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ABSTRACT

Many computer simulation models of A&E departments have been developed to aid clinicians and managers to maintain and improve performance of their departments. Here we present a model that can be also used to understand changes in performance that may occur as a result of the 4-hour target regime in the English NHS. The model simulates the performance resulting from normal activity and the differences between this and actual performance are revealing. Results from 2 departments are presented to demonstrate this mode of model use. These reveal the extent of special action taken in some A&E departments as patients approach the target time and also show the true, underlying performance of the departments.

INTRODUCTION

Since 2002, A&E departments in English NHS Hospitals have been required to meet a 4-hour target for the length of time taken to treat patients in the department. Under this target, 98% of patients arriving at an A&E must either be discharged on completion of treatment, or admitted as an inpatient for further treatment, within 4 hours. The target was introduced as part of the government's drive to reduce unacceptable waiting times for hospital care. Evidence [1] suggests that waiting times for A&E have reduced since the target was introduced and the vast majority of departments claim to process patients within 4 hours. There remains, though, a suspicion that meeting the 4-hour target may have forced clinicians to cut corners at times of high demand or may have encouraged managers to adopt some of the undesirable behavioural responses discussed in Smith [2] and Bevan and Hood [3]. This has been investigated at a macro level by Friedman and Kelman [4], [5], who conclude that no such gaming or corner cutting is evident.

Here we describe a generic simulation model of an A&E department designed to be used in one of two modes. First, it can be used to experiment with alternative configurations and staffing to see how this affects patient waiting times. Secondly, it can be used to understand historic behaviour and thereby to spot special action taken as a result of waiting time targets, which is the mode of use discussed here. We present the results from simulations of 2 English A&E departments to show how the model can be used to understand observed performance, even when a department apparently meets the 4-hour target. Goodhart's Law [6] is a neat summary of the potentially distorting effect of using a performance indicator as a target. With this in mind, the model could be used by commissioners to understand service quality and by regulators to observe the effect of waiting time targets.

Simulation models of A&E departments are not particularly difficult to construct using modern software and there are several presented in the literature, for example [7-12]. The one discussed here was developed as part of the DGHPSim project, in which the operating processes of whole hospitals are modelled to assess the effects on waiting times of capacities and processing rates within the hospital. For a detailed description of the A&E model see [13], and more information about the DGHPSim project can be found at www.hospitalsimulation.info.

AN OVERVIEW OF THE SIMULATION MODEL

Figure 1 shows the broad conceptual model on which the simulation is based. Like all models it is a simplification, which is what makes the model useful [14]. In this case, the simplifications aim to focus on tasks and processes that affect performance as measured by times spent by patients in the department. The model is implemented in the Micro Saint Sharp software (http://www.maad.com/index.pl/micro_saint), which is well-suited to the simulation of systems that involved human processes.

The model is configurable; that is, its structure represents a typical A&E department and, using data appropriate to a particular department, can be used to simulate the activities and performance of that department. It does not attempt to capture actions taken in special circumstances, such a major road traffic accident, but represents the normal activities of the department. Likewise, it does not represent special interventions that are made when patients look likely to breach the 4-hour target. Hence, represents the normal activities of an A&E department and could be use to help improve such a department. However, here we discuss its use to detect altered performance.

The processes represented in the model

Figure 1 shows that simulated patients arrive at the department either by ambulance or as walk-in cases. On arrival, the latter will be registered and may be triaged, (we assume five-colour Manchester Triage [15] and will then wait for treatment. In developing the conceptual model, we observed that there are typically two treatment streams, even when a five-colour triage system is in use, and we label these as major and minor. Patients arriving by ambulance are assumed to be urgent and may be registered en route, though they too may have to wait for treatment. Once called from the waiting area, patients are modelled as occupying a cubicle and will participate in a process that may have 3 stages: initial treatment, tests and re-assessment/treatment after tests. The cubicle is freed at the end of each of these stages for use by another patient. Doctors and nurses are required during initial treatment and re-assessment/treatment, but not during the tests. Following re-assessment/treatment, patients are either discharged or admitted as inpatients.

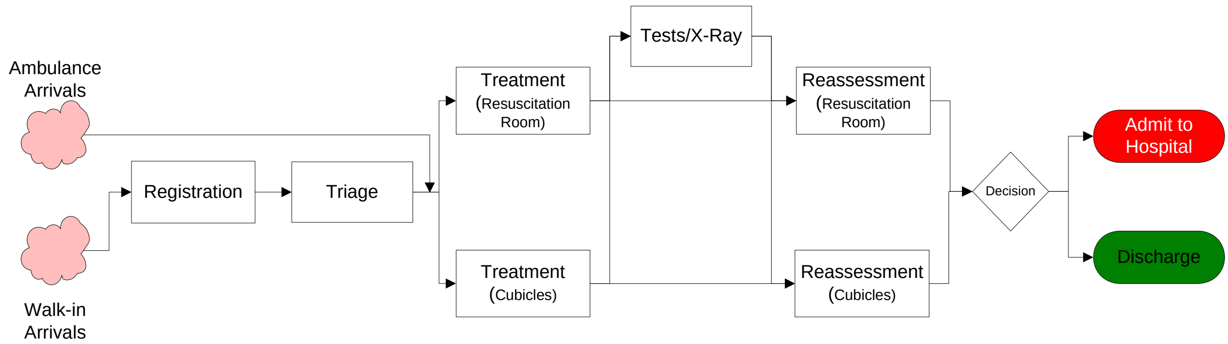

Figure 1: Outline conceptual model

Time dependent demand

The principal inputs to the simulation model are demand data, details of A&E staffing and process times. It is well-known that demand for A&E varies by time of day and by day of week (and in some departments, by time of year), which is represented in the model by non-homogeneous Poisson processes. This allows the model to display the type of dynamic variability that is all too familiar in real life. To simulate historical behaviour, the Poisson processes are constructed from records of actual arrivals at the A&E being simulated. If the simulation were to be used to simulate changes in demand from current levels, the probability distributions can be modified appropriately. Thus, the demand side of the simulation is a representation of individual patients as they arrive for treatment at the department and this demand varies through the day and the week.

Staffing workloads and task switching

The simulation assumes continuous operations on a 24/7 basis and, to represent a particular department, must be parameterised with staffing levels that specify the number of experienced doctors, trainee doctors, nurses and clerical staff using appropriate shift patterns. A failing of most A&E simulators described in the literature is their inability to represent task switching; that is, the well-known fact that each doctor and nurse is likely to be simultaneously responsible for more than one patient during busy periods.

The number of patients simultaneously treated has been studied empirically [16, 17] and the latter includes a time and motion study in the USA in which clinicians were shadowed for a month, defining 8 possible "tasks" including patient care and viewing diagnostic test results, and defining an "interruption" as any event that briefly required the attention of the subject but did not result in switching to a new task. If a subject switched from one task to another, the latter was defined as a "break-in task". The data reveal that that the number of patients managed simultaneously by experienced physicians is 5.1± 2.1 and that the number of break-in tasks increases during busy periods.

Since this task switching is a feature of A&E departments and is crucial to their operation, it is important that it be represented in a simulation model if the model is to give reasonable estimates of performance. The obvious way to do this is to find some way to record how long each interrupted task and break-in task takes. This is appealing, but rather difficult in practice, especially during busy periods. An alternative representation, adopted in our model, is to include multiple representation of each clinician (e.g. each doctor may be represented by several 'mini docs'). In this way, the same clinician can be simulated as attending to several patients concurrently. Based on Chisholm et al [17] we fragment clinicians into 6 for experienced doctors, 4 for trainee doctors and 2 for nurses.

TWO VERY DIFFERENT A&E DEPARTMENTS

Locker and Mason [18] analyses data from 83 English A&E departments, reporting that about 1 in 8 of admitted patients spent between 220 and 239 minutes in the department, which is a clear indication of the effect of the 4-hour target. However, such an analysis cannot reveal the underlying performance of a department – that is, how it would perform if no special actions were taken when a breach is imminent. It is important to know this, since it reflects the true, underlying performance of a department.

To illustrate the use of this simulation model in understanding this true, underlying performance of A&E departments, we present the results from two such departments. The data used is no longer current and so the performance of both departments will have changed. Figure 2 shows the performance of Department A. The horizontal axis shows the total time spent by patients in the department from their arrival to their discharge or admission. The vertical axis shows the proportion of patients treated within those times. The solid line is the actual performance of the A&E department during this period of operation and the dotted line is the results of the simulation of the department during that same period.

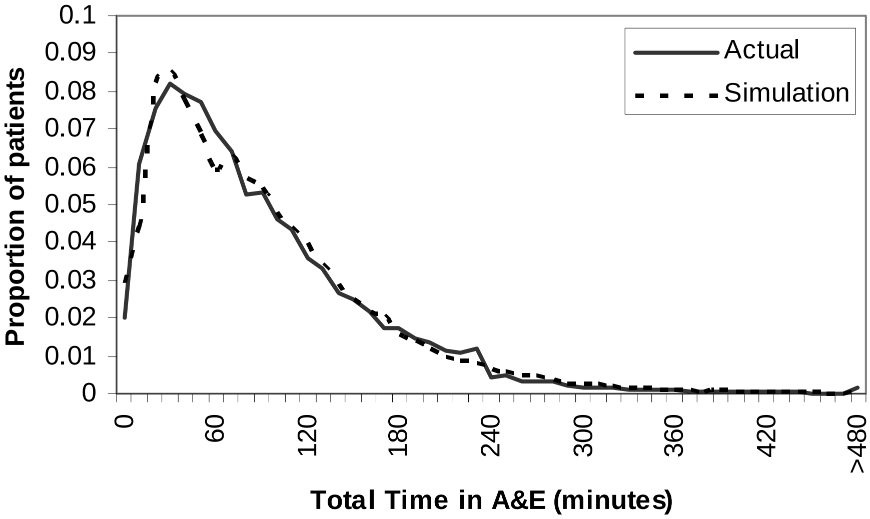

Figure 2: Performance of Department A

The graph shows that, in this case, the simulated performance is very similar to that actual performance of the department. The main, albeit small, difference occurs around 240 minutes when the line of the actual performance briefly rises. Since 4 hours is the A&E target and the simulation takes no account of the target, it is reasonable to suppose that the looming breech point caused the department to find ways to quickly complete the processing of a small proportion of their patients. As a consequence, the solid line drops below the dotted line after this point. In this case, the model reveals that the existence of the target may have caused staff to quickly complete the processing of a few patients – however, the proportion is small, which suggests that Department A is not indulging in any serious gaming to meet the 4-hour target.

Figure 3 shows the performance of Department B and the two lines are very different from those for Department A in figure 2. As before, the dotted line shows the simulated performance; that is, the expected performance if the department is run normally with no special actions taken as the 4-hour deadline approaches. The solid line, showing the actual, reported performance of Department B is very, very different. There is a substantial and sharp peak as the 4-hour deadline approaches. This suggests that special action is being taken in many cases as the deadline approaches, and the difference between the dotted line and the solid line indicates how many patients may be affected by this special action. This suggests that Department B may not be under control and that some serious interventions may have occurred to meet the four-hour target as that target approached.

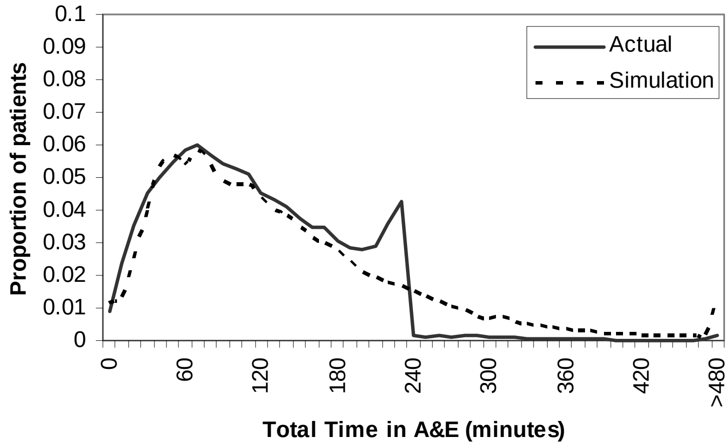

Figure 3: Performance of Department B

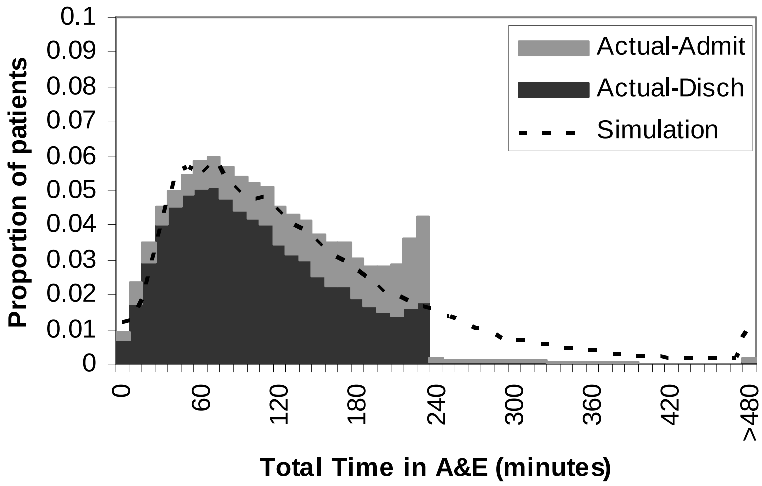

Figure 4: What's happening in Department B

Figure 4 helps us to understand what is happening in Department B. As before, the dotted line is the simulated performance but now the stacked histogram shows the proportion of patients who are admitted or are discharged. As the deadline approaches, the proportion of patients admitted starts to increase and peaks at about 4 hours. Why should this happen? Clearly some of these patients have been in A&E for a long time because there is uncertainly about their diagnosis and treatment or because longer treatment is needed. However, it seems unlikely that this is true of all the patients and it could be that some are admitted as inpatients simply to meet the target – placing inpatient resources under unnecessary strain. This accords with the findings of Locker and Mason [18] and of Cooke et al [19] that bed occupancy affects total time in an A&E department and complements the simpler approach of Bagust et al [20]. Such use of assessment units may not always be inappropriate, since many such patients will quickly be discharged after further assessment, however, its use in meeting or beating the 4-hour target seems questionable.

CONCLUSIONS

Computer simulation is a widely used and relatively straightforward tool that can help people to understand the performance of A&E departments. It is possible to build a generic model of such departments that, in the English NHS, provide an accurate enough representation of the performance of these departments. The generic model is populated by demand, staffing and resource data that is specific to a particular A&E in order to simulate that department. Since task-switching by staff is an important feature of A&E departments, the model described here represents this by fragmenting staff into 'mini staff', which reduces data demands and is sufficiently accurate.

Most simulations of A&E are intended to enable clinicians and managers to try out process configurations and shift patterns to maintain or improve performance and our model can be used in this way. In addition, though, our model is useful as a way to study altered performance in an A&E department as shown by the two examples in this paper. The model does not explain the causes of this changed performance but identifies it and encourages its further investigation with a view to ensuring that patients are appropriately treated in future.

The use of the model in A&E Department B suggests that macro economic studies [4], [5] may be over-optimistic in arguing that the 4-hour target is being met without any gaming or altered behaviour. The A& E simulator can help commissioners and regulators to understand the true, underlying performance of departments and demonstrates how the targets might, in some circumstances, be distorting the behaviour of healthcare staff even though targets are being met.

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COMPETING INTERESTS

None

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