Does a speciality ward structure remain a sustainable approach to meet the volatility, increasing demand and safety requirements for inpatient hospital treatment?

Dr Mike D Williams

University of Exeter Business School, Exeter, UK

m.d.a.williams@exeter.ac.uk

Dr Mike Allen

PenCHORD, Peninsula College of Medicine and Dentistry. Exeter, UK

michael.allen@pcmd.ac.uk

Mr Andrew Fordyce FRCS

South Devon Healthcare NHS Foundation Trust, Torbay, UK

andrew.fordyce@nhs.net

Mr Sasha Karakusevic

South Devon Healthcare NHS Foundation Trust, Torbay, UK

sasha.karakusevic@nhs.net

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Dr Mike D Williams

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michael.allen@pcmd.ac.uk

Mr Andrew Fordyce FRCS

South Devon Healthcare NHS Foundation Trust, Torbay, UK

andrew.fordyce@nhs.net

Mr Sasha Karakusevic

South Devon Healthcare NHS Foundation Trust, Torbay, UK

sasha.karakusevic@nhs.net

Abstract

Hospitals face increasing demand at the same time that budget constraints and other factors are reducing bed capacity. Structuring and staffing hospitals is changing with the introduction of assessment units. Research suggests that hospitals need to operate at 85% bed capacity to avoid bed crises and prevent access block for patients. This simple approach is challenged in the light of changing patient pathways. Analysis is undertaken by discrete event modelling using data from an NHS hospital. Hospitals traditionally have speciality wards rather than a single bed pool. This research shows that speciality wards have higher levels of volatility of demand than a single bed pool and require around 70% occupancy. An alternative larger bed pool approach is suggested and further research is advocated to study the potential advantages of change.

Keywords: hospital management, redesigning healthcare organisations, volatility

Emergency admissions are responsible for an increasing and volatile workload for acute hospitals. The increase is due to a continued rise in numbers of patients presenting, their changing age profile and increasing complexity due to co-morbidities (George, Jell and Todd, 2006, Blunt, Bardsley and Dixon, 2010). The challenge for hospital managers is how to plan for this workload in terms of beds, staff and other resources, whilst at the same time meeting the needs of elective patients and budget constraints in publicly funded healthcare systems such as the National Health Service (NHS) in the UK. In a number of countries the reductions in length of stay, the increased use of day case surgery and budget pressure has resulted in reduced numbers of acute hospital inpatient beds to meet the overall demand (Richardson and Mountain, 2009). Beds are not the only capacity issue but they are in some ways a surrogate marker for access to other services. It is not bed numbers alone that are the required resource but they are a measure of spaces that can accommodate patients who must be cared for by healthcare workers with varying skill sets. Where there is a shortage of beds then it can create significant patient care and operational problems, such as ‘access block’ where emergency patients wait for an inpatient bed (Williams, 2011, Richardson, Kelly and Kerr, 2009, Lowthian and Cameron, 2009).

Emergency admissions have increased by nearly 40% in England between 2001 and 2011, and account for the majority of the bed days used in an acute hospital (Department of Health, 2012). Many hospitals attempt to predict the number of emergency admissions by day of the week and week of the year to assist in their planning (Boyle et al., 2012). However, there are many variables that combine to determine the number of admissions, the length of stay for each patient and therefore, the overall bed occupancy at any point in time (Harper and Shahani, 2002). The usual practice of a midnight census of occupancy does not tell the story of peaks in bed usage during the day. It is widely reported that delays for patients in Emergency Departments (EDs) accessing beds (‘access block’) is a patient safety issue (Lowthian and Cameron, 2009, Cameron, 2006). Access block is defined variously in different countries with blocked patients being those who wait in ED longer than 4 hours in the UK, 6 hours in New Zealand and 8 hours in parts of Australia (Richardson and Mountain, 2009).

Previous work (Bagust, Place and Posnett, 1999), has shown that the pattern of emergency admissions is random, which makes it difficult to accurately predict outside of expected ranges. Most acute hospitals also have elective admissions. Such planned work adds considerable variation in the number of admissions into the total bed capacity. Experience in the UK suggests that hospitals are facing increasingly frequent bed crisis where 'access block' is being overcome by opening additional beds at short notice or converting day case facilities into overnight wards (escalation beds). Surgical beds are often used to 'outlie' medical patients, which can mean the cancellation of elective surgical cases with consequences for patient care, safety and financial performance (Alameda and Suárez, 2009, Lloyd et al., 2005, Elsayed, Cosker and Grant, 2005).

Managers and clinicians need to find ways to improve their understanding of and planning for the variation in demand for key resources such as beds and medical staff to enable hospitals to absorb the peaks in demand and continue to provide high quality and safe care. This paper focusing on a widely cited piece of research on hospital bed capacity planning (Bagust et al., 1999), and the contextual changes that now need to be taken into account. The method and results from a study of a NHS hospital using discrete event simulation modelling is presented. It is argued that a more sophisticated understanding about patterns of demand and how the size of the bed pool influences the risk of access block or outlying of patients. The current practice of speciality ward bed pools is questioned in the light of new pathways for emergency admissions and the analysis and modelling work presented.

LITERATURE REVIEW

There have been a number of modelling approaches to predicting demand on EDs but few which have also included the number of patients admitted into hospital or divided the pathway into separated bed areas (Boyle et al., 2012). The studies that have assessed the use of inpatient wards have adopted either a queuing or mathematical modelling approach (de Bruin, Bekkervan Zanten and Koole, 2010, Thompson, Nunez, Garfinkel and Dean, 2009). Simulation modelling has been used to study the relationship between occupancy and patient refusal for different specialities but has not modelled the new pathways for emergency medical patients (Harper and Shahani, 2002). Despite the wide ranging modelling found in the literature a widely referenced paper on planning for emergency admissions is (Bagust et al., 1999). The research reported was based on an excel software based discrete event stochastic simulation using data derived from two District General Hospitals in the UK. Emergency demand was simulated and a number of experiments were run to assess different scenarios for a 200 bed pool unit. The key message often taken from this paper is that when the bed occupancy of a hospital rises above 85%, then the risk of not being able to accommodate the demand increases. An 85% occupancy rate or less is suggested as there is a random pattern of emergency demand. To accommodate the random variation, without running out of bed capacity, the modelling shows that there needs to be an average occupancy of 85%. Bagust predicted that hospitals operating at 90% occupancy or above would frequently suffer bed crises from which it could take weeks to recover. The concept of 85% occupancy appears to have been taken to be a simple rule that could be applied by managers in NHS hospitals (Proudlove, Black and Fletcher, 2007). However, applying such a rule in policy and planning documents within the NHS misinterprets the research reported by Bagust et al (1999). In 2001 the UK Department of Health stated that research suggested that the average bed occupancy should be even lower at 82% rather than the 90% plus experienced at that time (Department of Health, 2001). This approach in stating a target occupancy for a whole hospital is misleading and fails to understand the different characteristics of demand and bed utilisation found in a general hospital (Harper, 2002, Proudlove et al., 2007). Using a standard occupancy rate for all wards is impractical and can lead to high numbers of patients being unable to access the required ward (de Bruin et al., 2010, Harper and Shahani, 2002).

There are three main weakness of the Bagust model. The first is that it used a 'notional baseline position' of a 200 emergency bed pool rather than an actual hospital, albeit using data analysed from two contrasting types of hospital. The pool of beds was not divided into speciality wards but rather assumed to work as all beds being of equal value for every patient. The second weakness is that although elective cases where initially included, the more simplistic emergency admissions only model was preferred and used to run the eleven experiments. Hospitals monitor their average percentage occupancy for all beds including those used for elective activity. Hospitals often have a lower average total bed occupancy due to having fewer elective patients in hospital at the weekend. Therefore, when Bagust quotes the NHS average occupancy of 79% when the paper was written, this will have included elective beds. The third weakness is that it models daily and not hourly patterns of admissions and discharges. The NHS measures occupancy of beds through a midnight census. However, actual occupancy of beds varies throughout the 24 hour period. Therefore, an average bed occupancy of 79% may be higher or lower at different times of the day and days of the week. It is the hourly, as well as the daily variation in demand and capacity utilisation that creates operational problems in hospitals (Williams and Smart, 2009, Bekker and de Bruin, 2010, de Bruin et al., 2010). In addition to the identified weaknesses, there have been other changes that need to be taken into account.

Changes in pathway and process design

Since the 1990s emergency demand for acute hospital care has continued to rise in many countries. Targets have also been set to see, treat, admit or discharge patients from the ED in several countries (Department of Health, 2009, Providence, Gommans and Burns, 2012, Forero, McCarthy and Hillman, 2011). As a result of the level of demand and other factors, new pathways for emergency admissions have been developed in the UK and elsewhere including New Zealand (Providence et al., 2012, Byrne and Silke, 2011). The new arrangements usually take the form of a specified short stay ward area with dedicated staff able to take either direct emergency medical or surgical admissions from General Practitioners (GPs) or accept them after an initial assessment in the ED (Department of Health, 2003). For the purpose of this paper these are termed Emergency Assessment Units (EAU). The pathway extant at the time of the Bagust paper in the late 1990s of patients arriving in ED and then moving to a suitable ward has now been superseded. There are now a variety of arrangements usually involving some form of EAU that can treat and discharge patients within a period of 12-48 hours or transfer the patient to a suitable ward (Byrne and Silke, 2011). Therefore, when considering how hospitals plan for random variation the pathway model has to differentiate between the ability of the ED, EAU and speciality wards to accommodate their individual patterns of demand.

Changes in patterns of demand

Not only are the numbers of emergency admissions rising but also their complexity. It is argued that the increasing attendance by the elderly raises the likelihood of multiple investigations, admission to hospital and a longer average length of stay (George et al., 2006). Recent data about the NHS supports the view that the complexity of the patients is increasing particularly in areas with high numbers of elderly, such as in the study hospital catchment population (Karakusevic, 2012, Imison, Poteliakhoff and Thompson, 2012). Up to April 2012 across the South West Region of England there has been a five year increase in spells in hospital for complex patients of 200% (those scoring between 20-49 points on the Charlson Index of co-morbidity (Charlson, Pompei, Ales and MacKenzie, 1987). The beds use for complex patients has increased by 168%. The study hospital area has a reported an increase of 150% bed use for complex patients (Table 1).

Outliers and safety concerns

There is a growing literature considering the safety implications for patients when hospitals do not have sufficient capacity to cater for peaks in demand. For example, there is evidence of the problems experienced by the overcrowding of EDs (Fatovich, Nagree and Sprivulis, 2005, Trzeciak and Rivers, 2003, Wears and Cook, 2010, Sprivulis, Da Silva, Jacobs, Frazer and Jelinek, 2006, Richardson, 2006, Mayor, 2007, Forero et al., 2011). There is also concern expressed about the overcrowding in the wider hospital system and the implications for patients (Cameron, 2006, Sprivulis et al., 2006, Cook and Rasmussen, 2005, Williams, 2011, Lowthian and Cameron, 2009). When hospitals are overcrowded medical patients can be accommodated on surgical wards; these patients are termed ‘outliers’. Patients waiting in ED for beds in the USA and Canada are called ‘boarders’. There is a limited literature on the implications for patients of being an outlier (Alameda and Suárez, 2009, Elsayed et al., 2005, Lepage, Robert, Lebeau, Silvain and Migeot, 2009, Lloyd et al., 2005, Williams, 2011). However, the consensus is that patients do not receive the most appropriate quality of care.

It can therefore be argued that hospitals need to improve their ability to accommodate emergency admissions in a manner and place that provides the optimum quality of care. Increasing the understanding about the pattern of demand at different points in the pathway will assist in planning for the future provision of services.

REASEARCH METHOD

As part of a larger research project, three years of data was obtained for all admissions to a NHS hospital on the south coast of England. Quantitative analysis and discrete event simulation was combined with qualitative data collection through interviews of expert informants (12 doctors, 5 nurses and 8 managers). The interviewees were purposively recruited due to their position, role and knowledge and to provide a range of views. The hospital has a recent history of reducing bed numbers in both medical and surgical wards due to the increase in day surgery, reduction in overall length of stay and the need to save money. The Hospital Trust has the lowest average length of stay in the South West Region of the NHS, which for medical specialities is currently 4.3 days. However, for many weeks of the year, due to the emergency and elective demand, the hospital has been in a position of ‘escalation’ where the medical bed reductions has been reversed and a day case surgery 14 bed ward has been converted into an inpatient facility for medical patients. This situation is not ideal as a number of medical patients are looked after on the wrong wards for their condition, the medical doctors are spread more thinly across the organisation and additional bank and agency (temporary) nurses have to be deployed. There are therefore significant patient care, staffing and financial consequences from the hospital having to be in ‘escalation’. This situation is becoming increasingly common within the NHS (Williams, 2011, Royal College of Physicians, 2012).

The three years of hospital data was used to construct a discrete event simulation model using ‘Simul8’ software. Discrete event simulation is justified as it allows the complexity of individual patient flows through the pathway and different scenarios to be modelled. The model outline structure is shown in Figure 1. Discrete event simulation models the movements of patients through the system, each “event” being a move from one step to another. For each patient the starting event is to enter into the system – this may be either into the emergency assessment unit or into the ward. Some patients may also require a period in the intensive care unit.

The model runs in one of two modes:

1) Deterministic: in this mode the model replayed the movement of patients exactly as recorded in the hospital PAS system. Each event (entry, move, or exit of a patient) replicates the passage of real patients through the hospital.
2) Stochastic: in this mode the model creates events based on distributions (e.g. of type of patient, length of stay, routing through the system) derived from the real data. In the first instance the model is run to check that it replicates the expected patterns of EAU and ward occupancy as observed in the hospital. The model may then be used to ask “what if?” questions as model inputs are changed (e.g. what would happen if the number of emergency patients increased by *x* percent, or what would happen in beds were removed from the system).

Both deterministic and stochastic results were shown to senior hospital staff to ensure credibility of results, who confirmed the model was replicating what they experienced within the system. Alternative scenarios were then tested and presented.

Analysis of the data was undertaken to ascertain the patterns of demand for both emergency and elective activity and the consequent bed occupancy at the three points of the pathway; ED, EAU and Wards. Interview data was used to assist in developing and checking the validity of the model and to gain insights into the implications of peaks in demand. Models were developed to examine different sizes of EAU and the implications for the number of outlying patients using different sizes of bed pools receiving patients post EAU. NHS ethics guidance was consulted (NHS Health Research Authority, 2012). As only staff were being interviewed and non attributable patient data used, ethical approval was not required.

A question arose as to the type of capacity required at different points of the pathway to allow the hospital to manage the different patterns of demand without having to resort to temporary escalation arrangements or outlying patients with the associated risks (Cook and Rasmussen, 2005, Williams, 2011, Goulding, Adamson, Watt and Wright, 2012).

FINDINGS

Pattern of demand

The emergency demand in the study hospital shows a Poisson distribution, which is a characteristic of random demand with considerable variation in medical emergency admissions from day to day (Figure 2). There is a statistical difference between the numbers of emergency admissions during the week compared to the weekend (**$p < .01$). The daily arrival pattern reaches a peak in the late morning in ED with a consequent lag for arrivals in the hospital wards post ED (Figure 3).

The elective inpatient demand is non-random and follows a weekly pattern with larger numbers admitted earlier in the week with three diminishing daily peaks of 8am, 12 noon and 4pm (Figure 3).

Pattern of bed occupancy – emergency and elective

The hospital manages around 70% of elective surgery as ambulatory day cases. The elective surgical inpatient cases accumulate during the week and create a peak on a Thursday; 32% higher occupancy than the weekly average. Most of these patients are prepared for surgery in an admission unit on the day of their operation and then go to the ward after surgery. All emergency admissions in the study hospital access the hospital through the ED. With the variation in both demand and whole hospital occupancy (Figure 3) it can make the situation difficult to manage. As one manager commented:

> "We know in the morning that we're approaching a situation where we're going to have to open some more capacity. But it's the worst thing in the world; all you do is pull the elastic band as thin as possible across the entire system and you've got doctors then not being so

> efficient because you're dragging them away from their specialty wards to go and sort out the escalation patients or escalation beds – so it's not ideal."

The number of patients admitted over a fifty day period was modelled by department (ED, EAU and Wards). The result shows that there is a difference in the percentage coefficient of variation for each department (ED: 55%, EAU: 17%, Wards: 6%) (Table 2).

Use of EAU

The EAU in the study hospital consists of two wards (24 and 25 beds = 49). One is located close to and on the same level as the ED. The other is one floor higher. The average number of admissions in 2011 on a weekday was 47 and 39 at weekends with Mondays being the busiest day (Table 3). The pattern of admissions is random with a Poisson distribution where the standard deviation is very close to equalling the square root of the mean (Table 4). This means that there is probably little opportunity to reduce the variability as it is not being driven by any systemic affect.

Stochastic modelling was used to reconstruct EAU occupancy over a one year period. The number of patients in the EAU was measured at one hour intervals. The EAU had an average occupancy of 37.8 patients (78% of 49 beds available). It is difficult to say from this data exactly what percentage of time the EAU cannot accept new patients as 'free beds' may reflect patient turnaround (in real life one patient never occupies a bed immediately after another one leaves). If the EAU is considered full when 47-48 beds are physically occupied (with 2-3 beds in turnaround at any one time) the unit would be blocked to new patients 4-7% of the time.

The real life EAU occupancy (Figure 5) demonstrates right-censoring indicative of capped capacity, but it is not a hard cut-off at the 49 bed capacity. This may be indicative of having an empty bed during patient turnaround and transit, or may suggest the imprecision in the hospital patient data (though as reconstructed occupancy almost never goes beyond nominal capacity it is more likely to reflect beds being empty during patient turnaround). Between 40-50% of patients were discharged from the EAU with the remainder admitted to a specialist ward. However, when a nurse was asked during an interview what she thought the occupancy of the EAU was she responded:

> "At the moment [laugh]... a 100%, it is always full. As soon as that bed is empty there is somebody in it. I think once I've seen a bay empty (6 beds) and thought that was nice."

Observation of the ward immediately after the interview at 10.15am found 6 empty beds. There was however a queue of 8 patients on the computer system being referred into the ED by their General Practitioner.

A model was developed where 16,000 patients (70% of emergency admissions) pass through the EAU in one year with a length of stay of 0.85 days (reflecting current use). EAU beds are unlimited in the model (Figure 6). This allows an estimate to be made of the proportion of time any particular size unit would be unable to accept new patients. If a target is set that the EAU should have an available bed 95% of the time, the bed requirements would be 49 and the average occupancy would be 77% (Table 4). The model therefore confirms target occupancy of ~77% in order for an EAU of this size to receive new patients 95% of the time. Different volumes of admissions and sizes of EAUs were modelled. To have a 95% chance of having an empty bed EAU with an EAU LoS of 0.85 days the occupancy needs to be 71%, 77% and 82% at throughputs of 25,45 and 90 patients per day [EAU size 30, 50 & 93 beds respectively]. This assumes even average loads Mon-Sun, which is different to reality. Some caution is required in these results. The model was based on the real life data where 70% of emergency patients are admitted to the EAU. This figure may be an under-estimate of real demand if some patients are not admitted due to insufficient capacity.

Size of bed pools

A model of a 200 ward bed pool was created using the average length of stay in England of 6.1 days for admitted emergency patients who spend at least one night in hospital (Department of Health, 2012). Results from running the model suggest that a bed occupancy of 87.5% could be achieved while maintaining a 95.2% probability of finding an empty bed when a new patient arrives. However, the study hospital, similar to most in the NHS, organises the wards on a speciality basis. For example, patients with respiratory disease are treated on a respiratory ward where there are nurses, doctors and other clinicians who specialise in that disease. The hospital has 16 wards acting as separate bed pools. The midnight occupancy rate for those wards is 93%. The average hourly occupancy is 95%. With the experience of patients often being accommodated on wards not directly related to their condition and increasing co-morbidities, a model was constructed to assess how many patients are outlied when a hospital is structured with wards acting as separate bed pools.

The model created a series of bed pools from 16 wards of 24 beds to 2 pools of 184 with equal demand for each pool. The average length of stay was set at 4 days (close to the study hospital's length of stay) with an exponential distribution. The patient throughput for one year was changed to achieve different average occupancy to create the results in Figure 7. The results from the modelling demonstrate that having small bed pools, even at 85% occupancy, means that 24% of patients will be outlied on the wrong ward. Applying those results to the study hospital infers that over 35% of patients will potentially be on the wrong ward with the current rate of occupancy and structure of small bed pools (Figure 8).

DISCUSSION

Hospitals have developed different pathways for admitting elective and emergency patients. There are considerable pressures to meet the rising and random pattern of emergency demand and provide a safe service. Therefore, a more sophisticated approach to capacity management than having an average hospital occupancy of 85% is required. Many hospitals now use some form of assessment unit for emergency cases. Such units operate as short stay wards with a high turnover of patients many of whom are discharged. As these units deal only with emergency demand the Bagust model could be applied. However, with a relatively small EAU bed pool compared to the 200 in the Bagust model, it means that the average percentage occupancy required to provide an empty bed 95% of the time, will be less than 85%. The modelling work undertaken suggests that a pool of around 50 beds needs to operate with 78% occupancy to achieve a 95% probability of a bed being available when needed. In the UK the EAU acts as a form of buffer for the rest of the hospital to absorb some of the daily and hourly variation in demand and reduce the probability of access block.

The higher variation (% coefficient of variation) in ED/EAU occupancy is because they are smaller units, and they also have more of systematic variation by time of day. This variation and scale of turnover with short length of stay creates a dynamic for staff where it feels constantly busy with many urgent tasks to be completed. This may partly explain the perception amongst staff that EAU is always full. In the wards the variation is pooled by the higher occupancy and while there is still some system-driven variation in the time of admission and discharges, that is reduced by the patients who are staying throughout the day. The resulting dynamic for staff and the supporting services is slower than found in the EAU, although still busy with the constant demand to discharge patients and create empty beds.

From the modelling it appears that a 200 bed pool can operate with an average occupancy of 87.5% and have a 95% probability of having an empty bed. However, that assumes that all beds are of equal value to the patient, as found in the Bagust model. In reality, few hospitals have one bed pool for all emergency admissions. Most hospitals have wards staffed by nurses, doctors and other clinicians with particular speciality expertise. This means that rather than having a single bed pool there are many small bed pools (individual speciality wards). As we know from the analysis, the smaller the bed pool the higher the coefficient of variation is likely to be. Small bed pools need to work with a lower average occupancy to ensure a bed is available when needed. Hospitals working near to capacity find that it becomes increasingly difficult to allocate patients to the most appropriate specialist ward. Even at 85% occupancy, the modelling shows that a speciality ward pool structure results in over 20% of patients potentially being outlied on another ward (Figures 7 and 8). During peaks in demand bed managers send patients from EAU or ED to wherever there is a bed, which can create both operational and patient safety issues as the staffing structure remains focused on the speciality ward.

Managers and clinicians therefore face a choice of using speciality wards or larger dependency based bed pools when planning how to organise the bed capacity of the hospital. The widely used current practice of wards with disease based specialist staff subdivides the bed pool. This policy has many advantages for both staff and patients when the wards can accept all their allocated patients. The leadership and expertise necessary for the patient treatment is concentrated in one area and staff do not spend time travelling to the patient. However, this method of working has disadvantages. First, it requires more beds to achieve the occupancy levels required to ensure that a bed is available to meet the random speciality demand, which will increase costs. Second, when there are not the speciality beds available when needed, as is becoming increasingly the case, patients are being accommodated and treated on wards and by staff not specialist in their disease area. In summary, the speciality ward policy means that the patient moves to the specialist. For patients in the wrong place this is a disadvantage to them. The speciality ward approach requires many small bed pools with a lower than 85% average occupancy to avoid the patient safety issues of patients being treated in the wrong place. The modelling indicates that to reduce the percentage of outliers to below 5%, the ward occupancy for 16 speciality wards would need to be in the region of 70% (Figure 8). Evidence of reducing bed numbers, rising demand and access block in many countries raises the question as to whether a speciality ward approach remains sustainable.

The alternative model is where larger bed pools are established. This may be on the basis of grouping disease groups (medical; surgical) or by patient dependency. In effect EAU and Intensive Care Units (ICU) are examples of a bed pool based not on disease but the assessment or treatment needs of patients. Acute physicians and other staff on EAU have become experts in assessing and treating a range of illnesses. They call in diseases specialists when required on a consultancy basis. If a larger bed pool for emergency cases is used it can work with a higher average occupancy, therefore requiring fewer beds than the specialist ward model. In summary, the specialist moves to see the patient. Therefore, the ways of working for staff is different. A consequence might be that a greater proportion of nurses and doctors maintain a higher level of generalist knowledge, as seen with acute physicians and a smaller number act as disease specialists, who work in a consultative role. The need for more generalist input within the UK in particular is being advocated, with the Royal College of Physicians expressing concern about poor patient care due to the current pressures on hospitals and medical staff (Kirthi, Temple and Patterson, 2012, Royal College of Physicians, 2007, Royal College of Physicians, 2012, Watcher and Bell, 2012). The argument is based on clinical grounds that patients have increasing co-morbidities and lack a continuity of care. The bed management issues highlighted add another dimension to the discussion.

This research has limitations as data collection used in the analysis and modelling is based on a single NHS hospital which has particular contextual features that may influence the flow of patients through the system. However, there is a general point that when hospitals work with small speciality based bed pools, those wards experience a high variation in demand, which requires a lower than 85% bed occupancy to reduce the risk of refusing a patient admission to less than 5%. Larger bed pools can operate with a higher average occupancy. Further research is planned to gather data from other hospitals and model in detail the different bed requirements of speciality ward versus larger dependency based bed pools.

CONCLUSION

Hospitals face volatility due to random emergency demand and peaks in elective activity. There are also the pressures of increasing demand for inpatient emergency treatment, a higher proportion of patients with co-morbidities and the global financial situation. There are therefore limited opportunities to pay for more capacity in terms of beds and staff to solve the problem. Policy makers, managers and clinicians need to consider alternative ways of structuring and staffing the hospitals of the future. There are potential implications for how clinical staff are educated and trained to allow a more generic dependency based organisation of wards rather than the current speciality ward based hospital model to prevail.

References:

Alameda, C. & Suárez, C. (2009) Clinical outcomes in medical outliers admitted to hospital with heart failure. *European Journal of Internal Medicine,* 20**,** 764-767.

Bagust, A., Place, M. & Posnett, J. W. (1999) Dynamics of bed use in accommodating emergency admissions: stochastic simulation model. *BMJ (British Medical Journal),* 319**,** 155-8.

Bekker, R. & De Bruin, A. M. (2010) Time-dependent analysis for refused admissions in clinical wards. *Ann Oper Res,* 178**,** 45-65.

Blunt, I., Bardsley, M. & Dixon, J. (2010) Trends in emergency admissions in England 2004 - 2009. London, Nuffield Trust.

Boyle, J., Jessup, M., Crilly, J., Green, D., Lind, J., Wallis, M., Miller, P. & Fitzgerald, G. (2012) Predicting emergency department admissions. *Emergency Medicine Journal,* 29**,** 358-365.

Byrne, D. & Silke, B. (2011) Acute medical units: Review of evidence. *European Journal of Internal Medicine,* 22**,** 344-7.

Cameron, P. (2006) Hospital overcrowding: a threat to patient safety? *Medical Journal of Australia,* 184**,** 203-204.

Charlson, M. E., Pompei, P., Ales, K. L. & Mackenzie, C. R. (1987) A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *Journal of Chronic Disease,* 40**,** 373-83.

Cook, R. & Rasmussen, J. (2005) "Going solid": a model of system dynamics and consequences for patient safety. *Qual Saf Health Care,* 14**,** 130-134.

De Bruin, A. M., Bekker, R., Van Zanten, L. & Koole, G. M. (2010) Dimensioning hospital wards using the Erlang loss model. *Ann Oper Res,* 178**,** 23-43.

Department of Health (2001) Reforming Emergency Care: First Steps to A New Approach. London, Department of Health.

Department of Health (2003) Emergency Assessment Units - a check list. London, DoH.

Department of Health (2009) The Operating Framework for the NHS in England 2010/11. London, Stationary Office.

Department of Health (2012) Hospital Episode Statistics: Headline figures, 2010-11. http://www.hesonline.nhs.uk/Ease/servlet/ContentServer?siteID=1937&categoryID=193.

Elsayed, S., Cosker, T. D. A. & Grant, A. (2005) Pressure for beds-does it put our orthopaedic patients at risk? *Injury,* 36**,** 86-87.

Fatovich, D. M., Nagree, Y. & Sprivulis, P. (2005) Access block causes emergency department overcrowding and ambulance diversion in Perth, Western Australia. *Emergency Medicine Journal,* 22**,** 351-354.

Forero, R., Mccarthy, S. & Hillman, K. (2011) Access Block and emergency department overcrowding. *Critical Care,* 15**,** 216.

George, G., Jell, C. & Todd, B. S. (2006) Effect of population ageing on emergency department speed and efficiency: a historical perspective from a district general hospital in the UK. *Emergency Medicine Journal,* 23**,** 379-383.

Goulding, L., Adamson, J., Watt, I. & Wright, J. (2012) Patient safety in patients who occupy beds on clinically inappropriate wards: a qualitative interview study with NHS staff. *BMJ Quality & Safety,* 21**,** 218-224.

Harper, P. R. (2002) A Framework for Operational Modelling of Hospital Resources. *Health Care Management Science,* 5**,** 165-173.

Harper, P. R. P. & Shahani, A. K. A. (2002) Modelling for the planning and management of bed capacities in hospitals. *Journal of the Operational Research Society,* 53**,** 11-18.

Imison, C., Poteliakhoff, E. & Thompson, J. (2012) Older people and emergency bed use; exploring variation. London, King's Fund.

Karakusevic, S. (2012) The Future Challenge. Torbay, South Devon Healthcare NHS Foundation Trust.

Kirthi, V., Temple, R. M. & Patterson, L. E. (2012) Inpatient care: should the general physician now take charge? *Clinical Medicine,* 12**,** 316-9.

Lepage, B., Robert, R., Lebeau, M., Silvain, C. & Migeot, V. (2009) Use of risk analysis method to improve care management for outlying inpatients in a university hospital. *Quality and Safety in Health Care,* 18**,** 441-445.

Lloyd, J. M., Elsayed, S., Majeed, A., Kadambande, S., Lewis, D., Mothukuri, R. & Kulkarni, R. (2005) The practice of out-lying patients is dangerous:: A multicentre comparison study of nursing care provided for trauma patients. *Injury,* 36**,** 710-713.

Lowthian, J. A. & Cameron, I. A. (2009) Emergency demand access block and patient safety: A call for national leadership. *Emergency Medicine Australasia,* 21**,** 435-439.

Mayor, S. (2007) Lack of hospital beds causes emergency departments to miss targets. *BMJ,* 334**,** 111-.

Nhs Health Research Authority (2012) Does my project require review by a Research Ethics Committee? London, NHS Health Research Authority.

Proudlove, N. C., Black, S. & Fletcher, A. (2007) OR and the Challenge to Improve the NHS: Modelling for Insight and Improvement in In-Patient Flows. *The Journal of the Operational Research Society,* 58**,** 145-158.

Providence, C., Gommans, J. & Burns, A. (2012) Managing acute medical admissions: a survey of acute medical services and medical assessment and planning units in New Zealand. *Internal Medicine Journal,* 42**,** 51-56.

Richardson, D., Kelly, A.-M. & Kerr, D. (2009) Prevalence of access block in Australia 2004–2008. *Emergency Medicine Australasia,* 21**,** 472-478.

Richardson, D. & Mountain, D. (2009) Myths versus facts in emergency department overcrowding and hospital access block. *Medical Journal Australia,* 190**,** 369-374.

Richardson, D. B. (2006) Increase in patient mortality at 10 days associated with emergency department overcrowding. *Medical Journal of Australia,* 184**,** 213-216.

Royal College of Physicians (2007) Acute medical care: the right person in the right setting – first time. London, Royal College of Physicians.

Royal College of Physicians (2012) Hospitals on the edge? The time for action. London, RCP.

Sprivulis, P. C., Da Silva, J. A., Jacobs, I. G., Frazer, A. & Jelinek, G. (2006) The association between hospital overcrowding and mortality among patients admitted via Western Australian emergency departments. *Medical Journal of Australia,* 184**,** 208-212.

Thompson, S., Nunez, M., Garfinkel, R. & Dean, M. (2009) Efficient Short-Term Allocation and Reallocation of Patients to Floors of a Hospital During Demand Surges. *Operations Research,* 57**,** 261-273.

Trzeciak, S. & Rivers, E. P. (2003) Emergency department overcrowding in the United States: an emerging threat to patient safety and public health. *Emerg Med J,* 20**,** 402-405.

Watcher, R. M. & Bell, D. (2012) Renaissance of hospital generalists. *BMJ,* 344.

Wears, R. L. & Cook, R. I. (2010) Getting Better at Being Worse. *Annals of Emergency Medicine,* 56**,** 465-467.

Williams, M. D. (2011) Developing a System Resilience Approach to the Improvement of Patient Safety in NHS Hospitals. *Business School.* Exeter, University of Exeter, available at http://hdl.handle.net/10036/3256

Williams, M. D. & Smart, P. A. (2009) System resilience and patient safety during a bed crisis in an NHS hospital in England. *16th Annual EurOMA Conference.* Goteborg.

Table 1: Change in over 65 Non Elective (NE) hospital spells and bed use 2007 – 2012 in South West England

Peer (SHA)	5yr over 65 NE activity	5yr complex NE activity	5yr bed use change	5yr complex bed use
ALL	117%	200%	98%	168%
Bath and North East Somerset PCT	113%	200%	94%	145%
Bournemouth and Poole Teaching PCT	107%	213%	74%	141%
Bristol PCT	112%	187%	95%	151%
Cornwall and Isles Of Scilly PCT	124%	239%	165%	300%
Devon PCT	117%	172%	100%	143%
Dorset PCT	112%	205%	89%	167%
Gloucestershire PCT	126%	224%	96%	183%
North Somerset PCT	110%	173%	95%	138%
Plymouth Teaching PCT	127%	239%	104%	186%
Somerset PCT	118%	198%	105%	182%
South Gloucestershire PCT	115%	152%	99%	132%
Swindon PCT	125%	253%	108%	214%
Torbay Care Trust	114%	181%	92%	150%
Wiltshire PCT	119%	202%	83%	156%

The data is extracted from Dr Foster PPM v4 for the period April 11 – March 12. It focuses on non – elective activity (NE) for over 65 year olds. The 1st column is all spells. The second column is for people scoring between 20-49 points on the Charlson Index of co-morbidity. Columns 3 and 4 replicate this for bed use. (http://drfosterintelligence.co.uk/solutions/nhs-hospitals/practice-and-provider-monitor-ppm/)

Table 2: Variability in number of patients by department over a fifty day period

	ED	EAU	Ward
Mean	17	39	285
SD	9	7	16
%CV	55%	17%	6%
Max	46	53	325
Max/average	2.7	1.3	1.1

Table 3: Average number of admissions to EAU by day of the week

	Average EAU admissions	Std dev EAU admissions
Mon	49.1	8.0
Tue	45.7	6.3
Wed	47.4	5.8
Thu	46.5	6.8
Fri	47.7	6.2
Sat	39.1	6.6
Sun	39.4	6.1

Table 4: EAU admissions statistics 2011

	Mean	Std Dev	Sqr Root Mean
Weekday	47.3	6.7	6.9
Weekend	39.3	6.4	6.3

Table 5: Number of EAU beds required to ensure availability

Target proportion time bed will be available	Required beds	Bed occupancy
80%	43	88%
90%	46	82%
95%	49	77%
98%	52	73%

Figure 1: Outline of Model Structure

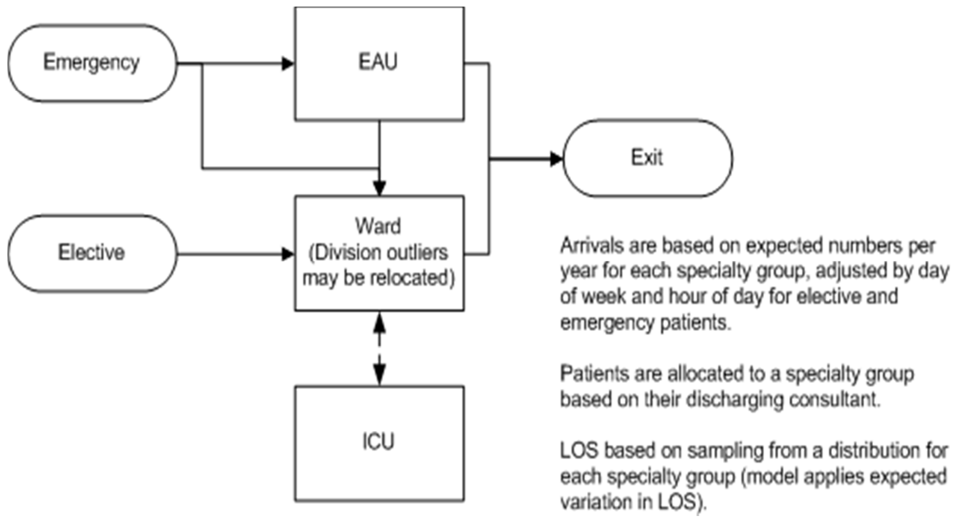

Figure 2: Variation in Medical Admissions 2011

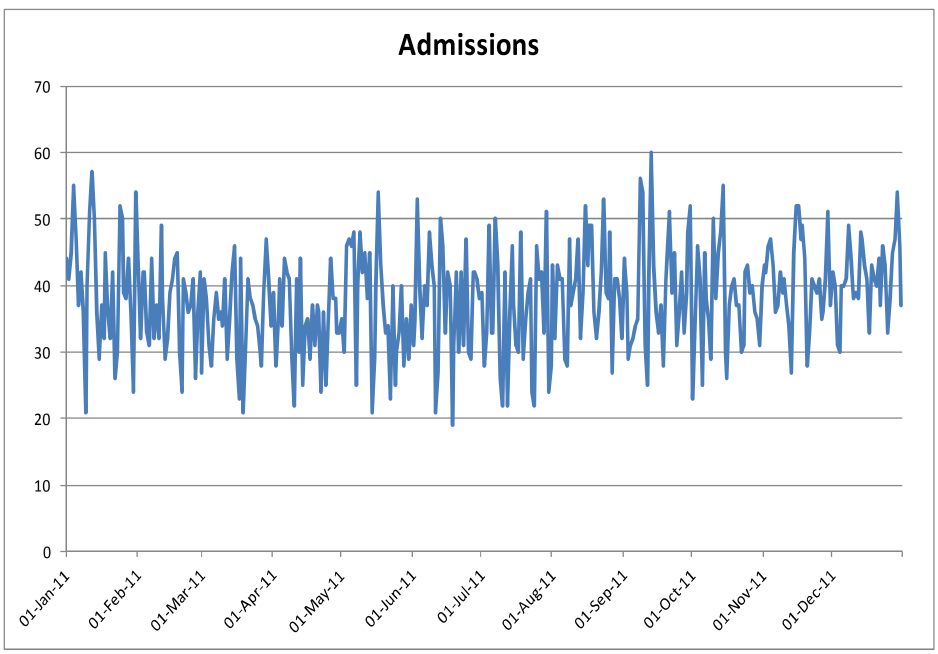

Figure 3: Arrival and Discharge patterns by hour of the day

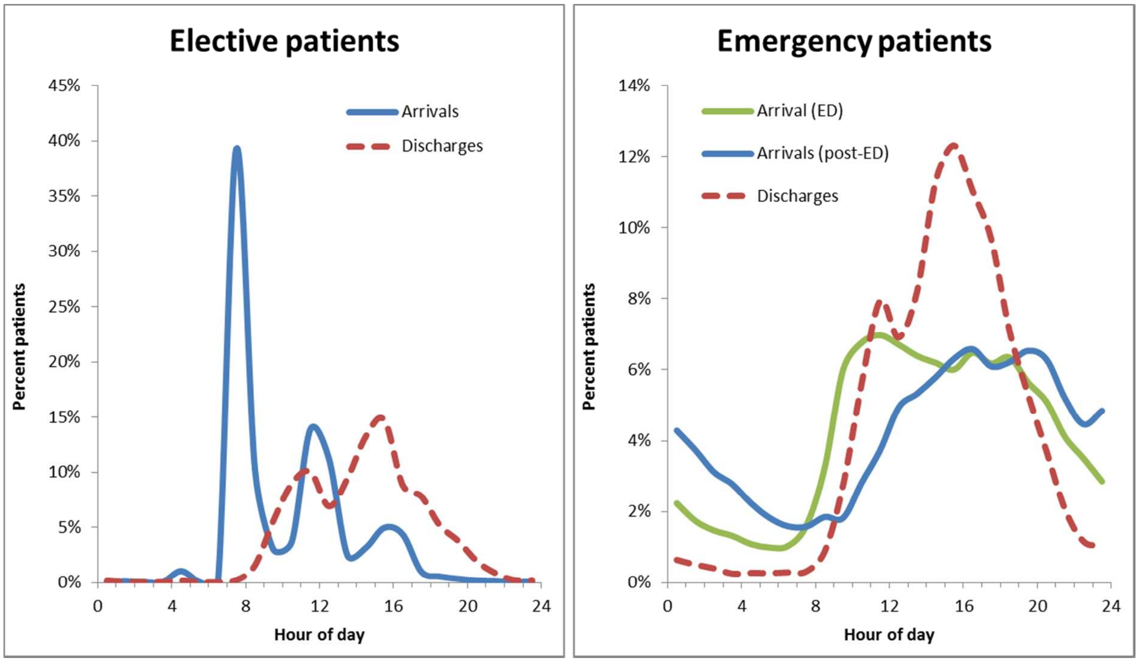

Figure 4: Whole hospital occupancy at midnight by type of admission 2011

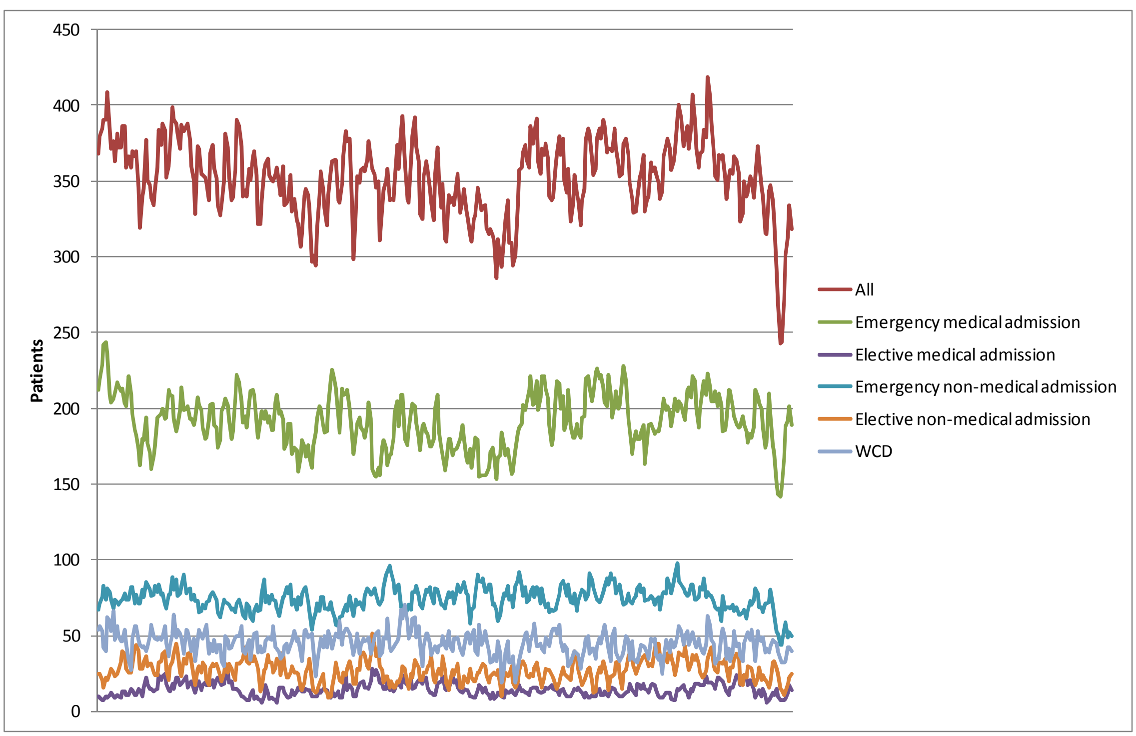

Figure 5: EAU actual occupancy for one year reconstructed from 2011 data

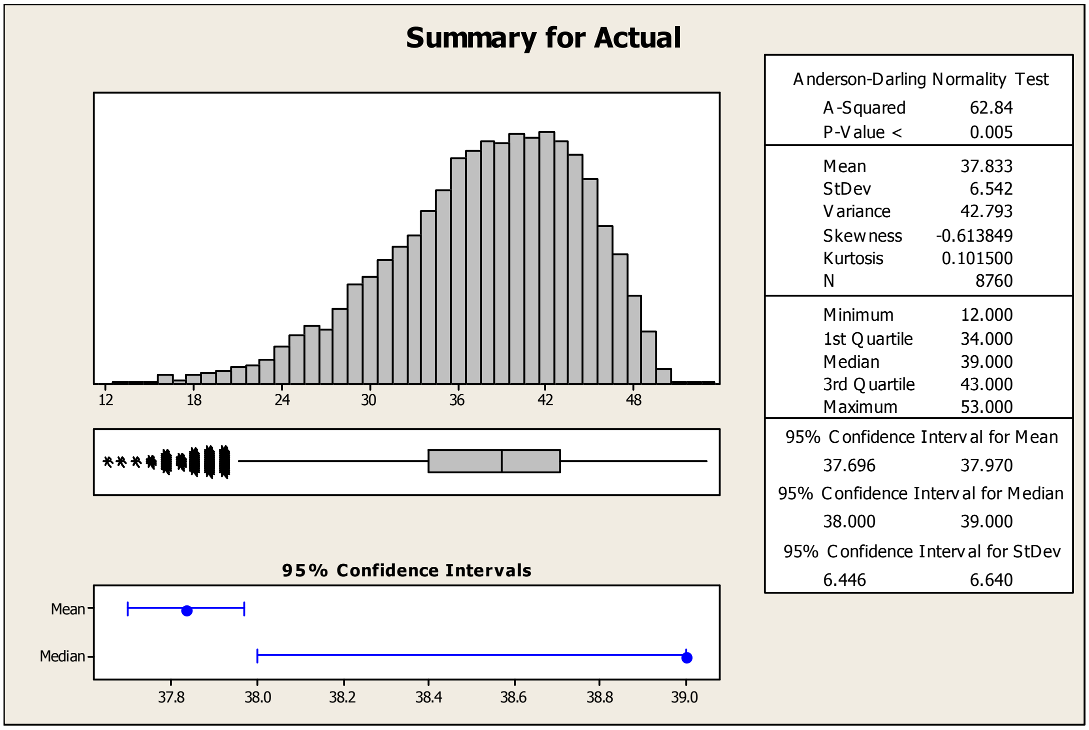

Figure 6: Model of EAU occupancy admitting 70% of patients without a limited bed capacity

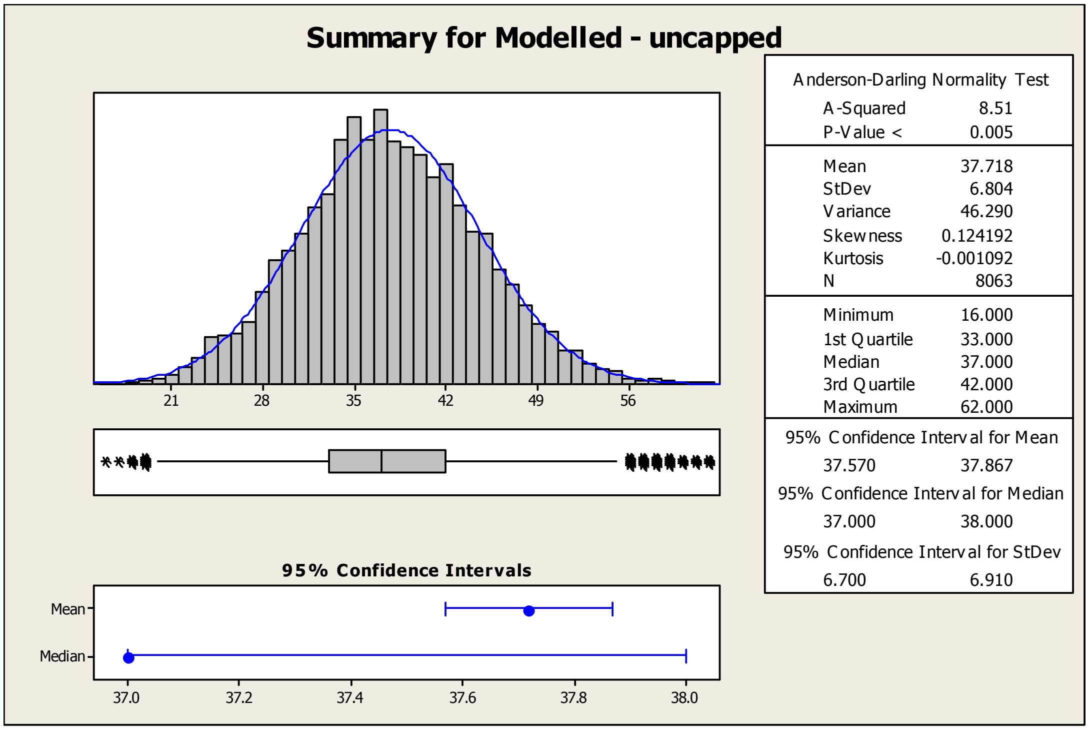

Figure 7: Number of outlying patients based on different bed pooling sizes and percentage occupancy

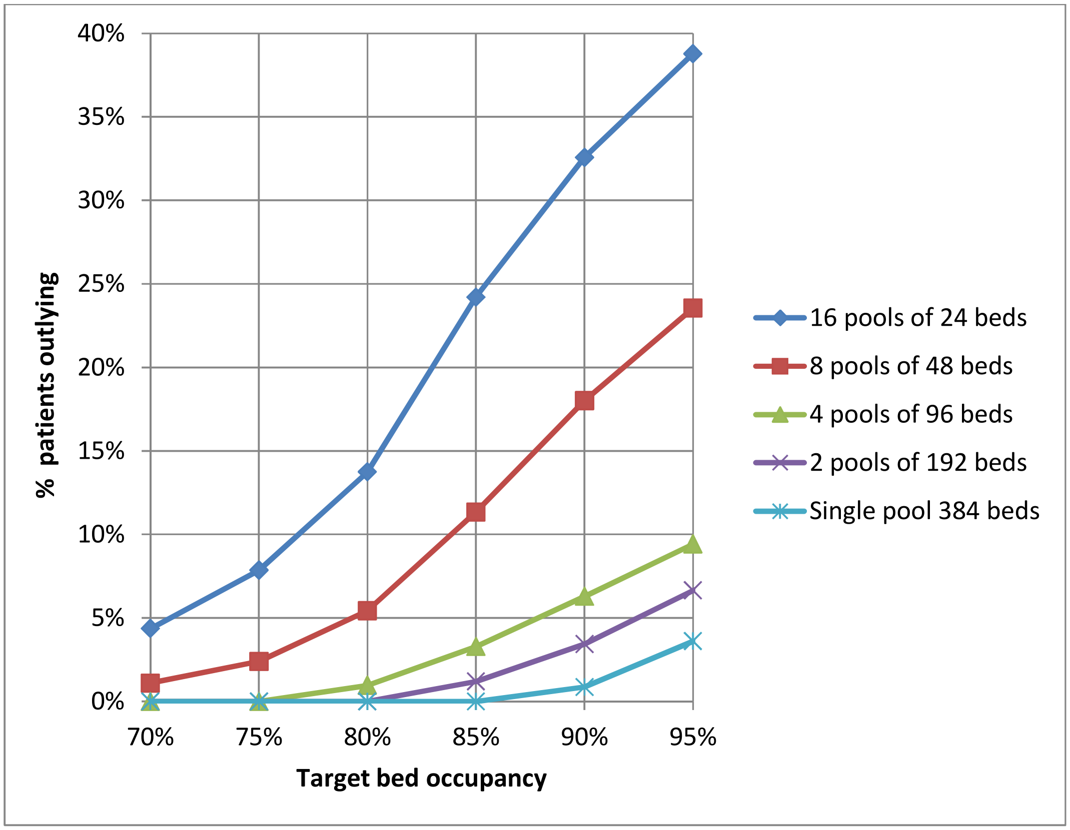

Figure 8: Contour map of percentage of outlying patient dependent on bed pool size and occupancy