



Strategic Promotion of Ageing Research Capacity

**Modelling Health
Systems:
delivering care to
older patients with
hip fracture**
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Chooi Lee

*Meeting the challenges of
an ageing society*

Funded by

EPSRC

Engineering and Physical Sciences
Research Council

bbsrc
biotechnology and biological
sciences research council

April 2008

Modelling Health Systems: delivering care to older patients with hip fracture

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Improvements to health care systems can only be achieved once their extreme complexity is fully understood: this study provides a significant step forward in this process. The standards of care for older people with hip fracture vary greatly across the UK, but are often found to be unsatisfactory, and this is an area of care which would benefit considerably from reorganisation. Understanding the very complex systems which operate during the care of patients with hip fractures needs very detailed, precise analysis. This requires mapping the journey taken by the patient from initial admission to hospital through to discharge, including all the activities and processes involved in their care. This study has shown that it is possible to do this and to produce detailed maps of the patient journey, which can ultimately be incorporated into high powered computer tools to support the evaluation of alternative approaches to the reorganisation of the care of patients.

Key Findings

- The first National Audit of Falls and Bone Health highlighted the need for improvements in the care of older patients with hip fractures in the UK. However, there have been few recommendations about how this might be achieved. One approach is to develop computer-based simulation tools similar to those which have been successfully used to re-engineer business processes. Simulation tools enable health professionals and managers to play out different scenarios on the computer and help them to identify potential improvements. This study strongly supports the feasibility of the development of such high-powered tools to aid decision makers in their quest for the better organisation of the care of hip fracture patients.
- Simulation models require a detailed and accurate understanding of the health care system. This enables the development of maps which show the way in which a patient moves through the care system, and the people, processes and influences that are encountered on that journey. The study describes the use of a particular set of mapping tools to describe the care of older patients with hip fracture in an acute hospital setting. These mapping tools provide information which is used to develop simulation models.
- The models are represented by simple diagrams which are visually easy to interpret by people from a range of professional backgrounds. This increases the likelihood that different stakeholders will accept the findings and recommendations made by experimenting with the models.
- The knowledge gained from this study will help guide best practice in preparing an effective integrated care pathway. This could potentially lead to improvements in patient outcomes, such as better survival rates, faster recovery, and an increase in those regaining their independence after the fracture.

Introduction

The Issues

The process of caring for older patients with hip fracture (also known as fractured neck of femur) is complex, long, and involves several diagnostic, therapeutic and administrative activities. These activities occur in the accident and emergency (A&E) and orthopaedic departments, the operating theatre, and in the community. They involve a wide range of health professionals, support staff and administrators.

Hip fracture is a major cause of morbidity (ill health) and mortality (death), putting pressure on health resources worldwide. In the UK, the delivery of care to patients with hip fracture has been identified as an area that has considerable potential for organisational improvement.

The Background

Health care systems are complex and difficult to analyse. Providing care to a patient population is a technologically advanced process and requires the collaboration of a wide range of specialists who have had many years of training and experience. The paths followed by patients typically depend on clinical judgement and personal choice, which therefore can make them uncertain and highly variable. The size of the UK National Health Service (NHS) makes understanding and mapping the organisation of care systems a complex task which requires the application of special techniques.

In the past, a variety of software engineering techniques and tools have been used for the analysis of health care systems. Recently, the 'object oriented' concept, and the establishment of the Unified Modelling Language (UML) in systems analysis and design has provided new tools for the modelling of health care systems. However, there are no clear standards or guidelines for the use of UML in the mapping of health care processes and any benefits have, so far, not been demonstrated.

The Aims of the Study

The aim of this research was to create a method for capturing and presenting information about the flow of patients through the care process. Specifically to:

- **describe** the activities involved in the care of older people presenting to an acute care hospital with a hip fracture;
- **create** a library of information with the results from mapping this process.

In the longer term, this information could be used for simulation studies that will evaluate how changes in the organisation of care might improve performance. This would show the impact of proposed policies on patient and care systems for the care of older patients.

The Study

A process mapping exercise was completed at a typical hospital. An approach known as **soft systems methodology** (SSM) was initially used to define the boundaries and basic concepts of the care process. A statement about the core purpose of the care system was expressed as a **root definition** and a **purposeful activity model**. To compile the root definition and to stimulate thinking about the care process a **CATWOE analysis** was conducted, which essentially is a checklist of necessary elements that combine together to show a human activity system.

Semi-structured interviews and meetings with care-givers and hospital managers were carried out. The aim of these interviews was to learn about the process of care, the system capacities, and the problems and suggested changes. This led to the production of a **narrative**, which is a written description of the progress of a patient through the care process.

The results of the process mapping were stored and presented in a systematic computer-based fashion. This library of information included the narrative as well as UML diagrams to represent the activities involved in the care process, and to describe the behaviour of the individual groups of people involved in the care system (e.g. patients, surgeons, physicians). Three types of tools were used in the analysis to describe the pathways and activities associated with each care stage.

- **UML activity diagrams** showed the sequence and conditions of the progress of patients through care activities from a care-system perspective;
- **Use cases** provided details about the function performed by each care activity shown in the UML activity diagram;
- **UML state diagrams** described the different states a patient may be in while progressing through the care process, the events that trigger changes between the states, and any associated conditions. For example, a patient deemed fit for operation triggers the sequence of events which lead to the operation.

Main Findings: CATWOE

CATWOE for transformation process ‘Older patient presents to A&E with hip fracture’ to ‘Older patient has condition treated’.

CATWOE	Details
Customers	Patients presenting with FNOF symptoms to the A&E department
Actors	Care givers, hospital managers, social-care workers
Transformations	The symptoms are alleviated by a series of investigative, therapeutic, rehabilitative, and administrative actions
Worldview	Civilised societies need to care for sick people
Ownership	NHS Trust; Primary Care Trust
Environment	Clinical guidelines, financial constraints, resource availability

FNOF - Fracture neck of femur; A&E - Accident and Emergency; NHS - National Health Service

Main Findings: Root definition

The root definition of the care process was: *An NHS and Primary Care Trust (PCT) owned system operated by care givers, hospital managers, and social-care workers to treat older patients presenting with fractured neck of femur to the A&E department by a series of investigative, therapeutic, rehabilitative, and administrative actions, whilst taking into account clinical guidelines, financial constraints and resource availability.*

Main Findings: Narrative

The narrative describes the sequence of events related to the process of care for patients with hip fracture. The example narrative description is of the care process for patients presenting to an A&E department through to admission to an orthopaedic ward.

Example Narrative

Acute Care: Admission to Hospital and Peri-operative Care

The pathway begins when a person falls and suffers a fracture. The person is transferred to the Accident and Emergency (A&E) department of the hospital by ambulance or private means. The triage nurse assesses the patient’s condition in the A&E department. The patient is classified according to the severity of the case (red, yellow, or green). A patient with symptoms of fractured neck of femur is most commonly assigned a yellow classification, which indicates an emergency but not life threatening condition. An A&E physician or nurse then checks the patient’s vital signs, records the pre-fall health condition of the patient and makes sure that the patient receives pain medication. Subsequently, in consultation with an A&E physician (if available), several basic tests (such as blood tests) and X-rays (hip and often chest) are ordered and performed. The patient is transferred to the radiology department for the x-rays. The A&E physician or nurse then reviews the test results. If a fracture of the neck of femur is diagnosed, the patient is deemed admissible and an intravenous (IV) drip is started. While in A&E, planning for prevention of thrombosis is also made and the patient is transferred to the orthopaedic ward for admission. An orthopaedic surgeon may also review the test results while the patient is still at the A&E.

Main Findings: Use cases

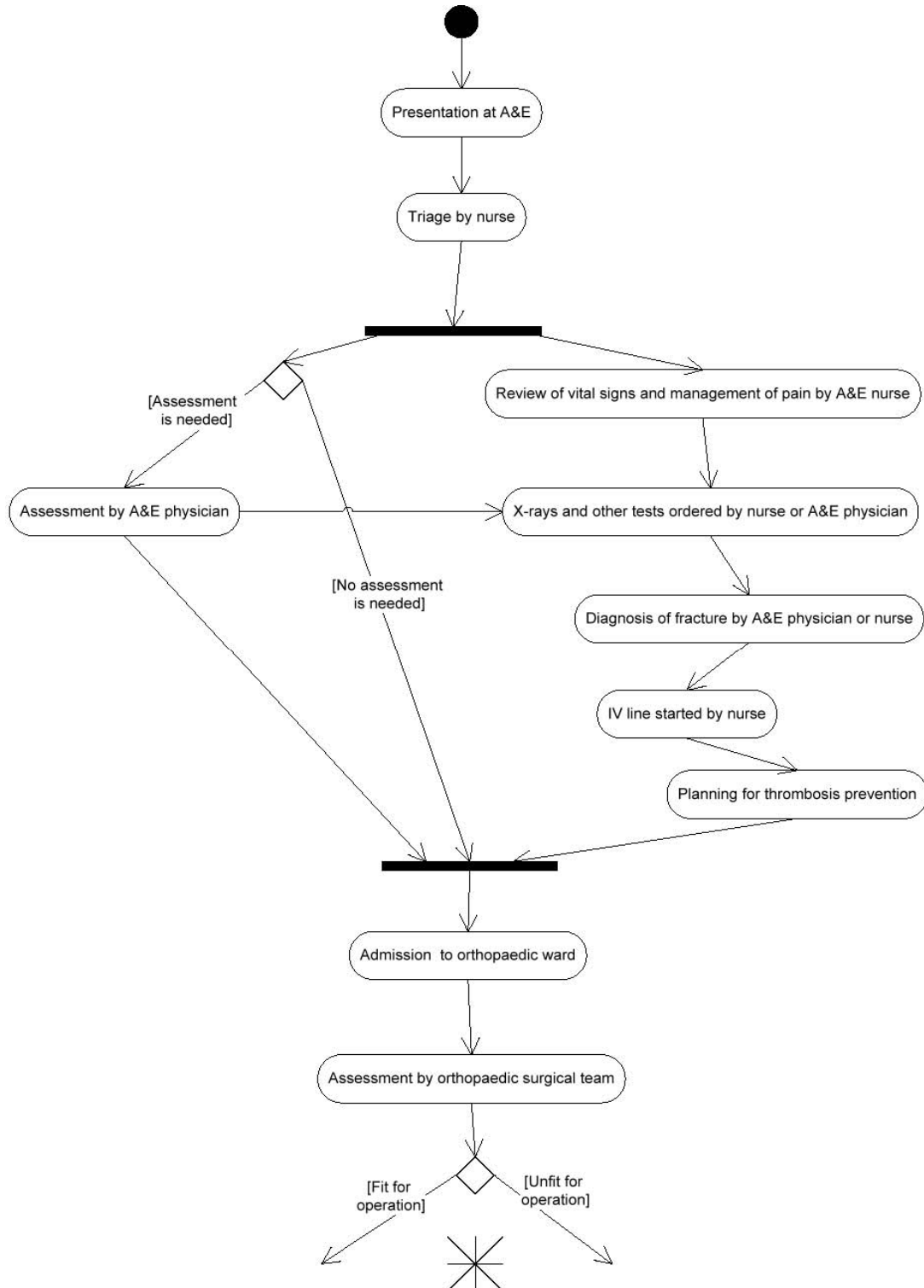
Use cases detail the function of each care activity shown in the UML activity diagram (see overleaf).

Use case for activity Triage by nurse at A&E

Use case	Triage by nurse at A&E
Aim	To classify patient’s condition on arrival and to assess the need for pain relief.
Actors	Patient, nurse practitioner (triage nurse)
Associated prior activities	Presentation to A&E
Preconditions	None
Typical sequence of events	The use case begins when the triage nurse sees the patient at A&E. The patient’s condition is classified according to the severity of the case (red, yellow, green). A patient with symptoms of hip fracture is usually assigned a yellow classification (emergency but not life threatening condition). The nurse checks the patient’s vital signs, records the pre-fall health condition of the patient and makes sure the patient receives pain medication to manage his/her pain. The use case ends when the patient is classified on the triage scale and his/her pain is managed.
Alternative sequences	None
Associated Post Conditions	Review of vital signs and management of pain by nurse; Assessment by A&E physician.

Main Findings: UML activity diagrams

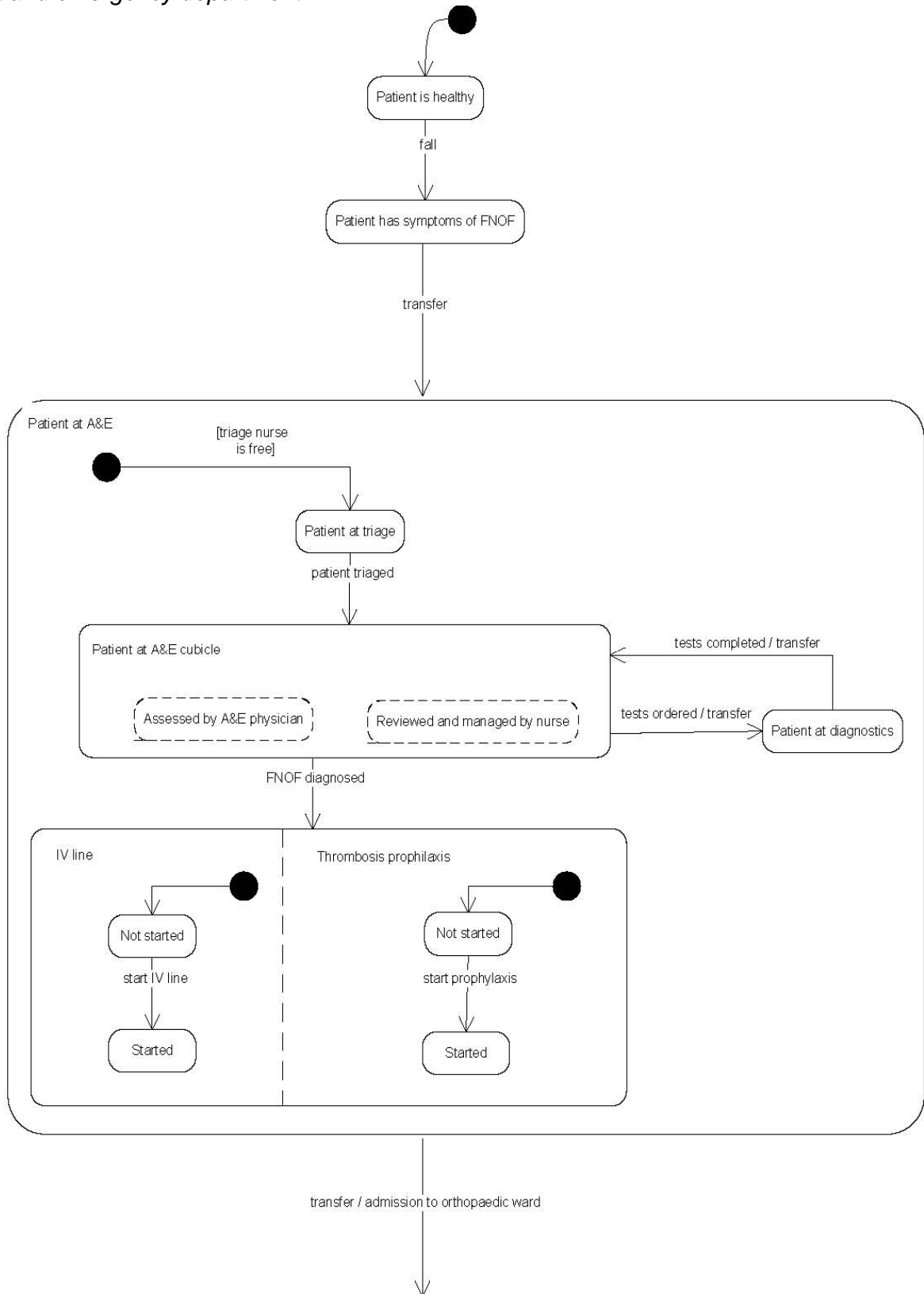
Example UML Activity Diagram: Care process for patients presenting with fractured neck of femur to an accident and emergency department



The UML activity diagram is essentially a flowchart: *rounded rectangles* represent activities; *arrows* show the flow between activities; *square brackets* represent a condition (or guard) on the flow; *diamonds* indicate where one flow enters and several are leaving (decision nodes); *black vertical bars* represent the beginning and ending of parallel activities; a *filled circle* shows the start and end points of the diagrams. In the activity diagram, for example, the assessment of the physician may take place at any time and throughout the patient's presence in the A&E department.

Main Findings: UML state diagrams

UML state diagram, care process for patients presenting with fractured neck of femur to an accident and emergency department.



The diagram represents the different states a patient may be in while progressing through the care process: *rectangles* represent the states; *arrows* represent transitions (movement from state to state). An arrow may have a label that includes the events which trigger the transition, and the conditions needed the transition to occur (shown in square brackets). The actions associated with the transition also appear on the labels. Drawing states inside other states represents hierarchy. Dashed rectangles symbolise parallel states.

Discussion and Implications

Review

The study has created a method for capturing and presenting details of the flow of patients through the care process using, as an example, older patients with hip fracture. Information was collected through interviews with health professionals, analysis of documents, and shadowing physicians on clinical rounds. UML tools were used to develop models of the care process from different perspectives. All primary information such as hospital documents and secondary information, such as UML diagrams were stored together in a library of information. This will be used as the basis to develop requirements for computer simulation models of the flow of patients through the care process. Simulations are commonly used for evaluating the likely response of a health system to changes in organisation, management and policy. To date, though, few health systems have used these simulations to dramatically change care delivery.

The difficulties in understanding and modelling the actual care process, and the lack of a systematic method for developing model requirements, are often thought to be the main factors preventing the development of patient flow models. However, the method presented here for capturing and storing information on the organisation of the care process, provides a valid way for overcoming these issues.

Benefits

This study shows the practical use of mapping methods to model a specific area of care. This is the first step towards the application of mathematical and computer modelling for planning future health services and improving health care; in this case for older patients with hip fracture. Improvement of such care pathways has great importance for the health and care of many older people. Indeed, the first National Audit of Falls and Bone Health highlighted the need for improvement in the care of older patients with hip fractures in the UK.

The benefits of process mapping which draws on a range of sources of information cannot be overstated. The processes described in this study enable analysts to gain a thorough understanding of how the care process is organised and executed, rather than how it should be in theory or according to policy guidelines. Although nationally agreed guidelines exist for the care of different types of patients, local deviations from standard practice are common given the different demands and resources available to each care provider. Acquiring and incorporating local knowledge is important for the model to be relevant and accepted by the stakeholders.

The models are simple diagrams which are visually easy to interpret by people from a range of professional backgrounds. This increases the likelihood that different stakeholders will accept the findings and recommendations made by the models.

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The Study

The study, which was carried out in collaboration with Kingston Hospital NHS Trust, received financial support from SPARC of £38,838 and ran for 12 months ending in October 2007. Additional support was provided by Westminster University where Dr Vasilakis was initially based, and later by University College London.

Dr Vasilakis is continuing his work on healthcare modelling as co-investigator on *Developing a participative user tool to aid the conceptual development of simulation models in healthcare* which has received funding of £198,236 from EPSRC.

The complete documentation including the full narrative and the remaining diagrams are available from Dr Vasilakis.

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Acknowledgements

The research team is indebted to the health professionals interviewed during the study and to Professor Peter Millard who was mentor to the team.

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SPARC

SPARC is a unique initiative supported by EPSRC and BBSRC to encourage the greater involvement of researchers in the many issues faced by an ageing population and encountered by older people in their daily lives. SPARC is directed, managed and informed by the broader community of researchers, practitioners, policy makers and older people for the ultimate benefit of older people, their carers and those who provide services to older people.

SPARC pursues three main activities: **Workshops** to bring together all stakeholders interested in improving the quality of life and independence of older people.

Advocacy of the challenges faced by older people and an ageing population and of the contribution of research to improving quality of life. SPARC is inclusive and warmly welcomes the involvement of everyone with a relevant interest.

Small Awards to newcomers to ageing research, across all areas of design, engineering and biology and at the interfaces relevant to an ageing population and older people. In 2005 and 2006 SPARC received 185 applications for support in response to two invitations for competitive proposals of which 34 were supported.

Executive Summaries

SPARC is supporting its award holders through funding, mentoring, a prestigious dissemination platform, professional editorial assistance, international activities and provision of contacts. Each of the projects has been small, yet the enthusiasm for discovery, and impatience to contribute to better quality of life for older people, has more than compensated for the very limited funding which was provided.

This executive summary is one of a series highlighting the main findings from a SPARC project. It is designed to stand-alone, although taken with summaries of other projects it contributes to a formidable combination of new knowledge and commitment by newcomers to ageing research, with a view to improve the lives of older people. This is a tangible contribution towards ensuring that older people receive full benefit from the best that research, science and technology can offer.