

Institution: University of Stirling		
Unit of Assessment: 17. Business and Management Studies		
Title of case study: Improving NHS operational efficiency and patient experience through modelling		
Period when the underpinning research was undertaken: 2013-2018		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
John Bowers	Professor of Management Science	1991-12/2020 (deceased)
Carol Marshall	Lecturer (T&R) Lecturer (T&S)	06/2014-12/2018 12/2018-Present
Period when the claimed impact occurred: 2016-2020		
Is this case study continued from a case study submitted in 2014? No		
1. Summary of the impact		
<p>More efficient use of scarce resources, reduced waiting times, and enhanced patient outcomes have been enabled in the NHS by our health care modelling research on improving patient flow. Our research has contributed to the design of a variety of NHS health care systems across the UK, including the NHS Boards and Trusts of Forth Valley, Fife and Royal Berkshire, as well as the national organisations of the Royal College of Midwives and NHS Scotland. Notably, our impacts include:</p> <ul style="list-style-type: none"> • Embedding modelling and improving patient flow in NHS Scotland, leading to reduced waiting times for surgery • Effective resource allocation in maternity services, leading to increases in breast feeding and reductions in neo-natal readmissions, reallocating resources between hospital and community care. 		
2. Underpinning research		
<p>Our research has responded to the need to model the behaviour of agents within an operational health care system, notably the responses of patients and staff to queues and workloads. Additional work has considered management decision-makers' behaviour and their response to the modelling process itself. Our work has explored various approaches to incorporating agents, both in the models and the modelling process with:</p> <ol style="list-style-type: none"> a) developments in simulation modelling to include better approximations of the behaviour of patients and staff, such as decisions about patient discharge (outputs R1, R2, R3) b) mechanisms to encourage more engagement of stakeholders throughout the modelling process (R4, R5) c) ensuring that the modelling spans the diverse priorities of different stakeholders reflecting both efficiency and patient experiences (R3, R4, R5, R6) <p>The theme is common to many different health care services and there has been much synergy across the body of work with the research in one project leading to theoretical developments and contributions to applications in other services.</p>		
2.1 General health care modelling		
<p>A variety of funded projects (see the selection included in contextual data) were undertaken often using a combination of simulation and scheduling in the redesign of health care systems including: Accident and Emergency Departments, outpatient clinics, surgery, ICU (R1), delays to discharge, patient transport, community care (R2, R3), maternity services (R3, R4, R6). Typically, each study involved the adaptation of existing models contributing to theory as well as practice, such as methods for incorporating agents' behaviour. This series of projects led to more general reflections and recommendations for successful modelling interventions in health care. Key insights included the identification of the wide range of roles for simulation in the NHS and the special collaboration and engagement requirements in an environment where the organisational power reflects a balance between the management and clinical staff (R5).</p>		
2.2 Embedding modelling in NHS Scotland		

Three projects had an explicit objective to support the development of a modelling capability in NHS Scotland: Health care redesign in NHS Fife; Evaluation of whole patient flow; Advancing Analytics. The NHS Fife project focussed on the key NHS organisational challenges of meeting the A&E 4-hour target and reducing elective waiting times. The project developed a suite of flow modelling tools ranging from more effective visual mapping through to agent-based simulation. A key insight from this project was the identification of criteria for the selection of appropriate modelling methods for NHS studies (**R5**). In summary, sophisticated simulation may be needed for some applications but often more accessible modelling tools are more effective, with greater impact.

The NHS Fife project provided a foundation for a series of modelling projects over several years. This research was the basis for the recent work in support of NHS Scotland's initiative to enhance whole system patient flow and embed modelling more securely in the NHS. Our main contribution was a formative evaluation of the adoption of modelling in NHS Scotland over the two-year programme. The evaluation spanned a number of Boards with intermediate assessments of progress and the provision of guidance to help ensure a successful outcome. A significant output from the project was the development of a more structured framework for evaluating modelling interventions, based on our earlier research into realising the potential benefits of simulation in health care (**R5**). This framework emphasises the wide range of benefits from modelling in support of the innovation process in health care systems' design.

2.3 Effective resource allocation in maternity services

Many of our recent healthcare modelling studies have been undertaken in support of the redesign of maternity services, working with NHS staff and also collaborating with other academic staff, notably the [Nursing Midwifery and Allied Health Professions Research Unit](#) (University of Stirling and Glasgow Caledonian University). A particular theme has been the policy to shift the balance of care from acute, hospital-based services into the community. This policy can offer many benefits but there may be some costs both in the efficient use of some resources and also effectiveness, improving some patient outcomes but potentially impairing others. Modelling can help establish an optimal balance of care provision between hospital and the community, in maternity and indeed in other health care services (**R2**, **R3**). One significant output of our programme was a decision support tool, PRAM (Postnatal care Resource Allocation Model), that encapsulates widespread research allowing NHS staff to explore the reallocation of resources and appreciate the consequences for both cost and a variety of quality measures (**R4**). A specific practical result from the research was that reducing bed-stay for some categories of mothers can enhance quality of care as well as the efficient use of resources, but only if adequate staffing is provided (**R6**). A further insight was the value of more explicit categorisation of mothers' and babies' care needs to help ensure that resources are deployed effectively.

Health care modelling studies have usually focussed on improving quantitative measures of throughput and waiting. But our research has explored the importance of explicitly including continuity of care as another key objective. Our modelling study of the allocation of community midwives examined the balance between enhancing continuity and travel-time efficiency. In addition to providing guidance for NHS staff, this work also developed the traditional Travelling Salesmen theory, incorporating the concept of continuity of contacts when examining staff allocation and routing options (**R3**). Continuity of care is a major concern across health care and our research in this area is expanding, both in exploring new theory and novel applications.

3. References to the research (Stirling UoA 17 authors in **bold** text)

- R1. Bowers J** (2013) Balancing operating theatre and bed capacity in a cardiothoracic centre, Health Care Management Science, Vol.16, No.3, pp. 236-244. DOI: [10.1007/s10729-013-9221-7](https://doi.org/10.1007/s10729-013-9221-7)
- R2. Bowers J, Marshall C, Mould G** (2015) Location of services and the impact on healthcare quality: insights from a simulation of a musculoskeletal physiotherapy service, Journal of the Operational Research Society, Vol.66, No.7, pp.1212-1221. DOI: [10.1057/jors.2014.85](https://doi.org/10.1057/jors.2014.85)
- R3. Bowers J, Cheyne H, Mould G, Page M** (2015) Continuity of care in community midwifery, Health Care Management Science, Vol.18, No.2, pp.195-204 DOI: [10.1007/s10729-014-9285-z](https://doi.org/10.1007/s10729-014-9285-z)

- R4. Bowers J**, Cheyne H, Mould G, Miller M, Page M, Harris F, Bick D (2018) A multicriteria resource allocation model for the redesign of services following birth, BMC Health Services Research DOI: [10.1186/s12913-018-3430-1](https://doi.org/10.1186/s12913-018-3430-1)
- R5. Bowers J**, Ghattas M, Mould G (2012) Exploring alternative routes to realising the benefits of simulation in healthcare, Journal of the Operational Research Society, Vol.63, No. 10, pp.1457-1466. DOI: [10.1057/jors.2011.127](https://doi.org/10.1057/jors.2011.127)
- R6. Bowers J**, Cheyne H (2015) Reducing the length of postnatal hospital stay: implications for cost and quality of care, BMC Health Services Research, Vol.16, No.16. DOI: [10.1186/s12913-015-1214-4](https://doi.org/10.1186/s12913-015-1214-4)

Selected funded projects in health care modelling

- 1. Continuity of care and Best Start GBP10,000 (Chief Nurse, NHS September 2019
- 2. Advancing Analytics GBP50,000 (Health Foundation) October 2018
- 3. Evaluation of whole system patient flow GBP50,000 (NHS Scotland) September 2015
- 4. Quality and resource appraisal model for postnatal care GBP124,486 (ESRC KTP with Royal College of Midwives) October 2012
- 5. National postnatal care redesign GBP100,000 (Chief Nurse, NHS April 2011 Scotland)

4. Details of the impact

4.1 Impact Engagement Process

Our collaborative approach to research allowed us to gain valuable input to the emerging models, while NHS staff developed a much better appreciation of the role of modelling. This collaboration and engagement enhanced the research and the impact through more effective implementation of tools and insights (Figure 1). NHS-wide dissemination was achieved through presentations to Boards and Trusts and at NHS-organised events. Other dissemination included: participation in UK-wide events targeted at a mix of academic and professional health care staff, such as those organised by the Health Foundation; websites and webinars. The engagement of a wide variety of stakeholders in model development and their use in option appraisal was a critical element in the immediate impact of the specific project, while the subsequent dissemination activities helped deliver benefits to a wider community. Our experience illustrates how modelling both demands and also stimulates effective collaboration, maximising impact.

Engagement in the modelling process	Dissemination	Beneficiaries
Problem definition	Evaluation & identifying lessons	NHS analysts
Data collection	NHS meetings, seminars & websites	NHS decision makers
Feedback on prototype models	Operational Research publications & conferences	NHS clinical staff
Option appraisal		Patients: waiting times, outcomes

Figure 1. The mechanisms for translating research into impact for beneficiaries

4.2 Impact: Embedding modelling and Improved Patient Flow in NHS Scotland

All NHS services have problems with patient flow and the consequent inefficient use of resources and aggravated waiting times. Modelling can provide greater insights into specific problems and help redesign services to provide better flow, and patient outcomes. The Evaluation of Whole System Patient Flow project provided many opportunities to transfer experiences from earlier work (see 2.2, **R1**, **R2**, **R5**), contributing to the longer-term objective of embedding modelling in NHS Scotland (**S1**). Follow-up studies that evolved from this project have contributed to: the redesign of specific health care systems; continuing the development of technical modelling skills in NHS Scotland; and also a wider appreciation of the role of modelling. We have participated in various NHS UK-wide events using these opportunities to share modelling experiences more widely.

The Evaluation of Whole System Patient Flow provided short and long-term benefits, both for specific NHS Boards and more generally across Scotland. Sampled **NHS Boards have observed substantial improvements in patient flow** with clear benefits for patients, such as emergency

and urgent surgery where one hospital introduced a more systematic protocol to prioritise flows, reducing the breaches of CEPOD (Confidential Enquiry into Perioperative Deaths, see <https://www.ncepod.org.uk/>) times to surgery from 13% to 6%. More generally, modelling skills have been enhanced in NHS Scotland and there is also now a much greater appreciation of the potential for such modelling across NHS services (**S1**). While some benefits may be quantifiable, improvements in patient outcomes or efficiencies in flows, other equally important benefits may be more qualitative, such as **enhancing decision-making and the redesign process**. In particular, as stated by the Director of Whole Systems Patient Flow, NHS Scotland, the overall objective for NHS Scotland was to build capacity so that operations management techniques could be used across Scotland. As the Director states, this was achieved, and NHS Scotland particularly valued our emphasis on the need for

“a more iterative and inclusive approach be taken to these (modelling) activities. We have subsequently adopted the approach suggested by the University of Stirling and have certainly seen significant benefits in terms of local engagement and ownership together with the development of local capacity to use these tools and approaches.” (**S1**)

This reflected earlier research (**R5**) and the themes of the underpinning research. The Director of Whole Systems Patient Flow emphasises that “the Scottish Government has also benefited from the experience and expertise of the University which has helped to shape and improve programme delivery across Scotland” (**S1**).

A series of projects was undertaken in response to specific requests, such as a study in support of the design of the Intensive Care Unit at Glasgow’s Golden Jubilee National Hospital Heart and Lung Centre. This study modelled the interactions of scheduling decisions, staffing, ICU bed and operating theatre, to ensure a better use of expensive resources, reducing procedure cancellations and waiting times for critical surgery (**R1**). This stimulated further studies of the inter-relationship of operating theatre and bed capacity, examining staff behaviour in discharge decisions: an example of the theme identified in the underpinning research. These projects often entailed significant modelling innovations (**R1**, **R2**) that were then adopted in later studies, illustrating the positive feedback loop between research and practice that is critical to impact. The modelling studies have also spawned projects, such as an examination of the allocation of orthopaedic consultant time across the hip/knee pathway. By 2019, both projects contributed to **improving patient flow typically reducing waiting times for patients, and also to helping more NHS staff appreciate the value of modelling in health care (S2)**. As a key project partner at NHS Forth Valley states,

“Working with and educating other Health Boards has been an important part of and is a very valuable legacy of the project. ... This is a significant departure from previous practice and having access to reliable modelling will help individual Boards plan how best to implement service changes given their existing resources. It is not possible to quantify accurately the effects of waiting times to date. However, I have worked on improving access to orthopaedic care for over 20 years and I confirm that your work presents a major opportunity for improvement in waiting times.” (**S2**)

Further impact creation from **R1** and **R2** used statistical modelling to produce a tool to generate a daily email identifying those patients with a higher probability of delayed discharge. As the NHS Forth Valley Information Services Manager confirmed:

“discharge coordinators who now pro-actively work on planning those patients discharges and eliminate or reduce the length of any delay. ... the algorithms and computer code has been shared with all health boards information leads to allow duplication in other boards.” (**S3**)

As with the capacity-building impacts of Whole System Patient Flow described above, these projects also meant that:

“a) Decision making is more pro-active and timeous as a result of getting predictions the day after admission rather than waiting several weeks before identifying these patients. [and] b) Staff use their resources more effectively by planning in advance patient discharge and reducing lengths of delay. This saves money on hospital stays.” (**S3**)

Ultimately, this created positive impacts for patients, as “The outcomes for patients is much better as they transfer out of hospital much more quickly and reduce risks of hospital acquired diseases and satisfaction is higher as they are home more quickly” (S3).

4.3 Impact: Effective resource allocation in maternity services

A common problem in many areas of the NHS is the balance in resource allocation between acute and community care (R2). Our modelling in maternity services focused on improvements in various aspects of quality by reallocating staff and reducing bed-stay for some categories of mothers and babies, shifting the balance of care between acute and community services and delivering an estimated cost to service saving of 7% or approximately GBP4,000,000 (R4, R6). The implementation of PRAM (see 2.3) in NHS Royal Berkshire made a substantial contribution to their redesign of postnatal care. Staff were enthusiastic about how the approach had helped structure their diagnoses of the problems with the old system and the exploration of new options. This experience emphasised the value of producing models designed to encourage **stakeholder empowerment and engagement**, as noted in section 2. Comments from staff included: “We would not have put this data together except for PRAM”; “It makes you reflect when you’re looking at the journey as a whole”; “It has put postnatal care on the agenda”; “It helps you to articulate ... (and) argue your case to commissioners” (R4). A particular benefit has been the tool’s capability to encompass a range of quality and financial measures, addressing the sometimes-diverse concerns of mothers, staff, and management; this is often critical (as noted in section 2). By June 2018, when the resultant redesigned service was fully implemented, **staff reported major improvement in mothers, and staff, experience**. An NHS audit (S4) identified specific benefits, including:

- “increased number of women who initiated breast feeding are still breastfeeding on discharge to the Health Visitor (55% vs 85%)”
- “reduction of 22% in neonatal hospital re-admissions with a 25% reduction in re-admissions for neonatal weight loss.”

Following the successful implementation of PRAM in NHS Royal Berkshire we are now working with other NHS Boards/Trusts, as well as New South Wales Ministry of Health, Australia. In addition to the general mechanisms for maximising impact through engagement and dissemination (see 4.1), other activities were undertaken such as a webinar (see stir.ac.uk/4f6) with the Royal College of Midwives (R4).

Our research in continuity of care (R3) has been deployed in recent work with NHS Scotland staff on the Best Start programme in response to the Review of Maternity and Neonatal Services. We used our simulation-based tools to analyse a variety of delivery models, **helping NHS management identify a practical plan for enhancing continuity of care in maternity services**. As stated by NHS Scotland’s [text redacted for publication at request of stakeholder] (S5). Greater continuity of care enhances satisfaction, but it can also have clinical benefits. NHS Scotland state that the research in continuity in maternity care is helping NHS staff deploy resources more effectively to reduce [text redacted for publication at request of stakeholder] (S5), demonstrating that modelling can have significant impacts on operational efficiency, NHS costs, and patient health.

5. Sources to corroborate the impact

S1. Testimonial from Director of Whole Systems Patient Flow, NHS Scotland.

S2. Testimonial from Consultant Surgeon, NHS Scotland.

S3. Testimonial from Head of Information Services, NHS Forth Valley.

S4. Postnatal Resource Allocation Model (PRAM) Project Evaluation Audit No: N4326 June 2018.

S5. Testimonial from NHS Scotland [details redacted for publication at request of stakeholder].