accessible from this centre, which makes orientation within the building simple, even for first-time visitors. The roof of this central space extends from the front area over the entrance, flooding it with natural light.
The concept was to divide the hospital into three clearly defined building forms. Low-rise three-storey nursing units are clustered at the east end of the site and their dimensions were established so that in-patient rooms could be converted for polyclinic or day hospital use. A single-storey block spreads out to the north-west containing the polyclinic emergency facilities. Above these are the operating theatres, diagnostic research areas, intensive care and mother and baby in-patient wards. Support services have their own entrance to the south-west.

The design of the new hospital combines a number of innovative elements such as:

- a non-universal building grid;
- each function cluster has a specific building design with its own supporting structure and building grid, as well as specially co-ordinated built-in units and an individual level of finishing;
- no basements; despite the piles extending down, sometimes more than 30 m, a simple foundation without expensive damming constructions was sufficient;
- optimisation of storey height was achieved by localising functions requiring more vertical space at the “top storey level” (X-ray and operation ward, physiotherapy, pharmacy, laboratories and all technical equipment rooms).

Treatment and diagnostic functions are housed in one building, with all out-patient clinics located on the ground floor and the X-ray/operation ward and nuclear diagnostics on the upper floor. These are directly accessible from the patient service centre.

The building for the main service functions is located completely outside the patient area, but at a minimum distance from hospital functions.
In-patient accommodation

During the design process, economies of scale instigated by CvZ made the reduction of floor areas a necessity, and this affected the modular nature of the in-patient rooms. The architects incorporated principles that they had developed for the design of old people's homes into the design of patient rooms.

In the search for beds of equal value, a new room type was developed for the Antonius Hospital. Each bed is situated near to a window and has its own corner; the four-bed rooms can be divided into double rooms. This building block formed the basis for the design of all patient accommodation.

The original design also allowed for the subdivision of double rooms but this option eventually proved to be uneconomical.

A nursing sector serves 72 surgical or medical beds. This is divided into two Y-shaped wings that each comprise 36 beds sharing most support services. Each wing is divided primarily into two 18-bed nursing units designed using standard modules including two isolation rooms. This gives patients the feeling that they are in a small section and nursing teams can easily serve each unit.

Entry to each 18 in-patient unit is well supervised by one shared nurse base, which is adjacent to the main clinical preparation area and kitchen/beverage preparation area. Each of the teams is located at the base, which is situated close to the six single rooms in each unit.

Two groups of six beds (a four-bed and a two-bed) are clustered on either side of the strategically placed dirty utility/disposal room and the emergency access for the fire brigade. A linen store and flower bay are the only other support facilities within the bedroom zone.

Although the layout of the bedrooms is quite compact, the maximum distance to a bed from the nurses’ station exceeds 25 m. The average distance is approximately 18 m. The dirty utility room is very well placed within each 18-bed unit and would have been the logical place for a nurse team sub-base with travel distances less than half those from the main base which serves all 36 beds.

The bedrooms themselves are not particularly generous if compared to the patient rooms at Groningen University Hospital, which were designed some ten years earlier. However, their layout does provide parity for all the beds. The four-bed room is visually quite busy but can be subdivided. There seems to be no real spatial advantage in combining two double rooms other than for better observation.

The en-suite bathrooms are large enough to be accessed by wheelchairs, with space on either side of the WC for assistance. Each bedroom is provided with a locker, desk and chair for each patient. Additional folding chairs for visitors are hung on the wall. All beds are provided with a nurse call unit, telephone, and television control.

The wide inward-opening doors take up space in the double rooms and are quite obtrusive. Manoeuvring space for the introduction of bedside equipment is limited and access to the en-suite bathrooms is very close to one of the beds.

<table>
<thead>
<tr>
<th>Summary table of areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
</tr>
<tr>
<td>cluster</td>
</tr>
</tbody>
</table>
Large windows on the diagonal wall flood the rooms with light, and the glazed doors to the fire escape bring unexpected and welcome light into the centre of a cluster.

Given that almost all rooms in the in-patient wards have natural daylight and ventilation, it is surprising that the four external bathrooms do not have windows. In the children’s wards all en-suites are placed on external walls to maximise observation internally. The dayrooms are glazed to the external corridor, allowing borrowed light and external views from the staff base.

The emphasis on use of space and room configurations raised a number of issues, which are discussed in the summary of findings towards the end of this document.

**Summary**

Overall, the size and layout of an 18-bed unit works well. The attempt to develop a range of room sizes based on a standard module was, unfortunately, not realised due to cost constraints on floor area, but the concept is worthy of further investigation. The designs for Norrtälje Hospital in Sweden, the Rikshospital in Oslo, Norway and Nuremberg South Hospital in Germany have also explored the possibility of modular bedrooms.
Groningen University Hospital  
(Academisch Ziekenhuis Groningen (AZG))

**Background**

The Groningen University Hospital was established in 1797. Originally known as Nosocomium Academicum (the academic hostel for the sick), it was the only hospital in the city at that time, with eight beds. It gradually expanded during the nineteenth century to a capacity of 124 beds. Crowded wards and infection problems necessitated the construction of a new 350-bed hospital on the outskirts of the city in 1903. Known as the General Provincial City and University Hospital, when first built it was considered to be of the most up-to-date design. Since 1976 a completely new Groningen University Hospital has been developed on the old site close to the city centre.
Programme

In 1976 a structural plan was developed consisting of a central medical complex (on the partly vacant central area) with nursing wards at the periphery. The first phase began in 1980 with five nursing wards and four sections of the central medical complex. The second phase consisted of three nursing wards, four sections of the central medical complex, and an underground car park for 750 cars on three levels. Both phases were completed in 1996.

General description

The hospital is the largest in the Netherlands (232,000 m² on four storeys plus a basement). It is one of the most expansive and sophisticated hospitals in Europe with 22 operating theatres, 20,000 m² of laboratory space and an enormous underground internal transport system; a helicopter platform is situated on top of the building. It was considered important that the hospital remain part of the city and it was redeveloped on its original site close to the city centre, which is only five minutes’ walk away.

Building organisation

Although this new teaching hospital is one of the largest buildings in the Netherlands, care was taken to design a non-massive structure with a limited height of four storeys.
The main circulation spines were developed as a system of named streets and squares – an extension of the city – with a variety of forms, colours and materials employed to help wayfinding.

Environmental control

A unique feature of the Groningen Hospital is the use of computer-controlled retractable roofs in the many atria, which can be opened in good weather. Following a study of alternative roof systems, including the Chelsea and Westminster Hospital in London, it was decided that to deal with fire safety issues an opening roof was preferable to a sacrificial pillow system or mechanical venting (as employed in the atrium at Antonius Hospital, Sneek). The design is carefully integrated with climate control, cloud spot metering and weather forecasting systems. The roofs automatically close to 95% when rain is imminent. Similarly a slight temperature change of 17°C to 18°C will increase the open area from 5% up to 50%.

In previous phases of the hospital’s development the atria were open courtyards. The external walls of those courtyards have now been stripped of their original cladding and insulation and this has been replaced with sound-absorbing panels to control the acoustic environment. In winter the resulting heat loss from the hospital into its covered street maintains an ambient temperature of around 10°C.

The Netherlands Organisation for Applied Scientific Research (TNO) in Delft, which oversees fire design proposals, carried out fire studies and concluded that each atrium required a minimum of 300 m² of clear opening and that their “external” cladding was not required to have 30 minutes’ fire resistance.

Technical innovation means that patients are now able to do more to control their own environment. External shading and bed height and position can be controlled electronically at the bedside.

In-patient accommodation

The average length of stay is approximately eight days (10.66 if psychiatric patients are included). Bed utilisation rates are 78% and both sexes may be accommodated in the same room, although this practice is changing. Of the 33 ward floors, 32 are in constant use.

There has been a drop in the use of in-patient beds; elective day surgery in particular has reduced demand. A fall in birth rate and the well established community midwifery services have resulted in a reduction from 120 to 30 beds in the maternity unit. Dermatology has progressively reduced its quota by 50% to 15 beds.

A typical ward block at Groningen comprises four identical floors of up to 32 in-patient beds arranged on a racetrack corridor and split into two 16-bed units arranged on either side of a central nurses’ station. All the clinical and some administrative support occupy the core. Day spaces and offices overlook the internal streets or atria. Each floor of a ward block is managed as two 16-bed units by day and as a 32-bed unit during the night.

At least one of the double rooms is used as an additional single room, which may be reflected in the stated bed utilisation rates.
A structural grid of 7.8 m × 7.8 m was established, allowing a sub-grid of 3.9 m and a clear room width of 3.75 m. This not only allows adequate circulation space at the end of the bed, but also accommodates an en-suite shower room and nurses’ working area on either side of a 1400 mm clear entrance lobby. This space can be fully enclosed when barrier nursing is required.

The internal shower cell dimensions are 1.6 × 1.6 m² and they are factory assembled using metal studs and fibreglass following problems with the use of plasterboard over the years.

Single and four-bed rooms were the preferred options for bed distribution but it has been acknowledged that, for economic reasons, there is an unwillingness to move away from two-bed rooms.

Single rooms are located nearest to the nurses’ station and the four-bed rooms are specifically designed at the corners of the ward block, taking advantage of the extra space produced in the diagonal geometry. Window sills have been deliberately lowered to give beds at the back of the room views into the street below. The fold-down bed/seat incorporated into the external wall is a clever space-saving device in the children’s wards.

The standard layout, with minor adaptations for maternity and children’s wards, is used throughout the hospital.
Summary

AZG is the biggest hospital in the Netherlands. It follows in the wake of comparatively large projects in Amsterdam, Utrecht and Maastricht, all of which have used an urban format of streets and squares to reduce the apparent scale and make wayfinding easier.

Its proximity to the city centre and the adoption of “street” frontages and urban blocks to define functional zones or departments is successful. Cafeterias and shops spill out into each concourse or square. Entrances to out-patient departments are arranged behind shop fronts and, together with the circulation cores, are numbered and colour-coded at street level.

The metamorphosis of the enclosed pavilion and block hospital into a single volume required much of the framework to be established early in the project history. The ward blocks were designed over 15 years ago and, although they are still functional, there have been considerable technological advances affecting the use of space elsewhere; however, these ward blocks have remained almost unchanged.

Placing the high public concourse along the whole of the front elevation, behind a glass facade, has the effect of diminishing the overall scale of the building whilst at the same time creating a space similar to an airport, railway station or shopping centre complete with shops, kiosks and information desks. This appropriation of a familiar spatial model makes the hospital less alienating or overwhelming, to the extent that the local citizens stroll through the building at weekends and use the public facilities. Golf carts can be seen transporting the elderly or infirm people along the streets to their destinations.
Germany

Organisation
Responsibility for the German healthcare system is spread over three levels. The overall legal framework for healthcare is set by the Federal Government. The States are responsible for hospital planning and investment. Healthcare is provided by local physicians and also by independent, not-for-profit and private hospitals. Operating costs are financed by the health insurance system.

Funding
 Hospitals are funded by a combination of government subsidy and statutory and private health insurance. The principal sources of healthcare funding in Germany are:

<table>
<thead>
<tr>
<th>Source of Funding</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social insurance/compulsory contribution</td>
<td>66.9%</td>
</tr>
<tr>
<td>Private insurance</td>
<td>5.7%</td>
</tr>
<tr>
<td>Employer-funded insurance</td>
<td>16.9%</td>
</tr>
<tr>
<td>Household expenditure</td>
<td>10.5%</td>
</tr>
</tbody>
</table>

Out-patient facilities were introduced in hospitals at the beginning of 1993. Patients can be treated as out-patients for three days in a time span of five days before in-patient treatment and for seven days in a time span of 14 days after in-patient treatment. Out-patient treatment primarily covers diagnostic tests, procedures and medication. This is intended to lead to a reduction in the average length of stay in hospitals and, in the long term, to a decrease in bed capacity.

Hospital associations and social insurance funds negotiate at federal state level to determine which surgical procedures are carried out by the hospitals on an out-patient basis.

Design guidance
The Federal Government sets legal guidelines for hospitals. The responsibility for hospital planning and financing investments rests with individual states. Each publishes their own standards in the form of “Gesetze, Verordnungen, Normen und Richtlinien für Krankenhäusern”, which cover in very broad terms the key areas of the hospital and indicate minimum standards of floor area or environmental conditions required in different hospital departments.

Design research
Precedents for the Nuremberg South Hospital were set in the 1970s in the research project “Care Facilities” sponsored by the German Research Foundation and undertaken by Jurgen Joedicke and Walter Mayer at the Institute for the Foundations of Modern Architecture and Designers, University of Stuttgart. The solution realised for the nursing areas at the hospital is derived from the developments in care over the past decades. Trends in designing for acute, in-patient care had already been initiated by the architects Joedicke and Mayer decades ago and have now been realised in this building project.

National healthcare statistics

<table>
<thead>
<tr>
<th></th>
<th>1994</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-patient care hospitals – Beds per 1000 population</td>
<td>9.7</td>
</tr>
<tr>
<td>In-patient bed days – Number of days/person</td>
<td>3.0</td>
</tr>
<tr>
<td>In-patient occupancy – % available beds</td>
<td>83.2</td>
</tr>
<tr>
<td>Total expenditure on health – Millions ecus</td>
<td>177,309</td>
</tr>
<tr>
<td>Total expenditure on health – % of GDP</td>
<td>10.3</td>
</tr>
<tr>
<td>Total expenditure: in-patient – Millions ecus</td>
<td>64,542</td>
</tr>
<tr>
<td>Total expenditure: in-patient – % of GDP</td>
<td>3.7</td>
</tr>
<tr>
<td>Social protection: in-patient care – Coverage/total population</td>
<td>92.2</td>
</tr>
<tr>
<td>Length of stay-in patient – Mean length of stay</td>
<td>14.7</td>
</tr>
<tr>
<td>Total population – Thousand persons</td>
<td>81,423</td>
</tr>
</tbody>
</table>

(Source: OECD Health Data)
Nuremberg South Hospital, Nuremberg (Klinikum II in Nürnberg-Süd)

Hospital profile

<table>
<thead>
<tr>
<th>Date completed</th>
<th>1993</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of beds</td>
<td>1022</td>
</tr>
<tr>
<td>Overall floor area m²</td>
<td>98,000</td>
</tr>
<tr>
<td>Gross area/bed m²</td>
<td>95.9</td>
</tr>
</tbody>
</table>

Introduction

Following debates in the 1960s about the reduction of in-patient numbers, a more humane approach to hospitals, specialisation in medical disciplines, new treatments and technologies, the economic size and cost of operating units, and the changing nature of patients’ demands led to a re-evaluation of Nuremberg’s town hospitals.

The new Nuremberg South Hospital replaces one of the largest community hospitals in Germany. In 1979 the decision was made by Nuremberg city council to divide the existing municipal hospital in Flurstrasse, opened in 1897 and containing 2700 beds, into two new complexes serving north and south Nuremberg. Moving about 1000 beds to the southern part of the town meant that provision was better distributed to meet the needs of the eastern, south-eastern and southern areas of the town. Dividing the beds between two hospitals led to more manageable, economic and user-friendly services.
The development plan was approved in 1981 and formed the basis for a national architectural competition. The resulting design was built without significant alterations to its clear functional structure, which divided the hospital into nursing units attached to a central building. The building was completed in 1994 after a planning period of six years followed by a further seven and a half years of construction work.

**Concept – “The building as a small town”**

An institution that houses 1022 in-patients, together with 4000–4500 people who either work, are treated there or visit patients, forms a population equivalent to that of a small town. The idea of a building as a small town underpins the architects’ design approach in which the building comprises a graduated system of places, streets and paths of wide and narrow corridors. These places represent spatial references and meeting points, just as in a town there are public areas and those that require a semi-public or private character.

**Brief**

The aim was to create a hospital that put people at its centre. To achieve this, a new type of ward or nursing unit was conceived to respond to the requirements and wishes of patients and staff. An entrance hall with fountains, shops and a patient café was included to create a relaxed atmosphere and reduce any anxiety about entering a hospital. The many internal lightwells ensure that there is natural light in all rooms even on the lower storeys. Courtyards, gardens and the hospital’s woodland context were exploited in order to create a healing environment.

**Site and context**

The site lies on the south side of Nuremberg with good access routes for private transport from the town centre and nearby motorway junctions. The public transport system offers connections with the underground and local train networks and a link into the pedestrian and cycle track network.

The hospital has been integrated into the landscape of the residential suburb of Langwasser, which is typical of the 1950s era in both form and scale.
The site itself is covered in mixed woodland and slopes from east and west. Following a forest fire, a clearing with a diagonal avenue of trees had been established. The new building was placed in the resulting space, retaining the wide band of woodland to protect the hospital from car emissions. By arranging the plan on an east–west axis, and taking advantage of the sloping terrain, the buildings containing the patient units have been kept below the tree canopy, allowing the patients a view the natural surroundings from their rooms.

Building organisation

The hospital comprises a seven-storey central building, which contains the main entrance, general support facilities and diagnostic and treatment suites, to which are annexed two, three or four-storeyed buildings for in-patient accommodation. By using this arrangement it was possible to create two self-contained departments for internal medicine and surgery within the overall organism, and also to create semi-autonomous units such as the paediatric department.

At the centre of the hospital is the two-storeyed main entrance hall, which has the atmosphere of a “public” square with external paving, street lighting and a fountain under a glass cupola. This area provides the setting for the public facilities, which include a “street”-cafe, shops and the chapel. From here galleries, adjacent to inner courts (lightwells), lead to the lifts and provide access for visitors.
Ward plan

1. single-bed room
2. two-bed room
3. three-bed room
4. four-bed room
5. en-suite WC
6. en-suite shower
7. smoking room
8. day room
9. dining room
10. kitchen
11. staff base
12. office/multipurpose
13. staff rest room
14. staff changing room
15. treatment/examination room
16. dirty utility
17. clean utility
18. bulk store
19. doctor on-call suite
20. waiting area
21. store
22. switchroom
23. cleaners room
24. linen cupboard
25. WC
26. assisted WC
27. staff WC
28. shower
29. assisted bath
30. trolley bay
31. disposal
32. equipment
33. wheelchair park
34. bed maintenance
35. bed bay
36. meeting room
37. rehabilitation
Each court is intended to give an identity to the connected departments or the hospital room zones. For example, the internal medicine department lies at the “fountain” court, the surgery department at the “terraced” court and the flooring in the paediatric department depicts a seven-walk labyrinth.

In-patient accommodation

Special importance was given to the conception of the in-patient accommodation. In order to move away from long end-lit corridors, with the usual deeply planned two-bed patient rooms, a solution was sought that complemented the functional needs and ethos of the nursing units.
Within a concentric plan form, a graduated system of routes and places was developed and accentuated through the introduction of natural lighting. This finally led to a square structural module of 7.2 metres. When joined together, this generated a system of paths and small squares, lit from above and divided by an inner courtyard and outside terraces with plants.

This concept, consisting of low buildings for the patient units, goes against the traditional design approach, but is economic and effective. The architects argued that multi-storey accommodation lends itself better to examination and treatment facilities, and supply and disposal systems. These departments are arranged in a long, six-storey central building, which appears to be only three storeys high because it is located on the terrain that slopes away from the entrance area in an east–west direction. The buildings containing the patient units are connected to this central building on the narrow sides in the east and west, each level having three squares with 60 beds each. Further sub-division provides clusters of 16 and 22 beds to a nurse base.

This close relationship of the buildings, which ensures short connections between general treatment facilities and the nursing areas, also has the advantage of providing a high degree of natural lighting to all the functional areas.

There is a patients’ garden on the roof of the services section. Works of art from municipal collections and loan exhibitions from private galleries are displayed in the corridors and passageways, where it is also possible to stage cultural events.

**Patient rooms**

The disadvantages of the two-bed room, which is usual in Germany, are caused by the unequivalence of the bed positions. One bed is placed near the window, the other one in the depth of the room, and separation in case of medically delicate situations is impossible as the two beds stand so close to each other.
The architect’s aim was to achieve the equivalence of the bed positions, “the qualities of a one-bed room within a two-bed room”, although early studies had also investigated a single room version. The final solution provides two-bed rooms, each patient having the same orientation and relationship with both the window and the door, and their own territory with wardrobe and bath unit. Contact is possible, but the way the beds are placed allows a separation. Each wardrobe stands on rollers so that it can be used as a room subdivider, if so desired.

In front of the rooms, day zones invite contact with other patients. These zones receive daylight through light cylinders.

Summary

In an earlier version of the design of this scheme the ward geometry was derived from single rooms. Subsequently, a predominantly two-bed room solution has resulted utilising wide shallow rooms on a building facade that is cleverly folded to increase its length.

The plan has some similarities with the one developed for the hospital at Neu-Ulm (1982) but is unlike any other featured in this study. By turning the room through 90° the architect has achieved for the patient a strong connection with the external world and retained a relatively efficient floor area and net-to-gross ratio. The unit is flooded with daylight and the central corridor is eliminated. This project, possibly more than any other, demonstrates that innovative solutions are affordable, reduce travel distances and can provide a generous bed area for each patient.
Spain is divided into 17 regional governments (Comunidades Autonomas), each administering its own health service. The Spanish healthcare system is made up of a mixture of public and private sectors in both financing and provision. The Sistema Nacional de Salud (National Health System) is mainly in charge of the public sector. Together with other associations for public employees, this covers 98 per cent of the population.

The private sector is made up of insurance companies and private institutions. Several of these institutions have specific agreements with the public sector to treat patients, for which they are reimbursed.

The National Health Institute (INSALUD) retains healthcare responsibilities for the regions that do not organise their own services.

INSALUD currently administers approximately 45 hospitals. The 460 private hospitals (60 per cent for profit) contain 30 per cent of hospital beds.

Sixty-six per cent of healthcare funding comes from general taxation, 29.4% from social insurance and 4.5% from other sources. In the past, private hospitals collaborating with the public system were reimbursed on a per diem basis. In future it will be on a per episode basis.

Public hospitals will have more autonomy from central/ regional government than at present, especially in the areas of operational management and human resource policy. In the future, funding will be totally through taxation.

The General Health Law (1986) formalised the national health service as a nationally integrated framework for the 17 health services. Seven autonomous communities now manage their own services directly and issue their own guidance or standards.

The publications department of the Health Ministry in Madrid produces new guides and manuals relating to hospital design, which set out general organisational and functional criteria for selected departments.

Before the establishment of INSALUD, hospitals and government entrusted architects to arrive at solutions for hospitals based on their experience and expertise. Such an approach, however, did not necessarily lead to consistency (either quantitative or qualitative). The present procedure for planning a major hospital project was established approximately nine years ago.

Each hospital is now required to develop its own functional plan (FP) following a detailed study of existing and projected service needs. The study is designed to incorporate data on existing facilities within a particular catchment area and will include epidemiological projections and comparisons with other autonomous regions. Following this study, an FP can be produced that...
sets out the functional content, service criteria and spatial requirements of each project. All subsequent design proposals are assessed against this FP.

The functional plan (FP)

A commission/project team is established comprising the hospital director, design team representatives of the hospital department and service users, and INSALUD representatives. Depending on the size and complexity of the project, an FP can take up to one year. Following the successful completion of the FP, all projects can proceed only on the instructions of the government.

In the past the FP has been carried out by INSALUD, but more recently private consultants have been used, which has raised difficulties in achieving a high level of consistency in documentation.

Once the FP is complete and a site has been chosen, a design team is appointed through open competition by advertising in the Official Journal of the European Communities (OJEC). Usually, no more than 20 teams participate in the competition. Their brief is to produce ideas in the form of a concept design that demonstrates good understanding of the FP, opportunities to develop the site, and overall competence to undertake the technical requirements of the project. The competition stage usually lasts six months and the successful proposal has to be endorsed at ministerial level.

The design period usually lasts for one year and involves close collaboration with INSALUD. In the three case studies from Spain there are common themes and aspects of design philosophy that have emanated from INSALUD’s architect advisory team. These include circulation issues, access between different departments and means of escape, together with an overall generic planning approach.

Design process

The design team works together with INSALUD to determine the basic strategic decisions with regard to circulation, functional relationships, and access arrangements; they establish conceptual diagrams for functional organisation that recognise distinctive service areas. Proposals are generated with detailed circulation routes that are arranged and organised within a generic framework, which is devised during the functional planning stage.

In order to define these routes more clearly, a precise analysis of functional groups and various units of the hospital is conducted. This analysis has to take into consideration each department and its functional relationship with other services.

The final allocation of space in the hospital is achieved so that each unit or service finds its own place in this service “network” and various organisational alternatives present various options. This results in a hospital structure where modification and extension are not only possible but invited.

Introduction to the case studies

The emphasis on the primary circulation framework was a major influence in the design approach to planning the in-patient accommodation for all three hospitals in the case studies.
Alcorcón Hospital, Madrid
(Hospital de Alcorcón)

Hospital profile

<table>
<thead>
<tr>
<th>Date completed</th>
<th>1998</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>Annual throughput per bed</td>
<td>45.63</td>
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Introduction

At the end of 1990 a decision was made by INSALUD to build a new referral hospital for Navalcarnero and Villaviciosa, the suburbs of Alcorcón, a town that is located to the south-west of Madrid. INSALUD commissioned a functional plan that would predict the future healthcare needs of the area, based on a projected population increase of 35.5 per cent to 237,000 by the year 2001.

The planning commission comprised a multidisciplinary team of doctors, nurses, architects, urban planners, engineers and other technicians experienced in the planning, design and administration of hospitals. The main task of this team was to set the basis for the design of the future hospital according to social, economic, demographic and technological factors. The commission estimated that a total of 576 beds would be required.

Site and location

The regional government (Comunidad de Madrid) transferred a plot of land to INSALUD for the construction of the new hospital. The 330 m × 450 m plot (148,000 square metres) is inside the new urban development of Alcorcón and is very easily accessible to the population within its catchment area.
Spain – Alcorcón Hospital, Madrid

General Arrangement

Emergency Access

Level 1

1 Main Entrance
2 Admissions
3 Library
4 Cafeteria
5 Auditorium
6 Reception/ Information
7 Teaching and Training
8 Psychiatry
9 Mortuary
10 Staff Change
11 Sterilization
12 Kitchen
13 Pharmacy
14 Laundry
15 In-patient Wards
16 Out-patients Department
17 X-ray
18 Accident & Emergency
19 Operating Theatre
20 Plantroom
21 Toilets
22 Intensive Care
23 Dialysis
24 Laboratories
25 Rehabilitation
26 Blood Bank
27 Day Surgery
28 Mortuary
29 Work Shops+ Stores
30 Day Hospital

Level 0

KEY
- In-patient Wards
- Technical Blocks
- Public Access

0 100 metres
Design process

The design team produced a plan that established four main zones, each characterised by its function:

- external and very public areas (entrance hall, out-patient department, physiotherapy etc);
- semi-public areas (mainly wards);
- internal and staff areas where all the diagnosis and treatments are performed (technical block);
- the industrial areas situated at the rear (kitchen, storage, power plants etc).

From the early stages in the design process of the hospital, architectural elements used in urban designs were assumed by the design team, including streets, plazas, spare space for future growth and extension, green areas, and separation between residential and industrial areas.

Brief

The brief for the design was based on the following concepts:

- high quality of medical assistance;
- humanisation of architecture to increase comfort of patients;
- a modern hospital with “hi-tech” solutions to implement future medical technology and procedures;
- efficiency and productivity;
- flexibility of use and ease of growth in the future;
- safety to users and ergonomic robustness;
- technical solutions to reduce costs of operation and maintenance;
- quality of construction for maximum durability.

Circulation areas, based on a network of corridors, are organised according to functional areas such as wards, clinical areas, non-clinical areas or industrial areas. Three types of circulation area are recognised:

- public – for patients, visitors, staff, students;
- staff – internal circulation among departments (technical block, emergency, in-patients);
- service – for supplying meals, linen, medicines and materials to each department.

General description

The general layout of the hospital is based on two primary circulation corridors, perpendicular to one another, to which the two three-storey blocks and the single-floor technical block are connected. The intersection of these two axes at ground floor level forms the main lobby of the hospital, a three-storey-high space containing the public elevators and escalators, which serves as the “main square” from where all the functions are accessed. Out-patient clinics and in-patient wards are located in relatively fixed three-storey blocks.
At basement level the main corridors are used as the main distribution lines for pipes, service ducts and supplies.

**Main entrance and public functions**

This accommodation is situated at the front of the hospital site and consists of a three-storey building that is recognised by the massive use of red solid brick as the external skin. The facade is divided by a granite-clad concrete “Ubox” that advances about 10 m from the red brick wall.

In the right-hand wing the admission, administration, and renal dialysis unit are situated at ground-floor level. The floors above contain the out-patient department.

In the left-hand wing the physiotherapy department is situated on the ground floor. The first floor includes the X-ray department, and the second, the offices for the general manager and the rest of the administrative and directive staff.

At the entrance to the building is the “main square”, a triple-height lobby that is covered by a glazed roof; the escalators are located here. From this point starts the main street (9.5 metres wide) that runs between the wards and the technical block at ground-floor level, organising the main traffic: visitors, students, doctors, staff etc. On the upper floors the corridor narrows, allowing natural light from skylights placed on the roof to reach the ground floor.

**In-patient accommodation**

The in-patient units are formed by three W-shaped blocks, which are connected to the hospital by the “main street” that runs through the whole length of the building (300 metres). Each ward occupies one half of the “W”, sharing the support areas in between. Wards have been designed to allow adaptability for specific needs.
Spain – Alcorcón Hospital, Madrid

1 single-bed room
2 two-bed room
3 three-bed room
4 four-bed room
5 en-suite WC
6 en-suite shower
7 smoking room
8 day room
9 dining room
10 kitchen
11 staff base
12 office/multipurpose
13 staff rest room
14 staff changing room
15 treatment/examination room
16 dirty utility
17 clean utility
18 bulk store
19 doctor on-call suite
20 waiting area
21 store
22 switchroom
23 cleaners room
24 linen cupboard
25 WC
26 assisted WC
27 staff WC
28 shower
29 assisted bath
30 trolley bay
31 disposal
32 equipment
33 wheelchair park
34 bed maintenance
35 bed bay
36 meeting room
37 rehabilitation

Ward plan
Each wing contains 32 beds (26 of which are contained within a single fire compartment served by its own escape/emergency access stair). All rooms are designed for two beds, but single bedrooms have been made the same size for flexibility. En-suites have been arranged back to back and can be serviced from the corridor. An additional wardrobe is provided in each room for visitors.

Rooms face south to open areas of the garden, which can be used by both patients and visitors. Each room has a WC and shower and integral bedpan washer and closets. Wall sockets for voice and data transmission permit permanent monitoring, access to the patient's medical record, or data transfer. Each patient has a ceiling-mounted television.

Bedhead services are provided in a low-level unit between the beds designed especially for the project. Bedroom doors are 1200 mm wide, the maximum (for Spain) to meet the fire protection requirements. All windows have integral blinds and solar reflective film.

---

**Summary table of areas**

<table>
<thead>
<tr>
<th>Type</th>
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<tbody>
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<td>Support area per bed m²</td>
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<tr>
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<td>Total area per bed m²</td>
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</tr>
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<td>Max distance from nurse base</td>
<td>36 m</td>
</tr>
<tr>
<td>% bed area of total</td>
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</table>
Technical block

The technical block (diagnosis and treatment areas) is laid out in a single floor with column-free areas of 22.5 m × 37.5 m that will allow any future layout or modification. A grid of corridors divides the block into 18 smaller units of 37.5 m × 37.5 m that can be configured into different departments, according to their size. This block is characterised by the massive use of fair face concrete for the exterior walls, contrasting with the warmer material used in the wards.

Summary

The space standard for this hospital is high in comparison with other Spanish examples. Rooms are large and, as a whole, Alcorcón has one of the highest percentages of space devoted to bed area of all the hospitals visited for this study. As a consequence it has one of the longest travel distances from the nurses' base, although during the design stages a travel distance of 30 metres to furthest bed was deemed acceptable. The separation of the staff and service zone from patients and visitors is ingenious but the additional space required to achieve this seems excessive. There are no single-bed rooms but it is assumed that any two-bed rooms can be allocated to provide the 15% required in the brief. It is unlikely that such generous space allowances will be applied in future projects in Spain. There is little in the general layout of the in-patient accommodation that would be instructive in the design of a new unit if tighter space standards were applied. The large sitting-rooms near the ward entrances cannot easily be supervised. No other dedicated day space is provided for patients and their visitors.
Manacor Hospital, Mallorca
(Hospital de Manacor)

Introduction

INSALUD is responsible for hospital healthcare in the Balearic Islands and is currently planning a second hospital within Palma as part of its programme to improve in-patient care. Efforts have been made to ensure adequate in-patient accommodation not only to all Balearic Islands residents requiring special care, but also to the considerable number of tourists and holidaymakers who visit the region. The island’s tourist population, which fluctuates between 55,000 during the winter and 375,000 in the summer, has a significant impact on health services.

Sixteen per cent of the Mallorcan population is located in the Manacor sector, with the majority, 53.5%, living in Palma. In Mallorca, the average number of hospital beds is 1.9 per 1000 population; this compares to 2.35 hospital beds per 1000 population for all the INSALUD health regions. Six days is the average length of stay, while bed occupancy is 85% (this can drop to 50%).

Manacor Hospital is part of an ongoing programme to provide hospital care to the “Mallorcan” population. The hospital opened during the first months of 1997; since then the inhabitants of the north and east of the island no longer have to travel to Palma to receive care. It serves a population of 120,000 with a capacity of 200 beds, and constitutes an example of the latest thinking in medical architecture.

General description

Manacor Hospital is an acute hospital, comprising an emergency ward able to deal with the most critical situations and equipped with the best technology. The hospital has 200 beds, four operating theatres and two delivery rooms. The consultation area provides all medical and surgical services, supported by all necessary diagnostic and therapeutic equipment – including the most advanced technology such as a CAT scanner, digital remote control, mammography, as well as ultrasound and conventional X-ray. A day hospital and dialysis unit are available for patients who need special care but do not need to stay overnight. A large ambulatory surgery unit (Unidad de Cirugía Mayor Ambulatoria) guarantees the same reliability as services for in-patients.
Site and location

The hospital site covers 25,000 m², located on the outskirts of Manacor, on the road that links Manacor to Arta. The site slopes 4 metres from the west and the building is oriented north–south, built into the hillside with the main entrance to the east. Car parking is laid out around the edges of the site. A separate covered entrance for the emergency department is located at the north end of the building.

Building organisation

The brief emphasised the need for a modern, highly serviced and flexible solution, with equal attention given to the human dimension of healthcare.

The plan was developed organically rather than formally, with the architects keen to develop a framework that broke down the building into its functional parts.

The architects were particularly concerned about the type and quality of lighting in the building. The depth of plan required for various departments of the hospital meant that natural light played a major role in the development of the spatial composition of the building. Roof lights have been specially designed and oriented for particular functions.

The roof profile and building materials aim to develop an architectural language appropriate to the Mallorcan context. The facade is made up of a group of small rooms that reflect traditional Mallorcan architecture. The opposite facade comprises five domes that accommodate the plantrooms above the surgery ward, defining the technological character of the building.
At ground level, where privacy is required in clinical areas, there are small courtyards and closed views around the perimeter that reflect the quality of the local vernacular.

The functional design of the hospital, in a primarily longitudinal development, provides for internal traffic flow along dedicated corridors in order to avoid congestion.

**In-patient accommodation**

In-patient accommodation comprises 200 beds located on the three upper storeys of the building. Although all the rooms can accommodate two beds it is anticipated that 10% will be used as single rooms. The implication of this is that the floor area per bed increases.

All rooms face east to take advantage of the fine views of the island and because a western orientation would be too hot in summer. The two lowest storeys are deep plan and contain all out-patient, diagnostic, treatment and hospital support facilities.

A typical floor accommodates two groups of 32 beds divided by a fire lobby located at the mid-point of the block, which enables patients to be evacuated horizontally in case of fire. Each pair of bedrooms has access to shower and WC rooms directly from its corridor recess.

Each ward is accessed at its mid-point by stairs and visitors’ lifts, which are situated opposite the nurses’ station. A cluster of three dedicated lifts in the
service zone gives access to beds, food, supplies and medical staff. Behind the support rooms is a separate service corridor that enables delivery and disposal of supplies to go on behind the scenes and minimises the number of doors on the main corridor.

Summary

The desire by the architects to establish an equivalence of orientation for all the beds has resulted in a narrow linear block spanning the whole width of the hospital buildings. Two wards are laid out end to end, with a second corridor serving staff-only areas. The impact on the distribution of space is to produce the second smallest bed area of all the hospitals in this study (only Kuopio in Finland is smaller), with by far the highest percentage of space devoted to circulation and the highest net-to-gross ratio of 1.73. Such planning is inefficient in the use of space and may stem from a requirement within the design brief to separate staff and service traffic from patients and visitors.

The width of a bedroom is well below the width adopted by other hospitals, for example at Groningen in the Netherlands and Skejby in Denmark. Travel distances are second longest of all the hospitals visited, which seems perverse given that each ward has a central nurse base. It would be reasonable to suggest that narrow linear ward designs are not the most efficient way of planning in-patient accommodation.

<table>
<thead>
<tr>
<th>Summary table of areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
</tr>
<tr>
<td>Number of nurse bases</td>
</tr>
<tr>
<td>Total number of beds</td>
</tr>
<tr>
<td>Single beds</td>
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<tr>
<td>Area per bed m²</td>
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<tr>
<td>Support area per bed m²</td>
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<td>Nett total per bed m²</td>
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<tr>
<td>Circulation per bed m²</td>
</tr>
<tr>
<td>Total area per bed m²</td>
</tr>
<tr>
<td>Max distance from nurse base</td>
</tr>
<tr>
<td>% bed area of total</td>
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</table>
Huelva Hospital, Huelva
(Hospital de Huelva “Juan Ramón Jiménez”)

Hospital profile

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
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<tr>
<td>Date completed</td>
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<tr>
<td>Total number of beds</td>
<td>620</td>
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<td>Overall floor area m²</td>
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<td>Gross area/bed m²</td>
<td>100.2</td>
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<td>Average length of stay (days)</td>
<td>8.0</td>
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Introduction

The new hospital caters for the needs of a population of 230,000, dispersed between the capital and many surrounding municipalities. It contains 620 beds (200 more than the hospital it has replaced).

In 1983 the health organisation set a number of targets concerning special care facilities:

- to attain the number of beds required by INSALUD, which had established 2.5 beds per 1000 inhabitants as a standard;
- to decentralise existing resources away from regional capitals towards the provinces, in order to increase the number of hospitals in rural areas;
- to ensure cost-effectiveness of existing public resources with the integration of all public hospitals of Andalucia.

This hospital has increased the number of services available in Huelva, including the incorporation of new services and technology, and is now considered as a referral hospital offering specialised care for the whole province. The added services also support those offered by the two other hospitals of the Andalucian Health Service.

A primary consideration was the importance of daylight, which not only contributes to making areas pleasant to inhabit but also plays an important role in the curative process. As a result, the building is low and extended in plan, with importance being given to horizontal rather than vertical relationships.
Building organisation

The hospital comprises three main elements – the clinical block, a plant and maintenance building, and a storage building for general supplies.

There are six floor levels: basement, ground (accessible through east and west facades), first floor (accessible through west facade) and three upper levels without direct access to the outside. A natural slope in the terrain allows access to ground and first floors. This slope also allows for easy access to the two corresponding levels through a service tunnel below the first floor, which provides entrance to all services of the hospital.

The hospital is composed around a double circulation route, running north–south, between which are located the main vertical communication nucleii. This route divides the hospital into four levels in two clearly distinct zones: towards the east, the in-patient accommodation, and towards the west, almost all the care units for diagnosis and treatment.

In addition to the central circulation axis there are three more longitudinal circulation routes. The first, which runs parallel to the eastern facade on the ground floor, caters for all out-patients, visitors and administrative personnel. From here there is direct access to in-patient units and all administrative and management services.

The second axis is located on the first floor, parallel to the western facade; it is intended for all persons receiving care with the exception of planned admissions, allowing access to all diagnosis and treatment facilities as well as accident and emergency. Circulation on this route relieves the principal central axis, which is intended to be preserved for the sole use of personnel and in-patients. On each side of the central axis are all clinical administration areas, the hospital’s direct training department, offices, meeting rooms, auditoria and clinical secretariat.

The third axis, situated on the ground floor, is formed by a service tunnel allowing access to all general services.

In-patient accommodation

The two patient care units are identical, and each has four floors which are organised around two L-shaped nursing units. These units close onto the central axis of clinical offices and support areas, which form square-shaped blocks, leading into a courtyard surrounded by rooms. These square-shaped blocks are connected from one side to the vertical nucleus, while the opposite side connects with the general central circulation route.

The diagnosis and treatment units are represented by three double blocks. Each has a shared central equipment zone and connects with the central circulation route, as well as connecting with the lateral axis, which is used by ambulatory patients.
The most southerly block houses the out-patient clinic, rehabilitation and central laboratories. The remaining two blocks contain the rest of the diagnosis and treatment facilities, except for nuclear medicine and radiotherapy.

Of the 620 beds, 448 are provided in 14 nursing units allocated as needs require. Rooms are single and two-bed; each has toilet and shower, telephone (receiving calls only), television, gas and oxygen outlets. Each in-patient care unit is equipped with personnel work areas, clinical offices for doctors, heads of department and supervisors, as well as meeting rooms, classrooms and family waiting areas.

Summary

The in-patient accommodation is ingeniously accessed directly from the entrance hall at the front of the hospital, leaving the services and staff connections to the rest of the hospital separate.

Like Alcorcón and Manacor, wards are arranged in pairs sharing some support accommodation. However, the in-patient areas are more economically planned than either Alcorcón or Manacor without significantly less space within the bed areas. Huelva does provide four single rooms per nursing unit, one of which is for barrier nursing.

2 × 32-bed nursing units

<table>
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<th>Summary table of areas</th>
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<tr>
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<td><strong>Total number of beds</strong></td>
<td>32</td>
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<td><strong>Single beds</strong></td>
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<td><strong>% bed area of total</strong></td>
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Bed distribution

<table>
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</tr>
<tr>
<td>2-bed</td>
<td>87%</td>
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Organisation

In Denmark all healthcare services are financed, planned and operated by public authorities. The state is responsible for the healthcare system, which is under the overall direction of the Ministry of Health.

The healthcare system is decentralised to a large extent. The 16 counties are responsible for hospital and primary care as well as health promotion activities. The only hospital run by the state, as opposed to the counties, is the National University Hospital (Rigshospitalet), which is under the authority of the Ministry of Health.

Funding

All citizens have equal access to almost all healthcare services free of charge, regardless of employment, financial and social status. Private, not-for-profit hospitals have until recently been run as part of the public hospital service, under agreements with the counties. However, there are now some private profit hospitals where treatment is paid for by patients themselves without public subsidies. Plans exist for more such hospitals.

Service trends

The trend is towards a more deregulated healthcare system with open competition between providers. In most cases patients, with the support of their general practitioners, are now free to choose the hospital they wish to attend. This reform increases competition between hospitals in order to attract patients.

Design guidance

As the principal health authority, the Ministry of Health is responsible for health legislation but not the creation of building or space standards. There are no official national standards for hospital design in Denmark. Standards tend to be set on an individual project basis by healthcare architects who have developed experienced-based norms. The 14 counties and the municipalities of Copenhagen and Frederiksberg, which plan, fund and run their own health services, are responsible for vetting space standards in their region.

The basic principle of equal access to healthcare for every citizen will be maintained and healthcare will continue to be funded by taxation and social insurance, although private insurance and household payments will increase.

Danish healthcare expenditure is low compared to other developed countries at only 6.2% of GDP in 1990.

National healthcare statistics

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<th>Category</th>
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<td>In-patient care hospitals – Beds per 1000 population</td>
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<tr>
<td>In-patient bed days – Number of days/person</td>
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<td>In-patient occupancy – % available beds</td>
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<tr>
<td>Total expenditure on health – Millions ecus</td>
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<tr>
<td>Total expenditure on health – % of GDP</td>
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<td>Total expenditure: in-patient – Millions ecus</td>
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<td>Social protection: in-patient care – Coverage/total population</td>
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<td>Length of stay-in patient – Mean length of stay</td>
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</tr>
<tr>
<td>Total population – Thousand persons</td>
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(Source: OECD Health Data)
Aarhus University Hospital, Skejby
(Skejby Sygehus)

Hospital profile

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<td>Annual patient throughput</td>
<td>32,840</td>
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<tr>
<td>Annual throughput per bed</td>
<td>64.52</td>
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</table>

Background

In 1977, Aarhus County Council approved an application to build a new hospital in the suburb of Skejby. A number of special facilities, particularly at the Aarhus City Hospital, were out of date and could no longer comply with modern requirements for a range of medical and surgical specialties. There was a particular demand for the development of facilities for cardiovascular surgery and cardiac medicine. In addition, up-to-date nephrological facilities were required for the increasing number of patients requiring dialysis.

Aarhus Hospital is now a university teaching hospital providing services for the whole of Jutland and acting as a national centre for some specialties. The hospital also participates in a wide variety of research and development work. It is expected that the fully constructed hospital will have about 600 beds and a staff of some 2200 people by the year 2000.

The architects, C F Møllers, have been involved in the design of hospitals for many years since they set up in Aarhus in the 1920s. The practice designed the large university campus and the former town hospital using traditional brick architecture, which is common in domestic buildings throughout Denmark.
Programme

The three-phase programme commenced in 1982 and the first patient was transferred from the Aarhus City Hospital in January 1988. The first phase, completed in 1992, included cardiology, urology, nephrology, hepatology, and gastroenterology. Phase two, which ran from 1992 to 1996, incorporated paediatrics, obstetrics, and gynaecology. The third phase, which was begun in 1996 and is expected to be completed by 2000, covers haematology, infectious diseases, microbiology, pathology, and forensic medicine. This part of the building will extend the existing site to the south and there are plans to complete the landscape with a lake to the west.

Building organisation

The hospital consists of two-storey buildings. To minimise distances for movement around the hospital of patients and staff, each specialty is housed in an independent unit containing its own wards, therapy and treatment spaces, and offices. The units are connected by a main “thoroughfare” consisting of the main entrance, reception desk, information centre, kiosk, bank, canteen, relatives’ rooms etc. The southern ward building provides 120 beds for heart, lung and vascular patients. The northern building is designed for approximately 120 beds plus dialysis units for patients with kidney and urological problems.

Circulation and transportation is organised on three levels:

- the basement is used to transport supplies to the various departments. All supply and disposal services are distributed in this way, together with primary power and heat and communication lines;
- patients and visitors are distributed at ground level to each department, or by lift and stairs to the in-patient accommodation on the upper floor;
- in-patients and hospital staff move around the building on the upper floor, which contains the wards, operating theatres, intensive care unit and laboratories.

In common with many recently developed large hospitals, Aarhus Hospital follows a linear street principle, which provides short cross-connections between critical functions whilst allowing scope for extending the plan as long as the site dimensions allow. The bend in the street allowed the second phase of the building to have a longer frontage and more entrance access points, and minimised the length of street. It was also able to accommodate the larger footprint required for the new paediatric block.

A separate block houses the hospital’s clinical immunology department. This contains the Scandinavian registry for organ transplants and the most extensive blood bank in Denmark, with laboratories for the determination of blood and tissue types.
In-patient accommodation

Each ward contains a combination of single, two-bed and four-bed rooms, all furnished in bright, friendly colours. Single rooms have an en-suite shower and WC while sanitary facilities for the multi-bed bays are located immediately outside the room. The rooms are well equipped, with outlets for nurse call, oxygen and vacuum connections, telephones, and radios. Television is transmitted by the hospital’s broadband network, which is also used to transfer information and data between departments. In addition to the bedroom areas, separate day rooms for smokers and non-smokers are provided. The accommodation is constructed around landscaped courtyards to provide each ward with natural daylight and a garden view.

The wards built during phase one were laid out in a “racetrack” layout of two 30-bed back-to-back wards with staff bases located near to their entrances. In later phases, other arrangements have been adopted, for example 14-, 20- and 26-bed wards.

The wards are notable for the amount of clinical and staff support facilities they contain. Clustered around each staff base is a drug dispensary, an office, a meeting/rest room and a staff smoking room. In the newer wards, the staff base is located in the centre of the ward with a pair of single rooms opposite and a clean utility room close by; the living and social spaces are adjacent to the entrance. Food preparation and wash-up activities are kept separate. Dining areas are either open to the corridor or separated by a glazed screen; some are used as multi-purpose spaces.
Perhaps the most interesting aspect of a typical ward is the allocation of space and key dimensions of patient rooms compared to some of the other case studies. The single rooms are 3.6 m wide while the double rooms are 4.2 m wide to allow the second bed to be manoeuvred in and out of the room. The rooms are approximately 4.8 m long, including the en-suite, which is normally located on the corridor wall. Doors have 1.5 opening leaves to give a clear opening of 1.45 m. They have special hinges that allow full clearance between the door jambs and reduce damage to the door. The most recent legislation relating to dimensions requires that assistance is available on each side of a sanitary appliance; this will have the effect of increasing the size of shower or bathrooms.

**Patient hotel**

The patient hotel, which is entered directly from the main entrance hall, provides 34 beds in relaxed and luxurious surroundings for ambulatory patients and their relatives. Ten of the rooms are specially designed family units for pregnant women and their families. All rooms have an en-suite bathroom. In addition to a number of day rooms, some informal sitting areas have been created off the corridors. A small restaurant is also provided.

**Treatment and therapy spaces**

Four directly linked wings form the framework for operations, examination and treatment. On the first floor there are two surgical departments, one for heart, lung and vascular patients, and one for patients with kidney and urological problems. In addition, this area contains a highly advanced cardiac section, an intensive care department and one of the hospital’s X-ray departments. The clinical departments and surgical theatres are equipped with modern technical units for ultra-modern diagnosis and treatment plus the latest apparatus for kidney and heart transplantation.

The ground floor contains out-patient departments for heart, lung and vascular patients plus facilities for patients suffering from kidney and urological ailments. This area also contains its own X-ray department and physiotherapy department.
Summary

The new design has resulted in familiar, restful and comfortably scaled buildings that are easy to maintain. The fact that entrances are placed between blocks projecting from the street diminishes their scale considerably and helps to make this very large building seem much smaller than it really is.

Aarhus Hospital has a conventional linear ward layout. There is an emphasis on space and bright, colourful interiors. The journey to and from the wards is along well-lit corridors containing artwork and views of landscaped courtyards. The hospital has a very quiet and peaceful atmosphere, which is an achievement in itself for such a large institution.
Vejle Hospital, Vejle (Vejle Sygehus)

Hospital profile

<table>
<thead>
<tr>
<th>Date completed</th>
<th>1997</th>
</tr>
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<tbody>
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<tr>
<td>Annual patient throughput</td>
<td>23,356</td>
</tr>
<tr>
<td>Annual throughput per bed</td>
<td>47.96</td>
</tr>
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Introduction

Vejle Hospital has recently undergone a radical facelift in its public areas as part of the whole hospital refurbishment. Its inclusion in these case studies is primarily to show how the design attempts to improve the patients’ whole experience of attending a hospital.

The original hospital was developed in the mid 1950s as a campus of brick and tile buildings. The 300,000 population of Vejle is currently served by four hospitals each with its own particular specialties.

A programme of redevelopment was devised which allowed the existing hospital to remain fully functional during each phase.

The purpose of the ward upgrade programme was primarily to:

- improve staff facilities;
- improve en-suite facilities;
- renovate existing services.
Site and location

It is a very compact hospital close to the centre of town, with a steep hill to the north. There was very little room on the existing site to expand, as most of the modifications were at the lower levels.

The car parking areas are enclosed by densely planted beech hedging. Separate footpaths lead to the new main entrance, which stands directly in front of the front lobby and deflects vehicles away from the fully pedestrianised area, hard-landscaped with water feature and seating. Wheelchairs are available in glass shelters adjacent to drop-off areas. A projecting glass bay provides shelter for those waiting for transport.

Building organisation

A new main entrance was constructed at the west end of the ward block, together with a new lift and extension accommodating new patient and visitors sitting/day rooms on each floor. Inside the main entrance is more akin to the foyer of a grand hotel, with marble floor, large shrubs, artwork, comfortable sofas and continental style cafe. Special attention has been paid to the design of directional signs and the combination of bold colour schemes and pictograms.

The new day accommodation is decorated and furnished in strikingly bold colours and, significantly, carpets have been re-introduced. In the day surgery suite, which has been open for six years, all rooms with the exception of the clinical treatment rooms are carpeted.
Ward plan

1 single-bed room  4 three-bed room  7 smoking room  10 kitchen  13 staff rest room  16 dirty utility  19 bulk store  22 switchroom  25 linen cupboard  28 shower  31 disposal  34 bed maintenance
2 two-bed room  5 three-bed room  8 day room  9 dining room  14 staff changing room  17 clean utility  20 doctor on-call suite  23 cleaners room  26 assisted WC  29 assisted bath  32 equipment  35 bed bay
3 four-bed room  6 en-suite shower  11 staff base  12 office/multipurpose  15 treatment/examination room  18 waiting area  21 store  24 WC  27 staff WC  30 trolley bay  33 wheelchair park  36 meeting room  37 rehabilitation
In-patient accommodation

The in-patient block comprises nine floors, each with beds in two wards on either side of the main circulation route. This block has been upgraded but not significantly altered so that patients are still arranged in two-, three- and four-bed rooms. Additional bathrooms have been installed and the nurse base has been rearranged. The three-bed rooms are more likely to be used by only two patients, and the two-bed rooms as single rooms. There is a single dedicated isolation room.

Cook/chill food preparation has been introduced and each floor has a reheat kitchen serving 60 beds. New dining and social facilities have been introduced at the centre of the block.

Summary

As pressure on resources elsewhere has led to inadequate investment in in-patient accommodation, many large hospitals have tended to become permanent building sites, not only to accommodate many new technologies, but also to upgrade poor interior environments that are now considered unacceptable. Bleak main entrances and out-patient waiting areas, dingy wards with large shared bedrooms, and minimal sanitary facilities are typical.

This hospital has been transformed to such an extent that the old hospital was virtually unrecognisable to a former patient. The result has been achieved through a complicated programme of phased works combined with a rationalisation of the circulation system from the new main entrance via a multi-levelled glassed structure linking the two main blocks.

Although conceived as a free-standing pavilion, the main entrance “centres” the hospital; it is sufficiently close to the main traffic flows to be a strong reference point during a hospital visit. As a multi-functional space it works well without requiring sub-division or signage. It contains all the comforts and facilities to be expected in a public building.
Køge Hospital (Roskilde Amts Sygehus Køge)

The competition to design Køge Hospital was won by the same architects who designed Aarhus University Hospital, C F Møller. It was planned after Aarhus commenced and is now complete. It represents an “ideal” concept and plan that the architects were able to realise as originally designed, and to that extent may be considered to be a more complete version of this type of building. It is illustrated because it has many similarities with Aarhus and with other case studies such as the Rikshospital in Norway.
Finland

National healthcare statistics

<table>
<thead>
<tr>
<th>Category</th>
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<tr>
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<td>10.0</td>
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<tr>
<td>In-patient bed days – Number of days/person</td>
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<td>In-patient occupancy – % available beds</td>
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<tr>
<td>Total expenditure on health – % of GDP</td>
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<td>Total expenditure: in-patient – % of GDP</td>
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<td>Social protection: in-patient care – Coverage/total population</td>
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<td>Length of stay-in patient – Mean length of stay</td>
<td>13.1</td>
</tr>
<tr>
<td>Total population – Thousand persons</td>
<td>5088</td>
</tr>
</tbody>
</table>

(Source: OECD Health Data)

Organisation

In Finland the Ministry of Social Affairs and Health directs and guides the operating principles and development of services in social welfare and health. Together with the Council of State and Parliament, it defines national social and health policy guidelines, prepares key reforms and guides implementation.

Since June 1997, Finland has been divided into five provinces, each run by a provincial government that supervises the provision of social welfare and healthcare in its respective area.

There are 455 municipalities, which provide health services alone or in joint boards formed with other municipalities. Primary care within the municipalities is handled in 250 health centres, each of which comprises a number of clinics. Most health centres have in-patient accommodation.

For specialist treatment the country is divided into 21 hospital districts. Each municipality belongs to a hospital district, which is responsible for organising specialised medical services and for co-ordinating hospital treatment within that district. Most districts have several hospitals, which may be regional hospitals, central hospitals or university hospitals.

There are university hospitals in the districts of Turku, Tampere, Kuopio and Oulu. Helsinki University Central Hospital is owned by a special joint municipal board. These hospitals handle the most specialised treatment in their area. Complex medical procedures are handled by a few specialist hospitals.

Funding

The healthcare provided by local authorities is funded partly by local taxes and partly from state subsidy; in addition, clients are charged for services. A wide range of private medical treatment is provided in the public sector, particularly in large towns. Sickness insurance covers a proportion of the patient’s costs for private care.

The local authority produces an annual budget for all activities including funding for the building of healthcare facilities. For projects under 2,000,000 FIM no further approval is required from the local authority. Projects of between 2m and 25m FIM require approval from the provincial authority. Those projects over 25m need to be included in the five-year building programme of social and health care.

Until 1991 there was a two-stage process for approval by government authorities, which was excessively long and complex, with the outcome that many new buildings were out of date by the time they were completed, although they generally achieved uniform quality and cost control. The situation has now changed, and projects are being pushed forward at the beginning of the design stage to try to ensure state subsidy; this, however, brings its own problems as the time for planning and design is shortened.

Design guidance

Control of all designs is through the local authority. The infrequency of new hospital projects, even during the most intensive building period from the 1950s to the 1980s, has resulted in no development of special standards or norms for hospital buildings except for those that apply to all
public buildings. These standards are administered centrally by the Ministry of the Environment. All building regulations are frequently updated and published centrally by Rakennustietosäätiö (Finnish Building Information Centre). There are no norms for hospital design but in new general hospitals the net area provision is 20–22 m²/bed and the gross floor area 35–40 m²/bed. Each patient room has an adjoining shower and WC. Ward sizes vary between 20 and 36 beds, and at least 50% of beds are in single or double rooms.

STAKES

The National Research and Development Centre for Welfare and Health (STAKES), established in 1992 following central government reorganisation, is supervised by the Ministry of Social Affairs and Health and financed by the Government.

The purpose of the agency is to enhance the health and social wellbeing of the nation and to promote social welfare and health services that are of a high quality and cost-effective for all citizens alike.

Its services include:

• evaluation, research and development of social welfare and healthcare services;
• procurement and dissemination of information;
• compilation and maintenance of statistics, databases and registers;
• promotion and implementation of postgraduate training programmes;
• collaboration with international organisations and research institutes.

STAKES occasionally publishes research and evaluation of healthcare buildings, promotes architectural competitions for hospital and healthcare buildings, and has recently produced some general “design notes on in-patient accommodation”.

Introduction to case studies

The trend for building large central and regional hospitals began in the 1950s and has lasted well into the 1990s. The modern block solution with multi-storey in-patient accommodation and a low podium for diagnostic, treatment and service units has been generally applied along with some horizontal hospital types. Kuopio and Lapland hospitals illustrate the former type, whilst Oulu represents one of the few horizontal schemes actually realised in Finland. Of the two hospitals featured here, only Kuopio was visited.
Introduction

The district served by Kuopio University Central Hospital has a population of 255,000 people with a wider catchment area of 865,000 people. In 1972, Kuopio Central Hospital became a university hospital, and a decision was made to realise the new premises by extending the old central hospital building which had been completed in 1959.

General description

The most recently completed phase of renovation and extension includes a new oncology unit and the upgrading of the original ten-storey ward building at the heart of the hospital, which contains medical specialties. The extension was designed in a circular form around the old hospital building. The intention was to retain the old hospital for its originally planned uses. The extension was realised in two building phases. In the first phase, carried out in 1983, the main entrance hall and polyclinics, the X-ray department, laboratories and the staff dining room were built at the front on three levels. The second phase, completed in 1987, comprises a new 300-bed ward building, operation departments, an intensive care department, pathological laboratories and autopsy facilities, and an equipment maintenance centre. The new buildings have three to four floors except for the ward building which, matching the old hospital, is ten storeys high.

Site and location

The hospital area is located on a steep slope of the Puijo ridge to the northwest of the city centre with direct access from the city ring road. The main entrance of the hospital faces south across an artificial lake. There were residential buildings for staff on the site but these have been adapted for hospital use.
In-patient accommodation

The nursing units are arranged on seven floors of a ten-storey ward block which, by virtue of its east–west axis, provides a southerly orientation for virtually all the in-patient bedrooms.

Each floor is made up of a pair of asymmetrical T-plan shapes connected by a central staircase and a bank of lifts, together with a zone of shared supporting facilities, which flank the main access corridor to each entrance.

In Northern Europe, south-facing ward units are essential due to the extremely short hours of sunshine during the winter months. Finland is no exception to this principle, and those bedrooms that cannot be south-facing are positioned to face east or west in the short extensions on the north side of the building.

The nurse stations are located in the middle of the unit at the junction of the central corridors, adjacent to an office, utility and treatment/examination room. Patient rooms are a mixture of south-facing four-person and east- or west-facing two-bed rooms, with single rooms close to permanently staffed areas and the isolation room in a more remote location.

Only the single rooms contain en-suite facilities whilst the multi-bed rooms share grouped sanitary facilities. The maximum distance from any bed to a WC does not exceed 12 m (a UK standard).

The zone towards the rear of each room provides dedicated space for trolleys, full height storage cupboards, and a clinical sink. The four-bed rooms do not appear small because of the large bay windows, although the space between the beds is very tight. The same applies to the double rooms, the widths of which are inadequate to remove the “window” bed from the room, although the outward-opening doors may help in this respect. External walls and windows are highly insulated.
The north-facing waiting area, dining room and a small sitting room, which are placed between the two bed units, are brightly furnished and extensively glazed, with views of the birch and pine forests that cover the hillside above the hospital.

By improving efficiency the hospital is now treating three times more in-patients than it was in the early 1970s. Hospital beds are being supported by intermediate care beds in local primary care centres. The spare capacity has enabled the hospital to take referrals from other parts of Finland.
Ward plan

1. single-bed room
2. two-bed room
3. three-bed room
4. four-bed room
5. en-suite WC
6. en-suite shower
7. smoking room
8. day room
9. dining room
10. kitchen
11. staff base
12. office/multipurpose
13. staff rest room
14. staff changing room
15. treatment/examination room
16. dirty utility
clean utility
bulk store
doctor on-call suite
waiting area
store
switchroom
cleaners room
17. linen cupboard
WC
assisted WC
staff WC
shower
assisted bath
trolley bay
disposal
18. equipment
wheelchair park
bed maintenance
bed bay
meeting room
rehabilitation
19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37.
Summary

In many respects the accommodation is conventionally laid out and competently planned. The gross floor area per bed is below average compared with the other units and the net to gross ratio about average at 1.46.

The overall ambience of the hospital and in particular the journey from main entrance to in-patient floor is punctuated by views and artworks. The interior design has been thoughtfully conceived combining colour, light and spatial effects to a high standard. The quality of finishes and materials is very high, notably the doors and ironmongery. Efforts have been made to avoid a uniform institutional look by giving each unit a character of its own, in particular, attention has been paid to the design of lobbies and entrances. Wherever possible, the rooms and corridors where the public have access, provide views of the surroundings and make orientation easier.
Lapland Hospital, Rovaniemi (Lapin keskussairaala)

Hospital profile

<p>| | |</p>
<table>
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<th></th>
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<td>Annual patient throughput</td>
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<td>Annual throughput per bed</td>
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Introduction

Lapland Hospital is located in the city of Rovaniemi on the southern side of Ounasvaara Hill, some 2 km from the city centre. Planning the new hospital began officially in 1976. Construction took a total of four years and the hospital admitted its first patients in early 1988.

The central hospital offers the population within the area complete central hospital services. Lapland Hospital is affiliated to the University Hospital in Oulu where most of the patients requiring specialised care are treated.

Approximately 14,500 patients are treated in the hospital annually, with an average length of stay of 6.2 days, making a total of 90,000 care days.

Building organisation

To provide for expansion and to accommodate external traffic, the building has been located at the centre of the 9 hectare site. The change of level across the site is 10 m; by manipulating the building section it was possible to build a ground-level entrance to four different floors. This arrangement provides a clear division of traffic flow within the building. The idea behind the building layout is to locate different operations within their own area, thereby providing short and clear internal connections. Another important consideration is that daylight could reach all main corridors.
The second floor handles nearly all patient and visitor traffic. The first floor contains the entrance to the emergency department, as well as some of the staff and patient entrances, and comprises the most important medical units such as first aid, X-ray, intensive care, surgery and anaesthesia, maternity, and the sterilization centre. The main entrance level contains public service facilities, most of the out-patient clinics, and the laboratory. The nursing units are stacked above the main entrance level (levels 3–6) with the exception of the paediatric wards, which are located in their own wing on the northern side of the building. The two lowest floors contain all the hospital support services and technical installations.

The hospital is constructed of in situ and pre-fabricated concrete with a column-beam framework. The facades are entirely of prefabricated elements. Use of fully prefabricated elements made it possible to minimise the effect of weather conditions on the progress of construction work.
In-patient accommodation

There are 4.5 storeys devoted to in-patient accommodation. Like Kuopio, every floor is divided into two units, each with up to 40 beds organised in a double corridor plan with a central core of clinical support rooms.

Over 60 per cent of the beds are in three-bed rooms; the remainder are in two-bed rooms together with two singles and one isolation room.

The nurses’ station is placed at the entrance to each unit, between the corridors and facing the lift lobby, giving full control over movement within each storey.

Like Kuopio and the other Finnish hospitals, Lapland is below average for in-patient areas, with an efficient net-to-gross ratio of 1.45.

Wards for adult patients are built on the so-called “large ward” principle. Each level has up to 80 beds, and the staff assigned to them are concentrated in the lobbies near the elevators. The beds are divided into two 40-bed groups, which are further divided into two groups of 20 by a common service space unit. Within the 20 beds there is a seven-bed sub-group.

These areas, as well as child neurology, oral diseases and psychiatry, have their own out-patient clinics. In addition, the hospital has a common first aid clinic, which includes an eight-bed observation ward. The purpose of the observation ward is to ease the workload of the other wards at night. The clinic also has a common surgery where minor operations can be performed.

Summary

As this hospital was not visited, comments are restricted to an analysis of the floor plans.

The majority of the rooms are for three persons. The plan is deliberately compact to conserve energy, and the building is orientated allowing sun on both long facades where bedrooms are located, but these do not provide ensuite sanitary facilities. All the support facilities are grouped centrally, producing a double corridor layout with large dayrooms at the ends of the building. Each floor provides some additional rehabilitation and treatment facilities.

The ward layouts offer little in the way of innovation, and the three-bed rooms are outmoded and unlikely to be repeated in future hospital designs. It is possible that they could be converted into two-bed rooms with en-suite bathrooms.
Sweden

Organisation

In Sweden the state is responsible for the overall direction of healthcare. The National Board of Welfare is the central supervisory authority for health and hospital services.

Healthcare provision in Sweden is undertaken by the 23 county councils and three municipalities. Under the county councils, the health and hospital services are divided into the primary health service, provincial hospital service and regional hospital service. Most hospitals are responsible for the treatment of the population within certain geographical areas.

Funding

Swedish healthcare is financed partly by taxation in each county and partly by state funding based on regional population levels. The proportion of GDP spent on health related activities has decreased by approximately 4.5% over the last ten years.

Service trends

In the last few years Sweden has moved towards a more deregulated healthcare system based on competition between healthcare providers. Several competitive health models are in operation, for example in Stockholm, Bohus and Dalarna. This deregulation of hospital services is expected to continue in other counties.

In the future it is believed that hospitals will be allowed greater autonomy, with managers adopting a more business-like approach. As experienced in other countries, it is predicted that there will be a reduction in the number of in-patient beds as these are replaced by out-patient and daycare facilities. In the future, it is expected that:

- primary care doctors will increase the scope of the care that they provide;
- patients will need to be referred to specialists by their primary care doctor;
- there will be closer co-operation between primary care doctors and hospitals.

A fall in the proportion of GDP spent on healthcare is expected, representing a fall from one of the highest-spending developed countries in terms of healthcare during the 1970s and 1980s.

The most likely and effective measures to be taken to control costs are:

- a reduction in hospital capacity;
- increased competition between providers;
- implementation of fixed activity-related payments.

IT will have a large impact on activities and procedures in hospitals – particularly communication between hospital departments, for on-line access to library information, and medical records. A computer system called “Bedside” has been introduced in Sweden to deal with patient reports, medicines and information flow; barcode readers have been specially developed for hospital supplies.

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National healthcare statistics

<table>
<thead>
<tr>
<th>Metric</th>
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<tr>
<td>In-patient care hospitals – Beds per 1000 population</td>
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<td>Total population – Thousand persons</td>
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(Source: OECD Health Data)
Design guidance

The Department of Healthcare Policy Federation of Swedish County Councils oversees standards in hospitals, although not all county councils have standards.

The Swedish Institute for Health Services Development (SPRI) is an independent research and development institute that promotes quality improvements, efficient use of resources and communication exchange. In collaboration with national and international academic institutions, it publishes and distributes information worldwide and offers a consulting service. It is financed by the Swedish government and the county councils. Until quite recently, the SPRI devoted resources to research and produced documents relating to the design of health facilities. Although it is now less active in this field, its library retains resource material and publications on healthcare building design.

SPRI now concentrates on quality improvement, evaluation and auditing, business monitoring, health economics, medical technologies, management systems, and information technology.
Norrtälje Hospital, Norrtälje (Norrtälje sjukhus)

Hospital profile

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<td>Gross area/bed m²</td>
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Introduction

Norrtälje is a community hospital with 96 acute care and five observation beds. It serves a large catchment area, complicated by the fact that it covers part of Sweden’s vast archipelago of some 10,000 islands. During the design and planning stage, a combination of factors helped to reduce the number of in-patient beds required from 138 in the old hospital to 96 in the new facility. The observation rooms in the emergency department allow patients – especially from the archipelago population – to be treated as out-patients, thus avoiding unnecessary in-patient admissions. Patients requiring intensive care are transferred to Stockholm.

General description

The new building contains four nursing units of 24 beds on two floors with an all-weather access lobby for vehicles, an emergency department, and units for X-ray, surgery, recovery, intensive care and endoscopy. It also includes the main entrance, pharmacy, telephone exchange and a goods terminal, as well as medical and X-ray record departments. There is a helicopter pad on the roof.

The buildings were constructed using a rich mixture of materials, with flush pointed pinkish-red brick, copper roofing, marble floor, natural birch ply and beechwood fittings.
Site and location

The town of Norrtälje is situated near the coast to the north-east of Stockholm, from where it is an hour’s journey by bus. The hospital is located a few hundred metres to the west of Norrtälje town centre on the banks of the Norrtälje river.

Brief

The planning of Norrtälje hospital was a close collaboration between care organisations, staff and representatives. The brief called for “a green hospital focused on the patient”.

In 1988 three architectural firms were invited to tender for the renewal of Norrtälje hospital. It was decided in 1991 that the renewal be achieved by additions and renovations to the existing 19th-century hospital. The project was completed by 1996.

The project began with a weekend workshop where 70 hospital employees met with the architect to become familiar with the planning process. The work was organised in groups, with participation from various staff categories. Each department had a group composed of eight people: doctors, nurses, nurses’ aids, secretaries etc, together with a representative of the county council and the architect.

Building organisation

The main entrance to the new building is marked by a piece of sculpture across the courtyard from the existing building. Entrance to the reception area is through a low porch with automatic doors. The high roof is supported on curved laminated timber arches above clerestory windows that flood the space.
with daylight. Within this area there are a cafeteria, shop, telephones, pharmacy, waiting area and lockers. Despite the accessibility and informality of the main entrance, the reception points comprise enclosed hatches rather than open desks.

A corridor running east–west on two levels overlooks landscaped courts and is the central axis of the building, with ward units on one side facing the Norrtälje river and the remaining accommodation on the other side facing the main “street”.

Bedrooms are arranged in compact clusters or “clover-leaf groups”, which shorten the overall length of corridors. The plan was developed to create three different room sizes and configurations to deal with some of the problems normally associated with two- and three-bed rooms such as loss of privacy or lack of an outside view. Some old wards have been converted into patient hotel facilities.

In-patient accommodation

The in-patient accommodation is arranged in two 24-bed nursing units, each sub-divided as three clusters of eight beds, each with its own nursing team. Each sub-group comprises three single rooms, a three-bed, and a two-bed room, all with en-suite facilities large enough to be used by patients in wheelchairs. There is a fold-down table and a utility room within each eight-bed cluster for use by each nursing team. The continuous development of staff competence is promoted, and patients are allocated their “own” nursing staff during their stay.

The integration of paramedical facilities (physical and occupational therapy rooms) in the nursing unit and the involvement of the nursing team in a smaller unit encourages early rehabilitation therapy and faster recovery. When the weather allows, patients can use the rehabilitation garden that was designed in collaboration with physiotherapists, an artist and the landscape architect.

Two guest rooms allow for increased family participation in the recovery of the patient, a benefit that has been used far more than had been expected.
Summary

During the 1980s new activities such as rehabilitation and admission procedures were introduced into the wards; now more out-patient and day surgery procedures are being utilised. Transferring certain procedures to the ward level liberates the central operating zone and improves the use of resources for the more complex and longer operations.

The location of in-patient accommodation, near diagnostic and treatment areas, aids communication between staff and patients. Advantages of such a layout include:

- staff continuity in pre-operative and post-operative care;
- reduction in waiting time for low-invasive operations;
- reduction in transport distances.

The compactly designed in-patient accommodation demonstrates the possibility of using innovative solutions to match nursing methods. One-, two- and three-bed rooms are derived from the same geometric principles in a well-thought-out plan. Each group of bedrooms is well served by storage and support rooms and situated not far from the open-plan kitchen, dining and sitting areas, which open up the internal corridor. Despite many of the standard components found in a typical hospital environment, this unit was one of the best-scaled, most colourful and relaxed units visited.
Vidarkliniken, Järna (Vidarkliniken Järna)

**Hospital profile**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Date completed</td>
<td>1985</td>
</tr>
<tr>
<td>Total number of beds</td>
<td>74</td>
</tr>
<tr>
<td>Overall floor area m²</td>
<td>8645</td>
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<td>Gross area/bed m²</td>
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<td>Average length of stay (days)</td>
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<tr>
<td>Bed utilisation</td>
<td>65%</td>
</tr>
<tr>
<td>Annual patient throughput</td>
<td>700</td>
</tr>
<tr>
<td>Annual throughput per bed</td>
<td>9.46</td>
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</table>

**Introduction**

The first part of the hospital opened in 1985 with 24 beds, and the rest of the building was completed by 1992. It comprises four nursing wards, a patient hotel and an out-patient clinic, which includes family doctors, a maternity unit and a child welfare clinic.

The hospital has applied an anthroposophical approach to medicine based on the theory developed by Rudolf Steiner (1861–1925), the Austrian-born scholar, scientist and artist. He saw the practice of anthroposophic medicine as an extension of Western scientific medicine, rather than an alternative to it. His goal was to engage the patient in a conscious process of self-healing and spiritual growth.

This holistic approach to healing includes treatments and therapies that recognise how the interaction between body, soul and spirit is affected by illness. Anthroposophical medicine considers illness to be a gift and an opportunity to gain new insight into the purpose of life. Self-help is considered important in aiding recovery and balance, and central to this philosophy is the understanding that different diseases and different stages of healing demand specific rather than general environmental support.
Site and location

The Vidarkliniken is located on Järna Bay near the town of Järna, approximately 50 km south-west of Stockholm. It is part of a larger community including a school, an art and performance centre, bookshop, a biodynamic farm, and a market garden; a number of curative homes for children and adults in need of special care are situated a few kilometres away.

The rural setting has developed over the past 30 years and each building has been carefully placed with respect to orientation, topography and vegetation.
Ward plan

1. single-bed room
2. two-bed room
3. three-bed room
4. four-bed room
5. en-suite WC
6. en-suite shower
7. smoking room
8. day room
9. dining room
10. kitchen
11. staff base
12. office/multipurpose
13. staff rest room
14. staff changing room
15. treatment/examination room
16. dirty utility
17. clean utility
18. bulk store
19. doctor on-call suite
20. waiting area
21. store
22. switchroom
23. cleaners room
24. linen cupboard
25. WC
26. assisted WC
27. staff WC
28. shower
29. assisted bath
30. trolley bay
31. disposal
32. equipment
33. wheelchair park
34. bed maintenance
35. bed bay
36. meeting room
37. rehabilitation

Sweden – Vidarkliniken, Järna
The form and layout of the hospital building takes advantage of a long east-facing slope below a wooded ridge. If it had been laid out as a linear block the building would have been too long for the available space, so it was “folded” to gain length and as a result encloses a garden, which opens to the west.

**Brief**

The architects worked with advisors at SPRI who helped to develop the spatial and functional requirements of the brief.

**Building organisation**

The architectural principles employed at the Vidarkliniken were planned to express the unity of opposites: for example, a cultivated garden on one side and wild, untamed landscape on the other. Different floors offer the same contrast. The basement contains spa rooms for mineral and herbal baths, a contrast to the light-filled and social character of the first floor. The spa is seen as the realm of earth and water, filled with strong scents of oils and ointments made from healing plants, and its location within the building affords it a protected and secure ambiance.

The second-floor assembly hall, used for musical and dramatic performances, is an exuberant, soaring space. In this room the upper, larger windows let in the light and lower, smaller windows provide “pictures” of the scenery outside. The second floor contains rooms for sculpture, music, eurhythmics (a special form of art where the therapist works with the patient on different gestures to form the art) and painting therapy. Here the mood is less buoyant and spaces are more constricted, mirroring the more intense concentration associated with therapeutic activity. Each of these rooms has been shaped to express and support one specific activity.

**In-patient accommodation**

The maximum number of beds sharing an en-suite room is four, although generally there are three patients to each shower room, which is located in a

1 × 23-bed nursing unit

<table>
<thead>
<tr>
<th>Summary table of areas</th>
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<tr>
<td>Number of nurse bases</td>
<td>1</td>
</tr>
<tr>
<td>Total number of beds</td>
<td>23</td>
</tr>
<tr>
<td>Single beds</td>
<td>3 (13.04%)</td>
</tr>
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<tr>
<td>Support area per bed m²</td>
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<tr>
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<td>23.90</td>
</tr>
<tr>
<td>Circulation per bed m²</td>
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<tr>
<td>Total area per bed m²</td>
<td>33.64</td>
</tr>
<tr>
<td>Max distance from nurse base</td>
<td>37 m</td>
</tr>
<tr>
<td>% bed area of total</td>
<td>44.37</td>
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lobby between the two-bed rooms. Single bedrooms are made large enough for a relative to stay overnight. Staff would prefer larger en-suite shower rooms so that they could assist patients more easily.

The hospital is considered full at 86% bed occupancy. There are 74 beds for in-patients; a separate house accommodates guests or relatives. It is acknowledged that ideally more single rooms are needed, although the view was expressed that people in double rooms do provide support for one another.

The architects have created patient rooms that are varied and interesting, with good views. Walls have been painted using the “lazur” method, where paint is applied in several thin transparent layers. Mineral or vegetable dyes in a casein and beeswax medium provide yellow ochre, warm rose and blue violet shades. Patients are prescribed warm- or cool-coloured rooms depending on the type of illness they have or what stage in the healing process they have reached.

Corridors are broken into short segments, with alcoves providing spaces that are designed to help arouse patients’ interest in increased activity. The day rooms feature a fireplace and exposure to sunlight in a more open and social environment.

The hospital is willing to mix patients with different levels of illness and diagnosis. It is acknowledged that patients will progress during their illness from a peaceful room with views of the natural world, to the upstairs corridor and through a series of spatial and social spaces to the external landscape itself. The balcony bridge provides an outdoor extension of the ward and access to the gardens below. Outside the in-patient wings, patients can explore the gallery, courtyard, kitchen, dining rooms and cafe, where they are exposed to nature, music and social discourse.

**Summary**

This project demonstrates that many qualitative aspects of a healing environment can be realised within a “clinical” institution. The inclusion of the Vidarkliniken within this study may therefore be fully justified if it encourages the procurers of acute care facilities to consider their aims in a new way. Many involved in the design of new hospital environments need ground-breaking projects such as this one to perform as exemplars, raise the spirits, and give confidence to those who believe it cannot be done.
Visby Hospital, Gottland (Visby Lasarett)

Hospital profile

<p>| | |</p>
<table>
<thead>
<tr>
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<tr>
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<td>147</td>
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<td>Annual patient throughput</td>
<td>9538</td>
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<td>Annual throughput per bed</td>
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Introduction

The inspiration for the ward layout at Visby Hospital came from the USA in the competition-winning design by ETV Architects of Stockholm.

The client was interested in the possibility of providing in-patient accommodation in the form of single rooms, which inspired the architects to find a layout that maximised functional efficiency.

The existing hospital had rooms with six and eight beds. It was felt that linear corridor layouts would be too long and would lose any advantage of a central staff base. The sense of isolation felt by the patient in a remote room was a concern for the client.
Site and location

The site overlooks the Baltic Sea to the north-west. The existing hospital was located within the old city of Visby, close to the city wall opposite the St George’s Church ruin where the earliest hospital had been established. The redevelopment plan aimed to replace and extend the existing facilities and to rationalise the different levels in adjacent buildings.

Building organisation

The winning scheme proposed a new zoning strategy. In-patient accommodation would overlook the park towards the sea, with a diagnostic and treatment zone facing the car park. The teaching facilities were to be placed at the junction between the old and new buildings, and articulated the change of axis in the plan.

The circulation principle of the new hospital was to distribute horizontally at ground level to the relevant lifts or stairs.

In-patient accommodation

The size of the circular wards was optimised at 16 segments containing 15 bedrooms and an emergency escape staircase. The staff base and essential support accommodation were placed at the centre, giving a direct view of all patients and the shortest travel distance to any bed. The open flight stairs were designed to allow good views of the sea in the distance from the staff base, although these have proved more restricted than first anticipated.

The rest of the support accommodation was placed in a shared zone between the two nursing units attached to the main hospital block.

Each bedroom is tapered and includes an en-suite WC and shower on the external wall, with table and chairs in the alcove adjacent. Surprisingly, the bedheads have been placed adjacent to rather than opposite the bathroom, which restricts views out.
The most recent research to be carried out on ward design in Swedish hospitals has been published by the Building Research Group, Royal Institute of Technology, Stockholm. The architects considered a “Nightingale ward in the round” as an appropriate arrangement for single room accommodation. A modified version of this circular layout was included in their recent competition entry for Trelleborg Hospital in which they were successful.

Although circular layouts have been used before in ward design, there have been none that combine single rooms with an almost entirely open centre from where all rooms can be observed. This solution goes some way to destroying the argument that single room solutions are difficult to supervise, given the relatively short travel distances from the nurse station to any bed and the ease of observation that the layout affords. This is not to say that the design is without some problems of its own. Apparently, the environment at the nurse base is not satisfactory in terms of:

a. acoustic design – sound is focused at the base and tends to be amplified;

b. visual links to the outside world – the intended view to the outside through the open-tread staircase is obstructed.

The staff working area and rest facility could possibly have been located more satisfactorily on the perimeter of the building at the cost of only one bedroom.

<table>
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<th>Type</th>
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<td>Max distance from nurse base</td>
<td>12 m</td>
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<tr>
<td>% bed area of total</td>
<td>40.97</td>
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**Summary**

The staff working area and rest facility could possibly have been located more satisfactorily on the perimeter of the building at the cost of only one bedroom.
Norway

National healthcare statistics

<table>
<thead>
<tr>
<th></th>
<th>1994</th>
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<tbody>
<tr>
<td>In-patient care hospitals – Beds per 1000 population</td>
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</tr>
<tr>
<td>In-patient bed days – Number of days/person</td>
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<tr>
<td>In-patient occupancy – % available beds</td>
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<td>Total expenditure on health – Millions ecus</td>
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<tr>
<td>Total expenditure on health – % of GDP</td>
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<tr>
<td>Total expenditure: in-patient – Millions ecus</td>
<td>n/a</td>
</tr>
<tr>
<td>Total expenditure: in-patient – % of GDP</td>
<td>n/a</td>
</tr>
<tr>
<td>Social protection: in-patient care – Coverage/total population</td>
<td>100</td>
</tr>
<tr>
<td>Length of stay in patient – Mean length of stay</td>
<td>10.1</td>
</tr>
<tr>
<td>Total population – Thousand persons</td>
<td>4336</td>
</tr>
</tbody>
</table>

(Source: OECD Health Data)

Organisation

An important principle characterising the Norwegian health service is its regionalisation and decentralisation of responsibility. The Norwegian counties have been responsible for hospital services since 1970. Political responsibility for the healthcare system rests with the Ministry of Social Affairs.

Norway has a smaller population spread over a larger area than the other Scandinavian countries; for example, there are approximately 13 inhabitants per square km compared with about 119 per square km in Denmark. It is divided into 19 counties with a total of approximately 450 municipalities. The counties are grouped into five health regions.

Funding

Healthcare services are financed through compulsory membership of the national insurance scheme, “Folketrygd”, which covers the entire population and has its own budget. The five main sources of income are:

- the central authorities and social service administration;
- the municipalities and the county municipalities;
- national contributions earmarked for priority areas;
- fees for service reimbursements from the national insurance to specialists;
- the patients themselves.

The municipalities and counties draw on local taxes and duties and receive funding from the state which is based on the size of the population, its age distribution and certain health and environmental criteria.

All in-patient hospitalisation is free of charge and is fully covered by national insurance. Hospitals are funded by fixed budgets from the county.

Health expenditure has constituted about 14% of total public expenditure over the last eight years.

Service trends

The number of hospital beds fell by 10% between 1988 and 1991, while at the same time there has been an increase in the number of patients treated. Out-patient facilities are playing an increasingly important role in patient treatment.

Trends indicate that Norway is moving towards a “diagnosis-related groups” (DRG) health system, for both information and financial reasons. So far, the DRG system has been tried out in four different hospitals in Norway.

Design guidance

The Norwegian Institute for Hospital Research, NIS, has been commissioned to produce articles for the Norwegian Board of Health on the design of hospital departments. These reports are well known in relevant departments throughout the Norwegian Health Services.
The planning of the new Norwegian State Hospital in Oslo was undertaken without direct reference to these, but was based on comparable projects together with a planning process involving the Ministry of Health and Social Affairs, hospitals and developers. No standards or legislation are being applied directly except in minor areas or for specific functions. Architectural practices active in this field tend to be those with a track record of hospital design in Scandinavia.

The two University Hospital projects for Rikshospitalet, Oslo and the Regional Hospital, Trondheim (RIT2000) are two of the largest projects featured in this study. They represent an interesting contrast in the development of hospital design at the end of the century.
The National Hospital, University of Oslo (Rikshospitalet)

Hospital profile

<p>| | |</p>
<table>
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<tr>
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<td>Total number of beds</td>
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<td>77%</td>
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<tr>
<td>Annual patient throughput</td>
<td>33,000</td>
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<tr>
<td>Annual throughput per bed</td>
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</table>

Introduction

The existing Rikshospitalet, which is a specialist hospital taking referrals from throughout Norway, has now outgrown its buildings and site. The proposed new building, which will be completed in 1998, represents the prevailing preference for low-rise, linear and expandable layouts organised on the basis of separate parallel traffic circulation systems and separate in-patient, out-patient and diagnostic and treatment zones accommodated within appropriate structural and service systems (see also Skejby, Køge, Huelva, Alcorcón).
General description

The state-funded Rikshospitalet will cover a total area of 130,000 m², which includes 30,000 m² for the University of Oslo Medical School. The new hospital will have the capacity to treat approximately 33,000 in-patients and 110,000 to 120,000 out-patients per annum.

The new Rikshospitalet in Oslo is the amalgamation of three existing institutions – the National, Orthopaedic and Rheumatic Hospitals. It will provide a new tertiary care centre and a University department of Medicine.

The hospital will become the national centre for medical research and give advice to national health authorities. Academic areas will be decentralised around the hospital.

Up to 70 per cent of patients are currently referred to the existing Rikshospitalet from other hospitals for pre-planned elective care, with the balance as emergency admissions. The new hospital will have 600 acute beds with another 74 intensive care and post-operative beds.
Site and location

The new hospital is on a 35 hectare site north-west of the city centre, close to the university and the Radium Hospital (specialist cancer centre). It is located on a south-facing slope which has a 19th-century psychiatric hospital (still in use) to the east, a forest to the west, and views of fjords to the south. The hospital has been designed to make the most of these features.

Programme

The project commenced in 1990 and the major part of the hospital will be opening in 1998. The last 10,000 m² will open in 1999–2000. Medplan, a consortium of four architectural practices, became the appointed architects in 1992 following a national architectural competition and a competitive tender.
Brief

Staff and 38 user groups were involved in the planning process. In addition to procuring a new stand-alone facility, there have been a number of sub-projects to develop the new hospital structure which have involved the merger and development of:

- the organisational structure;
- medical technology, including an £80m project;
- new applications in information technology and links with other regional hospitals;
- human resources management;
- commissioning new facilities.

Although the project started with very ambitious ideas these were moderated due to intense debate within the organisation.

Building organisation

A tower marks the hospital and its entrance from the suburban approaches. The main entrance will be accessed from the south-west-facing “town square”.

The hospital comprises six buildings which are connected by glass covered walkways (to facilitate orientation). The buildings vary in height from two to five storeys (one of which is a basement) but, because of they way they are arranged on the sloping site, the net effect is a low-rise design. This has the advantage of being able to provide “ground”-level entrances at a number of points up and down the site. All buildings are also connected via an underground supply channel. Stores are connected to wards by vertical shafts.

The medical section (including out-patients, X-ray, operating theatres and intensive therapy unit) is located at the centre of the site. Adjacent to the west, and overlooking the forest, is the paediatric unit with wards. Adjacent to the east with a view to the park around the existing psychiatric hospital are the general wards (surgery/medicine). To the south lies accommodation for teaching, administration, and medical research.

Internal traffic is divided by level: the A&E department and wards are on the upper floors (although the A&E entrance is on the “ground” floor because it is further up the slope). The out-patients department is on the same level as the main entrance, while the supplies department is located in the basement (with external access to the goods entrance at ground level, to the south).

There are three technical “mezzanine” floors in the medical building. These supply medical gases and other services to the operating theatres, X-ray departments and out-patient clinics, with endoscopy on the floors below.

It is expected that digitised X-rays and a patient archiving and communication system (pacs) will be used throughout in the future. The planning of the radiology department has allowed for this, although standard techniques will be used when the hospital initially opens.
Norway – Riskhospitalet, Oslo

Ward plan

1. single-bed room
2. two-bed room
3. three-bed room
4. four-bed room
5. en-suite WC
6. en-suite shower
7. smoking room
8. day room
9. dining room
10. kitchen
11. staff base
12. office/multipurpose
13. staff rest room
14. staff changing room
15. treatment/examination room
16. dirty utility
17. clean utility
18. bulk store
19. doctor on-call suite
20. waiting area
21. store
22. switchroom
23. cleaners room
24. linen cupboard
25. WC
26. assisted WC
27. staff WC
28. shower
29. assisted bath
30. trolley bay
31. disposal
32. equipment
33. wheelchair park
34. bed maintenance
35. bed bay
36. meeting room
37. rehabilitation
Key design issues

Key design issues were to achieve continuity, flexibility, short corridors, good views from all rooms and as much daylight as possible.

Because it is such a massive hospital it was intended that the scale of the patient floor be kept small by using three-storey buildings. Low window sills have been incorporated to allow patients to see outside from their beds.

Daylight has been provided to all areas where people will be based in full-time employment. This is particularly relevant for those in staff bases and clinical, technical and support areas, which are often windowless environments. The majority of operating theatres have windows. A consequence of this narrow floor plan is that all traffic will share the same corridors and there will be less segregation between different users at each floor.

Many lifts will be shared, although there will be some dedicated services lifts. Chutes will be used for bagged waste; the possibility of using the same chute for linen, with a diverter facility, is still under discussion.

In-patient accommodation

There will be 550 in-patient rooms when the hospital opens, and this will be expected to expand to approximately 600 within two years. In addition, a patient hotel with 90 beds is being built, and this can be expanded to 120 beds. Various designs for in-patient accommodation were explored, based on a 30-bed core module for which there are a number of variants.

A typical 30-bed nursing unit includes:

- four single rooms, including one isolation with facilities for barrier nursing;
- five two-person rooms;
- four four-person rooms.

Alternative ways of arranging beds in rooms have been explored so that the basic two-bed room can be combined to make any size of room containing up to ten beds. The unit plan illustration shows a majority of 2-bed rooms.

Although other designs for in-patient areas were more efficient, the adopted solution provides the best daylight, range of clinical support rooms, connections with the technical block and the most flexible traffic system. L-shaped modules can be combined with their neighbours, as appropriate.
There are two standard en-suite configurations for the two-bed rooms. Each room has en-suite shower and WC. The net area of a single room with en-suite is 18 m\(^2\). (All en-suite facilities in Norway and Sweden are fully wheelchair-accessible.)

The architects suggested that the four single rooms could have been designed as two-bed rooms, adding only an additional 28 m\(^2\) to each ward area. This, they believed, would have provided the in-patient areas with more flexibility for only a little extra cost.

The isolation room is at the far end of a wing, adjacent to the escape staircase. The four-bed rooms are sub-dividable for medical use. A pair of four-bed rooms can be combined to make, for example, an eight-bed room for intensive care of neurological patients.

Each room has a sitting space by the window and low window sills to enable people in bed to see outside.

Paediatric two-bed rooms are “combined” rooms, which comprise a bed and a sofa bed for parents who want to stay/sleep in the room with their child. Paediatric single rooms have an extra bed for parents.

**Summary**

The hospital is well designed, with effective internal and external links to existing buildings. Careful consideration has been given to the way the building form relates to the existing landscape. Functional elements are well integrated; for example, the clinical teaching facilities have been located within the wards and out-patient departments. The wards are cost-effective in the use of floor space and provide high-quality working conditions. The design is based on a highly centralised plan with strong horizontal communications between wards and treatment units.
Trondheim Regional Hospital (RiT 2000) Trondheim (Nytt Rikshospitalet)

Hospital profile

<p>| | |</p>
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<tr>
<td>Overall floor area m²</td>
<td>179,500</td>
</tr>
<tr>
<td>Gross area/bed m²</td>
<td>186.0</td>
</tr>
<tr>
<td>Average length of stay (estimated days)</td>
<td>6.0</td>
</tr>
<tr>
<td>Bed utilisation (estimated)</td>
<td>85%</td>
</tr>
<tr>
<td>Annual patient throughput (estimated)</td>
<td>49,898</td>
</tr>
<tr>
<td>Annual throughput per bed (estimated)</td>
<td>51.71</td>
</tr>
</tbody>
</table>

Introduction

In contrast to the Rikshospitalet in Oslo, the hospital at Trondheim will be reconfigured on its existing site, integrating with the urban context and developing over a much longer period. Although the strategic concept has been agreed in principle, the final design of the hospital is still to be determined; in principle, the site layout recalls the pavilion layouts developed for hospitals earlier this century.

The present condition of the University Hospital in Trondheim demonstrates many of the classic deficiencies of modern hospitals: an inappropriate mixture of outmoded buildings, dating mainly from the 1960s and 1970s; heavy building structures with little or no flexibility for change; fragmented organisational and operational solutions due to rapid technical and medical change; poor logistics; inadequate funding; long waiting lists; and, possibly the most alarming deficiency, inadequate means to improve the overall situation.

Development of the hospital site to the year 2013
Proposed Site Development Plan

1 Centre for Education and Service
2 Abdominal Centre/Central Supplies
3 Environmental Centre
4 Heart and Lung Centre
5 Psychiatric Centre
6 Neurological Centre
7 Women & Children Centre
8 Mobility Centre
9 Central Administration
10 Laboratories
11 Children's Nursery
12 Technical Block
13 Patient Hotel
14 Central Supplies and Technical Centre
15 Reserve
16 Park
Trondheim Hospital is situated near the city centre – close to the main transportation infrastructure and the Technical University, an important partner in teaching, research and development. Combined with financial constraints that limit the rate of redevelopment, these locational factors have been crucial in the decision to retain the existing hospital site. Furthermore, the new concept will have to be realised while the existing hospital continues to operate.

Background to the RiT 2000 Project

The RiT 2000 Project is not only a project for the provision of new hospital buildings. Organisational changes, quality improvements (especially in the eyes of the patient), productivity improvements, and cost reductions are equally important. Flexibility and readiness for change needed to be built into the solutions.

An interdisciplinary team was formed with specialists in architecture, economics, medicine, research, organisation and administration who had considerable experience in hospital activities.

RiT 2000 started with a pre-project evaluation where the strong and weak elements of the existing hospital were identified. An extensive evaluation was also made of all the hospital premises. The conclusion was that organisation, activities and premises no longer formed an integrated whole.

A user investigation was also included in the pre-project evaluation, which concluded that:

- the main focal point should be the patients;
- better information was needed;
- the number of staff treating a particular patient should be kept to a minimum, in order to build closer staff/patient relationships;
- there was a need to de-institutionalise where possible;
- a clarification of divisions of responsibilities between the primary health service and other hospitals was necessary.

A pre-project scheme based on the “Planetree” model is being tested in the rheumatological ward. The model is patient-focused, based on continuity and comprehensive treatment. The interior of the Planetree ward is characterised by peace, security and cosy domestic surroundings. Other departments at RiT have started to use the same philosophy and methods for redesigning their wards.

Competition

After qualification, six groups were invited to participate in an architectural competition to formulate conceptual solutions or ideas for the future of the hospital. The competition programme had no limitations in terms of size of the new buildings, number of beds or financial ceiling. Competitors were asked to provide the best solution for the teaching hospital taking into account expected changes and future trends. The competition brief placed emphasis on:
a patient-focused hospital;
the development design;
the development strategy.

It posed open questions about how to:

- establish a patient-focused hospital based on clinical centres (if that was the recommended solution);
- organise medical services in combination with clinical centres that could offer treatment both for in-patients and day surgery patients/out-patients;
- integrate training and research, making them central activities in the new model;
- overcome the problem of building a hospital on the same site as the existing one;
- integrate a dominant hospital structure into the existing urban surroundings;
- create flexibility for the future;
- ensure an increased integration of psychiatric and somatic activities;
- locate wards close enough to out-patient and day patient units to allow common use of personnel, equipment and space;
- de-centralise the administration facility, where elective patients are admitted, and direct emergency patients to a central unit with the necessary space for observation beds;
- adopt the holistic concept founded in the “Planetree” model.
Design concept

As a concept, the winning proposal by the consortium RiITLAEKKERT was considered unique. It retains the centre-based organisation where each individual clinical centre is virtually a self-sufficient unit with an academic section connected to the whole hospital. Treatment of patients, teaching and research are integrated in a manner that challenges and stimulates development and interdisciplinary co-operation.

The design is based on six clinical centres:
- female and child;
- sensory/neuro;
- abdominal;
- heart/lung;
- mobility;
- environmental.

In addition, there are six transverse centres:
- acute care;
- laboratory;
- patient hotel;
- teaching/service;
- administration;
- supplies.

The clinical centres are self-contained to a large extent so that patient and staff traffic is minimised. Each centre, therefore, has its own set of functions such as wards, out-patient clinic, examination/treatment area, out-patient surgery and operation ward, satellite laboratories, anaesthetic service, X-ray diagnosis, physiotherapy. In addition there are the following units:
- ergotherapy;
- intensive care;
- medical support;
- social services.

The hospital will have a centralised acute care unit but some patients will arrive directly at the appropriate centre. The core centre contains the teaching functions, library, shops and other service activities.

Each building is to have its own characteristic architectural form, harmoniously integrated with its surroundings. A great deal of emphasis is placed on the aesthetics of common areas, meeting points and meeting rooms, which embodies the patient-focused hospital philosophy and the architectural solution to this approach.

The separate block structure provides an appropriate solution for such a development. In addition, the block structure gives each individual centre the possibility of:
• separate public access and facade;
• individual outdoor areas;
• greater freedom of style and expansion according to individual needs;
• individual identity and distinctive character;
• a block structure connected to the existing road/street network;
• regulated building height equivalent to four to six storeys;
• east–west axis with a bridge over the River Nidelven for buses, pedestrian and bicycle traffic;
• de-centralised car parks on ground level around each centre;
• one main two-storey car park beneath the main access for approximately 480 cars.

Summary

This project is of interest for a number of reasons:
• it is programmed over a long period of time;
• the outcome is not finite;
• no one functional element is tied into a rigid construction framework that could exclude opportunity for change;
• the degree of separation/fragmentation is an unusual conceptual approach for a large teaching hospital;
• like Groningen, the masterplan integrates the form of the hospital with the form of the city.

The briefing and ongoing evaluative/iterative process may lead to quite an unusual physical entity and new sets of functional relationships.

In future, hospital developments may see more sophisticated architectural approaches that take account of site constraints, particularly in the urban context. Medical progress has allowed decentralisation, which calls for appropriately scaled hospital buildings that integrate with their surroundings and are capable of being reconfigured or extended.
Summary and analysis

This chapter organises the findings of the study into six areas for analysis and discussion:

1. schedules of accommodation;
2. ward shape;
3. bed distribution;
4. floor areas;
5. bedroom sizes and configurations;
6. bathrooms.

General statistics

As indicated in Table 1, two-thirds of the hospitals were completed in the last five years and half are teaching hospitals with 500 beds or more.

The range in overall hospital size is considerable, with gross floor areas from 8645 m² at Vidarkliniken (74 beds) to 232,000 m² at Groningen (1056 beds). The gross area per bed also varies widely: the largest can exceed the smallest by up to 400%. In this study, the largest gross areas per bed are found in teaching hospitals.

Average length of stay ranges from 4.3 days in Denmark to 8.0 days in Holland. The exception is the Vidarkliniken with 25.1 days, which reflects the type of care (intermediate and recuperative) it offers.

Table 1 Hospital profiles

<table>
<thead>
<tr>
<th>HOSPITAL</th>
<th>Date completed</th>
<th>Total no of beds</th>
<th>Overall floor area</th>
<th>Gross area/bed m²</th>
<th>Average length of stay</th>
<th>Bed utilisation</th>
<th>Annual patient throughput</th>
<th>Annual throughput per bed</th>
</tr>
</thead>
<tbody>
<tr>
<td>De Bijtjes</td>
<td>1996</td>
<td>148</td>
<td>15,245</td>
<td>103.0</td>
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<td>–</td>
<td>–</td>
<td>–</td>
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<tr>
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<td>1994</td>
<td>294</td>
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<td>98.6</td>
<td>7.8</td>
<td>72.3%</td>
<td>9,949</td>
<td>33.84</td>
</tr>
<tr>
<td>Groningen</td>
<td>1997</td>
<td>1056</td>
<td>232,000</td>
<td>219.7</td>
<td>8.0</td>
<td>80.0%</td>
<td>38,544</td>
<td>36.50</td>
</tr>
<tr>
<td>Nuremberg</td>
<td>1993</td>
<td>1022</td>
<td>98,000</td>
<td>95.9</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Alcorcón</td>
<td>1998</td>
<td>576</td>
<td>74,138</td>
<td>128.7</td>
<td>6.2</td>
<td>80.0%</td>
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<tr>
<td>Manacor</td>
<td>1995</td>
<td>200</td>
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<td>125.0</td>
<td>6.0</td>
<td>80.0%</td>
<td>8,273</td>
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<tr>
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<td>620</td>
<td>62,109</td>
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<td>80.0%</td>
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<tr>
<td>Aarhus</td>
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<td>4.5</td>
<td>85.0%</td>
<td>32,840</td>
<td>64.52</td>
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<tr>
<td>Vejle</td>
<td>1997</td>
<td>487</td>
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<td>5.3</td>
<td>70.0%</td>
<td>23,356</td>
<td>47.96</td>
</tr>
<tr>
<td>Kuopio</td>
<td>1985</td>
<td>926</td>
<td>95,000</td>
<td>102.8</td>
<td>4.5</td>
<td>85.0%</td>
<td>63,840</td>
<td>68.94</td>
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<tr>
<td>Lapland</td>
<td>1988</td>
<td>341</td>
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<td>14,514</td>
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<tr>
<td>Norrtälje</td>
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<td>96</td>
<td>14,000</td>
<td>145.8</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
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<td>1985</td>
<td>74</td>
<td>8,645</td>
<td>116.8</td>
<td>25.1</td>
<td>65.0%</td>
<td>700</td>
<td>9.46</td>
</tr>
<tr>
<td>Visby</td>
<td>1992</td>
<td>147</td>
<td>29,000</td>
<td>197.3</td>
<td>4.4</td>
<td>87.0%</td>
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</tr>
<tr>
<td>Rikhospitalet</td>
<td>1998</td>
<td>600</td>
<td>130,000</td>
<td>166.0</td>
<td>5.1</td>
<td>77.0%</td>
<td>33,000</td>
<td>55.00</td>
</tr>
<tr>
<td>Trondheim</td>
<td>2010</td>
<td>965</td>
<td>179,500</td>
<td>186.0</td>
<td>6.0</td>
<td>85.0%</td>
<td>49,898</td>
<td>51.71</td>
</tr>
</tbody>
</table>
1. Schedules of accommodation

In the majority of hospitals, accommodation in each ward comprises a core set of rooms:

- patient areas – bedrooms, sanitary facilities and day spaces;
- clinical facilities – treatment room, utility room and storage;
- support and administrative areas – a nurses' base, offices, staff restrooms.

Some hospital wards have dedicated accommodation for visitors, doctors on call, and/or rehabilitation services.

The case study wards include all of the functional components shown in Figure 1. Within each of these components there are differences in the number and sizes of rooms. The significant variable in the bed areas is the provision and location of bathrooms and day space for patients. Day space was provided either within larger bedrooms; in separate rooms; in multipurpose spaces; or not at all. Within the support areas it is evident that the provision for staff, visitors, rehabilitative therapy and storage varied widely. The number of rooms provided for each activity is shown in the tables below, which compare the schedules of accommodation of each hospital ward featured.

The schedules indicate what types of space are provided for a given number of beds, usually a ward or a nursing unit. Room areas are not included with the schedules because the information is at best incomplete and the drawings supplied were not all “as built”.

### Patient areas

<table>
<thead>
<tr>
<th></th>
<th>De Bijtjes</th>
<th>Antonius</th>
<th>Groningen</th>
<th>Nuremberg</th>
<th>Alcorcón</th>
<th>Manacor</th>
<th>Huelva</th>
<th>Aarhus</th>
<th>Veje</th>
<th>Kuopio</th>
<th>Lapland</th>
<th>Norrtälje</th>
<th>Viskoborg</th>
<th>Vilskerolitaet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beds served</td>
<td>30</td>
<td>18</td>
<td>32</td>
<td>16</td>
<td>32</td>
<td>32</td>
<td>29</td>
<td>30</td>
<td>24</td>
<td>23</td>
<td>15</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 bed rooms</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>8</td>
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<td>14</td>
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</tr>
<tr>
<td>2 bed rooms</td>
<td>4</td>
<td>6</td>
<td>6</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>9</td>
<td>1</td>
<td>5</td>
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<td>3</td>
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<td>5</td>
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</tr>
<tr>
<td>3 bed rooms</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 bed rooms</td>
<td>6</td>
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<td>4</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Isolation room</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Communal WCs</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>8</td>
</tr>
<tr>
<td>Assisted bathroom</td>
<td>2</td>
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<td>0.5</td>
<td>1</td>
<td></td>
<td>1</td>
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<td>1</td>
<td>0.5</td>
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<tr>
<td>Communal shower</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Dayroom</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0.5</td>
<td>0.5</td>
<td>1</td>
<td>0.5</td>
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<td>1</td>
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<td>1</td>
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<tr>
<td>Dayroom (smoking)</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Sitting/quiet</td>
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<td>1</td>
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<td></td>
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</tr>
<tr>
<td>Dining</td>
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</tr>
<tr>
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<td>0.5</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<td></td>
</tr>
</tbody>
</table>

The provision of dayrooms, eating and socialising space tends to decrease where a high number of single or double rooms are provided, or in older units. The exception is De Bijtjes, which caters for longer-stay patients. Bedrooms are discussed in detail later in this chapter.
Administration spaces

<table>
<thead>
<tr>
<th></th>
<th>De Bijjes</th>
<th>Antonius</th>
<th>Groningen</th>
<th>Nuremberg</th>
<th>Alcorcón</th>
<th>Manacor</th>
<th>Huelva</th>
<th>Aarhus</th>
<th>Vejle</th>
<th>Kuopio</th>
<th>Lapland</th>
<th>Norrtälje</th>
<th>Vråklinne</th>
<th>Visby</th>
<th>Sundsvall</th>
<th>Rikshospitalet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beds served</td>
<td>30</td>
<td>18</td>
<td>32</td>
<td>16</td>
<td>32</td>
<td>32</td>
<td>32</td>
<td>20</td>
<td>29</td>
<td>30</td>
<td>40</td>
<td>24</td>
<td>23</td>
<td>15</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Nurses’ station</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>1</td>
<td></td>
</tr>
<tr>
<td>Office/consult</td>
<td></td>
<td></td>
<td></td>
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<td>Nurse sub-base</td>
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<td>3</td>
</tr>
</tbody>
</table>

All hospital wards have a traditional nurses’ base, although its size and location varies. Some are positioned to provide views of all circulation areas and/or to act as gatekeeper at the ward entrance. In other hospitals, this function is not the primary criterion for location. Some nurses’ bases are shared by two wards during the day; a few are shared at night. Some bases are located at the centre of all nursing support functions and others are more remote.

In only a quarter of the in-patient units is there a specific room for consultations, interviews or counselling within the unit. In units without such accommodation, where there are large, shared bedrooms, privacy must be difficult to manage, particularly where visitors or relatives need to be seen in private.

Clinical spaces (treatment and utility rooms)

<table>
<thead>
<tr>
<th></th>
<th>De Bijjes</th>
<th>Antonius</th>
<th>Groningen</th>
<th>Nuremberg</th>
<th>Alcorcón</th>
<th>Manacor</th>
<th>Huelva</th>
<th>Aarhus</th>
<th>Vejle</th>
<th>Kuopio</th>
<th>Lapland</th>
<th>Norrtälje</th>
<th>Vråklinne</th>
<th>Visby</th>
<th>Sundsvall</th>
<th>Rikshospitalet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beds served</td>
<td>30</td>
<td>18</td>
<td>32</td>
<td>16</td>
<td>32</td>
<td>32</td>
<td>32</td>
<td>20</td>
<td>29</td>
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<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Consult/Exam</td>
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</table>

Nearly all wards have treatment rooms, at a rate of approximately 1 per 30 beds. Only two have more than one dirty utility room which, considering the long travel distances, was surprising. However, Alcorcón, with very long distances to the support accommodation, has a bedpan washer in each en-suite bathroom.
Domestic and stores

<table>
<thead>
<tr>
<th></th>
<th>De Bijtjes</th>
<th>Antonius</th>
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<th>Nuremberg</th>
<th>Alcorcón</th>
<th>Manacor</th>
<th>Huelva</th>
<th>Aarhus</th>
<th>Vejle</th>
<th>Kuopio</th>
<th>Lapland</th>
<th>Norrtälje</th>
<th>Vårtall</th>
<th>Visby</th>
<th>Rikshospitalet</th>
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<tr>
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Stores and their specific uses are difficult to identify on the plans provided. We have listed only those which are specifically named and which fall outside normal provision. The dishwashing room at Aarhus is an example.

Staff facilities

<table>
<thead>
<tr>
<th></th>
<th>De Bijtjes</th>
<th>Antonius</th>
<th>Groningen</th>
<th>Nuremberg</th>
<th>Alcorcón</th>
<th>Manacor</th>
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<th>Aarhus</th>
<th>Vejle</th>
<th>Kuopio</th>
<th>Lapland</th>
<th>Norrtälje</th>
<th>Vårtall</th>
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<th>Rikshospitalet</th>
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<tr>
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<tr>
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</table>

The provision of staff facilities on wards varies considerably, and it is assumed that where none exist within the unit, they are located centrally. The majority of restrooms are comfortably furnished and include facilities for making drinks. Only three hospitals, however, provide an additional, separate restroom for smokers. Few wards have changing rooms, although a number provide lockers in corridors, alcoves and offices. On-call suites for doctors are provided in six cases, with Spanish hospitals accounting for nearly 50% of the total. There is little dedicated teaching space in any of the wards visited, which is surprising given the proportion of university hospitals included in the study.
Visitors

<table>
<thead>
<tr>
<th></th>
<th>Groningen</th>
<th>Nuremberg</th>
<th>Alcorcón</th>
<th>Huelva</th>
<th>Kuopio</th>
<th>Norrtälje</th>
<th>Vidarkliniken</th>
<th>Rikshospitalet</th>
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</thead>
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<tr>
<td>Beds served</td>
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<td>16</td>
<td>32</td>
<td>32</td>
<td>30</td>
<td>24</td>
<td>23</td>
<td>30</td>
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<tr>
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<td>0.5</td>
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</table>

Dedicated waiting or sitting areas for visitors are evident in six units; ward social spaces in other hospitals are shared by patients, visitors and staff. Alcorcón and Huelva each have a large waiting room at the ward entrance, which is traditional in many Spanish hospitals. More than half the hospitals do not provide separate WCs for visitors or disabled people.

Therapy spaces

The two oldest wards have therapy rooms: one at Vidarkliniken, where physical therapy is integrated into a patient’s care plan; and a physiotherapy room at Vanta. Groningen has a large activity room in addition to two dayrooms, but its use is non-specific.

Shared space

<table>
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<tr>
<th></th>
<th>Nuremberg</th>
<th>Alcorcón</th>
<th>Manacor</th>
<th>Huelva</th>
<th>Aarhus</th>
<th>Vejle</th>
<th>Norrtälje</th>
<th>Vidarkliniken</th>
<th>Rikshospitalet</th>
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<tbody>
<tr>
<td>Beds served</td>
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<td>32</td>
<td>32</td>
<td>32</td>
<td>20</td>
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<tr>
<td>On-call</td>
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</tr>
<tr>
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</table>

Summary

The schedules reveal a degree of uniformity in hospital wards of different countries which belies the different layouts and management approaches. A comparison of individual room areas, which is beyond the scope of this document, would provide a more detailed insight into the use of space.
2. Ward shape

The most striking layouts are those which combine two or more nursing units around a common entrance with shared facilities and short travel distances (see Figure 2).

The majority of wards are based on the traditional design developed in the middle of this century and, with the exception of new communication and information technologies, have few innovative features.

Many of the hospitals featured, however, have tried to ensure that their in-patient accommodation is as flexible and adaptable as possible. At Antonius, for example, the architects have created a modular design which provides one-, two- or four-bed rooms using a combination of spaces. The ward blocks are also capable of being converted for other uses.

Rikshospitalet in Oslo has tried to achieve an even wider range of room sizes within a more conventional layout. By concentrating on designing flexible spaces, they have not had to resort to a new geometrical order. They have also investigated the possibility of using swing beds between the ward “fingers” as a way of varying the bed numbers for a given specialty.

The courtyard layout at Aarhus and Køge enables the size of ward sub-groups to be changed simply by sub-dividing beds at any point along the corridor. At some of the hospitals in use, staff indicated that they would prefer more single rooms. Only one hospital, Visby, has specified all single rooms in its new in-patient wards; the pairs of three-storey circular wards each have 15 single rooms equidistant from a central nurses’ base.

Table 3 shows that:

- linear racetrack units have a larger number of beds and produce the longest travel distances;
- cluster units and the circular ward at Visby have the fewest beds and significantly reduce/minimise travel distances;
- units with the nurse station at their entrance tend to be larger, with longer travel distances than those with centrally placed nurse stations;
- the number of beds served by one station has the most significant effect on travel distance;
- the two smallest units have the highest proportion of single rooms, are organised in clusters and have the shortest travel distances;
- the largest units with long travel distances tend to have a lower proportion of single rooms;
- maximum travel distance is directly proportional to the number of beds served, increasing by 1 to 1.5 m for each additional bed.

<table>
<thead>
<tr>
<th>Hospital</th>
<th>No. beds per station</th>
<th>Plan type</th>
<th>% single rooms</th>
<th>Maximum travel distance (m)</th>
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<td>cluster</td>
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<td>cluster</td>
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<td>Vejle</td>
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<tr>
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<td>racetrack</td>
<td>100</td>
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<td>Lapland</td>
<td>40</td>
<td>racetrack</td>
<td>7.5</td>
<td>48</td>
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</tbody>
</table>
Double corridor

This linear form is compressed by using a double corridor. The support rooms occupy the centre of the building, with bedrooms lining the two external faces. This layout enables the length of a block to be shortened but, like the “racetrack” design, requires the use of mechanical ventilation and lighting.

L-shaped linear

L-shaped and T-shaped plans are a variation on the linear single corridor layout. They are designed to shorten travel distances and enable the clustering of support services at the internal corners of the plan. The nurse base is usually placed at the intersection of the corridors.

Linear single corridor

This is the most common layout for in-patient accommodation. Bedrooms and support accommodation are located either side of a central corridor. Natural cross-ventilation is a feature of this design.

Figure 2  Ward shapes
Racetrack

This layout illustrates the development from the double corridor to a deeper plan where support spaces are grouped together in the centre of the floor. A central core is surrounded by a continuous “racetrack” corridor which serves bedrooms and dayrooms located on all four external walls.

The relatively compact layout results in shorter travel distances and reductions in external wall area, but relies heavily on the use of mechanical ventilation and artificial lighting in the corridor and support areas.

Cluster designs

As more and more single rooms are included within wards, layouts have been derived to reduce travel distances and to meet the needs of new nursing models. Cluster layouts allow a small number of beds to be grouped around local support spaces or a nursing sub-base.

In this cluster design, bedrooms are arranged in a circle around a nurse base and some social space.

Other support spaces are located in the “link” between wards where they can be shared.

This circular layout optimises room dimensions and useable space. A larger diameter would have provided a central core, resulting in a variation of the racetrack layout.

In this design, the two clusters in each Y-shaped wing share support services including a nurses’ base and the ward entrance.
3. Bed distribution

The study indicates that:

a. the majority of hospital wards have at least one lobbied single room for source and/or protective isolation;

b. the two-bed room is the most popular model of accommodation.

The most common multi-bed room has four beds, but only two hospitals accommodate more than 50% of their bed accommodation in four-bed rooms. None of the hospital wards have rooms containing more than four beds.

In the hospital wards featured, 226 of the total 430 beds are provided in two-bed rooms. The three Spanish hospitals employ two-bed rooms almost exclusively but it was acknowledged by Insalud that these would also function as single rooms when required.

There is no significant trend in the provision of single rooms except that there tends to be a higher proportion in the smaller, newer hospitals, for example Visby, Antonius and Norrtälje. It was, however, surprising how few had been included in the new Rikshospitalet, Oslo, due for completion in 1998. The lower proportion of single rooms at the recently completed Groningen Hospital can be explained by the fact that the wards were conceived some 15 years ago.

At some of the hospitals in use, staff indicated that they would prefer more single rooms. Only one hospital, Visby, has specified all single rooms in its new in-patient wards; the pairs of three-storey circular wards each have 15 single rooms equidistant from a central nurses’ base.

Three-bed rooms are generally unpopular; only three of the hospitals featured use them. The reasons for this unpopularity are examined in “Bedroom sizes and configurations”.

4. Floor areas

Table 4 analyses the floor areas. Areas were divided into three categories:

a. bed areas, including sanitary facilities and day space;

b. support areas, including assisted bathrooms, utility rooms and all staff areas;

c. circulation space, including internal partitions, space for pipes and ducts, and plantrooms.

The areas indicated are approximate and intended only to illustrate the relative spaciousness of the units. Inconsistencies may have occurred in the interpretation of the drawings.

a. Area per bed

The area per bed is the total floor area of the bedrooms, sanitary facilities and day spaces divided by the number of beds.
The bed areas in De Bijtjes hospital are much higher than average because the building is specially designed to provide full access for wheelchair users. The table gives two sets of average floor areas: one including De Bijtjes and another excluding it.

There is no direct relationship between ward shape and area per bed. The highest net and gross areas per bed are more than twice the size of the lowest, e.g., 36.20 to 15.01 and 45.90 to 20.72. This is not explained by the size or type of bedroom or the layout. The variable amounts of support accommodation and circulation rates create greater disparity than the areas devoted to patients.

<table>
<thead>
<tr>
<th>Table 4</th>
<th>Floor area analysis</th>
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</thead>
<tbody>
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<td></td>
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<tr>
<td>Vidarkliniken</td>
<td>17.17</td>
</tr>
<tr>
<td>Visby</td>
<td>18.81</td>
</tr>
<tr>
<td>Rikshospitalet</td>
<td>12.40</td>
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<td>AVERAGE 1 (inc De Bijtjes)</td>
<td>15.55</td>
</tr>
<tr>
<td>AVERAGE 2 (ex De Bijtjes)</td>
<td>15.07</td>
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</table>

Nett area range 36.20–15.01
Range of gross to nett ratios 1.20–1.73

The cluster designs tend to provide a higher proportion of bed area in each ward compared with the linear wards. The average bed area is approximately 15 m², with 7.5 m² support or ancillary space and 10 m² for circulation. The average gross area for each bed within a ward is about 33 m², which is considerably higher than in the UK.

Visby Hospital is an anomaly given its seemingly “efficient” plan, that is, generous bed area and short travel distance between staff base and bedroom. The circular part of the plan accommodates the beds with the shared link block providing most of the supporting rooms. With the exception of De Bijtjes this project exceeds the next highest gross area by nearly 20%, due mainly to its high rate of circulation.

The Rikshospitalet in Oslo has average gross and nett areas per bed but is low on space dedicated to patients, with approximately 20% less than the average.
b. Gross-to-net floor area ratios

The gross-to-net ratio (also known as the net-to-gross conversion factor) is the ratio produced by dividing any gross area (the sum of (a), (b) and (c) listed above) by the corresponding net area ((a) and (b)).

The ratio is an indicator of planning efficiency (where the lower the ratio the more efficient the plan) and can be used in the comparative analysis of different design solutions.

In many European countries the ratio is an important cost control tool. For example, in the Netherlands, hospital design proposals that do not achieve an overall ratio of 1.7 (1.45 in ward areas) or lower will not be granted a licence by the Ministry of Health.

A low ratio implies that savings have been made. In nearly all hospitals visited, these savings have been used to fund additional facilities within departments or large, impressive public spaces such as the main entrance at Antonius Hospital. At Groningen, the 60 m² saved in each ward area was re-allocated to provide more day and social spaces for patients, as well as an overall contribution to the hospital’s public areas.

5. Bedroom sizes and configurations

The configuration of a room is generally more important than its overall size. Although a large room tends to offer more useable space, a smaller but well planned room can meet the functional requirements just as easily. However, with architects under pressure to use space as economically as possible, there is a tendency to design down to the tightest acceptable dimensions. Such an approach does not make sense in the lifetime of the hospital. A better option is the "loose" fit design which enables rooms to be adapted in the future according to changes in function, equipment, technology and clinical practice. Despite greater capital costs, increased flexibility and adaptability are likely to produce substantial revenue savings even in the short term.

In this study, room sizes can vary widely according to local building codes, health and safety requirements, and furniture and equipment standards. Configuration, on the other hand, is determined by a number of functional requirements, for example the need for space around the bed for nursing, the intensity of care, and the need to ensure patient privacy.

Room dimensions (see also Appendix 3)

In single rooms sufficient space is required for the movement of staff and equipment around the bed; in multi-bed rooms, however, the clear dimension should be greater, as 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.

Of the countries visited, only the Netherlands provides any recommendation on the minimum clearance desirable for most access requirements.

In the case studies, clear dimensions in single rooms range widely, from 3.40 m to 4.05 m between cross-walls. A similar range was found in double rooms.
At Aarhus the architects have adopted a 4.20 m structural module (giving a clear dimension of 4.05 m) for double rooms, based on empirical evidence. At Groningen, however, a 3.9 m module was considered adequate, with a minimum 1.4 m clearance at the entrance to the room. They considered the commonly used 3.6 m structural module, giving approximately 3.45 m between walls, too small even for a single room. However, this dimension is still adopted in new designs, for example in Manacor and Alcorcón in Spain.

Room configurations

Single and two-bed rooms

The configuration of single and two-bed rooms is remarkably similar, despite the fact that internal room dimensions and floor areas vary considerably.

At Visby the bed position restricts the view through the window; however, with only some minor replanning of the layout, a more accessible and efficient use of space may be possible.

A variation on the single room has been developed for a more recent project at Trelleborg which shows how a double room can be combined with single rooms to achieve another solution.

Three-bed rooms

Three-bed rooms are unpopular with patients for social as well as functional reasons. In layouts where beds are arranged in a line, patients tend to prefer the bed by the window, with the bed by the door less popular, and the bed in the middle more unpopular still. Although these problems can also occur in a six-bed room (a common model in the UK), they are more readily tolerated, as a six-bed room is considerably more spacious.
Figure 3  Single and two-bed rooms

Figure 4  Three-person rooms. The two arrangements on the left are particularly unpopular. The other examples show how beds can be arranged more acceptably, with each bed having a ‘corner’ of the room.
- Figure 5: Four-bed rooms

- Figure 6: Joining together. These examples show how different room sizes can be combined using rectilinear and non-rectilinear forms. Note how each bed has a direct relationship with the window and its own territory within the room.
The example layouts illustrate a range of solutions for three-bed rooms. The layout at Lapland hospital is based on three beds side by side. A similar design at Halmstad in Sweden, conceived as recently as 1987, was the subject of vigorous public debate: the three-bed room was considered to be too cramped and did not ensure privacy for patients, relatives and visitors, and for staff undertaking clinical activities. The Kalmar design is probably considered to be a more acceptable solution, as the beds are grouped to face each other and the window. At Norrtälje the innovative plan form has integrated one-, two- and three-bed rooms elegantly into a plan form which provides each bed with a view and a “corner” within the room. At Vejle some of the three-bed rooms have been converted to two-bed rooms by installing a bathroom next to the corridor.

It is difficult to determine whether three-bed rooms are acceptable at all without a more detailed study; however, their advantages appear marginal and disadvantages considerable when compared with one- or two-bed rooms.

Four-bed rooms

The few examples of four-bed rooms follow the standard rectangular solution where pairs of beds are placed opposite each other. Exceptions are the splayed corner room at Groningen, the oversized room at De Bijtjes, and the staggered or offset room at Oslo. At Antonius, two-bed rooms are combined to make a long four-bed room with a good relationship with the window for each bed. The majority of four-bed rooms are supported by at least one en-suite bathroom, and sometimes two.

6. Bathrooms

Room configuration is determined not only by the circulation system, size of unit and overall form of the building, but also by the position of sanitary facilities. The options for creating bathrooms were illustrated and compared in HBN 4 Volume 1.

In this study, it was found that the majority of en-suite bathrooms are “internal”, in other words located next to the corridor.

However, in cluster layouts bathrooms are located in alternative positions on the external wall to allow close packing rooms with more compact circulation areas.

Internal bathrooms influence the relative position of the door to a room. There are three basic positions:

a. flush with corridor;

b. semi-recessed;

c. fully recessed.

A bathroom placed next to the corridor makes it possible to introduce into the bedroom a lobby, storage, and a clinical preparation area.

In some hospital wards, for example Groningen, WCs are provided in separate cubicles outside the bathroom to enable two patients to access the facilities simultaneously.
At Aarhus, two bedrooms share a WC and shower room which are located in a recess in the corridor. At Vidarkliniken the recess is used as a shared lobby between two rooms and as a buffer zone to the corridor where any clinical preparation can be done, as well as a means of additional visual and acoustic privacy.

At Kuopio and Lapland, sanitary facilities are grouped on the corridor away from the bedrooms. At Vejle there are internal WCs but showers are located elsewhere. Groningen provides a separate WC and shower room which, together with the clinical utility area, are accessed from an alcove within the room.

Rikshospitalet provides alternative layouts on either side of the corridor. One layout has an external shower/WC with two doors to allow for subdivision of the four-bed room into two double rooms. The other layout has its sanitary facility accessible from the main corridor in a tapering recess.

The bathroom at Norrtälje is located in the corner, with significantly less privacy.

Antonius is the only hospital to provide more than one WC for each four-bed room. These are located at the ends of the room, but in close proximity to two of the beds.

Given the very high proportion of en-suite facilities in single and two-bed rooms, it was surprising how low the general level of provision fell for three- and four-bed rooms.
Conclusion

In principle, the development of in-patient accommodation cannot be separated from the development of the whole hospital. However, it was apparent in looking at these hospitals that the most notable areas of innovation were in the design of public spaces, the introduction of information technology, and the overall development of treatment and diagnostic areas, with emphasis on increased daycare and low invasive techniques. The design of these areas has departed quite radically from the traditional hospital form.

The development of in-patient areas has concentrated more on qualitative issues than on a major reorganisation of layout or space. New legislation requiring better working environments for staff with natural light and ventilation, rest areas, day spaces, and improved catering facilities have all influenced ward design.

The Nuffield Study, ‘Studies in the functions and designs of hospitals’, published in 1955, has had considerable influence on ward design over the last 40 years. The study found that, in general, the effectiveness of in-patient care was determined not only by the nursing practices of the time but also by the size of the unit, the number of patients, location and availability of space to perform certain functions, and environmental factors including sunlight, daylight, ventilation and acoustics. These factors have remained relevant to the present day and can be applied almost universally to the design of in-patient accommodation as represented by the variety of layouts and bed arrangements illustrated in these European case studies.

One of the most important factors to emerge is the objective common in all the projects to achieve improvement to the quality of the environment for patients, staff and visitors. There is no single approach or consensus on how that quality can be achieved; instead, hospitals and their designers have adopted various strategies to achieve these aims.

This conclusion, drawing on examples from the individual case studies, brings together some key elements that affect environmental quality. It also looks at the pointers to anticipate ways that in-patient accommodation could develop in the future.

The importance of environmental quality

Environmental quality is dependent upon a wide range of interrelated variables. It can be argued that the quality of nursing care, above all, will most influence how people feel about their stay in hospital. However, the quality of food, standards of hygiene, pleasing non-clinical furnishings and decoration, and the ability to control temperature and lighting are also factors affecting a patient’s feeling of well-being. Striking the balance between the interests of patients, doctors, nurses and visitors when planning bed areas whilst at the same time developing and retaining a patient’s independence, should take high priority. This requires a progressive approach, which begins at the planning stage and ends with the finishes and furnishings. Good quality finishes and fittings cannot compensate for a poorly designed facility; at best they can improve the quality of the environment.

Environmental quality depends on:

- good functional relationships;
- adequate space;
- short travel distances;
- easy observation;
- barrier-free access;
- environmental control;
- appropriate facilities.

The criteria divide broadly into four groups, of which two are capital-intensive: those that rely on the functional content and spatial arrangements of the hospital, and those that rely on technology to control the environment. The other two groups are initially provided through capital but can be altered and modified on a continuous basis and financed through revenue budgets. They include finishes and furnishings, equipment and services.

Functional content

There should be sufficient space in bedrooms to comfortably accommodate the patient and a minimum number of staff and quantity of equipment to carry out both routine and emergency procedures. Space for family support should include adequate seating for up to three people – either built-in or stored nearby. Some of the wards in the study provided compact fold-down divans, which can be used for overnight stays with storage.
beneath. For personal storage most hospitals offered either a portable bedside unit combing table, wardrobe and shelf, or a larger built-in wardrobe near to the entrance of a room. Additional space is desirable for toiletries, reading and writing materials, radio, flowers, cards, and non-perishable food.

The conventional arrangement of rooms with more than one bed is to have a “window” bed and a “door” bed. Patients generally prefer a “window” bed with good views (nature and landscape); however, being able to see the daily activities within an in-patient area may also provide a stimulating alternative to the views through the external window, thus offering the patient an opportunity to “participate” in the life of the nursing unit. In some cases privacy rather than observation may be the more dominant factor in the planning of in-patient areas, and the design should balance the need for both.

Single rooms minimise patient transfers, increase privacy, provide some isolation services and incorporate larger en-suite bathrooms. Such flexibility, as well as the acknowledged preference for more privacy and peace, forms a persuasive argument for the increased use of single rooms.

Space in the hospital will also be required for a number of uses relating to patients’ social and rehabilitation needs, but from these case studies it is difficult to define the specific scope and function of this space. However, it is clear that there are opportunities for patients to make use of the “new generation” of public areas that was evident in almost all the hospitals visited, which in many cases were closely associated with the in-patient accommodation.

**Technology**

Energy efficiency can be improved by the use of sophisticated control systems. Many systems are based on the use of sensors which detect changes in environmental features such as heating, lighting and ventilation, and make adjustments as necessary. Natural ventilation can significantly reduce energy costs so that designers are encouraged to create natural inner climates using atria and conservatories. These have been successfully incorporated at Groningen, Antionius, Rikshospitalet and de Bijtjes hospitals. Such spaces provide alternative day spaces away from ward areas, a pleasant year-round micro-climate, alternative circulation patterns, and a reduction in the overall surface area of the buildings.

Allowing patients to control their own environment from the bed means more independence and requires less nursing attention. Easily understood controls for bed, TV, lights and nurse call with pressure-sensitive buttons, accessible with either hand, are now available, together with the means to control privacy or shading.

**Finishes and furnishings**

All finishes and furnishings in hospitals have to conform to strict health and safety requirements which focus in particular on containing the risk of fire and the spread of disease. There is a limited choice of products which comply with these requirements while remaining durable and attractive. Despite considerable care taken in product selection and choice of colours and decoration, the interiors of most hospitals visited are generally unexceptional. Instead, more emphasis has been accorded to the public areas, where materials and finishes are of a very high quality. Works of art are conspicuous in most of the hospitals as a direct result of proper funding through the requirement to spend a proportion of a new building’s capital costs on artworks.

At Trondheim, a pilot project incorporating the Planetree principles of care has been set up on a floor of the existing hospital in a rheumatic rehabilitation ward. The use of domestic furniture and household objects, together with complementary decor, has produced an intimacy and scale more normally associated with a house or family hotel. It remains to be seen whether the application of the same approach on a larger scale is practicable.

Although Vidarkliniken is not an acute or teaching hospital, its environmental qualities are underpinned by a holistic philosophy that aims to create an effective healing environment. Lessons can be learned from its distinctive use of unusual colours, materials and lighting to create high-quality environments. There seems to be no reason why in-patient accommodation in “mainstream” hospitals cannot achieve the same high standards of ambience.

**Equipment and services**

The impact of changes in equipment and furniture could not be properly assessed. However, if more and more equipment is brought to the bedside in the future, space will be required to store it either within or close to the in-patient accommodation.

There were a number of different solutions for bedhead services ranging from the conventional horizontal trunking to the more discrete low-level services unit as for example at Alcorcón, Madrid. In future, pendant and suspended systems may be required to keep floor areas clear for access to the patient.

TV sets were typically suspended or embedded in the soffit. Access to bedside telephones, personal data communication systems, and computers may be demanded as consumer expectations rise.

In the Netherlands, recent ergonomic research has discovered that people have generally become taller, and this trend will continue. The STAGG report concluded that
in future all floor plans would have to accommodate a bed measuring 980 mm wide by 2400 mm long. This would directly affect corridor widths, door openings and clearances where access is constricted. Such research ought to establish minimum criteria not only for the Netherlands but also for other countries in Europe.

**Key factors in the future of hospital design**

Eleven of the 16 hospitals selected for this study were commissioned following a competition. The wide range of hospital designs reflects the diversity of the authorities responsible for commissioning these buildings and the meticulous briefing procedures. The involvement of a team of judges ensures a broader input of expertise than is available with conventional design commissions. Higher budgets and operational innovation are often attributable to the competition system in Europe compared with the United Kingdom, which has looked into private sector involvement to fund projects but has not produced such a range of diverse or innovative ideas; there may be lessons to be learned from this approach.

Architecture can play a significant role in projecting positive images of healthcare, which can help to de-institutionalise and de-stress hospital environments. Appropriate environments for the delivery of healthcare to in-patients may be required to encompass a broad range of activities from “high-tech” interventions to health education and counselling. To balance this there needs to be an environment that is efficient and discreet, where information can be exchanged with confidence, where patients and relatives can personalise and furnish their space even during the shortest stay in hospital.

Inspiration for new hospital environments is coming increasingly from the leisure and retail sectors. As hospital standards develop along the lines of hostel, guesthouse and hotel, the higher costs of providing more comfortable accommodation are balanced by shorter lengths of stay. Raising the standards of in-patient accommodation is also achievable through the conversion of existing wards. For example, the conversion of two- and three-person rooms into single-bed rooms with en-suite facilities and additional space can fulfil the aesthetic, hygienic and clinical requirements and significantly improve the quality of the patients’ environment. The cost of providing a larger bed area may be offset by staffing economies, reduced future capital requirements and the reduction of travel distances.

Recent developments in medical technology have had relatively little effect on the structure and shape of hospitals. The drive to make hospitals more compact may become less important as integrated communication and information systems are developed. This “decompressing” of buildings may allow architects the opportunity to design hospitals that are more humane, energy-efficient, and easier to adapt and change.
## Appendix 1 – Comparative ward study: influence of form on area

<table>
<thead>
<tr>
<th>Linear</th>
<th>Alcorcón</th>
<th>Manacor</th>
<th>Huelva</th>
<th>Aarhus</th>
<th>Vejle</th>
<th>Kuopio</th>
<th>Vidarkliniken</th>
<th>Rikshospitalet</th>
</tr>
</thead>
<tbody>
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<td>Number of nurse bases</td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td>Size of nursing unit</td>
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<td>Area per bed</td>
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<tr>
<td>% circulation of total</td>
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<th>Groningen</th>
<th>Lapland</th>
<th>De Bijtjes A</th>
<th>De Bijtjes B</th>
<th>Antonius</th>
<th>Nuremberg</th>
<th>Norrtälje</th>
<th>Visby</th>
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<td>Size of nursing unit</td>
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<td>Total number of beds</td>
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<tr>
<td>Net total area per bed</td>
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<tr>
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<td>% bed area of total</td>
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<td>% support area of total</td>
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Appendix 2 – Ward typology and geometric designs

Ward layout typology

From the early tented layouts of military hospitals and linear wards advocated by Nightingale, new designs emerged to make observation and accessibility more convenient.

The tendency towards greater sub-division brought with it the need to maximise cross-ventilation and provide views, whilst maintaining efficient use of space generated plans in the shape of X’s, Y’s and T’s.

Deep ward plans were considered to be the most economical plan, by reducing the travel distance and external wall area, and were attractive for multi-storey solutions.

The focus on efficiency led to a proliferation of plan types suited to both horizontal and vertical applications. In recent years, the preferred method of horizontal evacuation of patients in case of fire has favoured low-rise accommodation.
The cluster layouts identified in this study are based on geometric designs. Geometric designs are used to gain more external wall area so that the use of natural light and ventilation can be increased. They also provide solutions to deal with deep plans and internal corners which commonly produce “dead” space which cannot be used for continuous nursing activity.

The diagrams above illustrate how space-filling surface pattern lattices and tessellations can generate a range of successful planning approaches, albeit with non-rectilinear modules (rooms). Close packing octagons and triangular arrangements are the most common models.
Appendix 3 – Ward dimensions: clear dimensions

These UK examples (from HBN 4 Volume 1, Stationery Office 1997) show the most recently published single-room layouts and their critical dimensions.

Flexible in the position of the bed is shown above in two room shapes which meet minimum working areas. These types of room plan have been used in close-packing cluster designs.

All the room diagrams are dimensioned either by their structural module, that is, from the centre lines of walls or columns, or as clear dimensions between walls. Where it is not possible to estimate the position of the external structure, a combination of centre line of internal wall to the inside face of external wall is used. All dimensions are either taken from detailed drawings or approximated.
Comparing published material from a number of countries reveals a lack of consensus on room dimensions. NB some dimensions are clear, others are structural.

**Italian design guide**

The recently published research ‘Mettaprogettazione per L'edilizia Ospedaliera’, CNR 1993

**Netherlands design guide 1995**

This diagram is based on minimum recommended clear dimensions suggested in the STAGG report 1995.

**German design guide 1992**

Typical generic room layouts and dimensions taken from ‘Krankenhausbau’, 1982.

**UK design guide**

## Appendix 4 – List of hospitals and architects

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<tr>
<th>Hospital</th>
<th>Architect</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Belgium</strong></td>
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</tr>
<tr>
<td>Mrs. Bea Tielemans</td>
<td>Mr. Richard Foque</td>
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<tr>
<td>1602 Vlezenbeek</td>
<td>2000 Antwerpen</td>
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| **Germany** | |
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| Klinikum II Nürnberg | Mr Prof. Hans Peter Haid |
| Breslauer Straße 201 | H & P Architects & Ingenieurs |
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| Spain | Spain |
| Tel.: 34 (1) 338 0437 | Tel.: 34(1)373 9705/373 9886 |
| | Fax: 34(1) 373-9472 |</p>
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