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Posters Introduction

Thierry Chaussalet
University of Westminster
Patients flow: mixed-effects modelling approach to predicting discharge probabilities

Shola Adeyemi (University of Westminster, UK)
Generally, healthcare is delivered via a series of processes (locations or states). The use of Pathways is a simple framework to represent these interconnected processes. Improving patient flow through hospital increases patient safety, positively impacts patient and staff satisfaction, leads to efficient resource consumption and generally improves the process of care. Hence studying patients flow and hospital length of stay is important in healthcare monitoring and management.

**Introduction**

This system assumes that patients entering into the system will undergo arrival (State 1) and then progress through primary (State 2), secondary (State 3) and discharge planning activities (State 4) before discharge. The probability of exit from each state is modeled by

$$p_i = \frac{a_{i1}x + a_{i2}y + a_{i3}z}{a_{i0} + a_{i1}x + a_{i2}y + a_{i3}z}$$

Under the model, there are estimated threshold values for which each of the paths is most likely.

$$r_i = \begin{cases} 0 & \text{if } a_{i1} < a_{i2} \\ 1 & \text{if } a_{i1} \leq a_{i2} < a_{i3} \\ 2 & \text{if } a_{i1} \leq a_{i2} \leq a_{i3} \\ \end{cases}$$

**Results**

**Conclusion**

We have demonstrated an alternative approach to patient flow modelling by the use of mixed models. This approach allows prediction of discharge probabilities based on individual patient pathways (flow paths) and patient-specific random effects. It also allows monitoring and understanding of the discrepancies between actual and desirable outcomes.
2- The dynamics of patient recruitment for a telecare system

Juan Adriano-Moran (City University, UK)
Introduction

The Department of Health (DoH) has seen the use of Information and Communication Technologies (ICTs) as a method to improve and supply access to health and social care; that is the domain of telemedicine and telecare.

By 2010, the National Program for Information Technology (NPfIT) expects that home based monitoring systems play an important role in the management of patients with chronic diseases. However, good quality studies showing the benefits of implementing telecare are currently restricted and insufficient [1].

Research Motivation

In order to make successful design and implementation of telecare, feasibility studies are required to be carried out in advanced. Traditionally, pilot projects have been implemented to capture organisational changes, direct benefits, and economic implications caused by the adoption of such systems into the medical practice.

An EU-funded project, the REALITY project, aimed to evaluate different aspects associated with remote home monitoring. However, the project has made evident the fact that analysing telecare, even at pilot stages, can be very complex. Under these circumstances, the use of conventional statistical tools and qualitative analysis may not be sufficient to address some of the complexity encountered in healthcare. System Dynamics (SD) is a way of understanding complex real-world organisations, such as those encountered in healthcare, and therefore in novel telecare.

This poster is focused on the dynamics of the patient recruitment process in the REALITY project. Previous studies have reported difficulties and challenges at this point [2, 3], and it seems to be an important step towards the successful implementation of telecare systems.

Methods: the Reality Project

Representative evaluation of evolving remote home-based patient monitoring delivery (REALITY), was a collaborative project funded by the European Union for two years. Its aim was to explore both strengths and weaknesses of remote monitoring services using hand-held devices.

Figure 1. The REALITY Service

Four clinical sites located in the UK, Estonia, and Portugal participated in the project. 211 patients with chronic diseases (diabetes, asthma, hypertension, respiratory and heart failure) were recruited, trained, and provided with handheld monitoring devices. The service (fig.1) combined physiological and quality of life measurements that were made and sent regularly by patients from home to centres of advice via the internet.

Initial Results

Our study sites were heterogeneous in terms of sample population and settings. Nevertheless, as it can be observed in fig. 2, the recruitment patterns remained the same. Because of this similarity, the pattern of the recruitment rate in the four sites can be approximated by the equation:

\[ y = Ae^{-bt} \]

where:
- \( y \) = recruitment rate.
- \( A \) = number of patients to be recruited per recruitment capacity.
- \( b \) = recruitment capacity.

Using this approximation, we propose that the level formalism for the recruited patients can be modelled as:

\[ \text{Recruits}(t+\Delta t) = \text{Recruits}(t) + \text{Recruitment}(t) - \text{Set up}(t) - \text{Early drop out}(t) \]

where:
- \( \text{Recruit}(t+\Delta t) \) = accumulation of patients consenting telecare participation and getting ready to start collecting data with handheld devices.
- \( \text{Recruitment}(t) \) = patients recruited per unit of time.
- \( \text{Set up}(t) \) = patients that successfully setup the handheld device per unit of time.
- \( \text{Early drop out}(t) \) = patients withdrawing per unit of time.

Figure 3 shows the dynamics of the REALITY recruitment process and its respective simulation for the UK site.

Conclusions

The essential purpose of these simulations was to reproduce the recruitment process and eventually to understand what factors were affecting this stage of REALITY (e.g. lack of time, discomfort with technology, lack of interest, disease severity, and so on) for future model simulation.

The model proposed above is compact, yet powerful. However, its complexity will increase when we include soft variables such as technology adoption, organisational, and human factors.

References

3- Modelling of allocated operating room time based on six months activity in a teaching hospital

Paul Avillach (Université Victor Segalen Bordeaux 2, France)
Modelling of Allocated Operating Room Time Based on Six Months Activity in a Teaching Hospital

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b Service de chirurgie plastique, Centre Hospitalier Universitaire de Bordeaux, France.

- 5 medical teams
- 6 surgical theatre
- 17 operating rooms
- 1 new big surgical theatre
- How many operating rooms?
Evaluating capacity provision in general ultrasound: a tool for the service manager

Chris Brasted (NHS London, UK)
Lumps & Bumps

Demand for General Ultrasound

Usually provided in a secondary care radiology department, generally a non-urgent examination in an acute setting.

• Referral for general ultrasound is usually split between the outpatient department and General Practice.
• GIHs have open access to general ultrasound examinations, due to the nature of ultrasound.
• Primary care referrals can differ in their preferences for ultrasound imaging in the management of patients, which might be suggested by a variety of clinical signs.
• There is evidence that demand rises as wards reduce and access improves (3).
• There is evidence that a radiological examination increases patient satisfaction (3).

General Ultrasound

In usually taken to include non-urgent diagnostic examinations and differential examinations for musculoskeletal conditions. In England, Australia, and New Zealand, general radiology occurs within an acute setting, which is generally provided separately and which has a much more predictable demand pattern.

Specialised Ultrasound

Includes Musculoskeletal, Vascular, Thyroid, and GI-guided biopsies.

Please Form an Orderly Queue!

by Christopher Brasted CEng CPhys MInstP
contact chris.brasted@cbs.net

The Rota

The reality of providing an ultrasound service is that the clinical workforce and machine availability are not constant on a day to day basis during the week. Typically a sonographer or radiologist will see a list of particular types of scan in a room for half a day, with other scan examinations split over two weeks in a bungling cycle, which affects association of specialist lists and availability of teams.

Metrics

Scale - proportion of each cycle of the model. It is the total duration within which % of all patients are seen.

Overhead - proportion of each cycle of the model. It is the maximum value of WAIT95 in each run. It is the conversion value of WAIT95.

Metrics

Utilisation is proportional to Overhead

5% Overhead gives 85% utilisation, 10% Overhead gives 90% utilisation, etc. The economic trade-off is between performance level and pricing capacity. To achieve the performance level, Overhead is expected to be the probability of them being days when there is insufficient demand to use all of the capacity.

The system is unstable with less than 4% overhead.

The most important variables in how capacity is provided are Overhead and Number of Empty Days in the rota.

In the absence of empty days in the rota, Overhead is the single most important control over the number of patients examined in the system. Urgent patients are seen from the start of the model run. Overhead conditions simply empty days. No, Cycle and Empty Days. This seems to be the condition for 'Flow'.

Consecutive Empty Days increase all Waits

Unsurprisingly, consecutive-empty-days in the rota force average and maximum waits up. The graph on the left shows how the waits are affected by consecutive-empty-days. The run that has a 10 day run is aggregated in different ways.

There are economies of scale

Scale and Overhead interact such that, at lower Overhead, the smaller scale operation (5 patients per day) has longer waits than the larger scale operation. With higher overhead, the system is less sensitive to scale.

References

Comparing modelling techniques for evaluating resource-constrained interventions for coronary heart disease

*Keith Cooper* (*University of Southampton, UK*)

Poster E
Objectives

- The aim of this paper is to investigate the modelling of resource-constrained interventions using Markov and discrete event simulation (DES) models. Is DES the more appropriate technique for dynamic systems which involve constraints or where patients compete for scarce resources?
- Models compared on the accuracy of results, speed to build and model complexity and a decision is taken on the preferred modelling technique.
- Models built to investigate likely costs and benefits of increasing capacity of revascularisation in the UK for Coronary Heart Disease (CHD).

Epidemiology and background

- Patients with angina pectoris suffer from recurring pain and discomfort in chest.
- Patients are at high risk of heart attack (myocardial infarction), unstable angina or CHD death.
- Clinical disease severity defined by number of vessels partially blocked: 1-3 vessel disease (VD), left main stem (LMS).
- Revascularisation techniques such as coronary artery bypass grafting (CABG) and percutaneous transluminal coronary angioplasty (PTCA) improve symptoms of angina and quality of life.

Methods

- Markov and DES models built to be identical to each other using same parameters and transitions between states and costs.
- Cohort model begins with initial revascularisation and patients start in 'No event after initial revasc' state.
- Patients can have recurrence of angina, and further revasc, be non eligible for further revasc or die.
- Model can be run for angina patients (ten states) or MI patients (six states).
- 1 year cycles, model run for 40 years for 60 year old men.

Results – accuracy

- Markov and DES results similar and models give same conclusions: ie PTCA more cost effective for less severe vessel disease, CABG more cost effective for more severe vessel disease.

Results – queuing vs no queuing

- Simulation model run with prevalence and incidence for UK with queuing versus no queuing for patients with 3 VD referred for repeat PTCA who had an initial CABG procedure.
- Resource levels 4-6 PTCA per month: waiting time 0.19-1.24 y.

Conclusions

- Using these models the results were not significantly affected by modelling the resources without using queues.
- DES is not necessarily the most appropriate technique for resource-constrained interventions.
- For this intervention, Markov model quicker and easier to build with similar results to DES model.

Figure 1 – Simple revascularisation Markov cohort model

Figure 2 – Cost effectiveness of revascularisation

Figure 3 – Queuing vs no queuing results

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Development of a model to predict of the need for blood transfusion following cardiac surgery

Lucy Culliford (University of Bristol, UK)

Poster F
**Development of a model to predict the need for blood transfusion following cardiac surgery**

Lucy Culford, Gavin Murphy, Gianni Angelini, Chris Rogers.

Clinical Trials and Evaluation Unit, Bristol Heart Institute.

**ABSTRACT**

To develop a predictive model to identify patients unlikely to require a blood transfusion during or after cardiac surgery. The ultimate objective is to more efficiently allocate blood bank resources.

**BACKGROUND**

- Unlike blood is routinely pre-ordered for all cardiac surgery patients, but is not used for 30% of patients.
- Allocated blood may only be used for 48 hours after surgery before being returned to the blood bank.
- Costly: 1 unit of blood is charged at £17.60 and £15.08.
- Blood cannot be used by others within the patient.

**METHODS**

- Routine data sources (cardiac surgery, blood transfusion and haematology databases).
- Multiple imputation by chained equations used to produce 10 complete datasets.
- Random split into training (2/3) and test (1/3) datasets.
- Functional form of continuous variables investigated.
- Baseline stepwise logistic regression on 10 bootstrap pool samples from each training dataset to select predictors.
- Features selected in ≥26 of 100 samples or final ≤1 of 10 bootstrap samples were moved forward to final model.

**RESULTS**

Table 1: Final model

<table>
<thead>
<tr>
<th>Predictor variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>z-value</th>
<th>p-value</th>
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<tbody>
<tr>
<td>Preoperative hemoglobin (g/dL)</td>
<td>0.41</td>
<td>0.001</td>
<td>4.10</td>
<td>&lt;0.001</td>
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<td>Preoperative haemoglobin ²</td>
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</tr>
<tr>
<td>Site of operation</td>
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</tr>
<tr>
<td>Ventricular septal defect</td>
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<td>0.000</td>
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<tr>
<td>Left main stem</td>
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**CONCLUSIONS**

- The model showed good calibration and discrimination.
- The area under ROC curve gives a negative likelihood ratio of 0.4, with 97.5% sensitivity and 24.5% specificity.
- Further validation will involve using more recent data from our centre and data from other centres.
- An RCT is planned to investigate impact of model on blood ordering.

**ABREVIATIONS**

BMI Body mass index, CABG Coronary artery bypass graft, Hb Haemoglobin, LR Likelihood ratio.
Turning steam into savings: the case of 417 NIMTS hospital

Vasilios Kapsalis (Synelixi OE, Greece)
1. Introduction
Steam can play a key role when introducing an energy management programme. Steam is an essential element in numerous processes in hospitals, which account for over 10% of the total energy consumption. In this study, we focus on the results following the implementation of an energy-saving project at the 477-bed hospital in London, England.

2. Project Description

- **Plant Expansion:** Two new steam boilers, one medium-pressure and one high-pressure, were installed.
- **Energy Production:** Total annual energy production was 70 GJ.
- **Utilities:** The energy consumption was as follows: steam, power, and water.

3. Methodology

- **Energy Audit:** A comprehensive energy audit was conducted to identify areas for improvement.
- **Data Collection:** Data from various areas were collected to analyze energy consumption patterns.
- **Energy Conservation Measures:** Several measures were implemented to reduce energy consumption, including:
  - **Insulation:** Improving insulation in areas where steam was consumed.
  - **Control Systems:** Installing new control systems to optimize energy usage.

4. Energy Conservation

- **Steam Generation:** The steam generation was optimized to reduce energy consumption. The new boilers were designed to operate at higher efficiency, reducing the overall energy consumption.
- **Heat Recovery:** Heat recovery systems were installed to capture excess heat from various processes and reuse it in other areas.

5. Results

- **Energy Savings:** Significant energy savings were achieved, reducing the overall energy consumption by 20%.
- **Cost Savings:** The cost savings were substantial, averaging over £100,000 annually.

6. Discussion & Conclusions

- **Energy Management Strategy:** A comprehensive energy management strategy was developed, including:
  - **Training:** Regular training sessions for staff on energy conservation practices.
  - **Monitoring:** Regular monitoring of energy consumption to identify areas for improvement.

- **Impact on Environment:** The energy-saving measures not only reduced costs but also had a positive impact on the environment.

- **Future Projects:** Further energy-saving projects are planned, focusing on areas with potential for significant energy savings.
Modelling of the imaging workforce in support of the 18 week wait initiative

Andy Knapton (South Central SHA, UK)
Prioritising future research relating to cardiac resynchronisation therapy in people with heart failure using non-parametric value of information analysis

**Stuart Mealing** (Peninsula Medical School, UK)
Value of Information Analysis: A case study

- Reimbursement decisions made in an uncertain environment
- “Wrong” choices always possible
- Value of Information analyses combines the probability of a wrong choice with the economic consequences of that choice
- Used to prioritise future research
- Case study part of a recent NICE technology appraisal

Assuming that the UK NHS is willing to pay £30,000/QALY, further information about hazard ratios and in particular about the risk of sudden cardiac death has the greatest impact on decision uncertainty.

Further information about costs, utilities or transition probabilities would have negligible impact on decision uncertainty.
Agent-based approach long-term capacity planning model for the U.K. long-term health and social care for elderly people

Christine Pelletier (University of Groningen, The Netherlands)
Agent-based approach long-term capacity planning model for U.K.'s long-term health and social care for elderly people

Dr. C. Pelletier, Dr. N. Szirbik, University of Groningen, Faculty of Economics, Management and Organisation

Aim of the research:
A model of the health and social care for elderly that
- catches the dynamic aspect of long-term care service organisation
- acknowledges the fact that decisions are local to care units
- allows each care unit to get its own view of the system
- acknowledges the complexity of the decisions processes (economic, political, and cultural aspects)
- investigate the impact of the behavioral change of one unit on the whole system

Agent-based model definitions

What is an agent?
An agent is a conceptual artefact that denotes a composed or atomic entity that is able to communicate in a high level language, can be empowered with decisional ability and can act autonomously, reacts to its environment and it also can plan proactively for the future

Examples of Atomic Agents:
A human, software component (specifically designed as agent)

What is a multi-agent system?
A multi-agent system is designed and implemented as several interacting agents, part or not of the same organisation. It is suited to represents a real system where components have their own perspective, a certain autonomous behavior to perform their role(s), and use sophisticated interaction patterns (cooperation, negotiation and coordination) while playing their role(s)

Model of long-term care services for elderly people

Results:
- A description of the long-term care service system with an emphasis on the interactions between the different components and their long term inter-dependencies

Future research
- Adding learning capacity to the local authority for his resource management,
- Developing strategies that enable agents to cope with changes,
- Enrich the behaviour of each component

Funding source
The model is being implemented using the technology developed at the The Agent Laboratory (TAL) at Groningen University (http://tbk15sfn.rug.nl/TAL)
Analyzing management policies for operating room planning using simulation

Marie Persson (Blekinge Institute of Technology, Sweden)
Analyzing management policies for operating room planning using simulation

- Resource allocation to improve efficiency
- Method: Stochastic simulation using optimization
- Can be used for:
  - capacity planning (elective - emergency)
  - prediction (what-if situations)

Marie Persson PhD Student
Blekinge Institute of Technology
Sweden
Using discrete event simulation in the design of step-down nursery capacity

Andrew Ramsden (Monash Institute of Health Services Research, Australia)

Poster L
Using discrete event simulation in the design of step-down nursery capacity

Authors: Ramsden, Dr. Andrew 1; Stockman, Keith 2; Campbell, Prof. Donald 3

1 Department of Business Services, Monash Medical Centre, Clayton, Victoria, Australia; 2 Manager, Health Service Operations Research Unit, Monash Institute of Health Services Research, Clayton, Victoria, Australia; 3 Director, Monash Institute of Health Services Research, Clayton, Victoria, Australia

ABSTRACT

Improvements in the survival of preterm and critically ill infants has placed progressively increasing demand on neonatal services in the State of Victoria, Australia. The requirement for intensive care beds in Victoria's four Level 3 Neonatal Intensive Care Units (NICUs) has been estimated, based on past in the results of simulation modeling, and considerable attention has been given in recent years to increasing the provision of NICU beds and implementing strategies to ensure their continuous availability.

A key factor impacting on occupancy of the NICUs is the availability of step-down beds in Victoria’s 15 metropolitan and regional hospitals with Level-2 Special Care Nurseries (SCNs). High demand in the SCNs, resulting mainly from in-house births, may cause step-down transfers from the NICUs to be delayed. This places further pressure on the resources of the State’s 4 NICUs and potentially limits access to neonatal intensive care services.

Capacity planning of Level 2 SCN services in the regional hospitals has not previously used a methodology which allowed capacity to be designed to achieve the combined goal of accommodating local demand and accepting step-down transfers without excessive delays. We initially developed a whole of system discrete event simulation but were hampered by limitations in available data.

Subsequently, we developed a simpler but effective simulation with which the occupancy and delay characteristics in the arrival streams that feed the Level 2 SCN could be studied. Historical patterns of bed utilisation in the source dataset showed wide variations between SCNs in admission rates, length of stay and transfer patterns for reasons which are partially understood. The simulation model has enabled the potential impact of reducing inter-hospital variability on occupancy and transfer delay to be explored.

OBJECTIVE

To develop a simulation model which will allow capacity in Victoria’s Level 2 SCNs to be designed to meet the requirements of local demand and requests for step-down transfers while maintaining transfer delays within acceptable limits.

METHOD

A discrete event simulation model was developed using AnyLogic 5.5 (Qdefine Technologies Pte Ltd). A schematic of the model structure follows.

- An online event simulation model was developed using AnyLogic 5.5 (Qdefine Technologies Pte Ltd).
- A schematic of the model structure follows.

- A single site’s Special Care Nursery is represented in the model.
- Each site’s simulated arrival streams are represented by a stepped exponentially distributed inter-arrival time derived from data issued from 2004 to June 2005 patient records.
- The base case average admission time is in this period for the respective hospital.

- Arrivals are divided into four distinct streams:
  - In-house births - babies born at the hospital
  - Level 3 transfers - transferred from Level 3 NICU
  - Other arrival streams - patients transferred after discharge from Level 1 NICU
  - External referrals - referrals not via any other hospitals

- Only a proportion of patients arriving in each stream will require a Special Care Nursery bed. This is simulated by a Special Care Nursery usage rate derived from historical patient records.

- Inhouse births and admissions are not denied access to an SCN bed in the real world. The model assumes all such arrivals can be accommodated regardless of the occupancy. Thus bed capacity is infinite for this patient group.

- Transfers from NICUs are only accepted by SCNs in the real world if the occupancy is below an agreed threshold or normal bed capacity at which the SCN Leak. If an SCN is closed transfers waiting for admission are queued and the model follows a ‘first come first served’ (FCFS) queueing discipline.

- When an SCN closes the model will not transfer patients waiting in the queue until the next day, even if occupancy falls below the agreed threshold. This mechanism is designed to mimic the once a day request for beds in the real world.

- The model was validated for each hospital by comparing LOS and average occupancy against 2004–2005 data. In all cases the results are similar to actual.

RESULTS

The model was validated for each hospital by comparing LOS and average occupancy against 2004–2005 data. In all cases the results are similar to actual.

The model was used to estimate the impact on transfer delay from Victoria’s four major neonatal intensive care hospitals. The results show that the number of Level 2 SCN beds under various scenarios, including varying the number of beds at the receiving hospital, improving birth rates and standardising the LOS and transfer rates to state averages. A selection of results follows.

- A relatively simple simulation model of neonatal patient flows provided a realistic way to simulate the impact of various flow and capacity variables on the occupancy of Level 2 SCNs and the frequency and duration of delays in accordance with requirements for step-down transfers from Level 3 NICUs.

- Traditional methods of designing neonatal bed capacity, by contrast, have relied on formulas that define a number of beds per 1000 births and fail to take into account key differences in hospital policy and performance, offer no insight into the variations in occupancy that can be expected and fail to address the impact that peaks in inpatient activity may have on upsurge capacity.

- The model provides a simple yet effective tool with which the capacity of Level 2 SCNs can be designed to fully meet the combined objectives of accommodating local demand and accepting step-down transfers within defined and acceptable periods of time.

- The tool provides a powerful demonstration of the potential value of simulation modeling in health service planning.
Using discrete event simulation to explore the radiotherapy planning process

Adam Sutton (University of Strathclyde, UK)
Using discrete event simulation to explore the radiotherapy planning process

The Beatson Oncology Centre is the lead provider of non-surgical cancer care in the West of Scotland. It administers around 6500 courses of radiotherapy annually, expected to grow at about 1.4% a year over the next 20 years. This is an ongoing project with a learning objective – learning how simulation can help the Beatson assess how to operate more effectively and efficiently.

The current model focuses on the multi-stage processes prior to treatment, through simulation and planning – with the objective of exploring the effectiveness of current and alternative policies for the utilisation of resources.

The key human resources are the 20+ Consultant Oncologists, specialising across the range of cancer types, and the treatment planners.

- Achieving a steady state presented a particular challenge in building the model and this led, step by step, to seek better data on expected arrivals and a more refined understanding of working practices.
- The model is being used to explore a number of potential changes, for example:
  - Changes in clinical practice (such as the extent of use of the simulators to check the plan);
  - Changes in working practices (such as the impact of consultants working in teams, the allocation of simulators to consultants, extended working hours, etc.), and anticipated changes in the incidence of cancer types.
  - Changes in physical environment – the Beatson currently operates on two sites in Glasgow, but has the option of consolidating operations in a new facility on a single site, which will be served by a different configuration of simulators.

This work, together with an exploration of the integrated use of System Dynamics and MCDA for Performance Measurement, has provided the impetus for the PhD research project outlined below.

Performance Measurement using System Dynamics and MCDA

Can engineering design be used to improve healthcare service delivery?

Anne Ticehurst (University of Cambridge, UK)
Integrated Healthcare Design
Anne Ticehurst, Dr. T. Dickerson, Dr. J.R. Ward, Professor P.J. Clarkson

Motivation
Approaches to healthcare service design often target specific issues without assessing the impact of change on other parts of the system. The complexity of healthcare systems requires an integrated design approach that crosses system boundaries, addresses change management issues, and recognizes interactions between different healthcare sub-systems.

Project Aims
1. To carry out a critical audit of current design methods within healthcare service planning.
2. To evaluate current engineering design methods in knowledge, change and process management, against healthcare requirements.
3. To evaluate the benefit of both approaches on stakeholders within the NHS, including patient groups and multi-disciplinary teams.

Questions
• To what extent does the healthcare industry have an integrated approach to the planning of service development, delivery and improvement?
• What would the requirements be for a more integrated approach?
• Which engineering design approaches can contribute to healthcare service planning?

Acknowledgements
Support for this project is provided by the EPSRC and Addenbrooke’s Hospital.

Method
1. Literature review and interviews to build a framework of current healthcare practices.
2. Observation and interviews to identify areas for improvement.
3. Case studies to evaluate existing engineering design tools against healthcare needs.
4. Validation of new approaches with healthcare professionals.
5. Consideration will be given to:
   • Primary and secondary care
   • Multi-stakeholder benefit
   • Multidisciplinary working
   • Integrated tools for service development, delivery and improvement.

Modelling and Simulation:
diagnosis and treatment of a thyroid disorder

As is’ process: mean duration 208 days

“To be” process: mean duration 166 days
Projection of demand for long-term care in an Italian region: a macrosimulation approach

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PROJECTION OF DEMAND FOR LONG-TERM CARE IN AN ITALIAN REGION: A MACROSIMULATION APPROACH

Introduction

Ageing of population is a demographic, social, cultural and economical issue. To understand the dynamic of the population at present, a simulation approach is developed for all Italian Regions (Friuli Venezia Giulia).

An overall approach to these issues was adopted by the PROSFRS Framework 2002-2003 (Friuli Venezia Giulia Region System). E-Wellness Project, an initiative for the PROSFRS Framework 2002-2003, was focused on the current regional long-term care (LTC) system and on the key drivers in the service provision.

Taking into account the complex nature of the phenomenon, population projections for regional population are disaggregated into macro-cells on the basis of sex, age, economic composition, living conditions, and type of care. The National Statistical Office (ISTAT) was involved in the investigation of the LTC needs through the PROSFRS Framework 2002-2003.

Multiple scenarios are developed on the basis of high-low population projections, relative to the ageing and dependency distributions, which impact on demand of the LTC services. The macro-simulation approach was developed for an Italian Region (Friuli Venezia Giulia).

In order to define the future context in which LTC policies will be applied, it is necessary to identify the trend and the level of future demand. Micro and Macro simulation models have been developed for LTC service demand and expenditure. Given the current data availability for the FVG network of care, the PSSRU model was developed by the Regional Health Agency “Bassa Friulana ASS 5”. It was focused on the current regional long-term care (LTC) system and on the key drivers in the service provision.

The PSSRU model is eXtended from the available data to the local reality; it is designed to adapt the definitions of residential and community population to the local reality; it refers to local data exploiting the informative potential of regional and national databases (the National Statistical Office population projections at the period 2000-2051, the 1999-2000 National Survey on Health Service Utilization, the 1999 National Survey on Health and Social Care Network, FVG Health Information System, and results from the Fresnesys screening study on frailness).

Many scenarios are eXamined within the model with a set of assumptions, which are possible to change on the demand side as well as on the supply side. These scenarios are generated to determine the future demand and the future supply of LTC services. They are eXpressed in the form of “what if”. Under base case assumption, the numbers of dependent older people in FVG are projected to grow from 2001 to 2031 by 68% given a 42% increase in the 65+ age group, gender, household type and housing tenure. Under base case assumption, the numbers of dependent older people in FVG are projected to grow from 2001 to 2031 by 68% given a 42% increase in the 65+ age group, gender, household type and housing tenure. The underlying assumption is that women in the middle age group are the more likely family members to provide informal care to the elderly.

The aged dependency ratio: the ratio of population over 65 to population in the age range 25-64 is a critical indicator not only for demand market considerations but also for the availability of informal care, despite the kind of support interest that families may have.

The caregiver ratio from the current 1:6 level will gradually drop to 1:56 in 2051. From the above 2 critical values per elderly person, will be reached the age dependency ratio is likely to happen. The age dependency ratio will result in the next 15 years reaching the value of 1:8. Focusing on demographic projections for the FVG Population, the ageing process is expected to be more and more evident. While the overall population will be increasing by +153.5%, while the over 85 will almost triple (+279.5%).

A simulation model is not used to make forecasts. It provides, on the base of a set of assumptions, answers to questions in the form “what if”. Under base case assumption, the numbers of dependent older people in FVG are projected to grow from 2001 to 2031 by 42% increase in the 65+ age group, gender, household type and housing tenure.

Maintaining the current network of formal care could not be feasible if the capability of services can’t match the increasing demand as supposed by the model.

The model of Friuli Venezia Giulia is not just a replication of the PSSRU experience. The model of Friuli Venezia Giulia is just a replication of the PSSRU experience.

The model of Friuli Venezia Giulia is not just a replication of the PSSRU experience. The model of Friuli Venezia Giulia is just a replication of the PSSRU experience. It tries to address the issue of frail elderly, which is not covered in the PSSRU model.

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Modelling health systems: delivering care to older people with hip fracture

Christos Vasilakis (University of Westminster, UK)
Delivering care to older people with hip fracture

Christos Vasilakis, PhD and Dorota Lecznarowicz, MA
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The Investigation

Objectives
- To describe the activities involved in the care for older people presenting with symptoms of fractured neck of femur to Kingston Hospital.
- To develop requirements for simulation models of the flow of older patients with fractured neck of femur through the care process.

Plan
For describing the care activities we
- collect information by conducting semi-structured interviews with care givers and hospital managers,
- store and present the results in a systematic and computerised manner.

For developing model requirements we employ Unified Modelling Language (UML) diagrams to
- represent the activities involved in the care process,
- describe the behaviour of the care system actors (e.g. patients, surgeons, physicians etc.).

The following UML diagrams are employed
- use case and use case diagram to capture the functional requirements of the care system
- activity diagram to capture the sequence and conditions of the progress of patients through care activities
- state diagram to capture the behaviour of actors
- class diagram to capture the structure of the care system

Potential Benefits
For older people
Fractured neck of femur, or hip fracture, is associated with osteoporosis and thus the incident rate is significantly higher in older people.

In the UK, the care for older patients with hip fracture has been identified as an area with the highest potential for improving the quality and value of clinical care through changes in the organisation of care delivery.

The knowledge gained from this research will help guide best practice in preparing an effective integrated care pathway in the collaborating NHS hospital. It may also lead to improvements in patient outcomes and satisfaction, such as the potential for survival, recovery, and independence after the fracture.

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Sample UML activity diagram of the care process
Optimisation of NHS 18 weeks target performance & costing using deterministic & stochastic modelling of healthcare pathways

Jorge Villacampa-Ortega (Barts and The London NHS Trust, UK)
Optimisation of NHS 18 weeks target performance & costing using deterministic & stochastic modelling of healthcare pathways

Information Department, Barts and The London NHS Trust
Jorge Villacampa-Ortega

Introduction
The UK Department of Health has set the ambitious target that by December 2008 all patients should receive their first form of treatment at a hospital within 18 weeks of referral from a General Practitioner.

The first milestone is to be achieved by March 2008 and offers both operational and financial challenges for both clinical and managerial staff. In particular, in terms of removing the backlog of patients waiting to be seen or admitted to a hospital. Targets for this milestone include:

- 85% for admitted patients (where treatment required a stay in hospital)
- 90% for non-admitted (where treatment was completed without hospital stay).

The patient journey has three key stages:

- Outpatient attendance
- Diagnostic procedures
- Admission to a hospital

The are varying degrees of complexity of pathways with combinations and permutations ranging from a patient receiving treatment at their first outpatient clinic to multiple diagnostic procedures and onward referral to other specialists before treatment starts.

Project Aim
The objective of this study is to quantify the volume, and associated costs, of removing the backlog and to increase the understanding of where the bottlenecks in the patient pathway will occur.

The solution proposed consists of three models:

- A deterministic model to calculate the additional patients that need to be seen within target times.
- A probabilistic simulation model to assess whether at each key stage of the patient pathway the final 18 week target will be met.
- An optimisation model used to identify ways to minimise the cost of the Trust while still meeting the 18 week target.

Data Requirements & Availability
The main datasets used in the models were based on activity and waiting lists for inpatients, outpatients and diagnostics. Particularly in terms of the relationships between different services.

The main limitation was the lack of historical data, lack of data on (and reasons for) waiting times for follow up appointments and a dataset that offers a complete picture of the patient journey.

Estimating the Waiting List Reduction

A deterministic model was developed in Microsoft Excel to estimate the volume of additional activity needed to meet the backlogs. This involved identifying the different waiting lists, developing relationships between specialties, identifying attrition and admission rates.

For operational reasons the 18 week target was estimated as 4 weeks for referrals, 4 weeks for diagnostics, 10 weeks for admissions.

Monte Carlo Simulation of Patient Pathways

The first model did not determine whether the hospital would meet the 16 week target. This second model was needed to estimate how many patients would be treated within 16 weeks.

A Monte Carlo simulation model at clinical speciality level was developed in Crystal Ball. This model calculates the average time waited for each of the patient pathways. A first average time waited for the Trust is calculated which provides the percentage of patients treated as in-patient or outpatient.

Six main patient pathways were identified depending on where the patient receives the treatment (i.e. where the “18 weeks clock” starts).

Optimisation of cost

The last model combined the results of the two previous models with a step-cost function. This was implemented by a meta-heuristic optimisation using Crystal Ball’s OptQuest package.

The results of the model provide the waiting list targets by specialty which minimise the Trust cost of doing at least 16 weeks additional activity while still meeting the March 2008 milestones.

Results

The results of the simulation model showed that:

- Non-admitted patients will meet the 16 week target.
- The main bottlenecks will be around admitted patients. The model shows that the target will be met as it is.
- However, tertiary referrals from other smaller hospitals account for around 10% of all referrals. This further complicates the target and increases the risk of missing the target. These referrals and associated waiting times are difficult to quantify and may be addressed in future projects.
- Service redesign is needed to reduce unnecessary waits in the pathways. There is a distinct relationship between the inefficiency and the chance of meeting the 16 week targets is reduced.

Future work

- More detailed additions to the model around:
  - Patient pathways
  - Estimated tertiary referrals
  - Cost function
- Using data mining techniques to identify patient groups going through long pathways. This would inform in service redesign.

References

- [1] "One-Stop Surgery"
Modelling the impact of resources on turnaround times for ultrasound tests

**Shyan Zubair** *(Barts and The London NHS Trust and University of Westminster, UK)*

Poster R
Modelling the Impact of Resources on Turnaround Times for the Ultrasound Tests

Shyan Zubair1,2, Thierry Chaussalet1, Farid Fouladinejad2
1University of Westminster, London
2Barts and the London NHS Trust

Background
- The National Health Service (NHS) hospitals are being driven to cut costs and provide quality healthcare.
- One example of such a situation occurs in the imaging department of a NHS hospital. A discrete event simulation model for the Ultrasound examination system has been developed.

Purpose
- The objective of the Ultrasound model is to provide a tool that will clearly identify the bottlenecks in the system.
- The model needs to answer the following questions:
  • What is the impact of different options/scenarios?
  • How would the service perform in the future?
  • How do we quantify/justify resource requirements?

Methods
- The simulation model attempts to capture the detailed operations of an Ultrasound examination activity.
- Input data provided by both medical experts and the hospital database are used.
- The essential information is interarrival times for test requests, mean service time to perform tests and number of each type of resources.
- The model was developed using the software package Simul8.

Results
- The model shows queues of patients and how the queues are influenced by changes in resources, arrival rate and service time.
- Patients who did not attend (DNA) the appointment affect the queue as these patients again join the queue.
- Other output measures that can be obtained from the model are total test turnaround times, waiting time of patients, utilisation of staff.

Conclusions
- The Ultrasound simulation model captures many features of the Ultrasound examination activity system and provides valuable insights into determining the input data that are critical to the service delivery.
- This model can be implemented as a software toolkit that can easily be used by the end user.
- The model can be enhanced by adding a cost variable to each of the facilities and resources. This additional feature will greatly assist the user, as the model will then show the effect on cost due to change in resources, and other factors, which will have an impact on cost.
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Martin Andrew Pitt (University of Exeter, UK)
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