doi: 10.1111/j.1742-6723.2006.00872.x *Emergency Medicine Australasia* (2006) **18**, 391–397

Redesigning emergency department patient flows: Application of Lean Thinking to health care

Diane L King, David I Ben-Tovim and Jane Bassham
Emergency Department, Flinders Medical Centre, Bedford Park, South Australia, Australia

Abstract

Objective: To describe in some detail the methods used and outcome of an application of concepts from Lean Thinking in establishing streams for patient flows in a teaching general hospital ED.

Methods: Detailed understanding was gained through process mapping with staff followed by the identification of value streams (those patients likely to be discharged from the ED, those who were likely to be admitted) and the implementation of a process of seeing those patients that minimized complex queuing in the ED.

Results: Streaming had a significant impact on waiting times and total durations of stay in the ED. There was a general flattening of the waiting time across all groups. A slight increase in wait for Triage categories 2 and 3 patients was offset by reductions in wait for Triage category 4 patients. All groups of patients spent significantly less overall time in the department and the average number of patients in the ED at any time decreased. There was a significant reduction in number of patients who do not wait and a slight decrease in access block.

Conclusions: The streaming of patients into groups of patients cared for by a specific team of doctors and nurses, and the minimizing of complex queues in this ED by altering the practices in relation to the function of the Australasian Triage Scale improved patient flow, thereby decreasing potential for overcrowding.

Key words: *access block*, *emergency department overcrowding*, *Lean Thinking*, *patient flow*, *queuing theory*, *streaming patient care*.

Introduction

The Flinders Medical Centre provides a comprehensive range of hospital services to a community of over 350 000 people in the southern suburbs of Adelaide, South Australia. The ED of the hospital is the major portal through which that community accesses time urgent, complex care, as evidenced by the fact that of

Correspondence: Dr Diane King, Emergency Department, Flinders Medical Centre, Flinders Drive, Bedford Park, SA 5042, Australia. Email: diane.king@fmc.sa.gov.au

Diane L King, MB BS, FACEM, Director Emergency Department; David I Ben-Tovim, PhD, MB BS, MRC Psych, FRANZCP, Director Redesigning Care and Clinical Epidemiology Unit; Jane Bassham, RN, BNg, Clinical Facilitator Redesigning Care.

the 50 000 who patients present to the department per year, 43% require admission to hospital.

By the winter of 2003, the Flinders Medical Centre ED had become so severely overcrowded that the Recovery Area of the Operating Theatre suite had been pressed into use as an ED extension. This disrupted the work of both the ED and the surgical services provided by the hospital. The level of overcrowding also resulted in serious concerns about the safety of the care within the ED.

The problems within the ED had grown over a period of years. They had commonly been attributed to an increasing problem of access block consequent upon high levels of occupancy within the body of the hospital.[1] Many of the accepted methods for responding to access block had been tried,[2] including opening additional beds,[3] improved discharge planning, adoption of centralized bed management practices and ED rapid assessment teams. None of those strategies had provided sustained relief and the depth of the crisis the department was facing prompted the hospital to seek a different way to improve the functioning of the department. Thus, the present article has two main aims: to describe an approach to redesigning ED processes, and to describe the method of streaming of patient care that resulted from the redesign strategy. An analysis of the impacts of streaming in the first 12 months of operation is provided.

The redesign strategy that was used was an application of Lean Thinking to health care.[4] Lean Thinking is an approach to the organization of complex processes that derives from industrial manufacturing experience.[5] A key element in Lean Thinking is the practice of starting, not with a potential solution, but with the development of a detailed understanding of how a complex process (such as the provision of care within an ED) is actually undertaken. In this case, the aim was to create a detailed schematic representation of how the Flinders Medical Centre ED actually functioned, emphasizing real life operations rather than intended modes of functioning. That was accomplished by creating a process map for ED processes that detailed both the movement of patients through the department, and the communication processes that facilitated or impeded those movements.[6]

Three sessions were required to create an overview of department processes. Session participants were drawn from the full range of staff working within the ED, from patient care assistants and clerical staff through to junior and senior nursing and medical staff. There were between 15–20 people at each session. The mapping demonstrated that care processes had become hard to follow and dependent on the extraordinary efforts of individuals rather than following designed processes and procedures. Our sense is that the problems that emerged were not particular to the Flinders Medical Centre ED, but could be repeated in many other large EDs in Australia and elsewhere.

Following the mapping, the flows of patients were restructured concentrating initially on a high volume patient group, namely those patients who were likely to be ultimately discharged directly from the ED. The triage nurses, who are a skilled and experienced group of staff, were asked to make their initial assessments, record a brief description of the presenting complaint, allocate an Australasian Triage Scale (ATS) score as had always been their practice, and they were then asked to predict whether in their judgement the patient was likely to be able to return home from the ED after treatment, or was more likely to require admission to hospital. A previous unpublished study within the department had identified that the triage nurses were accurate in these predictions in at least 80% of presentations.

Patients were then streamed in relation to their predicted outcome. Patients predicted as being likely to be able to return home directly from the ED (the dischargeable stream) were allocated to the 'B-side' team. This was a functional team of nurses and doctors located shift by shift in an allocated group of cubicles in the department. Patients predicted as being likely to require admission were allocated to the 'A-side' team, a separate team of nurses and doctors located in the A-side cubicles.

Triage category 1 patients continued to be taken straight into the designated resuscitation area of the ED.

Patients could be moved from the B-side to the A-side if the need for admission arose, with clinical handover occurring. Patients continued to be discharged from the A-side if admission to hospital was not considered needed after full clinical assessment. There has been no emphasis on the importance of 'getting it absolutely right' from the triage nurse perspective, as it is believed that the value in streaming is in the subsequent processes rather than the accuracy of the initial allocation.

The B-side team was instructed that in the absence of a threat to life or limb, need for time critical intervention or severe pain (as may be found in Triage category 1 or 2 patients) they were to see patients in order of arrival, rather than to prioritize in relation to triage

category. The staff were further encouraged to attempt as far as possible to complete one patient's journey before bringing the next patient out of the waiting room into a cubicle. The A-side staff were asked to continue to use the triage categories as a means of prioritizing which patients assigned to their area to see next.

The changes were supported at the most senior levels in the department. They were introduced on one specific day and have continued 24 h per day, 7 days per week, since then. The nursing and medical staff were given very brief training on the concepts underlying Lean Thinking and streaming prior to its introduction. No extra nursing or medical staff were provided for the adoption of the changed patient flows.

A quantitative analysis of the impact of the restructuring of patient flows in the first 12 months after streaming has been undertaken.

Methods

De-identified hospital administrative and clinical data systems were accessed and comparisons made between the 12 months before (from December 2002 to November 2003) and 12 months after (from December 2003 to November 2004) the changes described above. χ^2-tests were used to test the significance of difference in; the distribution of cases across triage categories; the numbers of cases seen within triage target times, and; the numbers of patients not waiting to be seen after booking in at triage. Differences in total time spent in ED were tested by means of *t*-tests. Differences in the number of deaths occurring within the ED (excluding those patients who were deemed to have been dead on arrival in the department) were tested using multivariate Poisson regression, with time period and triage categories being the independent variables.

For some years, compliance with triage times at the Flinders Medical Centre had been determined by the time of the initial medical consultation. Since streaming has been commenced, the functioning of the department is such that compliance with triage waiting times is determined by initiation of meaningful treatment by a doctor or a nurse, and this time is computed from the earlier of the existing doctor seen or nurse seen times on the ED computer system. Both assessment points are reported in the *Results* section. 'Meaningful treatment' is taken to mean the time of commencement of a detailed history and a clinical guideline, protocol or procedure. The taking of observations only is excluded. Nurse initiated procedures such as X Ray and administration of opioid pain relief occurred in both patient streamed areas and have been commonly practised both before and after the intervention.

Results

In the 12 months before streaming, there were 49 075 presentations to the Flinders Medical Centre ED, of which 9940 were under 16 years of age. In the 12 months after streaming, there were 50 337 presentations, of which 10 322 were under 16 years of age. Table 1 records the percentages of all patients seen each year that were allocated to Triage categories 1–5. In the year following streaming there was a trend for more patients to be allocated to Triage category 3 score and less to category 4, but that trend did not reach statistical significance ($\chi^2 = 0.49$, d.f. = 4, P = NS).

Table 2 shows a consistent pattern in relation to mean waiting times to see medical and nursing staff and percentage compliance with triage categories. Again, the table refers to all patients seen during each time period. Before streaming, there was a steady rise in waiting time across the triage categories, and a corresponding fall with compliance with ATS waiting times (except category 5). After streaming, there was a flattening out of times for review across the triage categories, especially in Triage categories 3–5. As a consequence, there was a modest decreases in compliance with Triage categories 2 and 3, and a slightly more marked increase in compliance in categories 4 and 5. The flattening of the review times was accompanied by a marked reduction in the variability of time spent waiting for review, particularly marked for the measures that included nursing review, but noticeable for the doctor only times also.

Looking at the mean waiting time in minutes, although there was no difference in the mean time to see a doctor, the time to initiation of meaningful treatment by the earlier of a nurse or doctor fell by a mean

Table 1. Percentages of total population of patients attending the ED assigned to ATS categories before (Period 1, $n = 49\,075$) and after (Period 2, $n = 50\,337$) patient streaming

	% of all presentations within ATS category				
	1	2	3	4	5
Period 1	1.2	14.2	39.2	44.2	1.2
Period 2	1.0	13.7	42.5	41.2	1.6

ATS, Australasian Triage Scale.

Table 2. Compliance with ATS waiting times (using either doctor, or doctor or nurse, as point of first contact), and actual duration of wait to see doctor, or doctor or nurse, before (Period 1, $n = 49\,075$) and after (Period 2, $n = 50\,337$) patient streaming

	ATS category					
	1	2	3	4	5	All
Mean (±SD) waiting time (min) to see doctor						
Period 1	0	24 (29)	79 (75)	113 (91)	90 (120)	86 (84)
Period 2	0	28 (33)	99 (74)	94 (69)	68 (68)	86 (72)
Mean (±SD) earliest of waiting time (min) to see doctor or nurse						
Period 1	0	10 (14)	36 (56)	65 (61)	72 (111)	46 (62)
Period 2	0	11 (16)	40 (43)	49 (47)	44 (48)	39 (44)
% of patients meeting ATS waiting times, using doctor seen time						
Period 1	100	36	25	35	73	32
Period 2	100	34	17	38	80	30
% of patients meeting ATS waiting times, using earliest of doctor or nurse seen time						
Period 1	100	73	62	61	79	64
Period 2	100	68	57	70	93	65

ATS, Australasian Triage Scale.

of 7 min [confidence interval (CI) 6.3–7.6], a fall that was statistically significant ($t = 20.6$, d.f. = 99 410, $P < 0.001$). Overall, this meant that for the time to see a doctor, there was a slight and not statistically significant overall decrease ($\chi^2 = 3.5$, d.f. = 4, P = NS) in the extent to which the waiting times to see a doctor fell within triage guidelines, and for the overall time to begin meaningful treatment (as determined by the earlier of the nurse or doctor time), there was a slight, and again not statistically significant ($\chi^2 = 4.5$, d.f. = 4, P = NS) increase in overall compliance.

The percentage of all patients attending but not waiting to be seen after initial triaging fell sharply from 2686 patients (5.5% of all presentations) in the 12 months before streaming, to 1592 (3.2% of all presentations) after streaming. The drop of 2.3% (CI 2.05–2.56) occurred immediately that the streaming commenced, remained constant over the 12 month period, and was highly statistically significant ($\chi^2 = 322.3$, d.f. = 1, $P < 0.001$).

Table 3 shows the percentages by triage category of all patients, presenting to the ED, who were subsequently admitted to hospital. The table shows minor variations after streaming except in Triage category 5, where the absolute numbers of patients were small.

In the year before streaming, 21% of all patients presenting to the ED waited at least 8 h before either being admitted elsewhere in the hospital, or discharged home. In 12 months after streaming, this fell slightly and non-significantly to 19.6%.

Table 3. Percentage of patients admitted to hospital before (Period 1, $n = 49\,075$) and after (Period 2, $n = 50\,337$) streaming

	ATS category				
	1	2	3	4	5
% of patients admitted to hospital by triage category					
Period 1	87.3	77.0	51.7	19.2	42.5
Period 2	85.6	78.6	52.1	21.0	11.3

ATS, Australasian Triage Scale.

The mean and standard deviations of the time that all patients spent in the ED before streaming was 5.8 (±9.2) h, and after streaming was 5.0 (±4.7) h. The reduction in time (0.8 h, CI 0.71–0.89) was highly statistically significant ($t = 16.99$, d.f. = 99 410, $P < 0.001$) The time spent in the ED for those patients who were subsequently admitted to hospital fell significantly from 8.5 (±13.2) h to 7.0 (±6.0) h after streaming. The mean difference of 1.5 h (CI 1.3–1.7) was highly significant ($t = 15.06$, d.f. = 43 441, $P < 0.000$) The time patients who were discharged from the department spend in the department significantly decreased from a mean 3.7 (±2.6) h in the department before, to 3.4 (±2.4) h after streaming. The mean difference of 0.3 h (CI 0.25–0.34) was again highly significant ($t = 13.86$, d.f. = 55 965, $P < 0.001$).

Figure 1 shows that the overall effect of these changes was that on average there were three to four patients fewer per hour in the department after streaming had commenced.

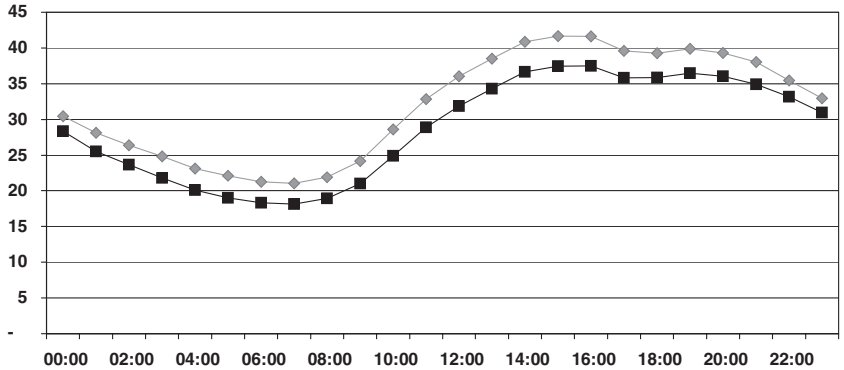

Figure 1. Average patient count in ED per hour of day. (—◆—) From December 2002 to November 2003, and (—■—) from December 2003 to November 2004.

Forty-eight per cent of patients overall spent 4 h or less in the department before streaming, and 53% after. Sixty-four per cent of patients who were discharged from the department were discharged in 4 h or less before streaming, and 71% after.

Fifty (0.10% of total arrivals) patients died within the ED in the 12 months before streaming, and 56 (0.11% of total arrivals) in the 12 months after. These differences were tested by Poisson regression. The Incidence Rate Ratio for difference in death rates over the two periods was 1.22 (CI 0.83–1.7) after adjusting for triage status ($P = 0.309$ NS). A total of 1302 patients represented within 24 h to the ED in the 12 months prior to streaming, and 1244 in the 12 months after streaming. There is no way of separating out those patients whose return was planned in relation to their underlying condition, and those patients whose return was unplanned, so no statistical analysis was undertaken.

Monthly morbidity and mortality review and adverse incident monitoring has not identified any incidents of concern with regard to patient safety attributed to the change in practice. Qualitative staff feedback reports an overall sense of a greater degree of patient safety, and sense of control.

Discussion

Taachi Ohno, the founder of the Toyota Production System from which Lean Thinking was derived, distinguished processes from operations.[7] In Lean Thinking, an operation is any specific step or activity in the transformation of a raw material into a finished product. In the case of health care, the raw material is the patient's presenting complaint and the finished product is that presenting complaint resolved as best it can be. A process is the complete sequence of operations required to transform the raw material into the finished product. Processes can be further grouped into value streams, which in relation to health care, we take to be groups of patients whose care processes are sufficiently similar that they can be managed together irrespective of more traditional features such as clinical diagnosis, or in this instance, triage category.[5] In Lean Thinking it is argued that segmenting, or separating out, care processes when distinctive value streams are present then managing each value stream separately, increases the overall efficiency and reliability of the processes involved. By contrast, making multiple queues within value streams is likely to lead to delays, as those queues interact and batches are formed in an effort to maintain some kind of flow.[8,9]

Patients presenting to an ED require many different steps or operations to complete their processes of care. We used a process mapping strategy to describe existing flows and patient care processes. We then hypothesized that the potentially dischargeable patients formed a separate value stream from the patients who were likely to be admitted. Apart from anything else, the overall processes required to complete the journeys of patients who would return home directly from the ED could be completed within the ED. Also, the care processes required by those patients were sufficiently similar to each other, in terms of process complexity, and were sufficiently different from those of patients that would be admitted to hospital, to further confirm that these were separate value streams. The separation of value streams in this way made sense in this particular ED; however, it must be stated that there are other ways of grouping value streams, even in the same

department (e.g. subsequent changes have resulted in the addition of a separate paediatric value stream, because processes for that group can also be thought of as being similar enough to logically group together).

The process mapping made it clear that the congestion within the ED at Flinders Medical Centre was a consequence of at least two interacting forces.

First, large numbers of patients identified as requiring inpatient care were boarded in the ED while a bed was being located in an overcrowded hospital. Because that process often took many hours, caring for those patients absorbed substantial amounts of the available clinical capacity so that delays in seeing new arrivals were commonplace. Thus, there was often a queue of new patients waiting to be seen and assessed.

Second, the use of the ATS as a method of prioritizing the order in which waiting patients were seen and assessed meant the overall length of time patients spent within the department was frequently extended. A patient's nominal place in the queue for assessment and treatment was always at risk of being pre-empted by the arrival of a patient (or patients) in a higher triage category. As waits extended, pre-emption could occur on a number of occasions. Staff used various ways of getting around this pre-emption, such as fast tracking when they could, rapidly assessing a patient and starting tests and then moving on to another patient, nursing staff advocating on behalf of a patient to move the patient up in the queue, and various other methods. It became evident that many of these increased the overall sense of chaos and lack of control, despite undoubtedly good intentions.

We moved away from complex queuing processes for the potentially dischargeable group of patients. Staff were instructed that, in the absence of threat to life or limb, they were to see B-side patients in order of arrival rather than by triage category. Initially, we were reluctant to take that step for patients likely to be admitted to hospital. However, since September 2004, A-side patients assigned a Triage category 3, 4 or 5 have also been seen in order of arrival.

The quantitative information provided in the *Results* section demonstrates that our streaming processes had a clear impact on aspects of the assessment and total time patients spent in the ED. Seeing patients in order of arrival, led, as expected, to a flattening out of the waiting time for initial assessment across the triage categories. This did not influence the adherence to triage times, but it significantly, diminished the actual mean time to initiation of meaningful treatment. Access block decreased slightly, but the total time spent in the ED decreased significantly both for those patients who went home from the department, and those admitted to hospital. This was despite a slight overall increase in the numbers of arrivals, and no increase in medical staff. As a result, the average number of patients in the ED at any time decreased for the first time in many years.

There was no evidence of a decline in the safety of the care provided, and the acceptability of the system to the patients was evidenced by the immediate, sustained and highly significant reduction in number of 'did not wait' patients, despite the overall increase in the number of presentations to the department.

The impact of the streaming was felt in other ways. From the first day that the new flows were instituted, the ED regained a feeling of control, and the new streams were readily accepted by the staff. Discussion with patients indicated that although they disliked waiting, they could accept it if they had a clear idea of where they were 'in the queue'. Seeing potentially dischargeable patients in order of arrival reduced the sense of frustration among patients. Anecdotally, levels of verbal and physical aggression fell within the department as soon as the new flows were instituted. This was particularly noticeable at the triage desk.

The authors believe that these findings have important implications for the way triage is applied. The demonstrable benefits over the traditional use of the triage scale means that patients presenting to this ED are functionally seen in two groups – those that require an immediate, or 'time critical' intervention (such as resuscitation, investigation to exclude the need for a medical intervention or urgent pain relief), and those patients that are safely seen in order of presentation. This system, by reducing the complexity of the queuing process, leads to reduction in total treatment times and reduced total patient numbers in the ED, it is more acceptable to patients, and in an environment that is in danger of becoming overcrowded and chaotic is, we believe, safer, because chaos is reduced enabling staff to concentrate on the task at hand.

The Flinders Medical Centre team were introduced to the notion of applying Lean Thinking to health care during a visit to hospitals in the UK National Health Service. However, the model developed at the Flinders Medical Centre is somewhat different to the models used in the National Health Service. Strategies such as 'see-and-treat' where patients are seen by senior decision making staff at the point of arrival, with the intention of immediately discharging a substantial number of patients were deemed as unlikely to be helpful in an

ED where the acuity of patients was high, as indicated by the admission rate of over 40%.[10,11] Similarly, the large numbers of patients of all types with complex conditions meant that rapid assessment teams[12] or fast-track areas[13,14] that took out only the manifestly well ED attendees would not see a large enough group of patients to justify themselves.

Limitations

This is a descriptive study of changes within one department where a consensus had been reached that a radical change was necessary, although the nature of that change was not evident before the redesign process began. Caution should be exercised before generalizing to departments whose situation is different from that described here.

Conclusions

Patient flows within a busy ED have been substantially redesigned. Incoming patients have been separated into those who are identified as likely to be able to return home, and those who are likely to be admitted to hospital. Patients within each stream are directed to different areas of the ED where they are cared for by different groups of staff. The key role of triage in making initial assessments then seeing and sorting patients according to clinical urgency, remains. However, the use of a triage score to create a complex queue has been superseded. Triage now functions as a means of identifying patients requiring a time critical intervention, with all other patients streamed by likely disposition in relation to admission to hospital or discharge home, each stream of patients then being seen in order of arrival. Streaming of patients in this way improves the flow of patients through the department and is well accepted by staff and patients alike. It deserves further study.

Acknowledgements

We are grateful for the assistance of Paul Hakendorf and Chris Horwood for data extraction and analysis, and for the continuing support Michael Szwarcbord, General Manager of the Flinders Medical Centre, has provided to the redesign process. Our colleagues in the Redesigning care team have been a continuous source of enlightenment and support. Funding for the redesign process was initially supplied by the Board of the Flinders Medical Centre, and has been continued by the Board of the Southern Adelaide Health Service.

Author contributions

All authors contributed actively to the original work in the planning and implementation of the patient flow changes. Manuscript authorship provided primarily by David Ben-Tovim and Diane King. Data collection and collation by David Ben-Tovim.

Competing interests

None declared.

Accepted 4 April 2006

References

1. Cameron P, Cameron D. Access block: problems and progress. *MJA* 2003; **178**: 99–100.
2. Bartlett J, Cameron P, Cisera M. The Victorian emergency department collaboration. *J. Qual. Clin. Pract.* 2002; **14**: 463–70.
3. Bagust A, Place M, Posnett JW. Dynamics of bed use in accommodating emergency admissions: stochastic simulation model. *BMJ* 1999; **319**: 155–8.
4. Womack J, Jones D. *Lean Thinking. Banish Waste and Create Wealth in Your Organisation*. London: Simon and Schuster, 1996.
5. Walley P. Designing the accident and emergency system: lessons from manufacturing. *Emerg. Med. J.* 2003; **20**: 126–30.
6. Rother M, Shook J. *Learning to See*. Brookline, Mass: Lean Enterprise Institute, 1998.
7. Ohno T. *The Toyota Production System: Beyond Large-scale Production*. Portland, OR: Productivity Press, 1988.
8. Jones C, Medien N, Robertson M *et al.* The lean enterprise. *BT Technol. J.* 1999; **17**: 15–22.
9. Hauswald M. Triage: better tools but the wrong problem. *Acad. Emerg. Med.* 2005; **12**: 533–5.
10. Leaman AM. See and treat: a management driven method of achieving targets or a tool for better patient care? One size does not fit all. *Emerg. Med. J.* 2003; **20**: 118.
11. Catille K, Cooke M. One size does not fit all. View 2. *Emerg. Med. J.* 2003; **20**: 12–12.
12. Grant S, Spain D, Green D. Rapid Assessment team reduces waiting time. *Emerg. Med. Australas.* 1999; **11**: 72–6.
13. Taylor DmCD, Bennet D, Cameron PA. paradigm shift in the nature of care provision in emergency departments. *Emerg Med. J.* 2004; **21**: 681–4.
14. Meislin H, Coates S, Cyr J *et al.* Fast Track: urgent care within a teaching hospital emergency department: can it work? *Ann. Emerg. Med.* 1988; **17**: 453–6.