

DGHPSIM: SUPPORTING SMART THINKING TO IMPROVE HOSPITAL PERFORMANCE

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ABSTRACT

DGHPSim is a suite of discrete event simulation models that enable managers and clinicians to investigate improvement scenarios for UK general hospitals. The models were developed in Micro Saint Sharp and are configured using hospital data and nationally available health episode statistics. The models can be separately but function best as a single, overall system model that allow users to develop understanding of the interaction effects of possible changes. An example of the use of DGHPSim is given, using UK NHS data, demonstrating how it can be used to investigate improvement options whilst keeping an eye on side effects.

1 PERFORMANCE MODELLING OF HOSPITALS

1.1 The NHS context

Patients usually wait for elective hospital care in publicly funded systems and this has been a long-standing problem in the UK National Health Service (NHS). Wishing to reduce these waiting times and to see other improvements, the UK Government launched a two-pronged attack some years ago. The first element of the improvement programme was a substantial increase in the funding available to the NHS, which, over the last 5 years, has increased annually in real terms by an average of 7.4%, from about £66 Billion to about £96 Billion (Wanless et al (2007)). It seems reasonable to hope that at least some of this extra cash led to improved performance by reducing waiting times. The second element of the improvement programme has been a performance management framework that includes waiting time targets that must be met by NHS organisations, including hospitals.

Most medical care in the NHS is provided by general practitioners (GPs), hospitals and community services (Office of Health Economics, 2008). Under the current arrangements, agencies that buy care for patients, known

as Primary Care Trusts (PCTs), are separate from those that provide it. PCTs cover defined geographical areas and have functions that partially mirror HMOs in the USA. PCTs receive NHS funds, mainly on a per capita basis and are responsible for buying care from provider units, most of which are NHS hospitals. The NHS hospitals themselves belong to NHS Trusts, which may have only a single hospital or several and may operate with a wide case mix or only highly specific cases (e.g. for cancer or orthopaedics). GPs are the gateway to elective hospital care and usually advise patients which hospital is most appropriate for their needs. GP income from the NHS depends on the number of patients they serve and whether they meet certain performance targets (e.g. % of infants immunised against common diseases).

As part of the commissioning process, PCTs must work with GPs to establish priorities for healthcare, resulting in contracts with provider Trusts and the private sector. Within the NHS, prices are fixed according to a national tariff, though private sector care can be priced somewhat differently. PCTs are also responsible for helping their providers to meet NHS performance targets. Since 2006 these are included in the 'Annual Health Check' (for details see Healthcare Commission (2008)), which refers not to patients but to the performance of provider Trusts and PCTs. The annual health check has two main components: quality of services and use of resources. The latter refers to the financial status of the Trust. Quality of services is assessed on three main dimensions:

1. Core standards: covering patient safety, clinical effectiveness and cost effectiveness, Trust governance, patient focus, accessible and responsive care, the care environment and amenities and, finally, public health
2. Existing national targets: left over from the previous 'Star Ratings' (see below), which include waiting times and clinical standards that specify

desirable outcomes, e.g. on acquired infection rates

3. New national targets: added to the previous targets

For the decade to 2005, NHS Trusts were assessed against national targets and their performance was summarised in Star Ratings. Rather like hotels, the better the performance of a Trust against the targets the more stars it was awarded. Chief Executives of low and no star Trusts often lost their jobs, though it less clear whether this affected the view that patients took of their hospital care. As an example of a target that was in the Star Ratings and continues in the Annual Health Check, no patient should spend more than 4 hours in an accident and emergency department (A&E – ER in the USA) from their time of arrival to their discharge or admission as an inpatient.

New national targets are added to the Annual Health Check to reflect changing clinical and political priorities. Non waiting-time targets include commitments to substantially reduce mortality rates by 2010 (from a 1995/97 baseline) from heart disease and stroke and related diseases by at least 40% in people under 75, with a 40% reduction in the inequalities gap between the fifth of areas with the worst health and deprivation indicators and the population as a whole.

1.2 The need for smart thinking

For good reasons (to provide better care) and less good reasons (job preservation) senior managers and clinicians in NHS Trusts need to maintain good performance as assessed in the Annual Health Check. This requires smart, holistic thinking. It is not enough to concentrate on achieving a single target because most hospitals are highly congested systems that run close to capacity for much of the year. In this sense, they resemble inflated balloons – squeeze them hard in one place and the pressure moves elsewhere, or the balloon bursts. However, there may be more to it than this. For example, some commentators have alleged that apparent improved performance in A&E may be caused by delaying entry to patients brought to the hospital in ambulances (Guardian, Feb 17th, 2008). Others have alleged that patients are being shifted from A&E into assessment wards as the 4-hour target approaches. If true, the latter has a further advantage to the admitting NHS Trust, because it may receive a higher payment for such an admission.

Examples of core standards and targets include:

- A four hour maximum wait in A&E from arrival to admission, transfer or discharge.
- A two-week maximum wait from urgent GP referral to first outpatient appointment for all urgent suspected cancer referrals.

- A maximum two-week wait for rapid access chest pain clinics.
- A maximum of 18 weeks from GP referral to hospital treatment.

Since hospitals and healthcare providers have limited resources, decisions must be made on the allocation of those resources, their better use and improve configuration. Essentially, managers and clinicians must take a systems view of a patient journey rather than treating it as a sequence of disjointed events. This is far from straightforward when applied to the whole of hospital care and requires tools that support dynamic systems thinking and analysis.

2 THE DGHPsim PROJECT

The DGHPsim project has the full title: Modelling for performance measurement and improvement to meet stochastic demand for public services: a study of acute hospitals. DGHPsim is a suite of discrete event models, written in Micro Saint Sharp, that simulate individual patients as they flow through a hospital. The models are based on a typical district general hospital and enable clinicians, managers and planners to see the effect of different actions on waiting times for A&E, inpatients and outpatients.

The DGHPsim models should be parameterised to fit a particular hospital using two data sources. The first is local data from the hospital's Patient Administration System (PAS), which was developed for local administration and for billing. Not all hospitals have the same PAS, but most are very similar in what they record. The second data source is a national data set, collected by the UK Department of Health as Health Episode Statistics (HES). All hospitals are required to submit data to the HES datasets, which contain anonymised data on each inpatient and outpatient episode. We have developed a software tool, the Health Activity Data Analyser (HADA) to enable the integration of PAS and HES data and to convert it into the form used by the DGHPsim suite.

Previous WSC papers (Günel and Pidd 2005, 2006, 2007) have described the DGHPsim project as it has developed. In its final form, the DGHPsim suite consists of four sub-models (see figure 1), models 1 to 3 can be run independently if desired, but running all 4 in concert provides a holistic, dynamic view of a hospital's performance.

1. Accident and emergency department: most general hospitals have these units, which accept patients who arrive themselves or are brought in by ambulance. Most A&E patients do not require admission as inpatients and, in many hospitals, those that do are initially admitted to assessment

- units for observation from which they may be discharged or fully admitted as inpatients.
2. Inpatients: this model simulates the operation of the main wards of a hospital into which patients are admitted for care as emergencies or electives. Patients may move between wards whilst in the hospital.
3. Outpatients: which receives referrals from GPs, sees patients through outpatient appointments and diagnostics and, if necessary, places them on waiting lists for inpatient care.
4. Waiting list: this model cannot be run alone, but serves as a bridge between outpatients and inpatients. Patients are added to a waiting list and then admitted for inpatient care according to rules defined by the user.

Thus, the models simulate individual patients, who may be emergencies (admitted via A&E or as direct referrals) or electives (admitted via outpatients). Taken together, the models provide a dynamic systems view of hospital performance.

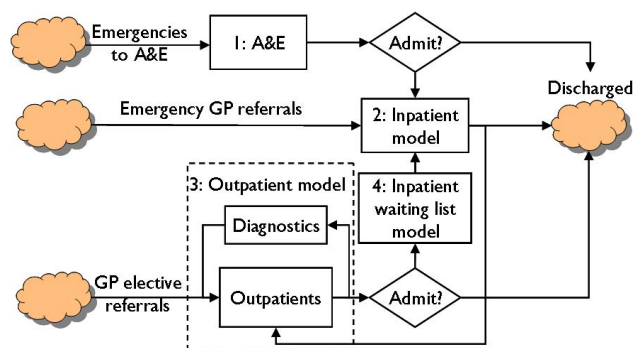


Figure 1: DGHPSim suite: 4 linked models

System dynamics models of health care systems are common: for example, Taylor and Dangerfield (2005), Brailsford et al (2004) and Lane et al (2000). Hence, it might reasonably be asked why DGHPSim employs discrete event simulation rather than system dynamics, given that a holistic, dynamic system model is needed. The answer is that it is well-known that, in congested systems, stochastic effects become very important. For example, queuing theory results suggest that even in a single server queue, variances of the arrival and service times have a major effect. The DGHPSim models simulate individual patients and their stochastic arrivals, referrals, treatments and other factors. This allows stochastic performance effects to be modelled properly. It is possible that simple, deterministic spreadsheet models would suffice if hospitals were not congested systems.

A further question to be addressed when modelling a multi-specialty hospital is the representation of case mix

and specialties. General hospitals serve many different types of patient and typical in-patient specialties include general surgery, cardio-vascular medicine, trauma, orthopaedics, ophthalmology, obstetrics, gynaecology and urology. There are several classification systems in use, for example ICD-10 (World Health Organisation, 1992), which allows causes of mortality and morbidity to be classified and coded for statistical analysis. Others were created to support payment systems, for example Health Resource Groups (HRGs) are used in the UK to determine charges to be levied by a provider to a PCT for healthcare episodes (NHS Information Centre, 2008). Both ICD-10 and the latest version of HRGs offer too fine a level of granularity for the performance modelling in DGHPSim, in which the user is allowed to specify their own level of granularity with a recommendation not to go below speciality level – otherwise, the data requirements become too onerous. Thus, HADA determines the current case mix of a hospital using HES and PAS data as inputs. As patients enter the simulated system, sampling routines allocate them to a specialty, which determines their resources needed and also, by further sampling process the characteristics of their treatment such as a length of stay.

3 USING DGHPSIM

3.1 General uses for DGHPSim

The DGHPSim suite can be used to help managers, clinicians and planners to investigate questions such as:

- For a given investment what level of waiting can be delivered?
- What advice should be given to hospitals seeking to achieve performance?

The answer to these questions is not obvious, as the relationship of waiting to resourcing is non-linear (twice the investment does not equal half the waiting time). Moreover, hospitals are complex systems dealing with stochastic demand flows in which actions which appear sensible when viewed in the context of one specialty (e.g. carving out bed space for patients with a particular condition) may often appear less sensible when viewed from the point of view of the interests of the organisation as a whole. DGHPSim enables them to add quantitative detail to the qualitative insights on which policy is too often based, and provides useful information both to those responsible for setting targets, and for those whose role is to help hospitals achieve higher levels of performance.

DGHPSim can be used to explore a number of questions, such as the following:

- Given this hospital's level of resourcing, what sort of performance characteristics (length of stay, use of day-case surgery) would be required for it to meet the 18 week wait target?

- Given this hospital’s performance characteristics, what sort of level of resourcing would be required for it to meet the 18 week wait target?
- Given hospitals are required to hold buffers against emergency demand, how does performance against elective targets trade-off against targets for emergency admissions? And within the elective wait, how does performance against waits for those whose journey stops as outpatient trade-off against those whose journey goes right up to inpatient admission?
- The development agency for the NHS, the Institute for Innovation and Improvement, makes a number of recommendations (e.g. concerning combining queues and outlying patients) which are thought to impact waiting time performance. Are these impacts substantial or are they dwarfed by uncontrollable factors (e.g. seasonal fluctuations in demand)?

3.2 An example of DGHPSim use

One success of the target regime in that patients wait for much shorter times in A&E than was the case some years ago; this is because NHS hospitals have worked hard to ensure that patients spend no longer than 4 hours in A&E. The current waiting time challenge is to reduce the time taken from GP referral to the start of elective treatment. When the drive to reduce waiting times began, many patients suffered extremely long waits for elective treatment. Waits of two years for hip replacement were far too common, as were long waits for cataract surgery. Since 1997, a series of targets have been applied to these waits for elective care and the current target requires this care to be provided within 18 weeks by the end of 2008. The waiting period can be divided into the three stages shown in figure 2. Stage 1 is the delay between a GP deciding that a patient needs to be seen by a specialist and the first out-patient appointment with that specialist. Stage 2 is the period of out-patient consultation, which may involve several visits to a clinic and diagnostic procedures. Stage 3 is the delay between a specialist deciding that a patient will require inpatient care and the admission of that patient for care.

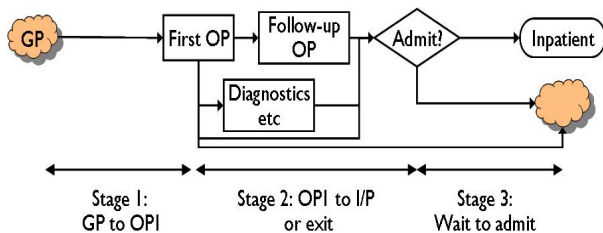


Figure 2: Stages in 18-week RTT journey.

By 2008, the total delay across all 3 stages suffered by patients should be no more than 18 weeks. To place this in context, a previous (2005) target required that stage 1 be complete by 17 weeks. This would leave just one week for stages 2 and 3 were stage 1 delays not reduced further. It is not uncommon to hear health service managers speak of reducing stage 1 delays to 4 weeks, stage 2 to 4 weeks and stage 3 to 8 weeks. On reflection, this is very strange, since only stage 2 of the 3-stage process is active and sensible time compression would focus on stages 1 and 3, especially stage 3.

So as not embarrass any hospital, the example of DGHPSim use described here is based on an analysis of stage 3 elective waits, using 2004 data. It is important to realise that the hospital in question is now performing much better than it was in 2004, though is still some way from reaching the 18-week target across all 3 stages. Figure 3 shows the actual stage 3 (waiting for admission) performance of the hospital in 2004/5. The case mix is divided into 6 super-specialties: trauma and orthopaedics; general surgery; ear, nose and throat; urology; paediatrics; ophthalmology; general medicine. During the period, the hospital treated nearly 3,000 elective patients (excluding day-cases) and almost 16,000 emergency patients.

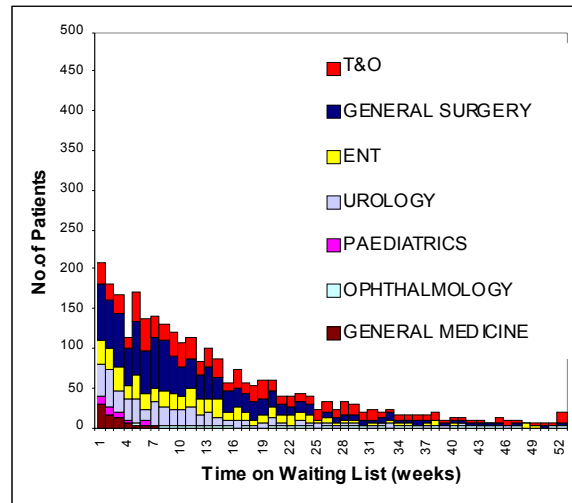


Figure 3: Actual waiting time performance in stage 3 (2004/05)

To demonstrate the use of DGHPSim, 3 different scenarios are imposed on the 2004/5 admissions data and hospital resources:

1. Suppose it was possible to reduce length of stay in all specialties, what effect would this have on stage 3 waiting times?
2. Suppose the hospital allocated 30% more of its in-patient beds to elective patients rather than

keeping them for emergencies, what effect would this have?

- Suppose that the hospital were able to treat a further 12% of its surgical patients as day-cases, what effect would this have?

Table 1 summarises the results of 20 replicated simulations of these scenarios and compares them with the base case. The results suggest that the biggest bang for the buck comes from creating greater elective capacity by devoting 30% more of the beds to elective admissions. This policy allows the hospital to admit more elective patients (3490 as against 2880) and reduces those waiting more than 8 weeks to 34%, as against 58%. Table 2 also shows the number of elective admissions cancelled and the number of emergency patients who could not be admitted, which the simulations assume will be diverted to other hospitals. This is not enough to reduce typical stage 3 waits to 8 weeks, but is a large step in the right direction. It would, of course, be possible to experiment with combined scenarios such as more beds allocated to electives and a reduced length of stay – whether this is feasible in reality is another question altogether.

Table 1: Comparative outputs of scenarios [std.dev.]

	Base	LoS down 20%	30% more electives	12% in- crease day- cases
	% Waiting			
> 5 wks	72.6 [1.2]	58.7 [3.5]	48.1 [2.5]	62.4 [1.8]
> 8 wks	58.2 [1.6]	43.8 [3.2]	34.7 [2.4]	48.2 [1.5]
> 10 wks	46.8 [1.7]	33. [2.9]	25.5 [1.9]	37.4 [1.2]
wait > 18 wks	28.5 [1.71]	17.6 [1.7]	13.4 [1.3]	22.2 [1.1]
	Side effects			
Elect pa- tients	2880 [21]	3396 [72]	3490 [93]	2654 [72]
Elect cancelled	90 [22] (3.1%)	73 [15] (2.1%)	114 [23.3] (3.9%)	51 [17] (2.5%)
Emerg outliers	469 [86] (3%)	405 [63] (2.7%)	505 [68] (4%)	469 [86] (3.2%)

4 BRINGING IT ALL TOGETHER

One important element in providing acute health care is ensuring that appropriate treatment is provided when it is needed and that patients do not have to wait for unnecessarily long periods for their treatment. Universal zero de-

lay treatment seems unlikely, since that would require a level of resourcing beyond that which is economically and politically feasible. In the UK, the government has provided incentives and extra money for healthcare providers to reduce waiting times from levels that were unacceptable. The incentives are based on targets to be achieved and there has been concern that the target regime has encouraged managers to focus their efforts on meeting these targets lowering performance elsewhere.

The DGHPSim suite can be used by managers and clinicians to investigate options for improvement and service reconfiguration. Not only can the models show the effect of the policies on meeting the targets but can also show the effects on other, very important aspects of hospital performance. For example, the simulations of 3 scenarios for reducing stage 3 waiting also show the effects on emergency patients and seem to show that, as at 2004/5, a considerable reduction in stage 3 waits would have been possible with very little effect on bed availability for emergency admissions.

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