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The DH accident and emergency department model - a national generic model used locally

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The DH Accident and Emergency Department model – a national generic model used locally

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Abstract

The Department of Health (DH) Accident and Emergency (A&E) simulation model was developed by Operational Research analysts within DH to inform the national policy team of significant barriers to the national target for 98% of all A&E attendances to be completed (discharged, transferred or admitted) within four hours of arrival in England by December 2004. This paper discusses why the model was developed, the structure of the model, and the impact when used to inform national policy development. The model was then used as a consultancy tool to aid struggling hospital trusts to improve their A&E departments. The paper discusses these experiences with particular reference to the challenges of using a 'generic' national model for 'specific' local use.

Keywords
Health Service, hospitals, emergency departments, simulation.

Running Heading (suggested)
Generic emergency department simulation

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1. Introduction

The Economics, Statistics and Operational Research (ESOR) division in the Department of Health (DH) provide analytical modelling and advice to policy leads on the design and implementation of DH policy, in public health and the National Health Service (NHS) in England. The primary author led analytical support in DH from December 2002 on the NHS Plan Target that by December 2004, 98% of patients arriving at Accident and Emergency (A&E) departments in England should be completed, i.e. admitted, discharged or transferred, within four hours. Around 13 million people attend around 200 'major' A&E departments in England every year, with no barrier to attendance at any time. Around 80% of attendees are discharged home, 20% being admitted to an inpatient hospital bed. This target was a major national performance indicator – at the time, the NHS was receiving significant increases in funding. It was important that targets such as this were seen to be delivered as evidence that NHS performance was being modernised and improved to meet patients expectations

In December 2002 the national figure was 78% completed within 4 hours. ESOR were asked to identify the key issues faced by A&E departments, and barriers to delivery of the target. An analytical programme of work was developed, which included the work described in this paper.

This paper has two main parts. The first part describes the development and application of a 'generic' simulation model of a 'typical' A&E department to help A&E policy leads understand the flows of patients in A&E departments. The second part reports on an opportunity that subsequently arose to apply this 'generic' model in hospital trusts.

Sections 2 to 7 describe the first part, including aims, methodology, model design, model calibration and validation, and finally examples of use of the model. Section 8 then describes the local application and the associated results. This is of interest because it addressed a real problem, and also provided the opportunity to investigate the practical pros and cons of applying a 'generic' model to specific problem situations. Section 9 then summarises these experiences and reflects on them in the context of some current simulation modelling debates.

2. Aims of the 'generic' national model

Within the programme of analytical work to support the national policy team in helping the NHS to improve A&E departments, a key requirement was to effectively communicate the issues facing a ‘typical’” A&E department. The ‘generic’ national model was designed to contribute in this area. Specific aims for the model are summarised as follows:

- Show, visually and numerically, how an A&E department works (key outputs being 4 hour performance by patient group and overall);
- Build a consensus within DH about the key issues facing A&E;
- Identify ‘quick wins’ to improve A&E;
- Communicate the effects of variability in demand and service provision;
- Show what success and failure look like;
- Run high level ‘what if’ scenarios to quantify the potential impact of key policy options;
- Direct available DH resources into the correct areas;
- Establish a baseline of performance and issues in a ‘typical’ department to measure changes against.

3. Methodology for the ‘generic’ national model.

Discrete event simulation is known to have potentially substantial benefits in communicating issues visually and numerically to stakeholders. Given the aims of the work, it was felt that discrete event simulation could help build common understanding in the national policy team of ‘baseline’ performance and issues in A&E at a time when improvement strategies were often driven by anecdote rather than evidence. Two of the authors also had substantial experience in industry applying discrete event simulation to improve industrial processes.

Specific benefits anticipated from use of discrete event simulation were:

- recognised success in replicating and improving pathways of multiple processes,
- ability to model individuals,
- visual impact when working with different stakeholder groups,
- ability to run ‘what ifs’ quickly.

4. Model design

4.1 Lessons from elsewhere

Jun et al (1999) provide an extensive review of 117 papers on the application of discrete-event simulation in health care. A&E department models are common, and are the focus of at least 12 of them. The reported work included models examining patient routing and flows (e.g using a fast track lane in minor care), scheduling of resources (e.g matching staffing to demand) and staff sizing and planning (e.g the mix and numbers of staff), all of which were important issues to incorporate into our ‘generic’ model. There is also a wide range of other recent published experience of A&E models. In this literature, there is more evidence of specific A&E models (i.e to one department) than generic. Many examples are in American Emergency Rooms, which have different designs to English A&E. Key outputs are typically time in A&E, queue length and staff/room utilization. Models often include A&E medical, nursing and clerical staffing, examination cubicles, diagnostics, decision to admit and bed management. Specific patient types are often modelled, often by time of day and day of week. Models occasionally directly model capacity constrained bed systems, diagnostic departments and surgery, but more often as capacity unconstrained time distributions. Techniques are mainly discrete event simulation, but some evidence of scheduling, queuing models and system dynamics. Design is usually through discussion with local experts. Data collection is generally through computerised records, also occasionally using work study and local consultation. Validation is discussed less, but is usually through comparison with computerised records, and/or “open box” type validation with local experts. Improvement scenarios include workforce scheduling, changed roles, bed management, fast track patients, diagnostic changes and overall capacity changes. Implementation is not widely discussed, but some evidence that both generic and specific models have similar designs and have been used with broadly equal success.

As discussed, a lot of this is experience in foreign departments where patient flows can differ significantly from England. Those developed in England include Lane et al (2000), who developed a system dynamics model of an A&E department, output being patient time in A&E, issues being demand profiles, patient testing, doctor utilization and bed management. Komashie and Mousavi (2005) describe a specific detailed A&E model, also including a Medical Admissions Unit, the key output being patient time. Modelled issues were around changes in bed capacity and demand patterns. As will be seen later, models described in the literature were similar to the issues modelled here.

We have seen that valuable lessons can be learnt from the literature on the key model building issues of model scope, design, performance indicators, analytical techniques, data collection, validation, improvement scenarios and implementation. The literature suggests that “generic” models were not noticably less successful than models specific to one A&E department.
In addition to learning general lessons from the research literature, our interest in model re-use, see for example Robinson et al (2004), required that we looked seriously for, and obtain access to any models that might be considered for re-use. DH contacts made us aware of a

model developed at Oldham hospital. This model was not published, but had a good reputation, was recent, had already been applied locally to model total time in A&E and was available immediately.

We learnt a good deal from this model, but we ultimately built a new model for a variety of reasons:

- Whilst the model included the key "bottleneck" processes we had agreed with the national clinical leads, it also contained many locally specific processes that were not nationally appropriate. For example, it included the formal initial triage of patients by nurses, whereas guidance from the NHS Modernisation Agency had led to many trusts dispensing with this process.
- The model used the traditional patient groupings of the "Manchester" triage system, which categorised patients by urgency of need. However, most A&E departments had moved away from this to a simple minor/major patient split – we wished to reflect this "new world"
- The Oldham model had a more detailed process flow than required in a national model.

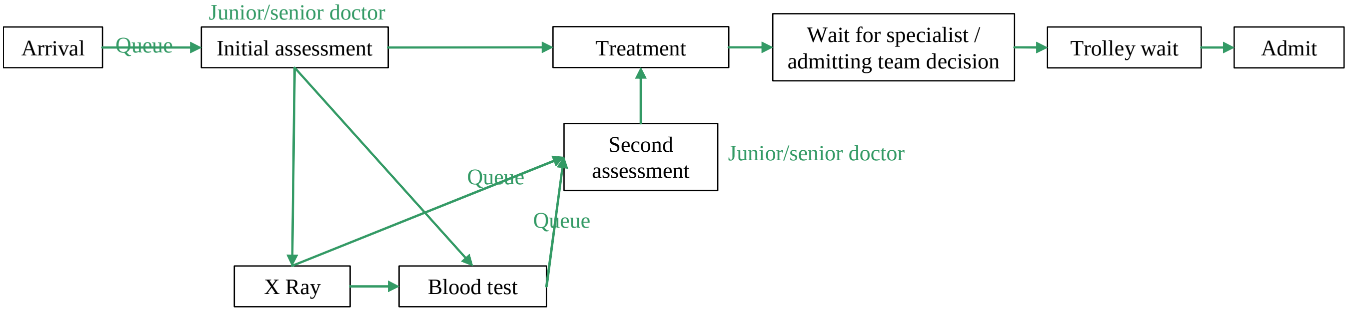
Our decision not to use the Oldham model was driven by confidence in our ability to build a national model without the issues identified above with somebody else's (specific) model. However, numerous lessons (and some process time data) were taken from the model and it was a significant aid in the design stages. Significant amounts of traditional work study had been conducted to generate the process times in the Oldham model. As described later, this helped give some validity to the assumptions used in the national model. We were also encouraged by their experience that it was possible to accurately model an A&E department using discrete event simulation.

We therefore developed the A&E model (in Simul8) within DH, with the help of targeted external consultancy support. Early iterations of the model were developed in the first part of 2003, with the first set of detailed survey data available in July 03 for validation.

4.2 Model Structure

In partnership with the national clinical and nursing advisers, we established generic flows through A&E departments of three types of patients (minor, major and admitted). These patient types had been defined and 'marketed' to the NHS by the NHS Modernisation Agency whose role was to spread good practice across the NHS. The most complex flow of subprocesses is for the admitted patients and is summarised in Figure 1.

Figure 1 Flows of admitted patients through A&E Departments



To interpret, for admitted patients the patient arrives in A&E and queues if necessary for an "initial assessment" by a junior or senior doctor. Diagnostic tests in the form of X Rays or blood tests may be required, in which case, interpretation of the results are needed, also by a doctor. Some sort of treatment process may be required, followed by a "decision to admit" by the hospital admitting team. Following this, the patient may wait for an inpatient bed to become available, described as "trolley waits".

Process flows for major and minor patients are similar, but neither group experiences waits for beds, and the minor group is also assumed not to experience a wait for a decision to admit.

There were two important features of the model design that should be highlighted:

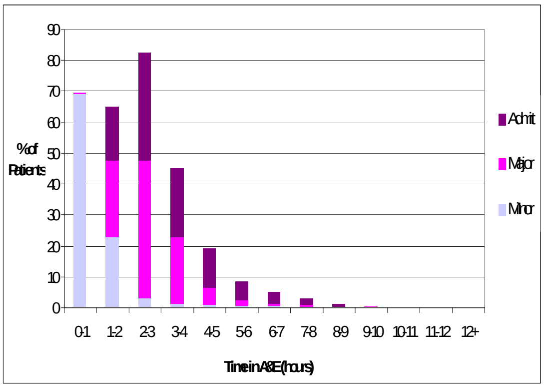
- The model had three patient flows: minor, major and admitted patients. These are modelled separately for visual and communication purposes. However, although minor patients are usually streamed effectively at the 'front door', many major patients are indistinguishable from admitted patients in the early stages of their journey. Hence, the model implies a false, retrospective clarity. This issue was weighed against ease of communication, the latter consideration winning the argument
- In line with much of the literature reviewed, processes outside the control of the A&E department such as diagnostic tests, decision to admit and admission were not modelled as capacity constrained processes, but as capacity unconstrained time distributions. The impact of these processes on the patient journey was represented, but lack of detailed data in these areas and the need for model simplicity meant that detailed capacity constrained submodels of these processes were not attempted.

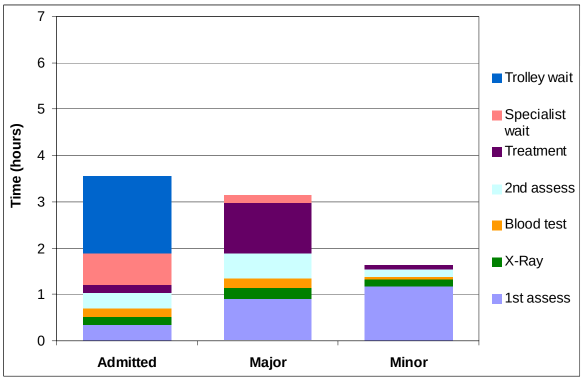
4.3 Model Outputs

Some example outputs from the model (reported via an Excel reporting engine), are shown in Figure 2. These are just a small selection of numerous communication devices.

Figure 2 Example outputs from one run of the National A&E model

Overall A&E 4-hr Performance	Min %	Avg %	Max %
Overall	90	**91**	91
Admitted	71	**75**	79
Major	89	91	94
Minor	95	97	97





The first table shows modelled 4 hour performance overall, and by patient group, and the variability in these measures by week (typical model run length was 20 weeks). In this run, 75% of admitted patients spent less than four hours in the A&E department overall, but by week this varied between 71% and 79%.

The right hand bar chart shows the numbers of patients completed in 0-1 hours, 1-2 hours, etc, by patient group. In this case the majority of minor patients are completed very quickly, whereas significant percentages of major and admitted patients require over 4 hours.

The final graph shows the average time in each process on the patient journey for each patient group, hence improving understanding of the key reasons for breaches of the 4 hour target.

5. Model Calibration

The model was to represent a ‘typical’ A&E department rather than a particular one, so the challenge of calibrating the model was unusual.

A typical demand profile was obtained from a detailed 7 day survey of a random sample of trusts which were asked to record, for every patient attending A&E in a 7 day period:

- Patient group (i.e. minor, major, admitted);
- Date/time of arrival;
- Date/time of completion;

- Age;
- If the patient was a breach, what process contributed the longest part of the patient's journey.

The survey was designed and run by ESOR and external consultants. The first survey was run in May/June 03 (and rerun subsequently). Twelve responses from trusts were received, which were indicative of national performance at that time.

Other sources of data were National DH statistics (QMAE), national medical workforce census, Audit Commission, A&E Surveillance Centre, advice from national clinical and nursing advisers and the Oldham model - and were used to set total patient demands, staffing levels, waits for beds, patients requiring diagnostics and decisions to admit. See table 1 for details.

Table 1 Data used to populate the national A&E model

Data	**Description**	**Sources**
Size of A&E department	Total number of attendances per annum	National DH statistics
Split by patient group	Percentage of attendees in the minor, major and admitted patient groups	A&E 7 day survey
Demand profile by hour of day	Percentage of attendees in each patient group every hour	A&E 7 day survey
Staff profile per hour of the day	Number of doctors and decision making nurses every hour	Doctors from national medical workforce census. Nurses from Audit Commission data
Process times	Minimum, average and maximum times in every process	Waits for bed from national DH statistics. Other process times were inferred from the reasons for breach in A&E 7 day survey.
Use of diagnostics	Percentage of patients in each patient group that require X Rays and Blood Tests	A&E Surveillance Centre – Birmingham University.
Decision to admit	Percentage of major patients that required a decision (not) to admit	Advice from national clinical and nursing advisers and local A&E models.

The initial setting of process times (apart from waits for beds) were based on the data from Oldham and expert opinion. However, because the crucial requirement for the generic model was that it should generate 'typical' problems, these times were adjusted until the incidence level of breaches and key reasons matched those observed in the survey. This issue is discussed further in section 6, as in many circumstances this 'fixing' of input parameters to reproduce observed output parameters should not be allowed.

Variability in demand by patient group was generated using inter-arrival times drawn from a negative exponential distribution (changed every hour to allow for demand profiles). Variability in process times was taken from national statistics where available, plus the Oldham model and advice from clinical and nursing advisers. Simple triangular distributions were used to aid communication. The model produced similar variability in weekly 4 hour performance to observed variability in A&E performance at trust level.

6. Validation

Pidd (1999) discusses two key validation techniques – "black box" and "open box" validation. Black box validation is where the model output is numerically tested against known characteristics of the system. Predictive accuracy is important. Open box validation is a critical assessment of the variables and relationships in the model. Performed in partnership with experts on the system being modelled, it generates mutual agreement that the model accounts for the key 'real world' issues. Both validation techniques were used here.

6.1 Black box validation

Failure of black box validation would normally require that the analyst should refer back to the real world to revisit the model. However, in this case the model was a communication tool representing a 'typical' A&E department. There was no particular real world department to check against. In fact, as noted earlier, because the model was designed to represent the key characteristics of a 'typical' A&E department, it was assumed that discrepancies between the model and a 'typical' A&E department could be corrected by adjusting process times. The black box test was therefore whether it replicated knowledge generated in the national 7 day survey. The steps taken were as follows

- Take an average sized A&E department (DH statistics)
- Split into patient groups of average sizes (7 day survey)
- Apply the arrival distributions by time of day for each patient group (7 day survey)
- Take an average staffing level of doctors and nurses and generate staffing rotas broadly matching the arrival patterns
- Adjust process times until the distributions of reasons for breach matched the survey

- In parallel, check that modelled four hour performance by patient group replicated the survey
- Finally, ensure the system variability replicated the weekly variability in 4 hour performance of a typical trust by adjusting process time variability

Data from the Oldham model was also very useful in this process as it gave an indication of average and variability in process times in a real A&E department. This data was used to crosscheck the generated process times.

This validation process took some time, and was a trial and error based iterative approach. Where conflicts arose, 4 hour performance by patient group took precedence - this was felt to be more accurate than information on reasons for breach. Eventually the 4 hour performance by patient group was reflected exactly, and modelled primary reasons for breach were within around 5-10% of survey results. In February 2004 the model was revalidated against a much larger (around 80 trusts) 7 day survey.

6.2 Open box validation

After the black box validation, open box validation was conducted. The national clinical and nursing adviser and other A&E consultants were shown the model and asked whether the bottleneck process times and broad patient flows looked 'right'. For example junior doctors were noted to tend to take longer to treat patients and to have higher utilisation; and the visual build-up of patients in the waiting room and waiting for beds in the middle of the day was – noted (with great feeling!) to match the A&E consultants' experiences.

Finally, the model builders also visited a number of A&E departments to 'walk through' the process with local experts, giving confidence to the model builders that the model reflected reality.

7. Application of the 'generic' model at national level.

The result of the validation process was a baseline model with the following characteristics:

- An average sized A&E department;
- With average demand splits by patient group;
- And average arrival patterns by time of day;
- Average staffing levels, profiled to the demand pattern;
- Inferred process times consistent with average 4 hour performance for each patient group and average distributions of reasons for breach.

The baseline model represented an imaginary trust, but was a good representation of the issues facing a ‘typical’ trust. By modifying the baseline model it was fairly simple to replicate issues of good or poorly performing trusts, large or small trusts, trusts with particular staffing issues, trusts with issues at a particular stage of its process, trusts with atypical patient mixes and trusts with atypical arrival patterns. Four examples of the ways in which it was used are described next.

7.1 ‘What if’ scenarios for national A&E team

The model was used for seminars with the national A&E team to discuss patient flows and the impact of potential policies. ‘What if’ scenarios enabled the national team to focus on aspects of the patient journey with the biggest potential to improve A&E performance. Not only a ‘typical’ department was considered, but also ‘good’ and ‘poor’ performers. These interactive sessions helped to generate a common understanding of issues in A&E in the national team. Internal discussion papers were subsequently written that addressed these key issues. Key scenarios investigated were:

- Nursing staff required to run a dedicated minor stream;
- Extra staff/reduced consultancy times;
- Moving demand from A&E;
- Extra demand at night time and weekend;
- Improved diagnostics;
- Better bed availability;
- Improving the decision to admit process;
- Changing working practices/responsibilities.

7.2 What does a 98% department look like?

In the early stages of the A&E project, there was much national debate about whether 98% performance in A&E was achievable and sustainable given the variability in demand and complexity of patient flows. The model was used to identify process times and service levels at each bottleneck process required to reach a sustained performance of 98%. The clinical advisers advised whether these process times were achievable. Some processes such as assessment required a certain time to be clinically safe, and others such as X Ray/Blood test had fixed process times. This exercise was valuable in generating common understanding that a 98% target was achievable, and what a successful A&E department might look like.

7.3 Resources to deal with "minor" demand

The model was run to illustrate the required nursing staff that would be required to deal with a dedicated stream of minor patients. This was compared with the equivalent number (and cost) of doctors that would be required, with assumptions on process times. The significant number of nurses required (over a thousand) was used to inform workforce policy in A&E.

7.4 Deflection of demand

The potential to improve A&E departments by deflecting minor patients away from A&E was investigated. This showed that it would not be a successful policy. Most of the delays in A&E are caused by whole hospital issues such as waits for beds and diagnostics. Releasing A&E clinical staff from dealing with minor patients would not help with these issues, and the average performance on the remaining, more complex case mix would be lower than that of the mix with minor patients included.

7.5 NHS improvement initiatives

The NHS Modernisation Agency ran A&E improvement programmes for all acute trusts. The model was demonstrated at numerous events to facilitate discussion with NHS participants on the issues facing A&E departments, and encourage them to pursue their own analysis and modelling endeavours. The sessions received highly positive feedback from participants, with numerous requests to use the model. (Local use is discussed later). Results from the model, allied to the 7 day survey results, also fed into guidance issued by the NHS Modernisation Agency to the NHS around improvements to the waits for bed, waits for specialists and waits for assessment processes.

8. Application of the 'generic' model at a local level

By Spring 2004 the model had fulfilled its national purpose. However, following a demonstration of the model to the head of the national A&E 'Intensive Support Team' (IST) (whose role was to help trusts struggling with the A&E Target), it was felt that the tool could have local benefit to some of these trusts. In theory, if the trust could provide an accurate local 7 day survey and staffing profiles, the model could be used to model that trust in detail to show where high impact interventions might be.

There also presented an important learning opportunity for ESOR to investigate whether a nationally developed OR model could be used to improve local NHS services. A full time OR analyst (Sally Huxham) was recruited to take the model to trusts nominated by the IST lead and to attempt to use it to aid improvement.

8.1 Experience with local trusts – the consultancy process

Between Summer 2004 and early 2005 we took the model to ten trusts, partly nominated by the IST, but also a proportion of those that volunteered following the demonstrations of the model at national MA events. Trusts were prioritised according to A&E 4 hour performance. Others were nominated, but had difficulties bringing together key stakeholders. Our target consultancy process would have completed all stages in Table 2 The actual numbers of trusts that made it to each stage are shown in the right hand column.

Table 2 The consultancy process – numbers of trusts reaching each stage

		Number of trusts
1	Initial demo of the generic model to key stakeholders in the trust (A&E consultants, A&E managers, nurses, performance directors, analysts)	10
2	Work with local analysts to get accurate data on demand, staffing, process times, performance by patient group, reasons for breach	8
3	Replicate the performance of the trust from the key parameters with the model and agree with trust	5
4	Run “what if” scenarios on potential improvement strategies	5
5	Implement improvement strategies	3
6	Test if the predicted improvements were made	0

At first glance, this table implies that the exercise was a failure - no trusts reached the end of the process. However, this reaction would underestimate the benefits achieved by reaching intermediate stages.

For example, for some of the trusts reaching stage 1, this was the first time that key stakeholders had convened to consider issues facing their A&E department. Using the generic national model (with national data) to facilitate these discussions was surprisingly effective in generating a common understanding of local issues. Sometimes it was possible to rapidly adjust the model data to illustrate local issues. For example, one trust felt their staff were not allocated optimally to match the demand. They were immediately shown the effects of mismatches between demand and resource using national data. This provided the incentive to resolve their local issues. In other cases, particular local issues such as waits for beds, diagnostics and admitting team opinions were discussed using the national model.

At stage two, many trusts obtained new insight into local issues from the exercise of finding or improving the quality of the required data.

For those trusts that reached stages 3 and 4, running the ‘what if’ scenarios on the agreed validated model enabled prioritisation of improvement strategies. However, time constraints driven by the looming A&E target meant that many strategies were adopted in parallel, making measurement of individual improvements impossible. For example, one trust’s suspicion that they did not have enough examination cubicles was well founded, and investment in this was supported, but this change was introduced in parallel with other measures. Hence unambiguous progress to stages 5 and 6 was rare.

8.2 Obstacles to local application of the ‘generic’ model

As implied in Table 2, local use of the model could have been more effective. At the outset, our main worries about applying the generic model locally were around those instances where local patient flows were so different from model assumptions that modelling became meaningless. We did encounter cases where local practice was significantly different from the national model assumptions. Examples were different patient routings (e.g extra triage), staff responsibilities and behaviours, admission techniques, local patient groupings and assumptions around resources required for trolley waits.

However these did not provide major obstacles to progress, as with some modelling expertise they could always be overcome by one of the following three methods:

- Flexible use of input data into the existing model structure (e.g putting two real life processes into one modelled process). The structure of the generic model was unchanged, but a local interpretation of the input data was required.
- Small changes to the structure of model. For example, because examination cubicles were a key constraint in one trust, these were quickly added to the model.
- Some issues were resolved by exporting modelled data to Excel and adding extra analysis offline. An example of this was a fast track admission process in one trust that could not be formally included in the model structure.

In fact the more crucial obstacles to progress were not related to the generic nature of the model, and were as follows:

- Data quality. This was poor in most of the visited trusts. In some cases this prevented effective model use. Unfortunately this issue is a common experience in the NHS
- Organisational dysfunction. The trusts were chosen because they were struggling to meet the A&E target. However a key reason for the struggle in many cases was organisational dysfunction. Problems in A&E are often a symptom of whole hospital issues. For example, if inpatient beds, the admission process, or diagnostics are under capacity or managed ineffectively, the effects are seen in A&E. However, for the A&E model to be used effectively, all these stakeholders must be active and well-informed participants. As noted above, stage one of the consultancy process often helped resolve such issues, but this was not always the case.
- Motivation. Some trusts only paid 'lip service' to the process, which may have been seen as being forced on them by DH. For example this often manifested itself at the point where the trust needed to make significant effort to find and/or improve data.
- Changes in A&E departments. Most trusts were employing numerous mechanisms over different time periods to improve A&E performance. It was therefore often difficult to validate the model locally and/or to identify the impact of individual changes.

9. Discussion and Conclusions

9.1 Development and Application of a generic model.

The work described in this paper was primarily concerned with developing and applying a 'generic' simulation model for a 'typical' A&E department. The work has been successful in this respect, achieving most of the objectives set for it. It provided:

- A visual and analytical representation of a typical A&E department;
- Illustration of the impact of variability of demand and process in A&E;
- A facilitation tool to focus national resources onto the key issues;
- The ability to run 'what if' scenarios, both visually and analytically;
- The ability to illustrate what success would look like.

The particular challenges in OR terms with use at national level were:

- Finding the appropriate 'level' of modelling. Designing the model so it was not overspecific to particular A&E departments, but detailed enough to explain national issues to an appropriate level. Required input data needed to be as simple as possible.

Striking this balance required numerous revisions of the model in development stages. For example, waits for bed at specialty level were not modelled to avoid unnecessary complexity.

- Data – interpreting the available national data and using it appropriately, making allowances for known inaccuracies.
- Communication and consultancy skills. Facilitating sessions to explain and run the model and build common understanding. Interpretation of results and use of the model in innovative, unanticipated ways.

We felt that the project was successful in the first two of these challenges in producing a model at an appropriate level of detail that used available data appropriately. On the third point, the seminars were successful in terms of feedback from participants, the common understanding that they generated, and the targeting of national efforts. However in retrospect, some of the local effort with the model may have been better spent on these sessions.

9.2 Local Application of the Generic Model

A secondary concern of the work was to use the 'generic' model to help individual trusts that were struggling to meet the A&E target. The main obstacles to effective use of the generic model were external to the model – particularly organisational and data quality issues. Where these were resolved, the model was flexible enough to resolve specific local issues, through different interpretations of the input data, small changes to the model structure or small amounts of offline analysis. For none of the 10 trusts did we reach the end of our target consultancy pathway, but significant benefits were achieved from the intermediate stages.

On more general modelling issues, the work provided some interesting case study evidence to contribute to debates surrounding model re-use, generic models and model validation.

9.3 Model Reuse

An important current debate in simulation modelling concerns model reuse. Robinson et al (2004) discuss dimensions of this, including a spectrum of reuse, from "code scavenging" up to full model reuse and weighing these considerations against development cost. A cycle of "grabbing and gluing" old ideas/models/pieces of code, running them, using them if workable, otherwise rejecting and retrying is proposed. The key benefits of model reuse are identified as time, cost and consistency of output; obstacles being the time/cost required on projects to support reusability, plus systems architecture issues. Pitfalls are around the required level of abstraction, and the potential for "force fitting" inappropriate models.

In the work described in this paper, reuse of the Oldham model was seriously considered. Reuse of the model was eventually rejected for practical reasons related to the costs of adopting a model which was not designed with reusability in mind, and the relatively low costs of building a new model. However reusing ideas, data and concepts from the Oldham model made a valuable contribution to our work, and this additional aspect of model reuse should perhaps be included in the debate around simulation model reuse..

9.4 Generic Modelling

A different perspective on model reuse also appears under the heading of 'generic modelling' and can be seen as attempts to use system architectures which facilitate reuse. In a study which concerns the simulation of emergency departments in Israel, Sinreich et al (2004) suggest three levels of genericity – the most generic being high levels of abstraction that can model any system and scenario, the least generic being those that can model only one specific system. In the middle are models at medium abstraction that can model any provider of a similar process. Sinreich et al claim that it is possible to model the emergency departments using a medium level of abstraction, on the grounds that in their extensive study of 5 hospitals, the processes received by patients depended much more strongly on the characteristics of the patients than on the particular hospital where they were seen. Without specifically doing either, they go on to imply two important uses of such generic models:

- to model a typical hospital to gain general insights about service improvements;
- to model a specific hospital to address specific local issues.

In this paper we provide concrete examples of both types of usage. In doing so we support the suggestion that modelling a 'typical' using a generic model with 'typical' inputs has value. In passing we also note that, as with much operational research, working for a client who wishes to gain general insights is a different situation from that often faced by academics who have the added challenge of trying to interest managers in the general insights provided by their models.

On the issue of local usage of a generic model we distinguish two different circumstances. If the purpose of the study is to model/predict the impact of local decisions, much work remains to be done as local input data is needed for calibration and local performance data for validation. In addition, local circumstances may require some modification of model structure. Nevertheless the ‘generic’ model was found to be a good starting place in the hands of those who had built and understood the model. Our experience of trying to reuse previous models suggests that ‘generic’ models may be less advantageous as a starting point in the hands of others.

If on the other hand the purpose of a local model is to generate interest and facilitate debate of alternative methods of improving performance, the experience of this project is that a generic model may be all that is required.

9.5 Validation

As described earlier, the process of validating the generic model described here was rather different than is traditionally suggested in text books. The validation process used was a mixture of black box and open box validation. In particular, input parameters were adjusted to reproduce the desired output, but with open box validation overseeing the process to ensure that this resulted in a reasonable, transparent and believable model.

9.6 Further Work

This experience of the potential value of generic models has motivated the primary author’s current research which focuses on the development of a generic model to examine whole hospital issues in dealing with emergency demand, and the applicability of such a generic model locally.

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References

1. Badri M, Hollingsworth J (1993), “A simulation model for scheduling in the emergency room”. *IJOPM Vol 13 No. 3 pp 13-24*
2. Baesler F, Jahnsen H, DaCosta M (2003) “The use of simulation and design of experiments for estimating maximum capacity in an emergency room”. *Proceedings of the 2003 Winter Simulation Conference*

3. Blake J, Carter M (1996), “An analysis of emergency room wait time issues via computer simulation”. *INFOR vol 34 no. 4 p 263 to 273*

4. Blasak R, Armel W, Starks D, Hayduk M (2003) “The use of simulation to evaluate hospital operations between the emergency department and a medical telemetry unit”. *Proceedings of the 2003 Winter Simulation Conference*

5. Centeno M, Giachetti R, Linn R (2003) “A simulation-ILP based tool for scheduling ER Staff” *Proceedings of the 2003 Winter Simulation Conference*

6. Gonzalez B, Perez P, (1994) “Evaluation of alternative functional designs in an emergency department by means of simulation”. *Simulation 63:1, 20-28*

7. Jun J, Jacobson S, Swisher J (1999) “Applications of discrete-event simulation in health care clinics: A survey.” *J Opl Res Soc* **50**: 109-123.

8. Komashie A, Mousavi A (2005), “Modelling emergency departments using discrete event simulation techniques*”* *Proceedings of the 2005 Winter Simulation Conference*

9. Lane D, Monefeldt C, Rosenhead J, (2000), “Looking in the wrong place for healthcare improvements: A system dynamics study of an accident and emergency department” *JORS (2000) 51, pp 518-531*

10. Mahapatra S, Koelling C, Patvivatsiri L, Fraticelli B, Eitel D, Grove L, (2003), “Pairing Emergency Severity Index5-level triage data with computer aided system design to improve emergency department access and throughput” *Proceedings of the 2003 Winter Simulation Conference*

11. Miller M, Ferrin D, Messer M (2004) “Fixing the emergency department: A transformational journey with EDSIM”. *Proceedings of the 2004 Winter Simulation conference.*

12. Miller M, Ferrin D (2003), “Simulating six sigma improvement ideas for a hospital emergency department”. *Proceedings of the 2003 Winter Simulation Conference*

13. Pidd M (1999*)*”Tools for thinking: Modelling in Management Science”, *Wiley and Son*

14. Robinson S, Nance R, Paul R, Pidd M, Taylor S (2004) “Simulation model reuse: definitions, benefits and obstacles”. *Simulation modelling practice and theory (2004) 479-494*

15. Rossetti M, Trzcinski G, Syverud S (1999) “Emergency Department Simulation and Determination of Optimal Attending Physician Staffing Schedules”. *Proceedings of the 2003 Winter Simulation Conference*

16. Samanha S, Armel W (2003), “The use of simulation to reduce the length of stay in an emergency department”. *Proceedings of the 2003 Winter Simulation Conference*

17. Sinreich D, Marmor Y (2004) "A simple and intuitive simulation tool for analyzing emergency department operations". *Proceedings of the 2004 Winter Simulation conference.*

18. Takakuwa S, Shiozaki H (2004) "Functional analysis for operating emergency department of a general hospital". *Proceedings of the 2004 Winter Simulation conference.*

19. Wiinamaki A, Dronzek R (2003), "Using simulation in the architectural concept phase of an emergency department design" *Proceedings of the 2003 Winter Simulation Conference*