The Health Foundation
Inspiring Improvement

No. 19

Improving patient flow across organisations and pathways

Evidence scan

November 2013

Contents

Health Foundation evidence scans provide information to help those involved in improving the quality of healthcare understand what research is available on particular topics.

Evidence scans provide a rapid collation of empirical research about a topic relevant to the Health Foundation's work. Although all of the evidence is sourced and compiled systematically, they are not systematic reviews. They do not seek to summarise theoretical literature or to explore in any depth the concepts covered by the scan or those arising from it.

Author
Dr Debra de Silva

Organisation
The Evidence Centre

Contact
debra@evidencecentre.com

Key messages

This scan compiled research about the methods used to improve patient flow across organisations or pathways.

The Health Foundation's work suggests that poor patient flow increases the likelihood of harm to patients and raises healthcare costs by failing to make the best use of skilled staff time. This evidence scan rapidly sourced examples of strategies to help improve patient flow across organisations or pathways of care to feed into the Health Foundation's ongoing work in this area.

The evidence scan addressed the question:

– What empirical literature exists about methods to analyse or alter patient flow across organisations or pathways of care?

Ultimately the Health Foundation wanted to consider how methods for analysing or changing flow might best be applied to support unscheduled care. However, it was important not to focus on individual departments so the scan examined how flow could be improved across wider pathways, organisations or systems of care.

Five bibliographic databases were searched from their inception to the end of October 2013 and 280 studies were included about pathway, organisational or system-wide initiatives. More than 150 additional examples were included to illustrate potential applicability to unscheduled care, even if on a narrower basis.

Approaches to patient flow

The most commonly researched techniques for analysing patient flow across organisations, systems or pathways included:

– analysing routinely collected data about service usage
– capacity and workflow planning
– computer models using simulation and queuing theory
– failure mode and effects analysis
– systematic feedback from staff
– ethnography and observation.

After analysing data and identifying areas for change, organisations may implement flow improvement strategies such as:

– reducing variation using structured approaches such as 'Lean'
– management based on real-time data
– matching demand and capacity, including workforce changes
– proactively planning discharge
– 'pulling' people through the system rather than relying on departments or services to 'push' people forwards.

The majority of published research focuses on patient flow in hospitals, though examples from primary care and other services are beginning to emerge.

Potential benefits

There is evidence that methods to improve patient flow can enhance throughput and continuity and reduce waiting time and length of stay. The size of the impact depends on the exact methodology used, but benefits have been found in both hospitals and care in the community across a wide range of pathways and specialisms.

The impact on patient satisfaction, safety and cost is less clear, due to few studies specifically investigating these outcomes. A small number of studies suggest that methods to reduce waiting time and length of stay are associated with improved patient satisfaction or cost.

However, it is important to bear in mind some caveats. The methods used to improve patient flow are heterogeneous so it is not possible to say that all flow-related methods result in similar outcomes. The outcomes will likely depend on the approach used. Few studies have explicitly compared whether one methodology is more effective than others.

Furthermore, a large proportion of studies provide *examples* of using various approaches in practice, but do not explore outcomes. The studies that do focus on outcomes have most commonly explored impacts on *process measures* such as throughput and length of stay, rather than issues such as cost or patient satisfaction. Therefore the evidence allows us to suggest that patient flow-related methods have potential when applied to pathways, organisations or systems of care, but further work is needed before unequivocal statements can be made about improved quality, experience and safety.

Lessons learned

Healthcare teams wanting to analyse and alter patient flow should note the following key learning points:

- Analysing patient flow and putting in place steps to address bottlenecks can have a measureable impact on throughput and length of stay.
- It is possible to transfer improvement techniques to a healthcare context, but it is essential to recognise contextual factors and adapt the methods.
- It is important to undertake detailed 'diagnostic' work to understand patient flow, rather than moving straight into redesigning services. Real-time demand and capacity management may be important.
- Flow issues may best be addressed by exploring processes across an entire hospital or a wider system comprising primary care, ambulance, hospital, social care and community services, rather than in specific departments.
- It can take time for new processes and systems to embed. Adequate time, resources and management support are needed to facilitate change.
- The most successful redesign initiatives include extensive staff engagement and training. If people are being asked to change the way they work, it is important that they understand why and what the benefits will be for themselves and patients.
- There is no 'one size fits all' approach. Many different methods have been used with the potential to improve healthcare.

1. Scope

Making sure that people can get the care they need quickly is a key component of providing safe and high quality healthcare. Ensuring that patients are flowing through healthcare systems is an important part of this. This scan examines research about how patient flow can be improved across organisations or pathways.

Purpose

Prompt access to healthcare is essential for safety and satisfaction. A growing number of people are using health services for scheduled and unscheduled care, so robust strategies are needed to deal with the high demand.[1] If people are not moving through the system appropriately, it may mean that others experience delays in accessing care that can cause significant harm.[2,3] This may also raise healthcare costs by failing to make the best use of skilled staff time and increasing the length of time that people are using services.[4]

It is therefore important to ensure that there is a match between capacity and demand in order to maintain patient safety, privacy and dignity. This can be done through ensuring timely availability of senior staff, access to diagnostics and investigations, good teamwork, adequate support from inpatient specialities and readily available hospital beds, for example.[5]

This is exemplified by The Health Foundation's learning report, *Improving patient flow*, and associated case studies describing the work from two NHS trusts to address poor patient flow in unscheduled care.[6,7]

'Patient flow-related methods' refer to any methods seeking to identify the bottlenecks in services and how to address them effectively.

The Health Foundation was interested in further understanding how methodologies to address patient flow may help to improve outcomes in unscheduled (emergency) care. This is important because there are more than 100 million NHS calls or visits each year related to unscheduled care, representing one third of all NHS activity and accounting for more than half of the costs.[8,9]

For example, NHS England's recent review of unscheduled care[10] found that every year there are about 24 million calls to NHS urgent and emergency care telephone services,[11–14] seven million emergency ambulance journeys,[15] 22 million visits to accident and emergency (A&E) departments, minor injury units and urgent care centres[16] and five million emergency admissions to hospitals in England.[17] This demonstrates the wide range of emergency services available and the extent of their use.[18]

However, an examination of research about using patient flow-related methods to improve outcomes in emergency care services found that much published literature about emergency care focused on specific departments rather than addressing wider systems, pathways or organisations.[19] In the purest sense, methods to analyse and alter patient flow may be best applied across more than just one department or section. Therefore, to provide more robust examples of analysing and improving flow, the Health Foundation decided to compile research about applying these methods across organisations or pathways of care rather than concentrating only on unscheduled care. The learning can then be applied to emergency services as well as many other facets of healthcare.

This evidence scan thus addresses the question:

- What empirical literature exists about methods to analyse or alter patient flow across organisations or pathways of care?

Scanning research

The scan focused on readily available research published in journals in the UK and internationally. It was completed over a two-week period in November 2013.

To be eligible for inclusion in the scan, studies had to:

- include empirical data
- be published in a print or online journal
- be published in the English language.

There were no geographic restrictions.

Priority was given to studies exploring methods for analysing or addressing bottlenecks across pathways, organisations or wider systems rather than in individual departments or services. However, given that an aim was to apply the learning to unscheduled care, some specific examples from narrower studies in emergency services were also included.

To identify relevant research, two reviewers independently searched six bibliographic databases for studies of any design. The databases comprised Pubmed/Medline, Embase, Cinahl, the Cochrane Library and Controlled Trials Register, Google Scholar and the Health Management Information Consortium. All databases were searched from their inception to the end of October 2013. If only a small number of published studies were available, it was planned to extend the search to grey literature. However, the searches identified a large number of relevant published studies so the search strategy did not need to be extended.

Search terms included combinations of flow; patient flow; flow methodology; flow techniques; process redesign; logistics management; systems engineering; parallelisation; queuing theory; constraints; theory of constraints; Lean; Six Sigma; clinical systems improvement; patient demand patterns; demand and capacity; capacity variations; statistical process control; bottleneck; variation; smoothing variation; pull factors; streaming; reducing variation; reliability; Forrester/bullwhip effect; FIFO (first in first out); 'carve out'; discharge planning; delays; waiting times; improving access; handoffs; transitions; process improvement; patient pathway; whole system; organisation and similes.

Abstract and title searches identified more than 5,000 studies about methods for analysing or altering flow in healthcare, though many were descriptive or did not report outcomes. 280 empirical articles met the inclusion criteria and more than 150 additional studies were also used to highlight how the wider findings may be applicable to unscheduled care.

Findings were extracted from all publications using a template. Studies were grouped according to key themes to provide a narrative summary. The studies were grouped according to whether they included methodologies to analyse patient flow or whether the approaches sought to make changes to flow.

All of the evidence was sourced and compiled systematically, but the scan is not a systematic review and does not seek to summarise every study about the impact of methods related to patient flow. Instead the aim is to provide examples of how these methods have been used to analyse and improve patient flow across organisations, pathways or systems of care, based on empirical evidence. There are many other studies examining flow-related methods within specific departments or units, but these were outside the scope of the review.

2. Assessing patient flow

This section provides examples of methods that have been used to assess patient flow across organisations or pathways (such as diagnostic analyses and models).

The main methods researched for assessing patient flow across organisations or pathways include:

- analysing basic routinely collected data about service usage
- capacity and workflow planning
- simulation and other forms of modelling
- queuing theory
- failure mode and effects analysis
- systematic feedback from staff
- structured observation and ethnography.

Examples of each of these methods and any research about their impacts is presented here. The next section focuses on methods to change patient flow, such as redesign activities.

It is important to note that these analysis methods may be used simultaneously and that they are often part of larger programmes to implement change. Examples of analysis approaches are presented here discretely solely to help clarify the range of methods used.

Analysing service use

Examples of use

There are many examples of health services, particularly hospitals, analysing routinely collected data to help understand how patients use services and whether there are trends based on particular times of the day or the types of staff or care involved.[20–22]

Retrospectively examining data over a set period of time is the most common approach. These analysis approaches can range from simple to very complex.

Analysis of routinely collected data to identify patterns in service usage has been done across hospitals, within specific subgroups or pathways of care and specifically for unscheduled care services.[23–39]

For instance, retrospective analysis of data from 23 Australian hospitals was undertaken by aggregating historic data into hourly intervals spanning a two-and-a-half-year period. The researchers examined admission and discharge rates, occupancy levels, length of stay for admitted and unscheduled care patients and access block. The study identified three stages of declining system performance or 'choke points' as hospital occupancy increased. Implementing strategies to support early discharge was predicted to improve patient flow.[40] These researchers also compared differences between weekdays and weekends and looked at whether the findings were different from patient flow in hospitals across the region. Having something to compare to and benchmark against was seen as important, as was analysing patient flow at a service level as well as on a hospital-wide basis.[41]

Another study from Australia used time-based clustering to visualise patient flow data from one hospital. Inpatient and A&E department patient episodes were clustered into hourly slots based on recorded timestamps and then grouped according to specific parameters. This was found to be a powerful tool for visualising and analysing interactions and interdependencies in patient flow factors across the entire organisation.[42]

In another part of Australia, a hospital developed a user-friendly interface to distil routinely collected clinical data into patient flow information to aid bed management. Historical snapshots were used to allow flow to be visualised across a day, week, month or year. Flow information about occupancy, arrival and departure rates, length of stay and access block were included, and could be filtered by age, departure status, diagnosis, elective status, triage category and admission unit.[43]

In the US, a children's hospital undertook a detailed analysis of the reasons for delayed discharge. They found that, over a month-long period, almost one quarter of patients could have been discharged sooner

than they were. The impact on length of stay and costs was substantial. The data was used to prioritise interventions such as improving discharge criteria, more efficient discharge planning and timely scheduling of consultations and diagnostic tests.[44]

The impacts of improvements made after analysing data about patient flow are described in section 3, 'Changing patient flow.'

Possible applicability for unscheduled care

There are many examples of how analysis of basic data has been useful for unscheduled care.[45–52] For example, in one US hospital, the data used for A&E department redesign included the current status of the organisation, national trends, user profiles, types of long-term conditions, insurance distribution, proportion of inpatient admissions, readmission figures, outpatient services and charges.[53] This is an illustration of how broader organisational data and data from outside the organisation were explored to understand the potential impacts on flow through unscheduled care. The study acknowledged that flow in A&E was a function of much wider system issues rather than solely related to an individual department.

There are many more examples of how analysing routinely collected data can help understand patient flow in unscheduled care. The most useful analyses tend to tailor the exploration to local needs, analyse data about a whole organisation or system rather than focusing on a specific department and build in an immediate strategy to make changes.[54–57] Approaches which use visual tools, such as scatterplots, have been found to have some merit.[58,59]

Capacity planning

Examples of use

In addition to looking at data about service usage, another approach involves exploring data about workforce issues and the capacity available to meet such usage demands. A number of different models have been used to explore workflow and to plan resource needs across healthcare organisations or systems. Although the exact models used differ, they have in common a focus on compiling quantitative data about various patient, staffing and resource inputs in order to consider the staffing needs and the impact of any changes to processes or patient numbers.[60–65]

Examples of outcomes from capacity planning are included in the section 3, 'Changing patient flow.'

Possible applicability for unscheduled care

Mapping workflow capacity against demand is as potentially useful for unscheduled care as for other parts of the healthcare system. However, most examples of this approach in unscheduled care have focused on a specific department or service rather than exploring capacity across the broader spectrum of care and how this might impact on unscheduled care.

An example of application in a specific department comes from the UK where an A&E department undertook an in-depth analysis of demand and capacity, drawing on techniques from manufacturing and other industries. The team found that proper capacity planning is vital for improving patient flow, but this is often done poorly. The researchers argued that it is important to understand demand and the variation in demand in order to ensure effective workforce planning and process redesign. They suggest that planning using aggregated data may lead to inadequate capacity.[66]

Eight US hospitals attempted to take a broader approach by using a 'hospital capacity assessment tool' and applying it to unscheduled care services. The tool was available in paper and electronic form and drew on other emergency care assessment tools. Three hospitals found it difficult to complete the questions because they did not collect patient flow data regularly. The other hospitals found the tool easy to use and thought it was beneficial for evaluating community-wide emergency care.[67]

Another example is a model developed to predict surge capacity bottlenecks in response to a mass-casualty incident involving multiple burn victims. Commercial software was used to model patient flow and anticipated resource use based on principles of disaster management and historical data. The model input the age and weight distribution for casualties, severity of burns, rate of arrival of casualties to hospital, triage to ward or critical care settings, eligibility for early discharge, occupancy of intensive care unit, surgical step-down care and wards, staff availability, floor and operating room resources, and the average hospital length of stay and mortality rate for patients with inhalation injury and different sized burns. This helped predict the time to bottleneck for each limiting resource and the average waiting time to hospital bed availability. Knowing the time that it would take the hospital to reach capacity meant that alternative strategies could be developed to care for those waiting.[68]

Simulation and models

Examples of use

Healthcare managers may make decisions about patient flow, workflow and capacity based on subjective information, especially where 'hard data' are not available. Discrete event simulation is a computerised method of modelling how things work in real-world settings over time and can be used as an evidence-based tool to develop and prioritise potential operational changes prior to implementation.[69,70]

There are a number of examples of using discrete event simulation or other forms of modelling to understand patient flow, manage bed capacity, schedule staff, manage admission and scheduling procedures, test the value of potential initiatives before they are implemented and use resources such as labs and pharmacies effectively.[71–89]

For example, a lack of intensive care unit (ICU) beds may cause ambulance diversion and surgery cancellation, thus affecting patient flow on a wider organisational or system-level. On the other hand, an excess of ICU beds may be a waste of resources. Researchers in Singapore used discrete event simulation to determine appropriate ICU bed capacity to balance service level, cost-effectiveness and patient flow. One years' worth of operational data such as emergency arrivals, elective arrivals and length of stay were fed into the model to capture variations in the system. The model was used to test 'what-if' scenarios regarding growth in demand.[90]

Another example is a US ICU that used an advanced predictive model to 'smooth flow' based on analysis of need, occupancy and length of stay, coupled with an active daily strategy for demand/capacity matching of resources and needs. Key activities included patient flow models based on surgical predicted need for intensive care and predicted length of stay; scheduling the case and an ICU bed at the same time; capping and simulation models to identify the appropriate number of elective surgical cases to maximise occupancy without cancelling elective cases; and a morning huddle between senior staff from many departments to confirm that day's plan and anticipate the next day's needs. This approach helped to ensure there was always ICU bed capacity.[91]

Elsewhere, a 'stock and flow' model was used to analyse the amount of blood stored in blood banks and hospitals in the US. The model simulated the potential impact on supply of using different blood management practices for transfusion such as first in-first out (FIFO), using the oldest stored red blood cell units first; preferentially selecting older blood; and preferentially selecting younger blood.[92]

Traditional discrete event computer simulation software can be quite complicated to use, expensive to purchase and require training. In Canada a simplified simulation platform was developed that ran using spreadsheets. Spreadsheets are low cost, popular to use and have good functionality, and these outputs may be just as reliable as those from traditional software. A comparison of commercial software versus simulation spreadsheets found that both were equally good at predicting patient flow characteristics but spreadsheets were easier to use, understand and implement.[93]

The impacts of improvements made after modelling patient flow data are described in section 3, 'Changing patient flow.' Most of these improvement studies do not explicitly state that models were used as a starting point, and instead focused on the change initiatives undertaken.

Possible applicability for unscheduled care

A number of studies have applied modelling tools to examine flow in unscheduled care, though most of these focus on specific departments rather than using hospital-wide or broader system-level data.[94–105]

There are some exceptions, however. For instance, researchers from England used simulation to create a 'perfect world model' for A&E care, not as it is, but as it could be. Importantly, the 'efficiency gap' between the 'perfect world' and the 'real world' was used to identify the location of bottlenecks in the current 'whole hospital' patient pathway and brainstorm ideas for improvement.[106] This shows that drawing on wider organisational-level data can lead to ideas for change in specific services.

Elsewhere in England, a primary care commissioning organisation focused on improving the use of unscheduled care and support efficiency gains in the local hospital. A model of the system was developed to help set usage targets at the micro-level of the hospital. The model drew on a small number of key readily available data items. The model emphasised that primary care had a key role in changing the culture, communication and care provided within A&E and other unscheduled services.[107]

US researchers used a model to test whether discharging people from inpatient hospital wards earlier in the day could affect crowding in A&E. The model suggested there was potential to reduce or eliminate the number of people admitted through A&E who had to be placed in temporary beds whilst awaiting an inpatient bed to become available.[108]

In Korea a simulation model was used to examine internal and external factors affecting patient flow and crowding at one unscheduled care department. Basic patient flow and process data were collected and computer simulations were used to evaluate diverting patient loads to another area as well as other improvement initiatives. Using simulation models allowed managers to think through the intricacy of the unscheduled care environment and how it related to other facets of the wider system. It also enabled experimentation to make inferences about how the real system might perform.[109]

Models have also been used to inform patient flow on a larger scale in unscheduled care. In Canada simulation was used to explore 'crowdinforming' as a method for controlling patient loads between six A&Es in one city. Six months' worth of data were analysed to determine factors influencing flow and to develop a process control strategy. A&E arrival rates were the most useful measure of 'busyness.' The researchers concluded that making live data available may help to redirect paramedics and also encourage patients and their families to visit unscheduled care services that are less busy.[110]

Queuing theory

Examples of use

'Queuing theory' is the study of waiting lines, or queues. Usually a mathematical model is constructed to help predict queue lengths and waiting times.[111] Historical data is analysed to explore how to provide optimal service while minimising waiting, thus providing an objective method of determining staffing needs during a specific time period.[112]

Though popularised in other industries, this approach has also been used in healthcare, particularly by hospitals wanting to understand waiting times for unscheduled care or the time spent waiting for specific equipment, surgery or laboratory results.[113–119] It is also applicable to wider systems of care or transitions.[120]

A hospital in England used queuing theory to analyse one year's worth of data to help understand the practical challenges associated with variation in patient demand for services and length of stay. The analysis found that daily bed shortages are mostly influenced by the timing of arrival and discharge of patients with a short length of stay and that bed shortages around holiday periods are not due solely to increased demand, but also a reduction in discharge capacity around this time.[121]

Possible applicability for unscheduled care

Queuing theory is very applicable to urgent care, but has tended to be applied at the level of individual departments or units rather than across wider organisations or pathways.[122–125]

For example, researchers in the US developed a model based on queuing theory to predict the effect of various patient crowding scenarios on 'left without being seen' rates in A&E. One years' worth of data from one hospital were analysed. A model previously used in a call centre was modified for use in healthcare. It was possible to use data about patient arrivals, treatment time, and non-availability of beds to predict the proportion of patients who left without being seen.[126]

At a broader level, a team from the UK used queuing theory to evaluate completion times in A&E departments. They suggested that flows through an A&E can be accurately represented as a queuing process, with visual aids helping to interpret data in a simple manner. The analysis suggested that government waiting time targets resulted in significant improvements due to better management and changes in the way patients are labelled and therefore counted through the system.[127]

Researchers in Canada used queuing theory on an organisational level to analyse the relationship between patient flow to A&E and patient flow to the inpatient unit. They then used the model to estimate the average waiting time for patients and the resources needed in unscheduled and inpatient care. The model was used to analyse the potential impacts on waiting time and resources of an alternative way of accessing unscheduled care and this helped managers plan the resources needed to enhance patient flow.[128]

Statistical process control

Examples of use

Statistical process control is a quality control method that was originally applied to manufacturing processes to ensure they operated within specific limits and eliminated waste. Control charts plotting the extent to which processes conform to standards are often used, along with rapid improvement changes.[129] This approach has been applied in healthcare to assess where processes conform to specifications, including changes in patient flow.[130]

A systematic review of 57 studies explored how statistical process control, with control charts as a core tool, has been used to improve quality in healthcare. The review found that this approach has been applied in a wide range of settings and specialties and across organisations. The reviewers reported that statistical

process control helped different stakeholders manage change, but only if applied robustly with risk adjustment and data stratification.[131] Another review of 34 studies found that control charts can be useful, but are not always developed and analysed robustly.[132]

Studies have reported improved efficiencies in care, reduced variation and more streamlined pathways following the use of statistical process control.[133,134] However this is merely an analysis approach and interventions need to be implemented to make changes (and monitored with ongoing analysis so adjustments are possible).

Possible applicability for unscheduled care

As an example of applying this approach to unscheduled care, researchers from the UK tested using statistical process control to monitor and provide prompt real-time feedback on strategies to reduce 'door-to-balloon time' for people suffering a heart attack. This spanned care across diagnosis, ambulance transfer, A&E assessment and immediate treatment. Median time to treatment fell significantly following changes in protocol. The team concluded that statistical process control provided a robust mechanism for assessing the effect of process redesign and gave a useful visual representation to support changes.[135]

Other examples in unscheduled care have tended to focus on a departmental level[136,137] but, as illustrated above, there is no reason why statistical process control cannot be applied spanning departments or pathways.

Critical path analysis

Critical path analysis is a modelling technique developed in the 1950s. It is used to examine relationships and interdependences in projects and has been used in construction, the military, IT and engineering contexts, as well as healthcare. The key steps are to develop a model or outline listing all activities required to complete the project, the time that each activity will take to complete, the dependencies between the activities and logical end points such as milestones or deliverable items. This can be used to visually identify areas that need to be prioritised, using Gantt charts or similar.[138,139] The NHS Institute for Improvement and Innovation's 'Improving Time to Care'/Productive Ward programme uses critical path mapping, among many other tools.[140]

Possible applicability for unscheduled care

The efficiency of unscheduled healthcare depends on interactions among the system structures, processes and outcomes so critical path analysis may be useful. Examples of this approach in unscheduled care have focused at the level of individual departments however, rather than incorporating wider organisations or systems.

A department-specific example comes from Korea where researchers examined the effect of structural adjustment (change in floor plan or layout) and process improvement (critical pathway implementation) on A&E performance for people with stroke. One large hospital adopted structural changes and another large hospital used critical path analysis to support process improvements. Before and after analysis suggested that both redesign of the layout and implementation of critical pathways improved most of the performance measures. Overall, adopting critical pathways appeared to be more effective for reducing waiting time or time to treatment. This was purportedly mainly due to the extensive staff training required to implement new pathways. The researchers concluded that combining structure-oriented and process-oriented strategies may maximise the effectiveness of efforts to improve patient flow.[141]

Failure mode and effects analysis

Examples of use

Failure mode and effects analysis is a systematic technique to identify potential errors or system failures. Originally developed in the 1950s by engineers studying malfunctions in military systems, this type of analysis tends to be qualitative in nature and involve reviewing as many components and subsystems as possible to identify possible failures and their causes and effects. Worksheets and templates are used to record the information. This approach has been used in healthcare, particularly to address aspects of patient safety.

Possible applicability for unscheduled care

Failure mode and effects analysis may be useful for unscheduled care.[142] In the US, national targets state that people presenting with a heart attack should receive intensive treatment within 90 minutes or less, and there is some evidence that receiving care within one hour significantly decreases in-hospital mortality. One hospital used proactive risk assessment with the failure mode, effects, and criticality analysis method to evaluate 'door-to-balloon time' processes and investigate how each 'failure' may affect the performance of the system. A multidisciplinary group of staff described the door-to-balloon time process then created a map and table listing all process steps. This was used to identify process failures, including their frequency, consequence and causes. Fifty-one failure points were identified across four phases of care. Thus the process was able to reveal areas of potential delay and vulnerability in unscheduled care.[143]

Time-motion analysis

Examples of use

Time-motion studies aim to directly and continuously observe tasks, in order to quantify activities and the time taken to do them and identify areas for improvement. A number of studies have used this technique or variations of it as part of patient flow analyses.[144–147]

An example of a sophisticated time-motion-type study comes from a US hospital that used real-time patient data from barcodes and local scanners to track the progress of patients throughout 17 points in the surgical care pathway. Data about timing between the activity points were used to identify inefficiencies such as bottlenecks and areas of high variation. The causes of variation were identified and multidisciplinary improvement teams then worked to create solutions.[148]

Elsewhere in the US a smartphone/iPad app has been developed to help collect information in healthcare time-motion studies.[149]

Possible applicability for unscheduled care

Time-motion studies may provide areas for further exploration in unscheduled care. To date, most published literature on this topic has focused on time-motion studies in individual unscheduled care services[150,151] but it is possible to apply this technique to consider broader level systems changes.

For instance, a US A&E department observed the time taken to register, assess, triage, treat and discharge patients over the course of seven time-motion analysis cycles spanning a five year period. Rather than analysing the results only at department level, an interdepartmental continuous quality improvement committee planned changes. The analysis found that a lack of availability of both A&E and inpatient beds led to significant delays. The researchers concluded that time-motion studies are an effective method of identifying areas of delay in patient care and can help to plan targeted interventions.[152]

Staff feedback

Examples of use

Another method used to identify patient flow issues involves systematically collecting feedback from staff.[153] Surveys appear to be most popular for this purpose and are often combined with other analysis and change methodologies.[154–156]

Possible applicability for unscheduled care

This method is equally applicable to unscheduled care as to other aspects of healthcare and a number of studies have documented how staff surveys or interviews have canvassed patient flow issues for specific unscheduled care services.[157,158]

In Australia researchers canvassed hospital doctors and nurses about difficulties assessing and managing people with mental health issues who attend A&E. More difficult or complex patients can impact on overall flow and throughput, so the aim was to understand the barriers and potential solutions from clinicians' point of view. Interviews suggested that a range of resource, environmental, staff and patient factors contributed to difficulties managing people with mental health concerns. Suggested solutions included additional resources, further education about mental health, A&E redesign and improved links to resources outside A&E. Importantly, the researchers concluded that many of the issues are systems-based and thus require systems-based solutions rather focusing on individual departments.[159]

However, caution is advised when relying on staff feedback to prioritise patient flow initiatives. In Australia, hospital staff were surveyed about their perceptions of the causes of delay in patients' journeys through A&E. This feedback was then compared with findings from an analysis of key constraints to patient flow using real-time diagnostic/decision support software. The researchers found that staff perceptions regarding patient flow issues did not correlate well with real-time analysis, suggesting that staff may not always have accurate insights into the most important areas for improvement.[160]

Observation

Examples of use

Observation is sometimes used as part of time-motion studies or may be part of detailed ethnography or more surface level assessments of patient flow.

Ethnographies provide detailed descriptions and observations about environments and interactions. They aim to be holistic and include a history of the issue and an analysis of the terrain, habitat and relationships in a specific site.[161]

More simplistic structured observation is also possible. While this does not look in as much depth as ethnography, it can still provide valuable insights into how emergency care is operating and potential areas to improve patient flow.[162]

Although the evidence scan identified a number of studies about using observation to explore patient flow, the impact of this method on patient and process outcomes was not detailed.

Possible applicability for unscheduled care

There is no reason why observation cannot also be a useful tool in unscheduled care. However, most examples in this field have focused on individual departments rather than taking a broader pathway or organisational perspective.[163]

For instance, in Australia, a year's worth of ethnographic observations of patient flow were undertaken in two A&E departments. This included detailed observation of the communication and activities of A&E doctors and nurses and semi-structured interviews. This resulted in the theoretical concept of an A&E 'carousel,' whereby staff need to diagnose and treat individual patients, alongside taking a higher level view in order to lead the department and manage the staff skill mix. Using ethnography helped to extend traditional representations of patient flow and allowed concepts to be displayed visually.[164,165]

As an example of how useful less in-depth observation can be, a team visited all health boards in New Zealand and followed up with a report noting the observed challenges, initiatives and successes in relation to reducing delays in unscheduled care. The reports were then used to collate information about significant challenges and promising initiatives across the country. Access to hospital beds, access to diagnostic tests and inpatient team delays were the most common challenges.[166]

Observation is often part of broader redesign initiatives. In the UK, an action research approach was used to improve unscheduled care pathways and patient flow at one hospital. Three action / reflection cycles were conducted with hospital teams. Data were collected using patient record review, staff interviews, observation of patient pathways and a survey of team climate.[167]

Summary

To summarise, this section has overviewed some of the most commonly researched approaches for analysing patient flow across organisations and pathways, as well as their potential applicability to unscheduled care. Although the scan describes each method separately, in practice many of these approaches may be used together and combined with the approaches for changing flow described in the next section. As an example, an outpatient clinic in the US used a structured approach to identify sources of variability and areas for improvement. A process map was developed to visualise the flow process at the clinic and sources of variability that may contribute to congestion in flow were identified. Data about task times were collected by observing the process with stopwatches or using historical records. A simulation model was then developed to test potential service changes before implementing them in practice.[168] This is a good example of how many of the methods described in this section can be combined to examine flow from many angles.

Most of the studies examining ways to analyse flow were from North America, but examples from the UK, Europe and Australia were also available. What is striking is that in most cases the empirical literature focused on describing the approach used rather than exploring potential outcomes, such as the impact on patient satisfaction or safety. This is largely because the analysis approaches are not an end in themselves, but rather result in some type of redesign work to change systems and processes. Research about methods for changing patient flow in this way is described in the next section.

3. Changing patient flow

This section provides examples of methods that have been used to change, redesign and improve patient flow across organisations or pathways of care.

The main methods that have been researched about changing patient flow at an organisational, system-wide or pathway level include:

- addressing variation, often using systematic continuous quality improvement approaches such as Lean/Six Sigma
- real-time management by applying data and assessing priorities
- matching capacity and demand, including workforce initiatives such as adding capacity, changing skill mix and using new roles such as patient flow co-ordinators
- proactively planning discharge
- pulling rather than pushing people through the system, such that the next link in the chain is actively seeking to move people onwards.

These approaches are not mutually exclusive and often overlap in their definitions or are used together within initiatives to improve patient flow. They are outlined in separate sections here to facilitate the clarity of examples, but there is a great deal of overlap and one approach is not necessarily more effective or appropriate than others.

Addressing variation

Examples of use

The main ways to reduce variation in order to improve patient flow documented in the empirical literature are:

- applying Lean methodologies or other continuous quality improvement approaches
- 'smoothing' or scheduling care differently
- implementing integrated care pathways (described in 'Pulling through systems' on page 21).

Methods to address patient flow may strive to reduce variation in the care provided or in the number of people using services at different times. Structured continuous quality improvement programmes have been used to support this.[169] For example, the Lean approach was originally developed for manufacturing and production methods in order to improve processes and eliminate waste.

Lean principles aim to help organisations enhance process steps that are necessary, relevant and valuable while eliminating those that do not add value. The focus is on creating value for the end user. Any activity not adding value in this way is thought to be 'wasteful' and thus a potential target for elimination. Essentially, the Lean model, which is closely associated with Toyota car manufacturing, aims to preserve value with less work. This approach analyses potential sources of waste and implements cycles of continuous quality improvement.[170]

Lean is about a fundamental change in the way organisations think about delivering care, but the specific changes employed tend to be simple – such as small procedure modifications relevant to the unique staff, processes and environment.[171]

The approach may include: 'value mapping' whereby the extent to which tasks and processes add value from the patient point of view is assessed; quality function deployment to assess causes and potential solutions; rapid cycles of improvement.[172,173] This approach to reducing variation may also draw on the 'theory of constraints,' a management paradigm often used in conjunction with Lean that focuses on the concept that 'a chain is no stronger than its weakest link.' It views any system as being limited only by a small number of constraints, and seeks to identify these constraints and restructure organisations and work processes around them.

This methodology has been applied in healthcare with some success,[174–178] although some argue that it is not always applied robustly.[179]

In Australia, a number of hospitals have implemented Lean principles to improve efficiency and reduce waste, concluding that approaches that emerged in the manufacturing sector may be readily translated for healthcare. These redesign initiatives tend not to change the specifics of clinical practice, but rather focus on improving the flow of patients through clinical and other systems. The most successful examples redesign care on a hospital-wide basis.[180–182]

Impact on processes

There is evidence that applying Lean principles can improve throughput and process indicators without negatively impacting on safety.[183–196]

In the UK, a hospital mapped the steps in an endoscopy pathway and used Lean thinking to attempt to add value and reduce variation. The minimum and maximum time per step, bottlenecks and between-staff interactions were recorded. A patient pathway template was created and rolled out to another unit. The pathway reduced patient and staff travelling distances, waiting times, paperwork and handovers and nursing staff requirements reduced by 25%.[197] Other tests in the UK have found similar gains in pathway efficiency.[198]

A hospital in Norway used Lean principles to improve flow across the system for people with lung cancer. Initially there was an average 'work-up' time of several months, due to potential patient delays, doctors' delay and waiting times for x-rays and scans, referral to specialists, and waiting time for chemotherapy and radiotherapy or surgery. This was an organisation-wide approach because all levels of the institution were involved in focus groups and workshops to analyse data and suggest and implement improvements. Workup time decreased from an average of 64 days to 16 days and the median time from diagnosis to surgery reduced from 27 days to 15 days.[199]

Other quality improvement initiatives aiming to reduce variation or standardise care have also been found to be useful. These often focus on scheduling or 'smoothing' variation. For example, a US study used data from 39 children's hospitals to explore ways to smooth inpatient occupancy and reduce crowding. Occupancy levels were calculated and the impact of changing the number of patients and patient-days was modelled based on different scheduling techniques. Weekday occupancy was higher than weekends. Smoothing (or reducing variation via scheduling on different days of the week) helped to reduce overcrowding. The researchers concluded that hospitals may have substantial unused capacity and smoothing occupancy over the course of a week could help to reduce crowding.[200]

In Australia, a large-scale programme was undertaken to improve patient flow and efficiency at more than 60 hospitals. During a 'diagnosis phase', a number of disconnections and misalignments in the process of care delivery were uncovered. Solutions aimed to address the entire patient journey through the hospital, to produce smoother patient flow. The approach included redesign, additional bed capacity and more rigorous hospital performance management. There was an improvement in flow and performance which was sustained over a three-year follow-up period. A key lesson learned was that to achieve sustained improvement, numerous solutions should be simultaneously implemented in each hospital.[201]

Another study reported how five hospitals in Australia redesigned hospital services, including emergency services. Two of the hospitals took part in an externally-facilitated redesign programme, two hospitals implemented ward-based innovations using standardised processes sourced externally and one hospital undertook internally-led redesign including a medical assessment and planning unit and new bed management processes. Results were measured using control charts. Only one externally-led redesign resulted in short-term reductions in A&E blockages, but this was not sustained over time. The internally-led redesign was associated with an average reduction in access blocks from 55% to 22%. The researchers concluded that internally-led redesign was associated with superior and sustained improvements in A&E access block because structural reforms were driven by committed clinicians and managers and cut across departmental boundaries.[202]

A hospital in Spain standardised admission and discharge processes to improve patient flow. Over a two-year period, the proportion of patients admitted the same day as surgery increased from 65% to 86%, the number of cancelled interventions due to lack of beds decreased from 216 per annum to 42 per annum and the median number of planned discharges increased from 43% to 86%. Average length of inpatient stay reduced from 8.6 days to 7.9 days. The researchers concluded that standardising admission and discharge processes is something that is largely within the control of hospitals, so may be an opportunity to improve bed capacity and hospital throughput.[203]

Impact on safety

There is some evidence to support claims of improved safety from Lean or similar approaches being used to address flow issues.[204,205] For example, an emergency general surgery ward in the UK tested the impact of Lean process redesign on patient safety. Compliance with targeted process measures improved and good compliance continued for at least ten months after the active intervention ceased. The proportion of people requiring transfer to other wards fell from 27% to 20%. There were no major changes in rates of adverse events or potential adverse events. Most adverse events and potential adverse events were due to delays in investigation and treatment caused by factors outside the ward. The researchers concluded that Lean can improve compliance with safety related processes but this may not translate into improvements in safety outcomes unless a system-wide approach is adopted across the entire hospital.[206]

Impact on patient satisfaction

Reductions in waiting times as a result of applying Lean principles have been linked to greater patient satisfaction, though the evidence is sparse.[207–209]

Impact on cost

Although a number of studies postulate that the improvements in processes and length of stay resulting from Lean approaches would translate to greater cost-efficiency,[210–213] fewer articles actually quantify any cost savings.[214]

There are some exceptions, however.[215] For example, a US hospital saved US$5.3 million by adopting Lean principles across the organisation. There were improvements in unscheduled admission rates and overall patient flow.[216]

Another example also comes from a US hospital. 'Integrated Facility Design' is an adaptation of the Toyota 3P (Production, Preparation, Process) programme. The goal is to accelerate development time and lower start-up costs. A children's hospital in the US used this process to design a surgery centre with reduced variation and improved cost-effectiveness. Using this approach resulted in completion 3.5 months ahead of schedule, with estimated savings of US$30 million in project costs and improved patient throughput.[217]

Variations in the flow of patients through surgical theatres impact on hospital performance and finances. Natural variation (uncontrollable, unscheduled surgery) and artificial variation (controllable, scheduled surgery) require different management. A hospital in the US used variability methodology to analyse surgeries over a three month period and construct mathematical models of the resources used for scheduled and unscheduled cases. Guidelines and capped use were implemented to smooth the daily schedule and minimise variation. There was an increase in productivity and effective use of resources. Overtime staffing decreased by 27%, staff turnover decreased by 41% and the number of elective scheduled same day changes decreased by 70%. There were significant financial savings.[218]

Possible applicability for unscheduled care

These concepts have demonstrated applicability for unscheduled care, though in the past they have often been applied at a departmental level. [219–233]

For instance, a review of 18 studies about applying Lean principles to A&E departments in the US, Australia and Canada identified many changes in processes. These were often accompanied by structural changes such as new technologies, communication systems, staffing changes and the reorganisation of physical space. Patient care usually improved after A&Es began using Lean principles, with many A&Es reporting reduced length of stay, waiting times and proportions of patients leaving without being seen. There were few negative patient care effects reported. Impacts on patient quality, satisfaction or safety were usually not reported. The effects of Lean on staff were rarely measured, though there was some indication of positive effects on the workforce and organisational culture. Success factors included staff involvement, management support and organisational readiness for change.[234]

In Ireland, researchers used Lean principles and the theory of constraints to identify bottlenecks in patient journeys through A&E. For each stage of the patient journey, average times were compared and disproportionate delays were identified using a significance test. A Lean value-stream map and the five focusing steps of the theory of constraints were used to analyse these bottlenecks.[235]

There are a smaller number of examples of how Lean and other continuous quality improvement processes have been applied across organisations or pathways to improve flow in unscheduled care.[236]

In particular, Australian hospitals have implemented Lean on a large-scale, and found improved efficiency.[237–239] One study described a process redesign based on task analysis and Lean thinking. Analysis of data from one year before and one year after implementation found a 55% reduction in episodes of ambulance bypass and a decrease in most waiting times.[240]

A US hospital used Lean concepts to redesign A&E facilities. Even though the focus was a specific department, success factors included using the approach in an integrated manner across departments and having a large proportion of clinicians in the improvement teams. This approach was found to produce facility designs that were custom-fit to patient needs and professional work processes. There was also a reduction in operational costs.[241]

In Israel, a continuous quality improvement process based on Lean principles aimed to address delays in thrombolytic therapy for people arriving at a high-volume A&E with heart attacks. The improvement team followed a seven-step protocol: problem definition; present-state screening; factors analysis; solution development; outcome evaluation; standardisation; conclusions. Average 'door to needle time' reduced from 62 minutes to 48 minutes.[242]

Overall, the evidence suggests that quality improvement approaches that address variation such as Lean / Six Sigma, may help tackle patient flow issues across organisations or pathways of care. However, reviews suggest that the true impact of these approaches is difficult to judge and that there is a lack of rigorous evaluation or sustained improvements. This applies to both unscheduled care and wider care pathways.[243–246]

Real-time management

Examples of use

Real-time management of demand and capacity involves proactively collecting and using data regularly to support decisions about care and transitions.[247]

Some healthcare services have implemented IT systems to speed up access to information about patients or manage beds to improve patient flow.[248–250] For example, a hospital in Scotland found that patient flow from acute admission units into hospital beds was not always efficient during peak periods. Real-time management tools such as wireless local area networks and handheld devices were used to support patient management and avoid unnecessary treatment delays in overcrowded admission areas.[251]

Many other studies are available about novel technologies[252] but examples were only included in the scan if they explicitly aimed to improve patient flow.

Impact on processes

In Australia, one health service district tested the value of using whiteboards as a tool to improve patient flow. Whiteboards were placed in three hospital inpatient wards and in a day clinic to help record real-time flow data. Data collected via observation, interviews and photographs over an 11-month period found that the content and levels of use by various professional groups varied. Whiteboards were most well integrated into the day clinic and became a key part of multidisciplinary rounds, being updated several times daily. Staff in the clinic and on the wards generally perceived the whiteboards to have supported more timely referrals, improved patient flow and enabled better discharge planning, but some nursing staff described them as being an imposition and a cause of conflict among team members.[253]

A community hospital in the US used a traffic light system to provide real-time data about patient flow on wards. The tool was used to assess current capacity and provide a graded, colour-coded 'workload tolerance' for each hospital unit (such as red meaning 'closed to new admissions'). Each unit could instantly update its own status and look at the status of other work environments in the hospital. Over a six-month period there was an increase in efficiency and staff satisfaction.[254]

A US hospital tested capacity management approaches for improving patient flow. A four-step approach to 'real-time demand capacity management' was used: predicting capacity, predicting demand, developing a plan, and evaluating the plan. Standard structures for unit bed huddles and the hospital bed meetings were developed. The approach used was tested in various hospital departments as well as unscheduled care. Improvements in median length of stay and the proportion of people who left A&E without being seen were achieved and sustained over several years.[255]

Impact on patient satisfaction

There is little information about the impact on patient satisfaction of flow-orientated IT systems or similar tools. An exception is where a US hospital installed an automated patient-flow management system throughout, from A&E to admissions and the inpatient area. The system helped the hospital better use capacity, decreased diversion rates, increased efficiency and productivity and improved nurse, doctor and patient satisfaction.[256]

Possible applicability for unscheduled care

Unscheduled care services have also implemented IT systems or real-time data management systems to improve patient flow, though this tends to be within individual departments.[257–262]

A number of redesign programmes have been implemented in unscheduled care services based on diagnostic data, staff feedback or the need to respond to surges in demand.[263–269] For instance, a systematic review identified 33 articles about the causes of A&E crowding, 27 studies about effects and 40 studies about potential solutions such as adding extra staff, observation units, increasing access to inpatient beds, non-urgent referrals, ambulance diversion, destination control, crowding measures and queuing theory.[270]

Matching demand and capacity

Examples of use

The three main ways to match demand and capacity in order to improve patient flow explored in the empirical literature are:

- scheduling and prioritisation (such as comparing first-in, first-out with advanced scheduling approaches)[271–273]
- structural changes such as physical layout[274–276]
- workforce planning and changes.[277–279]

Mechanisms to match the demand for services versus the capacity to provide them may be as simple as using appropriate patient scheduling systems for appointments and procedures. For instance, in Egypt, a new scheduling system was set up for procedures associated with the most severe bottlenecks in patient flow at one hospital. The intervention was associated with significant reductions in waiting time and patient crowdedness, with little financial investment.[280]

During a military conflict in Israel, the government issued a directive to change patient flow to hospitals in a metropolitan area. Admissions were monitored to determine if any changes occurred after the policy change. The directive did help to change patient flow patterns, suggesting that it is possible to take a top-down approach to rationalise the use of resources on a geographic scale in the short-term.[281]

Another example of an approach used to match demand and capacity comes from Italy, where three hospitals redesigned their physical layout, the capacity planning system and the organisation of wards in order to address flow issues. Here a focus on the physical environment was as important as technological and staffing solutions.[282]

Other ways to match demand and capacity have often focused on changes to the healthcare workforce. According to the empirical literature, three main types of workforce changes have been used to enhance patient flow across organisations or pathways:

1. adding additional capacity or teams or asking people to work in different ways[283,284]
2. testing different skill mix[285]
3. setting up new liaison or patient flow co-ordination roles.[286]

A US hospital undertook a social network analysis to suggest that efficiency gains could be achieved by redesigning social network patterns alongside organisational changes and using an integrated information technology system to model workflow. Knowledge experts and coordinators to draw on in times of crisis were identified and a new communication structure was developed that was more conducive to trust and knowledge sharing.[287]

Regardless of the exact intervention put in place, initiatives to match demand and capacity (or reduce 'queues') tend to include compiling information about how to improve accessibility, finding ways to monitor varying demand and capacity and improving patient processing by reducing variations.[288] In other words, there are overlaps with methods outlined in many of the other subsections of this evidence scan.

Possible applicability for unscheduled care

Workforce-orientated initiatives have potential for unscheduled care, though they have largely been tested previously at a departmental level.[289–292] However, there are some examples of drawing in a wider range of staff to work in particular unscheduled care departments.[293,294] A US hospital decided to locate a hospital inpatient doctor and an allied health professional in A&E during the day in order to facilitate patient flow and care for people waiting in beds in corridors. Using inpatient staff in this way reduced diversion by 27% and increased A&E discharges by 61%. A&E doctors said that having immediate access to an admitting team streamlined the admitting process and ensured that patients are sent to the most appropriate wards for care. The approach required commitment from inpatient staff, a willingness among A&E staff to have this type of team in the department and a productive rather than confrontational relationship between A&E doctors and inpatient staff.[295,296]

A US hospital created a new position, an A&E 'flow facilitator' nurse, who assigned patients to the east and west zones of the department and who handled all ambulance calls. The role required highly competent nurses who were able to multi-task and handle high levels of stress. Before and after analysis found that despite increasing patient volumes, there was a

reduction in the proportion of people who left without being seen and a decrease in length of stay and door-to-bed times.[297]

Another example involved modifying a paramedic position to act as an 'A&E expeditor' between 1pm and 1am daily. Six months of data from before the intervention were compared with six months of data afterwards. Regardless of increased numbers of patient visits, length of stay decreased by 25 minutes, as did rates of ambulance diversion.[298]

Two hospitals in the US tested using inpatient nurses in a novel way. When admitting people from A&E, inpatient nurses would come down from wards to meet the A&E team and family members. Following verbal handover, the nurse would accompany the patient to their designated ward. Before and after comparisons found improved patient satisfaction ratings.[299]

A systematic review searched ten bibliographic databases and included three studies about the effects of introducing GPs to provide care to patients with non-urgent problems in A&E. Two of the included studies found that GPs used significantly less healthcare resources, including fewer blood tests, x-rays, admissions to hospital and referrals to specialists. There were marginal cost savings. The third study found no significant differences. No data were reported on patient wait-times, length of hospital stay, or patient outcomes such adverse effects or mortality.[300]

An example of adding capacity comes from a hospital in Singapore that used capacity demand analysis to set up new rostering systems for unscheduled care. A demand-based rostering tool matched doctor-unit-hours to patient arrivals and severity.[301]

In addition to interventions focused on matching demand and capacity through workforce changes, some studies have examined other options. For instance, a systematic review of ten studies into ways to reduce ambulance diversion without worsening A&E department crowding found that diversion only minimally improved A&E waiting room times. Adding holding units for those placed on beds in corridors, A&E-based fast tracks, improving laboratory turnaround times and smoothing elective surgery caseloads were all found to reduce diversion. Some studies suggested that it was important to have a cooperative agreement between hospitals to prevent defensive diversion behaviour by a hospital when a nearby hospital goes on diversion but regional bans on diversion were not recommended.

This is an example of how multiple interventions at different levels of the system may be important for addressing patient flow issues.[302]

The other main area of applicability for unscheduled care is in terms of scheduling and prioritising patients. A large number of studies have examined the potential of different approaches to prioritisation within unscheduled care services, though this tends to be done at the level of individual departments rather than taking into account organisational or pathway factors.[303–316]

Triaging is a way of determining the priority order in which patients will be seen and treated. The aim is either to see the most serious and urgent conditions first, since resources tend to be insufficient for everyone to be treated immediately, or to 'fast track' non-urgent cases to less senior staff, thus freeing up resources for use on more severe patients. A number of studies have explored the impact of triaging on patient flow.[317]

For instance, a systematic review of 25 studies assessed the extent to which triage processes in unscheduled care impact on patient flow. There was moderate evidence from a range of health services that combining triage and initial treatment in less resource-intensive cases can have a positive effect on patient flow. Triage systems that only prioritise patients without providing any treatment may not improve overall patient flow, although tailoring triage criteria more specifically to the patient population or using triage to prioritise treatable cases may be useful.[318]

Another systematic review of 33 studies of A&E triage included streaming, fast track, team triage, point-of-care testing (performing laboratory analysis in A&E) and nurse-requested x-ray. There was good evidence that fast track systems improved waiting time, length of stay, and rates of people leaving without being seen. Team triage was also found to have an impact on rates of people who left without being seen, but the evidence about all other interventions was limited or insufficient. The reviewers concluded that fast tracking patients with less severe symptoms results in shorter waiting time, shorter length of stay and fewer patients leaving without being seen.[319]

Sometimes special units are set up to provide urgent care, or to take the pressure off emergency services. A hospital in the UK expanded its acute medical unit from 29 to 81 beds. Patients with expected length of stay of less than five days were managed by the acute medical team only. Doctors provided twice-daily ward rounds, supported by specialist teams, allied healthcare professionals and investigation facilities. Within three weeks, the admission process for urgent cases had become more efficient, average length of stay had decreased by 1.3 days and bed-occupancy was reduced from 98% to 91%. Readmission rates, mortality rates and numbers of complaints were not affected.[320]

Planning discharge

Examples of use

Proactive discharge planning involves thinking about how to move people on from services safely and appropriately as early as possible in the care pathway. This involves work to prioritise discharge planning within organisations, but also improving the communication and co-ordination between services such as hospital and community care.[321,322] It may also involve assigning staff especially to concentrate on discharge processes or having nurses rather than doctors undertake the majority of discharge work.[323] Special 'discharge rounds,' rapid discharge units or other proactive approaches may also be used.[324,325]

In England the Community Care (Delayed Discharge) Act (2003) and subsequent policy initiatives have aimed to address delayed discharges, such as through investment in intermediate care services to promote independence among older people after hospital admission and joint working between health and social services.[326]

Studies have also explored the factors that may impede proactive discharge planning, such as insufficient staff capacity and communication as well as family/caregiver barriers and organisational-level issues such as not assigning an estimated discharge date from the outset or delayed diagnostic or allied health services.[327–343]

For instance, researchers from England examined the determinants and outcomes of delayed transfer of older adults from hospital into the community. Over a month-long period, 37% of elderly patients on two wards had a delay in the transfer of their care. Most were awaiting social services physical therapist assessments or home care, rather than NHS care. Some patients developed additional medical issues during the delay which made them unfit for discharge and led to an average of five further days in hospital per person.[344]

Impact on processes

A number of studies and reviews have found that when discharges are proactively planned, often alongside other educational or improvement initiatives, they can safely reduce length of stay.[345,346]

For example, one hospital in Australia implemented a range of communication strategies to support safer and more integrated discharge planning practices for older people living in rural and remote settings. There was an increase in the proportion of patients with a documented discharge plan, who received timely risk screening and who were referred to community health services. Improved communication processes between hospital and community staff were reported.[347]

A number of studies have examined tools to improve the quality of discharge and transition processes. For instance, a hospital in the US tested a computerised tool for providing patients with concise, easy-to-read discharge instructions and referral agencies with consistent information and directions for patient care. The information was automatically extracted from patient hospital records. The tool was found to strengthen the multidisciplinary discharge care planning process, speed transitions out of hospital by reducing the nursing time needed to prepare discharge plans and increase patient satisfaction.[348]

However the findings about discharge planning and tools to support it are mixed. A systematic review of 11 trials exploring the effectiveness of planning hospital discharge found that the impact on readmission rates, hospital length of stay, health outcomes and cost is uncertain and potentially not significant.[349] Another review of 48 studies reported similar findings, though noted improved patient satisfaction.[350]

In England, one hospital undertook a patient pathway mapping audit of admissions for a specific surgery and implemented changes as a result. There were substantial reductions in the length of stay. Early discharge planning involving staff and patients as active participants had the greatest impact on reducing length of stay, however the researchers concluded that earlier discharges may also lead to increased readmissions if appropriate follow-on support is not available.[351]

Elsewhere in England, a study to improve interprofessional collaboration in discharge planning explored the use of an integrated care pathway to help move people with a specific condition throughout one hospital. Interviews, notes audit and analysis of variances from the integrated care pathway found that although integrated care pathways led to improved process outcomes for the hospital, interprofessional relationships and communication did not appear to be enhanced. The key factors in discharge delays appeared to be organisational rather than professional.[352]

Another study from England assessed the effectiveness of a discharge coordinator, whose sole responsibility was to plan and coordinate the discharge of patients from medical wards. There was an improved discharge planning process and a reduction in problems reportedly experienced by patients after discharge and in people's perceived need for healthcare services. However, there was no evidence that the discharge coordinator resulted in a more timely or effective provision of community services or that the appropriateness or efficiency of bed use was improved. The study concluded that a discharge coordinator improved the quality of discharge planning, but at additional cost.[353]

Impact on cost

A review found that few studies have explored health outcomes or cost savings from proactive discharge planning on a large scale or over the longer term.[354]

Impact on safety

There is limited information about the impact of discharge planning or prompter discharge on safety, though some studies suggest more adverse events or readmissions if robust support mechanisms are not in place.[355]

However there is research to suggest that interventions that proactively speed discharge do not need to be associated with negative clinical outcomes. A hospital in Scotland set up a fast track rehabilitation programme for people undergoing hip or knee replacement, with the aim of speeding discharge. Around eight out of ten patients were able to be discharged within three to five days of surgery using this approach, which also included discharge planning and linkages with social and community support. There were no adverse safety effects.[356]

Impact on patient satisfaction

Although the impact of proactive discharge planning on flow outcomes, safety and cost is debated, more studies agree that improved individualised and early discharge planning can improve patient satisfaction.[357,358]

Possible applicability for unscheduled care

Hospital discharges may occur late in the day, with some studies suggesting clusters after 4pm. A US study explored using a protocol to encourage discharge earlier in the day. This could potentially affect patient flow because when patients leave earlier in the day, new admissions awaiting beds may be able to leave A&E more quickly, thus reducing waiting room backlog.[359]

Pulling through systems

A limited amount of research has examined approaches that aim to proactively move people through the system, whereby the next service in the chain is actively 'pulling' people towards them rather than waiting for them to be 'pushed' on from the previous department. This terminology is used by the US Institute for Healthcare Improvement.[360,361]

The main focus in 'pull' initiatives spanning different departments within an organisation tends be improving co-ordination and communication between teams.[362] This has sometimes been done by implementing clinical pathways that provide guidelines about components of care and encourage services to be more proactive about taking on specific roles.[363]

A clinical pathway defines the optimal care process, sequencing and timing of interventions by healthcare professionals, departments or services for a particular diagnosis or procedure. This type of process improvement tool has been gaining popularity. The pathways tend to be developed via collaboration between doctors, case managers, nurses, and allied healthcare professionals with the aim of improving the quality of patient care, minimising cost, reducing unnecessary variation reducing delays in discharge and ensuring that all facets of the system know their role and when to proactively begin it.[364]

Impact on processes

A number of studies about clinical pathways have suggested favourable impacts on throughput and length of stay,[365,366] although findings are not always positive.[367,368]

A systematic review of randomised trials about integrated care pathways found that, for relatively predictable trajectories of care, pathways can support proactive management, speed up access to care, improve guideline adherence and improve communication between teams and with patients. Pathways may be particularly effective for changing professional behaviours where there is much scope for improvement or where roles are new. However, pathways may be less effective at improving quality where patient trajectories are highly variable, where services are already based on best evidence or where multidisciplinary working is well established. There was insufficient evidence about the cost-benefits of integrated care pathways.[369]

In the US, a large study explored whether using a clinical pathway that included 'pull factors' would reduce hospital costs and length of stay among children with asthma. The pathway provided guidelines for things such as: frequency of patient assessment; medication use; monitoring and measurement; social work interventions; discharge planning. The pathway resulted in a decreased length of stay and overall cost, without an increased rate of readmission.[370]

Another US study explored whether using a clinical pathway focusing on pre-operative discharge planning and pre-emptive pain and nausea management lead to reduced length of stay, better pain management and more rapid functional gains without an increase in complications for people undergoing specific surgery. Physical therapy began the day of surgery. The pathway was associated with a reduced length of stay, which may in turn increase patient throughput and increase hospital capacity.[371]

A more novel approach comes from a US hospital that used 'parallel processing' to increase efficiency in ambulatory surgery. Rather than patients moving through surgical care in a linear fashion, starting at registration and finishing in the recovery room, patients received their local anaesthesia in an induction room while the operating theatre was being cleaned and set up. Compared to the usual pathway, this parallel approach resulted in shorter turnover time and induction time which ultimately allowed more operations per day. The researchers concluded that it was possible to increase efficiency by changing patient flow rather than simply streamlining existing steps.[372] Similar approaches have been found to be cost-effective.[373]

In England, researchers explored whether GPs referring people with suspected cancer straight for a test reduced time to diagnosis and treatment compared with being referred first to an outpatient hospital appointment. The median time to first diagnostic test was half the time using the 'straight to test' pathway compared to those seen in the outpatient clinic. Median time to first treatment was also significantly less.[374]

Impact on safety

In Malawi, a clinic for young children that provided outpatient services, immunisations and treatment for medical emergencies trained staff in emergency care and triage and sought to develop close cooperation between inpatient and outpatient services. There was also a restructuring of the physical layout of the department. These improvements streamlined the delivery of care and led to a reduction in inpatient mortality from 18% to 6%.[375]

Impact on cost

Studies of clinical pathways have suggested that these can have knock-on effects on cost, by reducing overall length of stay.[376–378] However these studies do not always make it explicit whether 'pull' was built in to the approach used.

In the US, a hospital developed a care pathway to support people undergoing an operation to prevent stroke. The pathway addressed different parts of the system and aimed to provide more proactive care and transitions between each link in the chain. Interventions included: a computerised order tool; standardised discharge instructions; a patient teaching brochure; a patient flow algorithm that helped to select patients to bypass some areas of care. This resulted in significant cost savings and increased the availability of beds for higher acuity patients without negatively affecting patient outcomes.[379]

Another example of a potential 'pull' approach is offering hospital at home services, whereby patients are treated in their homes rather than in hospital beds. This can be as a form of supported early discharge or to avoid admission altogether. A US case study found that this approach can have significant cost savings.[380]

Possible applicability for unscheduled care

Initiatives which seek to formalise care pathways and pull people through the wider system of care have also been found to be effective in unscheduled care.[381,382]

The most effective redesign processes may involve wider organisational planning. For instance, structural and staff reorganisation of an A&E in Spain took an organisational-wide approach, acknowledging that the efficiency of A&E was closely linked to inpatient and discharge-related factors. After the reorganisation, the proportion of patients remaining in A&E due to hospital-related or non-A&E and non-hospital-related factors decreased. The reorganisation was associated with a reduction in the average number of patients waiting to be seen and a decrease in waiting time from 87 to 24 minutes. The researchers emphasised that A&E effectiveness and overcrowding are influenced by both internal and external pressures. Measuring patient flow across A&E and the wider organisation helped to detect these factors and plan change.[383]

Another success factor may be wide staff engagement. A multidisciplinary team of nurses, doctors, clerical staff, a social worker and paramedic worked together to redesign trauma services at one Australian hospital. Staff collaboration, the involvement of wider stakeholders and buy-in and sponsorship from the hospital executive team were found to be crucial for improving patient flow.[384]

4. Summary of key findings

This section outlines some of the implications for improving patient flow across organisations or pathways of care.

Approaches used

Many methods have been tested to analyse and improve patient flow across organisations or pathways of care. Some of the more well-known or most researched approaches include techniques for analysing flow, such as:

- analysing basic routinely collected data about service usage
- capacity and workflow planning
- simulation and other models
- queuing theory
- failure mode and effects analysis
- systematic feedback from staff
- observation and ethnography.

As well as analysing flow, a range of methods move on to make tangible changes to services via:

- reducing variation, including using structured approaches such as Lean thinking
- management based on real-time data
- matching demand and capacity, including workforce changes such including extra capacity and liaison roles
- proactively planning discharge
- 'pulling' people through the system rather than relying on previous departments or services to pass people onwards.

Impacts

Impact on processes and flow

There is evidence that methods to analyse or alter patient flow can improve throughput and continuity and reduce waiting time and length of stay. The size of the impact depends on the methodology used, but few studies have explicitly compared whether one method is more effective than others. The methods used to analyse or alter patient flow are heterogeneous so it is not possible to say that all flow-related methods result in similar outcomes. The outcomes will likely depend on the approach used.

Impact on other outcomes

The impact on patient satisfaction, safety and cost is less clear because few studies have investigated these outcomes at an organisation-wide or whole system level. Some studies suggest that methods to address patient flow reduce length of stay, which would in turn have cost implications, but there are few cost analyses which specifically look at the financial implications of using these methods.[385,386] A key finding is that there is a paucity of evidence about the benefits of strategies to address patient flow on satisfaction, safety and cost.

Things to bear in mind

When interpreting the findings of this evidence scan it is important to bear in mind several caveats.

Firstly, the scan is not exhaustive. More than five thousand studies have been published about methods to analyse or alter patient flow across pathways, organisations or healthcare systems. The scan presents examples of readily available published empirical studies in order to give a flavour of available research, to signpost readers to interesting material and to highlight some of the key implications for practice and applicability to unscheduled care.

There are many descriptions of flow-related methodologies but such descriptions were not eligible for inclusion in the evidence scan unless they were based on published empirical research. This means that there may be many types of flow-related methods being used that are not included here because there is little research published about them.

Similarly the change techniques used were only included if they explicitly sought to analyse or alter patient flow across pathways or organisations (apart from the narrower unscheduled care examples).

Another important point is that there are relatively few studies providing detail about the exact approaches used or step-by-step guides to allow replication of patient flow approaches. There are even fewer studies detailing the impacts of methods to analyse or improve flow on outcomes such as patient satisfaction, cost or safety. This does not mean that these outcomes are not important or are not affected by flow-related methods, just that little has been published about these topics.

As well as issues with the quantity of evidence available, there are also some caveats about the quality of studies. Many of the studies included in the evidence scan were small and conducted in single hospitals, often outside the UK. They also tended to use simple before and after designs, without controlling for other potential influences on the outcomes. Furthermore, there were few studies comparing different methods for analysing or changing flow, so it is not possible to conclude that a specific approach is more or less effective than another.

Learning points

Bearing in mind the above, the published empirical research suggests five key learning points for healthcare teams wishing to implement methods to analyse or improve flow across organisations or pathways, or to apply these approaches at a broad level to unscheduled care.

1. Focusing on patient flow has the potential to improve outcomes when a whole-systems approach or organisational-wide focus is taken

The evidence suggests that methods to analyse or improve flow have some merit and could be explored further in healthcare.

In order to really address patient flow issues, it may be necessary to look at processes across an entire hospital or indeed a wider system of services comprising primary care, ambulance, hospital, social and community care.[387–392]

In terms of applicability to unscheduled care, this means that improving patient flow may require revisions to the wider process of care to ensure prompt diagnosis and delivery to emergency services and prompt discharge or follow-on services.[393,394]

> *'Successful strategies to improve patient flow are distinguished by an organisation-wide commitment to measurement, transparency in data reporting, and sustained management attention. Focusing on transitions between [emergency] and inpatient units and maximising overall hospital capacity appears necessary for improvement. Hence, reductions in [unscheduled care] crowding require strategies that go far beyond [unscheduled care].'*[395]

With regards to access, unscheduled care services may be highly fragmented. People may be confused about how and where to access care. New forms of urgent care such as walk-in and urgent care centres have not significantly reduced A&E attendances in the UK.[396] Many patients may attend hospital towards the end of the day after they have had an opportunity to visit a GP or receive a GP home visit, so the process for GP visits to urgent cases may need rethinking.[397] Handover time from ambulances has also been found to be a key factor.[398,399]

In terms of discharge or follow-on care, there may be a lack of swift access to inpatient beds due to problems in outflow from the admissions units to longer-stay wards and from longer-stay wards to community discharge.[400] Poor sharing of information as patients move between different providers can lead to significant failures of care.[401] Thus, in order to really address patient flow in unscheduled care (and in other services), it may be essential to address bottlenecks across the whole continuum of care.

Strategies may include: signposting to help patients choose the right service; adjusting service levels in response to changes in demand; supporting hospitals, primary care and local authority social service and housing departments to work in partnership to reduce delayed discharges and shorten lengths of stay; redesigning structures and processes to support patient flow. Mapping and analysing patient flow around the system to identify bottlenecks and the potential for change is thus just one of a number of initiatives that could be implemented simultaneously.[402]

2. It is essential to undertake detailed diagnostic work when considering patient flow. Real-time demand and capacity management may be key.

Detailed 'diagnostic' work will help teams to understand patient flow before moving straight into redesigning services.[403,404]

Research has found that it is useful for services to have data to compare to and benchmark against and that analysing patient flow at both a service level and on an organisation-wide basis can provide useful insights.[405,406] Using resources that display data visually, such as statistical process control charts, fishbone cause and effect diagrams or pathway diagrams may help to get wider groups of staff engaged.[407–410]

Some of the issues that diagnostic work may seek to explore include: the measures that may best be used to understand and improve the efficiency and quality of interventions; how workforce factors may affect efficiency; how service design, patient flow structures and technology interact and impact on efficiency; which factors outside the organisation or service's control affect flow.[411,412]

Undertaking an appropriate needs assessment and analysis of potential bottlenecks then trying short tests of new approaches has been found to work well,[413] but there is no evidence to suggest that one method of analysing flow is any more effective than another. Instead, it appears useful for organisations to select easy to use approaches that fit with data availability and involve multiple stakeholders in exploring the findings and planning next steps. In other words, it is not the exact method used that appears important, but rather the process of examining flow and bottlenecks and engaging the wider team in generating solutions.

3. A number of methodologies can be used to analyse and improve flow, but localised adaptation is key

The evidence illustrates that there is no 'one size fits all' approach for addressing patient flow. Various strategies may work best in different contexts and it is important for organisations to tailor evidence-based strategies to redesign flow to suit their individual services.[414,415]

There is research to show that it is possible to transfer techniques used in other industries, such as Lean, queuing theory and capacity analysis, to a healthcare context, but it is essential to recognise contextual factors and adapt the methods appropriately[416–421]

Much work has been undertaken to apply flow-related methods successfully to individual departments, and it may now be time to explore how the wide range of methodologies available can be used more robustly across broader pathways or organisations.

Although for simplicity the evidence scan is divided into sections on 'analysing flow' and 'changing flow', each describing a range of discrete approaches, in practice many of these methods may be used together as part of a broad improvement programme.[422]

4. Time and resources are needed to address patient flow issues in a sustainable manner

It can take time for new processes and systems to embed.[423] Whilst changes to patient flow can result in reasonably prompt impacts, adequate time should be allowed to facilitate change.[424]

Research emphasises that organisational realignment and changes to flow require time and analysis of financial, clinical and demographic data. It can take time to build a collaborative model across multidisciplinary staff and between managers and clinicians.[425–427]

Key practical elements for success may include strong leadership by senior executives, clinical leadership, team-based problem solving, a focus on the patient journey, access to data, ambitious targets, strong performance management and having a process for ongoing improvement.[428–434] Having strategies for rollout and sustainability from the outset appears important.[435]

Another practical issue is that it can be time-consuming and complicated to extract patient flow data from routine (hospital) databases and to apply modelling tools. Spreadsheets and other simple tools may provide a starting point for analysis. It may also be useful to ensure that dedicated time is secured from technical staff.

5. Healthcare teams are a crucial resource so ensuring appropriate engagement and training may be a key success factor

Extensive staff engagement and training is included in the most successful flow redesign initiatives.[436–439] If people are being asked to change the way they work, it is important that they understand why and what the benefits will be for themselves and patients.[440] This could take the form of engaging clinicians in planning redesign elements as well as training and follow-up refresher sessions about new approaches.[441]

Numerous studies suggest that staff collaboration, the involvement of wider stakeholders and buy-in and sponsorship from the hospital executive team are crucial to improving patient flow strategies across pathways and organisations, specifically within unscheduled care services.[442–447] Some studies suggest that gaining commitment from each member of the interdisciplinary team is essential for successful outcomes.[448, 449]

Research also supports participating in cross-organisational learning networks and strategic selection of improvement team members.[450] Common challenges to initiatives for improving patient flow include staff resistance and entrenched organisational culture.[451] These can be mitigated to some extent by staff education and constant reinforcement by clinical and managerial leaders.[452]

Conclusion

To conclude, the empirical evidence suggests that methods to analyse and change patient flow have potential in healthcare both on an organisational or pathway-wide basis and also with specific applicability to unscheduled care. These approaches are heterogeneous, but have been applied in a number of countries with positive outcomes, particularly regarding improving throughput and reducing waiting time or length of stay.

Improving patient flow may seem like a relatively straightforward thing to do, but often services or departments work in isolation. Few organisations and health systems have funding that truly follows the patient through whatever journey is safest and most efficient for them, though this may be what is needed to really impact upon flow. More radical reorganisation of services and funding may be needed so that the patient pathway is the key focus, rather than specific services or departments. However evidence to date has focused on relatively small scale or narrow interventions that tend not to cut across services or sectors.

Research suggests that the five key principles of

1. whole-systems development
2. diagnostic needs assessment and real-time data
3. adapting the range of methods to local contexts
4. accounting for practicalities
5. staff engagement may be central to the success of implementing any patient flow methodology.

These factors are perhaps no different to the critical success strategies needed to support other types of quality improvement. Thus lessons about implementing and sustaining change more broadly may be equally applicable to organisations considering implementing methods to analyse or improve patient flow. Focusing on these core principles is likely to support improvement better than emulating specific process changes made at other institutions, but there is great potential in exploring ways to analyse and improve patient flow further.[453]

References

1 Blunt I, Bardsley M, Dixon J. *Trends in Emergency Admissions (2004-2009).* London: Nuffield Trust, 2010.

2 Collis J. Adverse effects of overcrowding on patient experience and care. *Emergency Nurse* 2010; 18(8):34-39.

3 Richardson DB. Increase in patient mortality at 10 days associated with emergency department overcrowding. *Med J Aust* 2006; 184:213-216.

4 Liew D, Liew D, Kennedy MP. Emergency department length of stay independently predicts excess inpatient length of stay. *Med J Aust* 2003; 179(10): 524-526.

5 Mason S, Locker T, Carter A, Walters S, Stride C, Casson J. *What are the organisational factors that influence waiting times in Emergency Departments.* Report for the National Co-ordinating Centre for NHS Service Delivery and Organisation R & D, 2006.

6 www.health.org.uk/publications/ improving-patient-flow/

7 Silvester K, Mohammed MA, Harriman P, Girolami A, Downes TW. Timely care for frail older people referred to hospital improves efficiency and reduces mortality without the need for extra resources. *Age Ageing* (published online November 2013).

8 NHS Alliance. *A practical way forward for clinical commissioners.* NHS Alliance on behalf of NHS Clinical Commissioners and sponsored by NHSCB, 2012.

9 www.nao.org.uk/report/emergency-admissions-hospitals-managing-demand/

10 NHS England. *High quality care for all, now and for future generations: Transforming urgent and emergency care services in England The Evidence Base from the Urgent and Emergency Care Review.* NHS England, 2013. www.england.nhs.uk/wp-content/uploads/2013/06/urg-emerg-care-ev-bse.pdf

11 Health and Social Care Information Centre. *Ambulance Services - England, 2011-12.* Health and Social Care Information Centre, 2012.

12 NHS Direct. *Business Plan 2011/12 to 2015/16: Our Update for 2012/13.* NHS Direct, 2013.

13 Department of Health. *National MDS NHS 111 Statistics.* London: Department of Health, 2013.

14 Fernandes A. Guidance for commissioning integrated urgent and emergency care: A 'whole system' approach. London: Royal College of General Practitioners, 2011.

15 Health and Social Care Information Centre. *Ambulance Services - England, 2011-12.* Health and Social Care Information Centre, 2012.

16 NHS England. *A&E quarterly activity statistics, NHS and independent sector organisations in England 2012-13.* NHS England, 2013.

17 NHS England. *A&E quarterly activity statistics, NHS and independent sector organisations in England 2012-13.* NHS England, 2013.

18 www.nhsimas.nhs.uk/what-we-can-offer/intensive-support-team/how-to-stabilise-emergency-care-in-england/

19 The Evidence Centre. *Improving patient flow in urgent care.* London: The Health Foundation, 2013 (unpublished).

20 Costa AP, Poss JW, Peirce T, Hirdes JP. Acute care inpatients with long-term delayed-discharge: evidence from a Canadian health region. *BMC Health Serv Res* 2012;12:172.

21 Potisek NM, Malone RM, Shilliday BB, Ives TJ, Chelminski PR, DeWalt DA, Pignone MP. Use of patient flow analysis to improve patient visit efficiency by decreasing wait time in a primary care-based disease management programs for anticoagulation and chronic pain: a quality improvement study. BMC Health Serv Res. 2007 Jan 15;7:8.

22 Shinjo D, Aramaki T. Geographic distribution of healthcare resources, healthcare service provision, and patient flow in Japan: a cross sectional study. *Soc Sci Med* 2012;75(11):1954-1963.

23 Harris M, Wood J. Resuscitate ED metrics with split-flow design. *Healthc Financ Manage* 2012;66(12):76-79.

24 Cowie B, Corcoran P. Postanesthesia care unit discharge delay for nonclinical reasons. *J Perianesth Nurs* 2012;27(6):393-398.

25 Gotlib D, Pullan S. A Web-based system for monitoring patient flow in an emergency department. *Psychiatr Serv* 2011; 62(11):1395.

26 Evans B, Potvin C, Johnson G, Henderson N, Yuen I, Smith T, Metham S, Taylor S, Sniekers D. Enhancing patient flow in an acute care hospital: successful strategies at the Juravinski Hospital. *Healthc Q* 2011; 14(3):66-74.

27 Ding R, McCarthy ML, Desmond JS, Lee JS, Aronsky D, Zeger SL. Characterizing waiting room time, treatment time, and boarding time in the emergency department using quantile regression. *Acad Emerg Med* 2010; 17(8):813-823.

28 Arkun A, Briggs WM, Patel S, Datillo PA, Bove J, Birkhahn RH. Emergency department crowding: factors influencing flow. *West J Emerg Med* 2010; 11(1):10-15.

29 Welch SJ, Jones SS, Allen T. Mapping the 24-hour emergency department cycle to improve patient flow. *Jt Comm J Qual Patient Saf* 2007; 33(5):247-255.

30 Asaro PV, Lewis LM, Boxerman SB. Emergency department overcrowding: analysis of the factors of renege rate. *Acad Emerg Med* 2007; 14(2):157-162.

31 Hu SC. Computerized monitoring of emergency department patient flow. *Am J Emerg Med* 1993; 11(1):8-11.

32 Lupfer PA, Altieri M, Sheridan MJ, Lilly CC. Patient flow in the emergency department: the chest pain patient. *Am J Emerg Med* 1991; 9(2):127-130.

33 Xu M, Wong TC, Wong SY, Chin KS, Tsui KL, Hsia RY. Delays in service for non-emergent patients due to arrival of emergent patients in the emergency department: a case study in Hong Kong. *J Emerg Med* 2013; 45(2):271-280.

34 Hsee L, Devaud M, Civil I. Key performance indicators in an acute surgical unit: have we made an impact? *World J Surg* 2012; 36(10):2335-2340.

35 Khanna S, Boyle J, Good N, Lind J. New emergency department quality measure: From access block to National Emergency Access Target compliance. *Emerg Med Australas* (Published online October 2013).

36 Edward GM, Razzaq S, de Roode A, Boer F, Hollmann MW, Dzoljic M, Lemaire LC. Patient flow in the preoperative assessment clinic. *Eur J Anaesthesiol* 2008;25(4):280-286.

37 Poulos CJ, Eagar K, Poulos RG. Managing the interface between acute care and rehabilitation - can utilisation review assist? *Aust Health Rev* 2007;31 Suppl 1:S129-40.

38 Poulos CJ, Eagar K. Determining appropriateness for rehabilitation or other subacute care: is there a role for utilisation review? *Aust New Zealand Health Policy* 2007;4:3.

39 Basson MD, Butler T. Evaluation of operating room suite efficiency in the Veterans Health Administration system by using data-envelopment analysis. *Am J Surg* 2006;192(5):649-656.

40 Khanna S, Boyle J, Good N, Lind J. Unravelling relationships: Hospital occupancy levels, discharge timing and emergency department access block. *Emerg Med Australas* 2012; 24(5):510-517.

41 Khanna S, Boyle J, Good N, Bugden S, Scott M. Hospital level analysis to improve patient flow. *Stud Health Technol Inform* 2013; 188:65-71.

42 Khanna S, Boyle J, Good N, Lind J, Zeitz K. Time based clustering for analyzing acute hospital patient flow. *Conf Proc IEEE Eng Med Biol Soc* 2012; 2012:5903-5906.

43 Jensen A, Boyle J, Khanna S. Visualising patient flow. *Stud Health Technol Inform* 2012;178:77-82.

44 Srivastava R, Stone BL, Patel R, Swenson M, Davies A, Maloney CG, Young PC, James BC. Delays in discharge in a tertiary care pediatric hospital. *J Hosp Med* 2009;4(8):481-485.

45 Peck JS, Benneyan JC, Nightingale DJ, Gaehde SA. Predicting emergency department inpatient admissions to improve same-day patient flow. *Acad Emerg Med* 2012; 19(9):E1045-1054.

46 Takase M, Carlin J. Modelling seasonal variations in presentations at a paediatric emergency department. *Hiroshima J Med Sci* 2012; 61(3):51-58.

47 Welch SJ, Jones SS, Allen T. Mapping the 24-hour emergency department cycle to improve patient flow. Jt Comm J Qual Patient Saf. 2007 May;33(5):247-55.

48 Bastiampillai T, Schrader G, Dhillon R, Strobel J, Bidargaddi N. Impact of a psychiatric unit's daily discharge rates on emergency department flow. *Australas Psychiatry* 2012;20(2):117-120.

49 Lucas R, Farley H, Twanmoh J, Urumov A, Olsen N, Evans B, Kabiri H. Emergency department patient flow: the influence of hospital census variables on emergency department length of stay. *Acad Emerg Med* 2009;16(7):597-602.

50 Arkun A, Briggs WM, Patel S, Datillo PA, Bove J, Birkhahn RH. Emergency department crowding: factors influencing flow. *West J Emerg Med* 2010;11(1):10-15.

51 Liu S, Hobgood C, Brice JH. Impact of critical bed status on emergency department patient flow and overcrowding. Acad Emerg Med. 2003 Apr;10(4):382-5.

52 Miró O, Sánchez M, Espinosa G, Coll-Vinent B, Bragulat E, Millá J. Analysis of patient flow in the emergency department and the effect of an extensive reorganisation. *Emerg Med J* 2003;20(2):143-148.

53 Mabe PR, Lengacher CA. Redesigning emergency care: financial and cost analysis of services provided. *Nurs Econ* 1998; 16(2):75-82.

54 Bullard MJ, Villa-Roel C, Bond K, Vester M, Holroyd BR, Rowe BH. Tracking emergency department overcrowding in a tertiary care academic institution. *Healthc Q* 2009; 12(3):99-106.

55 Leaver CA, Guttmann A, Zwarenstein M, Rowe BH, Anderson G, Stukel T, Golden B, Bell R, Morra D, Abrams H, Schull MJ. Development of a minimization instrument for allocation of a hospital-level performance improvement intervention to reduce waiting times in Ontario emergency departments. *Implement Sci* 2009; 4:32.

56 Bordoloi SK, Beach K. Improving operational efficiency in an inner-city emergency department. *Health Serv Manage Res* 2007; 20(2):105-112.

57 Irie M, Sakurai M, Kubota H, Minamie Y, Ashida N, Hasegawa T. Investigation and evaluation of the change in the outpatients flow before and after the move of the hospital. *Stud Health Technol Inform* 2001;84(Pt 2):1150-1154.

58 Doyle C, Jones M, Bell D. Monitoring patient flow in emergency departments: the use of scatterplots versus time-based measures to assess patient flow in A&E. *Eur J Emerg Med* (Published online September 2013).

59 Chazard E, Beuscart R. Graphical representation of the comprehensive patient flow through the hospital. *AMIA Annu Symp Proc* 2007:110-114.

60 Wang J, Li J, Howard PK. A system model of work flow in the patient room of hospital emergency department. *Health Care Manag Sci* (Publised online April 2013).

61 Ong ME, Ho KK, Tan TP, Koh SK, Almuthar Z, Overton J, Lim SH. Using demand analysis and system status management for predicting ED attendances and rostering. *Am J Emerg Med* 2009; 27(1):16-22.

62 Levin S, Aronsky D, Hemphill R, Han J, Slagle J, France DJ. Shifting toward balance: measuring the distribution of workload among emergency physician teams. *Ann Emerg Med* 2007; 50(4):419-423.

63 Siegel B, Wilson MJ, Sickler D. Enhancing work flow to reduce crowding. *Jt Comm J Qual Patient Saf* 2007;33(11 Suppl):57-67.

64 Benussi G, Matthews LH, Daris F, Crevatin E, Nedoclan G. Improving patient flow in ambulatory care through computerized evaluation techniques. *Rev Epidemiol Sante Publique* 1990;38(3):221-216.

65 Gabbay U, Bukchin M. Does daily nurse staffing match ward workload variability? Three hospitals' experiences. *Int J Health Care Qual Assur* 2009;22(6):625-641.

66 Higginson I, Whyatt J, Silvester K. Demand and capacity planning in the emergency department: how to do it. *Emerg Med J* 2011; 28(2):128-135.

67 Siegel B, Norton BL, Blanchard JC, Regenstein M, Jones KC. Creation and piloting of a new hospital capacity assessment tool in a major urban area. *Public Health* 2009; 123(11):714-722.

68 Abir M, Davis MM, Sankar P, Wong AC, Wang SC. Design of a model to predict surge capacity bottlenecks for burn mass casualties at a large academic medical center. *Prehosp Disaster Med* 2013; 28(1):23-32.

69 Wiler JL, Griffey RT, Olsen T. Review of modeling approaches for emergency department patient flow and crowding research. *Acad Emerg Med* 2011; 18(12):1371-1379.

70 Sobolev B, Harel D, Vasilakis C, Levy A. Using the Statecharts paradigm for simulation of patient flow in surgical care. *Health Care Manag Sci* 2008;11(1):79-86.

71 Hamrock E, Paige K, Parks J, Scheulen J, Levin S. Discrete event simulation for healthcare organizations: a tool for decision making. *J Healthc Manag* 2013; 58(2):110-124.

72 Ou L, Young L, Chen J, Santiano N, Baramy LS, Hillman K. Discharge delay in acute care: reasons and determinants of delay in general ward patients. *Aust Health Rev* 2009;33(3):513-521.

73 Harris M, Wood J. Resuscitate ED metrics with split-flow design. *Healthc Financ Manage* 2012;66(12):76-79.

74 Kumar S. Modeling patient flow operation of a US urban county hospital. *Technol Health Care* 2011; 19(4):247-260.

75 Kumar S. Modeling hospital surgical delivery process design using system simulation: optimizing patient flow and bed capacity as an illustration. *Technol Health Care* 2011; 19(1):1-20.

76 Levin S, Dittus R, Aronsky D, Weinger M, France D. Evaluating the effects of increasing surgical volume on emergency department patient access. *BMJ Qual Saf* 2011; 20(2):146-152.

77 Bair AE, Song WT, Chen YC, Morris BA. The impact of inpatient boarding on ED efficiency: a discrete-event simulation study. *J Med Syst* 2010; 34(5):919-929.

78 Hung GR, Kissoon N. Impact of an observation unit and an emergency department-admitted patient transfer mandate in decreasing overcrowding in a pediatric emergency department: a discrete event simulation exercise. *Pediatr Emerg Care* 2009; 25(3):160-163.

79 Holm LB, Lurås H, Dahl FA. Improving hospital bed utilisation through simulation and optimisation: with application to a 40% increase in patient volume in a Norwegian General Hospital. *Int J Med Inform* 2013;82(2):80-89.

80 Montgomery JB, Linville BA, Slonim AD. Desktop microsimulation: a tool to improve efficiency in the medical office practice. *J Healthc Qual* 2013;35(1):50-59.

81 Griffin J, Xia S, Peng S, Keskinocak P. Improving patient flow in an obstetric unit. *Health Care Manag Sci* 2012;15(1):1-14.

82 Sobolev BG, Sanchez V, Vasilakis C. Systematic review of the use of computer simulation modeling of patient flow in surgical care. *J Med Syst* 2011;35(1):1-16.

83 Ferreira RB, Coelli FC, Pereira WC, Almeida RM. Optimizing patient flow in a large hospital surgical centre by means of discrete-event computer simulation models. *J Eval Clin Pract* 2008;14(6):1031-1037.

84 Coelli FC, Ferreira RB, Almeida RM, Pereira WC. Computer simulation and discrete-event models in the analysis of a mammography clinic patient flow. *Comput Methods Programs Biomed* 2007;87(3):201-207.

85 Santos A, Gurling J, Dvorak MF, Noonan VK, Fehlings MG, Burns AS, Lewis R, Soril L, Fallah N, Street JT, Bélanger L, Townson A, Liang L, Atkins D. Modeling the patient journey from injury to community reintegration for persons with acute traumatic spinal cord injury in a Canadian centre. *PLoS One* 2013;8(8):e72552.

86 Duijvestijn JA, Grutters JP, Chenault MN, Joore MA, Manni JJ, Anteunis LJ. Shared care for hearing complaints: guideline effects on patient flow. *J Eval Clin Pract* 2011;17(2):209-214.

87 Reynolds J, Zeng Z, Li J, Chiang SY. Design and analysis of a health care clinic for homeless people using simulations. *Int J Health Care Qual Assur* 2010;23(6):607-620.

88 Kolker A. Process modeling of ICU patient flow: effect of daily load leveling of elective surgeries on ICU diversion. *J Med Syst* 2009;33(1):27-40.

89 Hansen AB, Hansen RN, Colding-Jørgensen M, Borch-Johnsen K, Lund-Andersen H. Model simulation of the patient flow through a screening centre for diabetic retinopathy. *Acta Ophthalmol Scand* 2005;83(6):678-686.

90 Zhu Z, Hen BH, Teow KL. Estimating ICU bed capacity using discrete event simulation. *Int J Health Care Qual Assur* 2012; 25(2):134-144.

91 Ryckman FC, Yelton PA, Anneken AM, Kiessling PE, Schoettker PJ, Kotagal UR. Redesigning intensive care unit flow using variability management to improve access and safety. *Jt Comm J Qual Patient Saf* 2009;35(11):535-543.

92 Simonetti A, Forshee RA, Anderson SA, Walderhaug M. A stock-and-flow simulation model of the US blood supply. *Transfusion* (Published online August 2013).

93 Klein MG, Reinhardt G. Emergency department patient flow simulations using spreadsheets. *Simul Healthc* 2012; 7(1):40-47.

94 Martin M, Champion R, Kinsman L, Masman K. Mapping patient flow in a regional Australian emergency department: a model driven approach. *Int Emerg Nurs* 2011; 19(2):75-85.

95 Storrow AB, Zhou C, Gaddis G, Han JH, Miller K, Klubert D, Laidig A, Aronsky D. Decreasing lab turnaround time improves emergency department throughput and decreases emergency medical services diversion: a simulation model. *Acad Emerg Med* 2008; 15(11):1130-1135.

96 Levin SR, Dittus R, Aronsky D, Weinger MB, Han J, Boord J, France D. Optimizing cardiology capacity to reduce emergency department boarding: a systems engineering approach. *Am Heart J* 2008; 156(6):1202-1209.

97 Franc-Law JM, Bullard MJ, Della Corte F. Accuracy of computer simulation to predict patient flow during mass-casualty incidents. *Prehosp Disaster Med* 2008; 23(4):354-360.

98 Kolker A. Process modeling of emergency department patient flow: effect of patient length of stay on ED diversion. *J Med Syst* 2008; 32(5):389-401.

99 Hoot NR, LeBlanc LJ, Jones I, Levin SR, Zhou C, Gadd CS, Aronsky D. Forecasting emergency department crowding: a discrete event simulation. *Ann Emerg Med* 2008; 52(2):116-125.

100 Hung GR, Whitehouse SR, O'Neill C, Gray AP, Kissoon N. Computer modeling of patient flow in a pediatric emergency department using discrete event simulation. *Pediatr Emerg Care* 2007; 23(1):5-10.

101 Coats TJ, Michalis S. Mathematical modelling of patients flow through an accident and emergency department. *Emerg Med J* 2001; 18(3):190-192.

102 Pennathur PR, Cao D, Sui Z, Lin L, Bisantz AM, Fairbanks RJ, Guarrera TK, Brown JL, Perry SJ, Wears RL. Development of a simulation environment to study emergency department information technology. *Simul Healthc* 2010; 5(2):103-111.

103 Rotstein Z, Wilf-Miron R, Lavi B, Seidman DS, Shahaf P, Shahar A, Gabay U, Noy S. Management by constraints: considering patient volume when adding medical staff to the emergency department. *Isr Med Assoc J* 2002; 4(3):170-173.

104 Brenner S, Zeng Z, Liu Y, Wang J, Li J, Howard PK. Modeling and analysis of the emergency department at University of Kentucky Chandler Hospital using simulations. *J Emerg Nurs* 2010;36(4):303-310.

105 Levin S, Dittus R, Aronsky D, Weinger M, France D. Evaluating the effects of increasing surgical volume on emergency department patient access. *BMJ Qual Saf* 2011;20(2):146-152.

106 Baboolal K, Griffiths JD, Knight VA, Nelson AV, Voake C, Williams JE. How efficient can an emergency unit be? A perfect world model. *Emerg Med J* 2012; 29(12):972-977.

107 Crilly T, Plant M. Reforming emergency care: Primary Care Trust power in action research. *Health Serv Manage Res* 2007;20(1):37-47.

108 Powell ES, Khare RK, Venkatesh AK, Van Roo BD, Adams JG, Reinhardt G. The relationship between inpatient discharge timing and emergency department boarding. *J Emerg Med* 2012;42(2):186-196.

109 Rasheed F, Lee YH, Kim SH, Park IC. Development of emergency department load relief area - gauging benefits in empirical terms. *Simul Healthc* 2012; 7(6):343-352.

110 Friesen MR, Strome T, Mukhi S, McLoed R. Load Balancing at Emergency Departments using 'Crowdinforming'. *Online J Public Health Inform* 2011; 3(2).

111 Eitel DR, Rudkin SE, Malvehy MA, Killeen JP, Pines JM. Improving service quality by understanding emergency department flow: a White Paper and position statement prepared for the American Academy of Emergency Medicine. *J Emerg Med* 2010; 38(1):70-79.

112 Tucker JB, Barone JE, Cecere J, Blabey RG, Rha CK. Using queueing theory to determine operating room staffing needs. *J Trauma* 1999;46(1):71-79.

113 Laskowski M, McLeod RD, Friesen MR, Podaima BW, Alfa AS. Models of emergency departments for reducing patient waiting times. *PLoS One* 2009; 4(7):e6127.

114 de Bruin AM, van Rossum AC, Visser MC, Koole GM. Modeling the emergency cardiac in-patient flow: an application of queuing theory. *Health Care Manag Sci* 2007; 10(2):125-137.

115 de Bruin AM, Koole GM, Visser MC. Bottleneck analysis of emergency cardiac in-patient flow in a university setting: an application of queueing theory. *Clin Invest Med* 2005; 28(6):316-317.

116 Abujudeh H, Vuong B, Baker SR. Quality and operations of portable X-ray examination procedures in the emergency room: queuing theory at work. *Emerg Radiol* 2005; 11(5):262-266.

117 McManus ML, Long MC, Cooper A, Litvak E. Queuing theory accurately models the need for critical care resources. *Anesthesiology* 2004;100(5):1271-1276.

118 Tucker JB, Barone JE, Cecere J, Blabey RG, Rha CK. Using queueing theory to determine operating room staffing needs. *J Trauma* 1999;46(1):71-79.

119 Day TE, Li WM, Ingolfsson A, Ravi N. The use of queueing and simulative analyses to improve an overwhelmed pharmacy call center. *J Pharm Pract* 2010;23(5):492-495.

120 Chaussalet TJ, Xie H, Millard P. A closed queueing network approach to the analysis of patient flow in health care systems. *Methods Inf Med* 2006;45(5):492-497.

121 Allder S, Silvester K, Walley P. Understanding the current state of patient flow in a hospital. *Clin Med* 2010;10(5):441-444.

122 Madsen TL, Kofoed-Enevoldsen A. Five easy equations for patient flow through an emergency department. *Dan Med Bull* 2011; 58(10):A4318.

123 Jiang L, Giachetti RE. A queueing network model to analyze the impact of parallelization of care on patient cycle time. *Health Care Manag Sci* 2008; 11(3):248-261.

124 [No authors listed]. Use split-flow approach to speed patients to needed care, eliminate inefficiencies and duplication. *ED Manag* 2013; 25(5):54-56.

125 Lin D, Patrick J, Labeau F. Estimating the waiting time of multi-priority emergency patients with downstream blocking. *Health Care Manag Sci* (Published online May 2013).

126 Wiler JL, Bolandifar E, Griffey RT, Poirier RF, Olsen T. An emergency department patient flow model based on queueing theory principles. *Acad Emerg Med* 2013;20(9):939-946.

127 Mayhew L, Smith D. Using queuing theory to analyse the government's 4-H completion time target in accident and emergency departments. *Health Care Manag Sci* 2008; 11(1):11-21.

128 Lin D, Patrick J, Labeau F. Estimating the waiting time of multi-priority emergency patients with downstream blocking. *Health Care Manag Sci* 2013 (Published online May 2013).

129 Wise SA, Fair DC. *Innovative Control Charting: Practical SPC Solutions for Today's Manufacturing Environment*. ASQ Quality Press, 1998.

130 Towbin AJ, Iyer SB, Brown J, Varadarajan K, Perry LA, Larson DB. Practice policy and quality initiatives: decreasing variability in turnaround time for radiographic studies from the emergency department. *Radiographics* 2013; 33(2):361-371.

131 Thor J, Lundberg J, Ask J, Olsson J, Carli C, Härenstam KP, Brommels M. Application of statistical process control in healthcare improvement: systematic review. *Qual Saf Health Care* 2007;16(5):387-399.

132 Koetsier A, van der Veer SN, Jager KJ, Peek N, de Keizer NF. Control charts in healthcare quality improvement. A systematic review on adherence to methodological criteria. *Methods Inf Med* 2012;51(3):189-198.

133 Bonetti PO, Waeckerlin A, Schuepfer G, Frutiger A. Improving time-sensitive processes in the intensive care unit: the example of 'door-to-needle time' in acute myocardial infarction. *Int J Qual Health Care* 2000;12(4):311-317.

134 Groome LJ, Mayeaux EJ Jr. Decreasing extremes in patient waiting time. *Qual Manag Health Care* 2010;19(2):117-128.

135 Kunadian B, Morley R, Roberts AP, Adam Z, Twomey D, Hall JA, Wright RA, Sutton AG, Muir DF, de Belder MA. Impact of implementation of evidence-based strategies to reduce door-to-balloon time in patients presenting with STEMI: continuous data analysis and feedback using a statistical process control plot. *Heart* 2010; 96(19):1557-1563.

136 Schwab RA, DelSorbo SM, Cunningham MR, Craven K, Watson WA. Using statistical process control to demonstrate the effect of operational interventions on quality indicators in the emergency department. *J Healthc Qual* 1999;21(4):38-41.

137 Kunadian B, Morley R, Roberts AP, Adam Z, Twomey D, Hall JA, Wright RA, Sutton AG, Muir DF, de Belder MA. Impact of implementation of evidence-based strategies to reduce door-to-balloon time in patients presenting with STEMI: continuous data analysis and feedback using a statistical process control plot. *Heart* 2010;96(19):1557-1563.

138 Kelley J. Critical Path Planning and Scheduling: Mathematical Basis. *Operations Res* 1961; 9(3).

139 Ip H, Amer T, Dangoor M, Zamir A, Gibbings-Isaac D, Kochhar R, Heymann T. Managing patient pathways to achieve lung cancer waiting time targets: mixed methods study. *JRSM Short Rep* 2012;3(10):69.

140 Wilson G. Implementation of Releasing Time to Care - the productive ward. *J Nurs Manag* 2009;17(5):647-654.

141 Hwang TG, Lee Y, Shin H. Structure-oriented versus process-oriented approach to enhance efficiency for emergency room operations: what lessons can we learn? *J Healthc Manag* 2011; 56(4):255-267.

142 Horwitz LI, Meredith T, Schuur JD, Shah NR, Kulkarni RG, Jenq GY. Dropping the baton: a qualitative analysis of failures during the transition from emergency department to inpatient care. *Ann Emerg Med* 2009;53(6):701-10.e4.

143 Khare RK, Nannicelli AP, Powell ES, Seivert NP, Adams JG, Holl JL. Use of risk assessment analysis by failure mode, effects, and criticality to reduce door-to-balloon time. *Ann Emerg Med* (Published online March 2013).

144 Baumgart A, Neuhauser D Frank and Lillian Gilbreth: scientific management in the operating room. *Qual Saf Health Care* 2009; 18: 413-415.

145 Shinder GA, Paradis PE, Posman M, Mishagina N, Guay MP, Linardos D, Batist G. Patient and work flow and costs associated with staff time and facility usage at a comprehensive cancer centre in Quebec, Canada - a time and motion study. *BMC Health Serv Res* 2012;12:370.

146 Burns CM, Bennett CJ, Myers CT, Ward M. The use of cusum analysis in the early detection and management of hospital bed occupancy crises. *Med J Aust* 2005;183(6):291-294.

147 Graves JL, Hudgins AA, DeLung J, Burnett CA, Scanlon P, Orentlicher D. Computerized patient-flow analysis of local family planning clinics. *Fam Plann Perspect* 1981;13(4):164-170.

148 Rotondi AJ, Brindis C, Cantees KK, DeRiso BM, Ilkin HM, Palmer JS, Gunnerson HB, Watkins WD. Benchmarking the perioperative process. I. Patient routing systems: a method for continual improvement of patient flow and resource utilization. *J Clin Anesth* 1997;9(2):159-169.

149 Huynh N, Taaffe K, Fredendall L, Burris R, Childers AK, Livingston J, Diller T. The use of a mobile application to track process workflow in perioperative services. *Comput Inform Nurs* 2011;29(6):368-374.

150 Koks DR, Zonderland ME, Heringhaus C. Development of an observational instrument to determine variations in the patient care process and patient flow among emergency physicians and internists at the emergency department. *Int J Emerg Med* 2013; 6(1):1.

151 Azzopardi M, Cauchi M, Cutajar K, Ellul R, Mallia-Azzopardi C, Grech V. A time and motion study of patients presenting at the accident and emergency department at Mater Dei Hospital. *BMC Res Notes* 2011; 4:421.

152 Kyriacou DN, Ricketts V, Dyne PL, McCollough MD, Talan DA. A 5-year time study analysis of emergency department patient care efficiency. *Ann Emerg Med* 1999; 34(3):326-335.

153 Campbell SG, Sinclair DE. Strategies for managing a busy emergency department. *CJEM* 2004; 6(4):271-276.

154 van Lent WA, Sanders EM, van Harten WH. Exploring improvements in patient logistics in Dutch hospitals with a survey. *BMC Health Serv Res* 2012;12:232.

155 Ip H, Amer T, Dangoor M, Zamir A, Gibbings-Isaac D, Kochhar R, Heymann T. Managing patient pathways to achieve lung cancer waiting time targets: mixed methods study. *JRSM Short Rep* 2012;3(10):69.

156 Holland CA. Preparing for the future: a case study of role changing and reengineering. Recognize and seize the new opportunities. *Clin Lab Manage Rev* 1995;9(5):363-369.

157 Van Vaerenbergh C. Using mixed methods to identify factors influencing patient flow. *Health Serv Manage Res* 2009; 22(4):170-175.

158 Leaver CA, Guttmann A, Zwarenstein M, Rowe BH, Anderson G, Stukel T, Golden B, Bell R, Morra D, Abrams H, Schull MJ. Development of a minimization instrument for allocation of a hospital-level performance improvement intervention to reduce waiting times in Ontario emergency departments. *Implement Sci* 2009;4:32.

159 Weiland TJ, Mackinlay C, Hill N, Gerdtz MF, Jelinek GA. Optimal management of mental health patients in Australian emergency departments: barriers and solutions. *Emerg Med Australas* 2011; 23(6):677-688.

160 Chan A, Arendts G, Wong S. Causes of constraints to patient flow in emergency departments: a comparison between staff perceptions and findings from the Patient Flow Study. *Emerg Med Australas* 2008; 20(3):234-240.

161 Erickson KC, Donald DS. *Doing Team Ethnography: Warnings and Advice*. California: Sage, 1997.

162 Fieldston ES, Li J, Terwiesch C, Helfaer MA, Verger J, Pati S, Surrey D, Patel K, Ebberson JL, Lin R, Metlay JP. Direct observation of bed utilization in the pediatric intensive care unit. *J Hosp Med* 2012;7(4):318-324.

163 Burström L, Starrin B, Engström ML, Thulesius H. Waiting management at the emergency department - a grounded theory study. *BMC Health Serv Res* 2013; 13:95.

164 Nugus P, Forero R, McCarthy S, McDonnell G, Travaglia J, Hilman K, Braithwaite J. The emergency department "carousel": An ethnographically-derived model of the dynamics of patient flow. *Int Emerg Nurs* (Published online May 2013).

165 Nugus P, Holdgate A, Fry M, Forero R, McCarthy S, Braithwaite J. Work pressure and patient flow management in the emergency department: findings from an ethnographic study. *Acad Emerg Med* 2011; 18(10):1045-1052.

166 Ardagh MW, Tonkin G, Possenniskie C. Improving acute patient flow and resolving emergency department overcrowding in New Zealand hospitals--the major challenges and the promising initiatives. *N Z Med J* 2011; 124(1344):64-73.

167 Endacott R, Cooper S, Sheaff R, Padmore J, Blakely G. Improving emergency care pathways: an action research approach. *Emerg Med J* 2011; 28(3):203-207.

168 Chand S, Moskowitz H, Norris JB, Shade S, Willis DR. Improving patient flow at an outpatient clinic: study of sources of variability and improvement factors. *Health Care Manag Sci* 2009;12(3):325-340.

169 Dhar S, Michel R, Kanna B. Improving visit cycle time using patient flow analysis in a high-volume inner-city hospital-based ambulatory clinic serving minority New Yorkers. *J Healthc Qual* 2011;33(2):23-28.

170 Dickson EW, Singh S, Cheung DS, Wyatt CC, Nugent AS. Application of lean manufacturing techniques in the Emergency Department. *J Emerg Med* 2009; 37(2):177-182.

171 Vest JR, Gamm LD. A critical review of the research literature on Six Sigma, Lean and StuderGroup's Hardwiring Excellence in the United States: the need to demonstrate and communicate the effectiveness of transformation strategies in healthcare. *Implement Sci* 2009;4:35.

172 Aakre KT, Valley TB, O'Connor MK. Quality initiatives: improving patient flow for a bone densitometry practice: results from a Mayo Clinic radiology quality initiative. *Radiographics* 2010;30(2):309-315.

173 Gremyr I, Raharjo H. Quality function deployment in healthcare: a literature review and case study. *Int J Health Care Qual Assur* 2013;26(2):135-146.

174 Parks JK, Klein J, Frankel HL, Friese RS, Shafi S. Dissecting delays in trauma care using corporate lean six sigma methodology. *J Trauma* 2008; 65(5):1098-1104.

175 Nicholas J. An integrated lean-methods approach to hospital facilities redesign. *Hosp Top* 2012; 90(2):47-55.

176 Aldarrab A. Application of Lean Six Sigma for patients presenting with ST-elevation myocardial infarction: the Hamilton Health Sciences experience. *Healthc Q* 2006; 9(1):56-62.

177 Kumar S, Thomas KM. Utilizing DMAIC six sigma and evidence-based medicine to streamline diagnosis in chest pain. *Qual Manag Health Care* 2010; 19(2):107-116.

178 Gayed B, Black S, Daggy J, Munshi IA. Redesigning a Joint Replacement Program Using Lean Six Sigma in a Veterans Affairs Hospital. *JAMA Surg* (Published online September 2013).

179 DelliFraine JL, Wang Z, McCaughey D, Langabeer JR 2nd, Erwin CO. The use of six sigma in health care management: are we using it to its full potential? *Qual Manag Health Care* 2013;22(3):210-223.

180 Ben-Tovim DI, Bassham JE, Bolch D, Martin MA, Dougherty M, Szwarcbord M. Lean thinking across a hospital: redesigning care at the Flinders Medical Centre. *Aust Health Rev* 2007; 31(1):10-15.

181 Ben-Tovim DI, Bassham JE, Bennett DM, Dougherty ML, Martin MA, O'Neill SJ, Sincock JL, Szwarcbord MG. Redesigning care at the Flinders Medical Centre: clinical process redesign using "lean thinking". *Med J Aust* 2008; 188(6 Suppl):S27-31.

182 Ben-Tovim DI, Dougherty ML, O'Connell TJ, McGrath KM. Patient journeys: the process of clinical redesign. *Med J Aust* 2008; 188(6 Suppl):S14-17.

183 Naik T, Duroseau Y, Zehtabchi S, Rinnert S, Payne R, McKenzie M, Legome E. A structured approach to transforming a large public hospital emergency department via lean methodologies. *J Healthc Qual* 2012; 34(2):86-97.

184 [No authors listed]. Lean-driven solutions slash ED wait times, LOS. *ED Manag* 2012; 24(12):139-141.

185 McDermott AM, Kidd P, Gately M, Casey R, Burke H, O'Donnell P, Kirrane F, Dinneen SF, O'Brien T. Restructuring of the Diabetes Day Centre: a pilot lean project in a tertiary referral centre in the West of Ireland. *BMJ Qual Saf* 2013;22(8):681-688.

186 Lin SY, Gavney D, Ishman SL, Cady-Reh J. Use of lean sigma principles in a tertiary care otolaryngology clinic to improve efficiency. *Laryngoscope* (Published online March 2013).

187 Szecket N, Wong HJ, Wu RC, Berman HD, Morra D. Implementation of a continuous admission model reduces the length of stay of patients on an internal medicine clinical teaching unit. *J Hosp Med* (Published online September 2011).

188 Niemeijer GC, Flikweert E, Trip A, Does RJ, Ahaus KT, Boot AF, Wendt KW. The usefulness of lean six sigma to the development of a clinical pathway for hip fractures. *J Eval Clin Pract* 2013;19(5):909-914.

189 Silich SJ, Wetz RV, Riebling N, Coleman C, Khoueiry G, Abi Rafeh N, Bagon E, Szerszen A. Using Six Sigma methodology to reduce patient transfer times from floor to critical-care beds. *J Healthc Qual* 2012;34(1):44-54.

190 Sedlack JD. The utilization of six sigma and statistical process control techniques in surgical quality improvement. *J Healthc Qual* 2010;32(6):18-26.

191 Albert K, Sherman B, Backus B. How length of stay for congestive heart failure patients was reduced through six sigma methodology and physician leadership. *Am J Med Qual* 2010;25(5):392-397.

192 Fischman D. Applying Lean Six Sigma methodologies to improve efficiency, timeliness of care, and quality of care in an internal medicine residency clinic. *Qual Manag Health Care* 2010;19(3):201-210.

193 van Lent WA, Goedbloed N, van Harten WH. Improving the efficiency of a chemotherapy day unit: applying a business approach to oncology. *Eur J Cancer* 2009;45(5):800-806.

194 Hina-Syeda H, Kimbrough C, Murdoch W, Markova T. Improving Immunization Rates Using Lean Six Sigma Processes: Alliance of Independent Academic Medical Centers National Initiative III Project. *Ochsner J* 2013;13(3):310-318.

195 Meliones JN, Alton M, Mericle J, Ballard R, Cesari J, Frush KS, Mistry K. 10-year experience integrating strategic performance improvement initiatives: can the balanced scorecard, six sigma and team training all thrive in a single hospital? In Henriksen K, Battles JB, Keyes MA, Grady ML (eds). *Advances in Patient Safety: New Directions and Alternative Approaches* (Vol. 3: Performance and Tools). Rockville (MD): Agency for Healthcare Research and Quality; 2008.

196 Bush SH, Lao MR, Simmons KL, Goode JH, Cunningham SA, Calhoun BC. Patient access and clinical efficiency improvement in a resident hospital-based women's medicine center clinic. *Am J Manag Care* 2007;13(12):686-690.

197 Hydes T, Hansi N, Trebble TM. Lean thinking transformation of the unsedated upper gastrointestinal endoscopy pathway improves efficiency and is associated with high levels of patient satisfaction. *BMJ Qual Saf* 2012;21(1):63-69.

198 Kullar P, Harris F, Lloyd SK, Briggs J, Vanat ZH, Willis J, Axon PR. The use of Lean Thinking techniques in implementing the Department of Health, UK, 18-week waiting time directive for cochlear implantation. *Cochlear Implants Int* 2010;11(3):133-145.

199 Aasebø U, Strøm HH, Postmyr M. The Lean method as a clinical pathway facilitator in patients with lung cancer. *Clin Respir J* 2012;6(3):169-174.

200 Fieldston ES, Hall M, Shah SS, Hain PD, Sills MR, Slonim AD, Myers AL, Cannon C, Pati S. Addressing inpatient crowding by smoothing occupancy at children's hospitals. *J Hosp Med* 2011;6(8):462-468.

201 O'Connell TJ, Bassham JE, Bishop RO, Clarke CW, Hullick CJ, King DL, Peek CL, Verma R, Ben-Tovim DI, McGrath KM. Clinical process redesign for unplanned arrivals in hospitals. *Med J Aust* 2008; 188(6 Suppl):S18-22.

202 Scott IA, Wills RA, Coory M, Watson MJ, Butler F, Waters M, Bowler S. Impact of hospital-wide process redesign on clinical outcomes: a comparative study of internally versus externally led intervention. *BMJ Qual Saf* 2011; 20(6):539-548.

203 Ortiga B, Salazar A, Jovell A, Escarrabill J, Marca G, Corbella X. Standardizing admission and discharge processes to improve patient flow: a cross sectional study. *BMC Health Serv Res* 2012; 12:180.

204 Shabot MM, Monroe D, Inurria J, Garbade D, France AC. Memorial Hermann: high reliability from board to bedside. *Jt Comm J Qual Patient Saf* 2013;39(6):253-257.

205 Mistry KP, Jaggers J, Lodge AJ, Alton M, Mericle JM, Frush KS, Meliones JN. Using six sigma(®) methodology to improve handoff communication in high-risk patients. In Henriksen K, Battles JB, Keyes MA, Grady ML (eds). *Advances in Patient Safety: New Directions and Alternative Approaches* (Vol. 3: Performance and Tools). Rockville (MD): Agency for Healthcare Research and Quality; 2008.

206 McCulloch P, Kreckler S, New S, Sheena Y, Handa A, Catchpole K. Effect of a "Lean" intervention to improve safety processes and outcomes on a surgical emergency unit. *BMJ* 2010; 341: c5469.

207 Ng D, Vail G, Thomas S, Schmidt N. Applying the Lean principles of the Toyota Production System to reduce wait times in the emergency department. *CJEM* 2010; 12(1):50-57.

208 Dickson EW, Anguelov Z, Vetterick D, Eller A, Singh S. Use of lean in the emergency department: a case series of 4 hospitals. *Ann Emerg Med* 2009; 54(4):504-510.

209 Waldhausen JH, Avansino JR, Libby A, Sawin RS. Application of lean methods improves surgical clinic experience. *J Pediatr Surg* 2010;45(7):1420-1425.

210 Niemeijer GC, Trip A, Ahaus KT, Does RJ, Wendt KW. Quality in trauma care: improving the discharge procedure of patients by means of Lean Six Sigma. *J Trauma* 2010; 69(3):614-618.

211 Scalise D. Six sigma in action. Case studies in quality put theory into practice. *Hosp Health Netw* 2003; 77(5):57-62.

212 Niemeijer GC, Trip A, de Jong LJ, Wendt KW, Does RJ. Impact of 5 years of lean six sigma in a University Medical Center. *Qual Manag Health Care* 2012;21(4):262-268.

213 Nicolay CR, Purkayastha S, Greenhalgh A, Benn J, Chaturvedi S, Phillips N, Darzi A. Systematic review of the application of quality improvement methodologies from the manufacturing industry to surgical healthcare. *Br J Surg* 2012;99(3):324-335.

214 Cima RR, Brown MJ, Hebl JR, Moore R, Rogers JC, Kollengode A, Amstutz GJ, Weisbrod CA, Narr BJ, Deschamps C. Use of lean and six sigma methodology to improve operating room efficiency in a high-volume tertiary-care academic medical center. *J Am Coll Surg* 2011;213(1):83-92.

215 van den Heuvel J, Does RJ, Bogers AJ, Berg M. Implementing Six Sigma in The Netherlands. *Jt Comm J Qual Patient Saf* 2006;32(7):393-399.

216 [No authors listed]. Florida hospital saves 5.3 M dollars by adopting principles of lean manufacturing. *Perform Improv Advis* 2005;9(1):10-11.

217 Pelly N, Zeallear B, Reed M, Martin L. Utilizing integrated facility design to improve the quality of a pediatric ambulatory surgery center. *Paediatr Anaesth* 2013;23(7):634-638.

218 Smith CD, Spackman T, Brommer K, Stewart MW, Vizzini M, Frye J, Rupp WC. Re-engineering the operating room using variability methodology to improve health care value. *J Am Coll Surg* 2013;216(4):559-568.

219 King DL, Ben-Tovim DI, Bassham J. Redesigning emergency department patient flows: application of Lean Thinking to health care. *Emerg Med Australas* 2006; 18(4):391-397.

220 Kreckler S, Morgan RD, Catchpole K, New S, Handa A, Collins G, McCulloch P. Effective prevention of thromboembolic complications in emergency surgery patients using a quality improvement approach. *BMJ Qual Saf* (Published online May 2013).

221 Ford AL, Williams JA, Spencer M, McCammon C, Khoury N, Sampson TR, Panagos P, Lee JM. Reducing door-to-needle times using Toyota's lean manufacturing principles and value stream analysis. *Stroke* 2012; 43(12):3395-3398.

222 Naik T, Duroseau Y, Zehtabchi S, Rinnert S, Payne R, McKenzie M, Legome E. A structured approach to transforming a large public hospital emergency department via lean methodologies. *J Healthc Qual* 2012; 34(2):86-97.

223 Hogan B, Rasche C, von Reinersdorff AB. The First View Concept: introduction of industrial flow techniques into emergency medicine organization. *Eur J Emerg Med* 2012; 19(3):136-139.

224 Piggott Z, Weldon E, Strome T, Chochinov A. Application of Lean principles to improve early cardiac care in the emergency department. *CJEM* 2011; 13(5):325-332.

225 Murrell KL, Offerman SR, Kauffman MB. Applying lean: implementation of a rapid triage and treatment system. *West J Emerg Med* 2011; 12(2):184-191.

226 Eller A. Rapid assessment and disposition: applying LEAN in the emergency department. *J Healthc Qual* 2009; 31(3):17-22.

227 Kelly EW, Kelly JD, Hiestand B, Wells-Kiser K, Starling S, Hoekstra JW. Six Sigma process utilization in reducing door-to-balloon time at a single academic tertiary care center. *Prog Cardiovasc Dis* 2010; 53(3):219-226.

228 Blick KE. Providing critical laboratory results on time, every time to help reduce emergency department length of stay: how our laboratory achieved a six sigma level of performance. *Am J Clin Pathol* 2013; 140(2):193-202.

229 Fernandes CM, Christenson JM, Price A. Continuous quality improvement reduces length of stay for fast-track patients in an emergency department. *Acad Emerg Med* 1996; 3(3):258-263.

230 Mazzocato P, Holden RJ, Brommels M, Aronsson H, Bäckman U, Elg M, Thor J. How does lean work in emergency care? A case study of a lean-inspired intervention at the Astrid Lindgren Children's hospital, Stockholm, Sweden. *BMC Health Serv Res* 2012; 12:28.

231 Parks JK, Klein J, Frankel HL, Friese RS, Shafi S. Dissecting delays in trauma care using corporate lean six sigma methodology. *J Trauma* 2008;65(5):1098-1104.

232 Niemeijer GC, Trip A, Ahaus KT, Does RJ, Wendt KW. Quality in trauma care: improving the discharge procedure of patients by means of Lean Six Sigma. *J Trauma* 2010;69(3):614-618.

233 Taner M. An application of Six Sigma methodology to turnover intentions in health care. *Int J Health Care Qual Assur* 2009;22(3):252-265.

234 Holden RJ. Lean Thinking in emergency departments: a critical review. *Ann Emerg Med* 2011; 57(3):265-278.

235 Ryan A, Hunter K, Cunningham K, Williams J, O'Shea H, Rooney P, Hickey F. STEPS: lean thinking, theory of constraints and identifying bottlenecks in an emergency department. *Ir Med J* 2013; 106(4):105-107.

236 Kelly EW, Kelly JD, Hiestand B, Wells-Kiser K, Starling S, Hoekstra JW. Six Sigma process utilization in reducing door-to-balloon time at a single academic tertiary care center. *Prog Cardiovasc Dis* 2010;53(3):219-226.

237 Ben-Tovim DI, Bassham JE, Bolch D, Martin MA, Dougherty M, Szwarcbord M. Lean thinking across a hospital: redesigning care at the Flinders Medical Centre. *Aust Health Rev* 2007; 31(1):10-15.

238 Ben-Tovim DI, Bassham JE, Bennett DM, Dougherty ML, Martin MA, O'Neill SJ, Sincock JL, Szwarcbord MG. Redesigning care at the Flinders Medical Centre: clinical process redesign using "lean thinking". *Med J Aust* 2008; 188(6 Suppl):S27-31.

239 Ben-Tovim DI, Dougherty ML, O'Connell TJ, McGrath KM. Patient journeys: the process of clinical redesign. *Med J Aust* 2008; 188(6 Suppl):S14-17.

240 Kelly AM, Bryant M, Cox L, Jolley D. Improving emergency department efficiency by patient streaming to outcomes-based teams. *Aust Health Rev* 2007; 31(1):16-21.

241 Nicholas J. An integrated lean-methods approach to hospital facilities redesign. *Hosp Top* 2012; 90(2):47-55.

242 Gilutz H, Battler A, Rabinowitz I, Snir Y, Porath A, Rabinowitz G. The "door-to-needle blitz" in acute myocardial infarction: the impact of a CQI project. *Jt Comm J Qual Improv* 1998; 24(6):323-333.

243 Glasgow JM, Scott-Caziewell JR, Kaboli PJ. Guiding inpatient quality improvement: a systematic review of Lean and Six Sigma. *Jt Comm J Qual Patient Saf* 2010;36(12):533-540.

244 Nicolay CR, Purkayastha S, Greenhalgh A, Benn J, Chaturvedi S, Phillips N, Darzi A. Systematic review of the application of quality improvement methodologies from the manufacturing industry to surgical healthcare. *Br J Surg* 2012;99(3):324-335.

245 DelliFraine JL, Langabeer JR 2nd, Nembhard IM. Assessing the evidence of Six Sigma and Lean in the health care industry. *Qual Manag Health Care* 2010;19(3):211-225.

246 Feng Q, Manuel CM. Under the knife: a national survey of six sigma programs in US healthcare organizations. *Int J Health Care Qual Assur* 2008;21(6):535-547.

247 Smith IR, Garlick B, Gardner MA, Brighouse RD, Foster KA, Rivers JT. Use of graphical statistical process control tools to monitor and improve outcomes in cardiac surgery. Heart Lung Circ (Published online October 2012).

248 Tortorella F, Ukanowicz D, Douglas-Ntagha P, Ray R, Triller M. Improving bed turnover time with a bed management system. *J Nurs Adm* 2013;43(1):37-43.

249 Cho S, Jung K, Yeom S, Park S, Kim H, Hwang S. Change of inter-facility transfer pattern in a regional trauma system after designation of trauma centers. *J Korean Surg Soc* 2012;82(1):8-12.

250 Proudlove NC, Boaden R. Using operational information and information systems to improve in-patient flow in hospitals. *J Health Organ Manag* 2005;19(6):466-477.

251 Thuemmler C, Morris C. Global case management: Scotland. Real-time monitoring of patient flow as an instrument to optimize quality of care in acute receiving units. *Lippincotts Case Manag* 2005;10(5):254-260.

252 Halm BM. Reducing the time in making the diagnosis and improving workflow with point-of-care ultrasound. *Pediatr Emerg Care* 2013;29(2):218-221.

253 Chaboyer W, Wallen K, Wallis M, McMurray AM. Whiteboards: one tool to improve patient flow. *Med J Aust* 2009;190(11 Suppl):S137-140.

254 Rozich JD, Resar RK. Using a unit assessment tool to optimize patient flow and staffing in a community hospital. *Jt Comm J Qual Improv* 2002;28(1):31-41.

255 Resar R, Nolan K, Kaczynski D, Jensen K. Using real-time demand capacity management to improve hospitalwide patient flow. *Jt Comm J Qual Patient Saf* 2011; 37(5):217-227.

256 Jensen J. United hospital increases capacity usage, efficiency with patient-flow management system. *J Healthc Inf Manag* 2004; 18(3):26-31.

257 Baumlin KM, Shapiro JS, Weiner C, Gottlieb B, Chawla N, Richardson LD. Clinical information system and process redesign improves emergency department efficiency. *Jt Comm J Qual Patient Saf* 2010; 36(4): 179-185.

258 Jensen J. Going with the flow. Tracking system helps midwest hospital streamline patient flow and lower emergency room divert rate. *Health Manag Technol* 2003; 24(12):43-45.

259 Baumlin KM, Shapiro JS, Weiner C, Gottlieb B, Chawla N, Richardson LD. Clinical information system and process redesign improves emergency department efficiency. *Jt Comm J Qual Patient Saf* 2010; 36(4): 179-185.

260 Georgiou A, Prgomet M, Paoloni R, Creswick N, Hordern A, Walter S, Westbrook J. The effect of computerized provider order entry systems on clinical care and work processes in emergency departments: a systematic review of the quantitative literature. *Ann Emerg Med* 2013; 61(6):644-653.

261 Shapiro JS, Baumlin KM, Chawla N, Genes N, Godbold J, Ye F, Richardson LD. Emergency department information system implementation and process redesign result in rapid and sustained financial enhancement at a large academic center. *Acad Emerg Med* 2010; 17(5):527-535.

262 Birkhahn RH, Wen W, Datillo PA, Briggs WM, Parekh A, Arkun A, Byrd B, Gaeta TJ. Improving patient flow in acute coronary syndromes in the face of hospital crowding. *J Emerg Med* 2012;43(2):356-365.

263 Hitchcock R. Speeding up the ED care process. Three hospital organizations mitigate overcrowding by improving patient flow, processes and documentation. *Health Manag Technol* 2012; 33(12):6-8.

264 Waseem M, McInerney JE, Perales O, Leber M. Impact of operational staging to improve patient throughput in an inner-city emergency department during the novel H1N1 influenza surge: a descriptive study. *Pediatr Emerg Care* 2012; 28(1):39-42.

265 Liu SW, Hamedani AG, Brown DF, Asplin B, Camargo CA Jr. Established and novel initiatives to reduce crowding in emergency departments. *West J Emerg Med* 2013; 14(2):85-89.

266 Popovich MA, Boyd C, Dachenhaus T, Kusler D. Improving stable patient flow through the emergency department by utilizing evidence-based practice: one hospital's journey. *J Emerg Nurs* 2012; 38(5):474-478.

267 Sharieff GQ, Burnell L, Cantonis M, Norton V, Tovar J, Roberts K, Vanwyk C, Saucier J, Russe J. Improving emergency department time to provider, left-without-treatment rates, and average length of stay. *J Emerg Med* (Published online June 2013).

268 McHugh M, Van Dyke KJ, Howell E, Adams F, Moss D, Yonek J. Changes in patient flow among five hospitals participating in a learning collaborative. *J Healthc Qual* 2013; 35(1):21-29.

269 Spaite DW, Bartholomeaux F, Guisto J, Lindberg E, Hull B, Eyherabide A, Lanyon S, Criss EA, Valenzuela TD, Conroy C. Rapid process redesign in a university-based emergency department: decreasing waiting time intervals and improving patient satisfaction. *Ann Emerg Med* 2002; 39(2):168-177.

270 Hoot NR, Aronsky D. Systematic review of emergency department crowding: causes, effects, and solutions. *Ann Emerg Med* 2008; 52(2):126-136.

271 Escobar A, Quintana JM, González M, Bilbao A, Ibañez B. Waiting list management: priority criteria or first-in first-out? A case for total joint replacement. *J Eval Clin Pract* 2009;15(4):595-601.

272 Bennett KJ, Baxley EG. The effect of a carve-out advanced access scheduling system on no-show rates. *Fam Med* 2009;41(1):51-56.

273 Sokhela DG, Makhanya NJ, Sibiya NM, Nokes KM. Experiences of Fast Queue health care users in primary health care facilities in eThekwini district, South Africa. *Curationis* 2013 5;36(1):E1-8.

274 [No authors listed] Low-cost strategies help improve flow. *ED Manag* 2009;21(11):124-126.

275 Van Vaerenbergh C. Using mixed methods to identify factors influencing patient flow. *Health Serv Manage Res* 2009;22(4):170-175.

276 Cohen MM, Wreford M, Barnes M, Voight P. Re-engineering surgical services in a community teaching hospital. *Cost Qual Q J* 1997;3(2):48-57.

277 Ahmed SV, Jayawarna C, Atkinson D, Rippon A. Following National Guidelines in Acute Care can improve emergency access and patient flow. *Acute Med* 2010;9(3):114-117.

278 Siegel B, Norton BL, Blanchard JC, Regenstein M, Jones KC. Creation and piloting of a new hospital capacity assessment tool in a major urban area. *Public Health* 2009;123(11):714-722.

279 [No authors listed] Process changes cut LOS by 100 minutes. *ED Manag* 2009;21(9):99-100.

280 Wong R, Hathi S, Linnander EL, El Banna A, El Maraghi M, El Din RZ, Ahmed A, Hafez AR, Allam AA, Krumholz HM, Bradley EH. Building hospital management capacity to improve patient flow for cardiac catheterization at a cardiovascular hospital in Egypt. *Jt Comm J Qual Patient Saf* 2012;38(4):147-153.

281 Adini B, Cohen R, Laor D, Israeli A. Can patient flow be effectively controlled? *Health Policy Plan* 2011;26(6):518-525.

282 Villa S, Barbieri M, Lega F. Restructuring patient flow logistics around patient care needs: implications and practicalities from three critical cases. Health *Care Manag Sci* 2009;12(2):155-165.

283 Chan TC, Killeen JP, Vilke GM, Marshall JB, Castillo EM. Effect of mandated nurse-patient ratios on patient wait time and care time in the emergency department. *Acad Emerg Med* 2010; 17(5):545-552.

284 Divecha HM, Smith RD, Cairns C, Bayer J. Improving patient flow: the impact of consultant work pattern on trauma ward efficiency. *Surgeon* 2011;9(4):175-178.

285 Milsten A, Klein J, Liu Q, Vibhakar N, Linder L. Retrospective analysis of quality improvement throughput measures at a high-volume community emergency department. *J Healthc Qual* (Published online June 2013).

286 Lees L, Ferreday J. The role of a flow coordinator in an emergency assessment unit. *Nurs Times* 2003; 99(32):32-34.

287 Samarth CN, Gloor PA. Process efficiency. Redesigning social networks to improve surgery patient flow. *J Healthc Inf Manag* 2009;23(1):20-26.

288 Eriksson H, Bergbrant IM, Berrum I, Mörck B. Reducing queues: demand and capacity variations. *Int J Health Care Qual Assur* 2011;24(8):592-600.

289 Howell JM, Torma MJ, Teneyck R, Burrow RE, Huang E. The impact of dedicated physician staffing on patient flow and quality assurance parameters in an Air Force emergency department. *Mil Med* 1990; 155(1):30-33.

290 McGarry J, Krall SP, McLaughlin T. Impact of resident physicians on emergency department throughput. *West J Emerg Med* 2010; 11(4):333-335.

291 Considine J, Martin R, Smit D, Winter C, Jenkins J. Emergency nurse practitioner care and emergency department patient flow: case-control study. *Emerg Med Australas* 2006; 18(4):385-390.

292 Healy-Rodriguez MA, Freer C, Pontiggia L, Wilson R, Metraux S, Lord L. Impact of a logistics management program on admitted patient boarders within an emergency department. *J Emerg Nurs* (Published online February 2013).

293 Love RA, Murphy JA, Lietz TE, Jordan KS. The effectiveness of a provider in triage in the emergency department: a quality improvement initiative to improve patient flow. *Adv Emerg Nurs J* 2012; 34(1):65-74.

294 Ducharme J, Alder RJ, Pelletier C, Murray D, Tepper J. The impact on patient flow after the integration of nurse practitioners and physician assistants in 6 Ontario emergency departments. CJEM 2009; 11(5):455-461.

295 [No authors listed]. Slash diversion, improve care of boarded patients with an ED-based hospital medicine (HMED) team. *ED Manag* 2012; 24(11):124-127.

296 Chadaga SR, Shockley L, Keniston A, Klock NE, Van Dyke S, Davis Q, Chu ES. Hospitalist-led medicine emergency department team: associations with throughput, timeliness of patient care, and satisfaction. *J Hosp Med* 2012; 7(7):562-566.

297 [No authors listed]. ED flow facilitators make throughput center stage, achieve decreases in LWBS, LOS, and door-to-bed times. *ED Manag* 2012; 24(9):103-105.

298 Handel DA, Ma OJ, Workman J, Fu R. Impact of an expeditor on emergency department patient throughput. *West J Emerg Med* 2011; 12(2):198-203.

299 [No authors listed]. Patient-centered transfer process for patients admitted through the ED boosts satisfaction, improves safety. *ED Manag* 2013; 25(2):17-20.

300 Khangura JK, Flodgren G, Perera R, Rowe BH, Shepperd S. Primary care professionals providing non-urgent care in hospital emergency departments. *Cochrane Database Syst Rev* 2012; 11:CD002097.

301 Ong ME, Ho KK, Tan TP, Koh SK, Almuthar Z, Overton J, Lim SH. Using demand analysis and system status management for predicting ED attendances and rostering. *Am J Emerg Med* 2009;27(1):16-22.

302 Delgado MK, Meng LJ, Mercer MP, Pines JM, Owens DK, Zaric GS. Reducing ambulance diversion at hospital and regional levels: systemic review of insights from simulation models. *West J Emerg Med* 2013;14(5):489-498.

303 Edwards T. How rapid assessment at triage can improve care outcomes. *Emerg Nurse* 2011; 19(6):27-30.

304 van der Linden C, Lindeboom R, van der Linden N, Lucas C. Managing patient flow with triage streaming to identify patients for Dutch emergency nurse practitioners. *Int Emerg Nurs* 2012; 20(2):52-57.

305 Liu SW, Hamedani AG, Brown DF, Asplin B, Camargo CA Jr. Established and novel initiatives to reduce crowding in emergency departments. *West J Emerg Med* 2013; 14(2):85-89.

306 King DL, Ben-Tovim DI, Bassham J. Redesigning emergency department patient flows: application of Lean Thinking to health care. *Emerg Med Australas* 2006; 18(4):391-397.

307 Chan TC, Killeen JP, Kelly D, Guss DA. Impact of rapid entry and accelerated care at triage on reducing emergency department patient wait times, lengths of stay, and rate of left without being seen. *Ann Emerg Med* 2005; 46(6):491-497.

308 Tsai VW, Sharieff GQ, Kanegaye JT, Carlson LA, Harley J. Rapid medical assessment: improving pediatric emergency department time to provider, length of stay, and left without being seen rates. *Pediatr Emerg Care* 2012; 28(4):354-356.

309 Buckley BJ, Castillo EM, Killeen JP, Guss DA, Chan TC. Impact of an express admit unit on emergency department length of stay. *J Emerg Med* 2010; 39(5):669-673.

310 Fernandes CM, Price A, Christenson JM. Does reduced length of stay decrease the number of emergency department patients who leave without seeing a physician? *J Emerg Med* 1997; 15(3):397-399.

311 Kwa P, Blake D. Fast track: has it changed patient care in the emergency department? *Emerg Med Australas* 2008; 20(1):10-15.

312 Perry E, Mackintosh S, Connor S. Role of an acute assessment and review area for general surgical patients. *ANZ J Surg* 2010; 80(6):425-429.

313 Ieraci S, Digiusto E, Sonntag P, Dann L, Fox D. Streaming by case complexity: evaluation of a model for emergency department Fast Track. *Emerg Med Australas* 2008; 20(3):241-249.

314 Preyde M, Crawford K, Mullins L. Patients' satisfaction and wait times at Guelph General Hospital Emergency Department before and after implementation of a process improvement project. *CJEM* 2012;14(3):157-168.

315 Alikhan LM, Howard RJ, Bowry R. From a project to transformation: how "going against the flow" led to improved access and patient flow in an academic hospital. *Healthc Manage Forum* 2009;22(3):20-26.

316 Laut KG, Foldspang A. The effects on length of stay of introducing a fast track patient pathway for myocardial infarction: a before and after evaluation. *Health Serv Manage Res* 2012;25(1):31-34.

317 van der Linden C, Lindeboom R, van der Linden N, Lucas C. Managing patient flow with triage streaming to identify patients for Dutch emergency nurse practitioners. *Int Emerg Nurs* 2012;20(2):52-57.

318 Harding KE, Taylor NF, Leggat SG. Do triage systems in healthcare improve patient flow? A systematic review of the literature. *Aust Health Rev* 2011; 35(3):371-383.

319 Oredsson S, Jonsson H, Rognes J, Lind L, Göransson KE, Ehrenberg A, Asplund K, Castrén M, Farrohknia N. A systematic review of triage-related interventions to improve patient flow in emergency departments. *Scand J Trauma Resusc Emerg Med* 2011; 19:43.

320 Ahmed SV, Jayawarna C, Atkinson D, Rippon A. Following national guidelines in acute care can improve emergency access and patient flow. *Acute Med* 2010;9(3):114-117.

321 Bryan K. Policies for reducing delayed discharge from hospital. *Br Med Bull* 2010;95:33-46.

322 Lim SC, Doshi V, Castasus B, Lim JK, Mamun K. Factors causing delay in discharge of elderly patients in an acute care hospital. *Ann Acad Med Singapore* 2006;35(1):27-32.

323 Graham L, Neal CP, Garcea G, Lloyd DM, Robertson GS, Sutton CD. Evaluation of nurse-led discharge following laparoscopic surgery. *J Eval Clin Pract* 2012;18(1):19-24.

324 Dutton RP, Cooper C, Jones A, Leone S, Kramer ME, Scalea TM. Daily multidisciplinary rounds shorten length of stay for trauma patients. *J Trauma* 2003;55(5):913-919.

325 Vrabec S, Oltmann SC, Clark N, Chen H, Sippel RS. A short-stay unit for thyroidectomy patients increases discharge efficiency. *J Surg Res* 2013;184(1):204-208.

326 Bryan K. Policies for reducing delayed discharge from hospital. *Br Med Bull* 2010;95:33-46.

327 Watts R, Gardner H, Pierson J. Factors that enhance or impede critical care nurses' discharge planning practices. *Intensive Crit Care Nurs* 2005;21(5):302-313.

328 Tan WS, Chong WF, Chua KS, Heng BH, Chan F. Factors associated with delayed discharges after inpatient stroke rehabilitation in Singapore. *Ann Acad Med Singapore* 2010;39(6):435-441.

329 Challis D, Hughes J, Xie C, Jolley D. An examination of factors influencing delayed discharge of older people from hospital. *Int J Geriatr Psychiatry* (Published online May 2013).

330 Napier RJ, Spence D, Diamond O, O'Brien S, Walsh T, Beverland DE. Modifiable factors delaying early discharge following primary joint arthroplasty. *Eur J Orthop Surg Traumatol* 2013;23(6):665-669.

331 Ou L, Young L, Chen J, Santiano N, Baramy LS, Hillman K. Discharge delay in acute care: reasons and determinants of delay in general ward patients. *Aust Health Rev* 2009;33(3):513-521.

332 Amy C, Zagorski B, Chan V, Parsons D, Vander Laan R, Colantonio A. Acute care alternate-level-of-care days due to delayed discharge for traumatic and non-traumatic brain injuries. *Healthc Policy* 2012;7(4):41-55.

333 Costa AP, Poss JW, Peirce T, Hirdes JP. Acute care inpatients with long-term delayed-discharge: evidence from a Canadian health region. *BMC Health Serv Res* 2012;12:172.

334 Ou L, Chen J, Young L, Santiano N, Baramy LS, Hillman K. Effective discharge planning - timely assignment of an estimated date of discharge. *Aust Health Rev* 2011;35(3):357-363.

335 Ou L, Young L, Chen J, Santiano N, Baramy LS, Hillman K. Discharge delay in acute care: reasons and determinants of delay in general ward patients. *Aust Health Rev* 2009;33(3):513-521.

336 Baumann M, Evans S, Perkins M, Curtis L, Netten A, Fernandez JL, Huxley P. Organisation and features of hospital, intermediate care and social services in English sites with low rates of delayed discharge. *Health Soc Care Community* 2007;15(4):295-305.

337 Lewis R, Glasby J. Delayed discharge from mental health hospitals: results of an English postal survey. *Health Soc Care Community* 2006;14(3):225-230.

338 Shirakami G, Teratani Y, Namba T, Hirakata H, Tazuke-Nishimura M, Fukuda K. Delayed discharge and acceptability of ambulatory surgery in adult outpatients receiving general anesthesia. *J Anesth* 2005;19(2):93-101.

339 Styrborn K, Thorslund M. Delayed discharge of elderly hospital patients-a study of bed-blockers in a health care district in Sweden. *Scand J Soc Med* 1993;21(4):272-280.

340 New PW, Andrianopoulos N, Cameron PA, Olver JH, Stoelwinder JU. Reducing the length of stay for acute hospital patients needing admission into inpatient rehabilitation: a multicentre study of process barriers. *Intern Med J* 2013;43(9):1005-1011.

341 New PW, Cameron PA, Olver JH, Stoelwinder JU. Defining barriers to discharge from inpatient rehabilitation, classifying their causes, and proposed performance indicators for rehabilitation patient flow. *Arch Phys Med Rehabil* 2013;94(1):201-208.

342 Lin F, Chaboyer W, Wallis M, Miller A. Factors contributing to the process of intensive care patient discharge: an ethnographic study informed by activity theory. *Int J Nurs Stud* 2013;50(8):1054-1066.

343 Cowie B, Corcoran P. Postanesthesia care unit discharge delay for nonclinical reasons. *J Perianesth Nurs* 2012;27(6):393-398.

344 Jasinarachchi KH, Ibrahim IR, Keegan BC, Mathialagan R, McGourty JC, Phillips JR, Myint PK. Delayed transfer of care from NHS secondary care to primary care in England: its determinants, effect on hospital bed days, prevalence of acute medical conditions and deaths during delay, in older adults aged 65 years and over. *BMC Geriatr* 2009;9:4.

345 Lemmens L, van Zelm R, Borel Rinkes I, van Hillegersberg R, Kerkkamp H. Clinical and organizational content of clinical pathways for digestive surgery: a systematic review. *Dig Surg* 2009;26(2):91-99.

346 Khanna S, Boyle J, Good N, Lind J. Unravelling relationships: Hospital occupancy levels, discharge timing and emergency department access block. *Emerg Med Australas* 2012;24(5):510-517.

347 Bolch D, Johnston JB, Giles LC, Whitehead C, Phillips P, Crotty M. Hospital to home: an integrated approach to discharge planning in a rural South Australian town. *Aust J Rural Health* 2005;13(2):91-96.

348 Siders AM, Peterson M. Increasing patient satisfaction and nursing productivity through implementation of an automated nursing discharge summary. *Proc Annu Symp Comput Appl Med Care* 1991:136-140.

349 Shepperd S, Parkes J, McClaren J, Phillips C. Discharge planning from hospital to home. *Cochrane Database Syst Rev* 2004;(1):CD000313.

350 Kumar S, Grimmer-Somers K. A synthesis of the secondary literature on effectiveness of hospital avoidance and discharge programs. *Aust Health Rev* 2007;31(1):34-48.

351 Schmid KJ, Tewari R, Nordin AJ. Improving patient care with shorter hospital admissions. *J Obstet Gynaecol* 2009;29(6):526-528.

352 Atwal A, Caldwell K. Do multidisciplinary integrated care pathways improve interprofessional collaboration? *Scand J Caring Sci* 2002;16(4):360-367.

353 Houghton A, Bowling A, Clarke KD, Hopkins AP, Jones I. Does a dedicated discharge coordinator improve the quality of hospital discharge? *Qual Health Care* 1996;5(2):89-96.

354 Hedges G, Grimmer K, Moss J, Falco J. Performance indicators for discharge planning: a focused review of the literature. *Aust J Adv Nurs* 1999;16(4):20-28.

355 Schmid KJ, Tewari R, Nordin AJ. Improving patient care with shorter hospital admissions. *J Obstet Gynaecol* 2009;29(6):526-528.

356 Schneider M, Kawahara I, Ballantyne G, McAuley C, Macgregor K, Garvie R, McKenzie A, Macdonald D, Breusch SJ. Predictive factors influencing fast track rehabilitation following primary total hip and knee arthroplasty. *Arch Orthop Trauma Surg* 2009;129(12):1585-1591.

357 Wells DL, LeClerc CM, Craig D, Martin DK, Marshall VW. Evaluation of an integrated model of discharge planning: achieving quality discharges in an efficient and ethical way. *Can J Nurs Res* 2002;34(3):103-122.

358 Kumar S, Grimmer-Somers K. A synthesis of the secondary literature on effectiveness of hospital avoidance and discharge programs. *Aust Health Rev* 2007;31(1):34-48.

359 Kravet SJ, Levine RB, Rubin HR, Wright SM. Discharging patients earlier in the day: a concept worth evaluating. *Health Care Manag* 2007;26(2):142-146.

360 www.ihi.org/knowledge/Pages/ IHIWhitePapers/OptimizingPatientFlow

361 www.ihi.org/search/pages/results.aspx?k=flow

362 Dutton RP, Cooper C, Jones A, Leone S, Kramer ME, Scalea TM. Daily multidisciplinary rounds shorten length of stay for trauma patients. *J Trauma* 2003;55(5):913-919.

363 Murphy MA, Richards T, Atkinson C, Perkins J, Hands LJ. Fast track open aortic surgery: reduced post operative stay with a goal directed pathway. *Eur J Vasc Endovasc Surg* 2007;34(3):274-278.

364 Cheah J. Clinical pathways-an evaluation of its impact on the quality of care in an acute care general hospital in Singapore. *Singapore Med J* 2000;41(7):335-346.

365 Cheah J. Clinical pathways-an evaluation of its impact on the quality of care in an acute care general hospital in Singapore. *Singapore Med J* 2000;41(7):335-346.

366 Choong PF, Langford AK, Dowsey MM, Santamaria NM. Clinical pathway for fractured neck of femur: a prospective, controlled study. *Med J Aust* 2000;172(9):423-436.

367 Cheney J, Barber S, Altamirano L, Medico Cirujano, Cheney M, Williams C, Jackson M, Yates P, O'Rourke P, Wainwright C. A clinical pathway for bronchiolitis is effective in reducing readmission rates. *J Pediatr* 2005 Nov;147(5):622-626.

368 Sulch D, Perez I, Melbourn A, Kalra L. Randomized controlled trial of integrated (managed) care pathway for stroke rehabilitation. *Stroke* 2000;31(8):1929-1934.

369 Allen D, Gillen E, Rixson L. Systematic review of the effectiveness of integrated care pathways: what works, for whom, in which circumstances? *Int J Evid Based Healthc* 2009;7(2):61-74.

370 Wazeka A, Valacer DJ, Cooper M, Caplan DW, DiMaio M. Impact of a pediatric asthma clinical pathway on hospital cost and length of stay. *Pediatr Pulmonol* 2001;32(3):211-216.

371 Ayalon O, Liu S, Flics S, Cahill J, Juliano K, Cornell CN. A multimodal clinical pathway can reduce length of stay after total knee arthroplasty. *HSS J* 2011;7(1):9-15.

372 Friedman DM, Sokal SM, Chang Y, Berger DL. Increasing operating room efficiency through parallel processing. *Ann Surg* 2006;243(1):10-14.

373 Stahl JE, Sandberg WS, Daily B, Wiklund R, Egan MT, Goldman JM, Isaacson KB, Gazelle S, Rattner DW. Reorganizing patient care and workflow in the operating room: a cost-effectiveness study. *Surgery* 2006;139(6):717-728.

374 Mukherjee S, Fountain G, Stalker M, Williams J, Porrett TR, Lunniss PJ. The 'straight to test' initiative reduces both diagnostic and treatment waiting times for colorectal cancer: outcomes after 2 years. *Colorectal Dis* 2010;12(10 Online):e250-254.

375 Molyneux E, Ahmad S, Robertson A. Improved triage and emergency care for children reduces inpatient mortality in a resource-constrained setting. *Bull World Health Organ* 2006; 84(4):314-319.

376 Dzwierzynski WW, Spitz K, Hartz A, Guse C, Larson DL. Improvement in resource utilization after development of a clinical pathway for patients with pressure ulcers. *Plast Reconstr Surg* 1998;102(6):2006-2011.

377 Jano S, Harlin SA. Designing a carotid endarterectomy critical pathway for your organization. *Mil Med* 2000;165(5):385-389.

378 Stahl JE, Sandberg WS, Daily B, Wiklund R, Egan MT, Goldman JM, Isaacson KB, Gazelle S, Rattner DW. Reorganizing patient care and workflow in the operating room: a cost-effectiveness study. *Surgery* 2006;139(6):717-728.

379 Knutson JA, Morse CJ, Eldrup-Jorgensen J, Estee M, Hayworth L, Herman TA, Vereshko AS. Carotid artery endarterectomy: a multidisciplinary approach to improving resource utilization and quality assurance. *J Vasc Nurs* 2013;31(2):84-91.

380 [No authors listed] Hospital at home helps improve patient flow. *Hosp Case Manag* 2012;20(12):174-175.

381 Torkki PM, Alho AI, Peltokorpi AV, Torkki MI, Kallio PE. Managing urgent surgery as a process: Case study of a trauma center. *Int J Technol Assess Health Care* 2006;22(2):255-260.

382 Crawford EA, Parikh PJ, Kong N, Thakar CV. Analyzing discharge strategies during acute care: a discrete-event simulation study. *Med Decis Making* (Published online September 2013).

383 Miró O, Sánchez M, Espinosa G, Coll-Vinent B, Bragulat E, Millá J. Analysis of patient flow in the emergency department and the effect of an extensive reorganisation. *Emerg Med J* 2003; 20(2):143- 148.

384 Edwards C, Seggie J, Murphy M. Redesigning the response to patients with trauma. *Nurs Manag* 2012; 19(3):31-36.

385 Dickson EW, Singh S, Cheung DS, Wyatt CC, Nugent AS. Application of lean manufacturing techniques in the Emergency Department. *J Emerg Med* 2009; 37(2):177-182.

386 Silvester K, Mohammed MA, Harriman P, Girolami A, Downes TW. Timely care for frail older people referred to hospital improves efficiency and reduces mortality without the need for extra resources. *Age Ageing* (published online November 2013).

387 Weiland TJ, Mackinlay C, Hill N, Gerdtz MF, Jelinek GA. Optimal management of mental health patients in Australian emergency departments: barriers and solutions. *Emerg Med Australas* 2011; 23(6):677-688.

388 Ben-Tovim DI, Bassham JE, Bolch D, Martin MA, Dougherty M, Szwarcbord M. Lean thinking across a hospital: redesigning care at the Flinders Medical Centre. *Aust Health Rev* 2007; 31(1):10-15.

389 Baboolal K, Griffiths JD, Knight VA, Nelson AV, Voake C, Williams JE. How efficient can an emergency unit be? A perfect world model. *Emerg Med J* 2012; 29(12):972-977.

390 Haraden C, Resar R. Patient flow in hospitals: understanding and controlling it better. *Front Health Serv Manage* 2004; 20(4):3-15.

391 Khanna S, Boyle J, Good N, Bugden S, Scott M. Hospital level analysis to improve patient flow. *Stud Health Technol Inform* 2013;188:65-71.

392 Brewster LR, Felland LE. Emergency department diversions: hospital and community strategies alleviate the crisis. *Issue Brief Cent Stud Health Syst Change* 2004;(78):1-4.

393 Nicholas J. An integrated lean-methods approach to hospital facilities redesign. *Hosp Top* 2012; 90(2):47-55.

394 Ardagh MW, Tonkin G, Possenniskie C. Improving acute patient flow and resolving emergency department overcrowding in New Zealand hospitals - the major challenges and the promising initiatives. *N Z Med J* 2011; 124(1344):64-73.

395 Siegel B, Wilson MJ, Sickler D. Enhancing work flow to reduce crowding. *Jt Comm J Qual Patient Saf* 2007; 33(11 Suppl):57-67.

396 Primary Care Foundation *Urgent care centres: What works best?* Primary Care Foundation, 2012.

397 Primary Care Foundation *Urgent care centres: What works best?* Primary Care Foundation, 2012.

398 NHS England. *Everyone Counts: Planning for Patients 2013/14*. NHS England, 2012.

399 CQC. National NHS patient survey programme Accident and Emergency Department Survey 2012: full results with 2004 and 2008 comparisons. CQC, 2012.

400 Higginson I. Emergency department crowding. *J Emerg Med* 2012; 29(6):437-443.

401 Lee RS, Woods R, Bullard M, Holroyd BR, Rowe BH. Consultations in the emergency department: a systematic review of the literature. *Emerg Med J* 2008; 25(1):4-9.

402 O'Connell TJ, Bassham JE, Bishop RO, Clarke CW, Hullick CJ, King DL, Peek CL, Verma R, Ben-Tovim DI, McGrath KM. Clinical process redesign for unplanned arrivals in hospitals. *Med J Aust* 2008; 188(6 Suppl):S18-22.

403 O'Connell TJ, Bassham JE, Bishop RO, Clarke CW, Hullick CJ, King DL, Peek CL, Verma R, Ben-Tovim DI, McGrath KM. Clinical process redesign for unplanned arrivals in hospitals. *Med J Aust* 2008; 188(6 Suppl):S18-22.

404 Wright SE, Baudouin SV, Kaudeer N, Shrestha S, Malone J, Burn L, Kanagasundaram NS. Patient flow from critical care to renal services: a year-long survey in a critical care network. *QJM* 2008;101(8):643-648.

405 Khanna S, Boyle J, Good N, Bugden S, Scott M. Hospital level analysis to improve patient flow. *Stud Health Technol Inform* 2013; 188:65-71.

406 Higginson I, Whyatt J, Silvester K. Demand and capacity planning in the emergency department: how to do it. *Emerg Med J* 2011; 28(2):128-135.

407 Kunadian B, Morley R, Roberts AP, Adam Z, Twomey D, Hall JA, Wright RA, Sutton AG, Muir DF, de Belder MA. Impact of implementation of evidence-based strategies to reduce door-to-balloon time in patients presenting with STEMI: continuous data analysis and feedback using a statistical process control plot. *Heart* 2010; 96(19):1557-1563.

408 Jensen A, Boyle J, Khanna S. Visualising patient flow. *Stud Health Technol Inform* 2012;178:77-82.

409 Mayhew L, Smith D. Using queuing theory to analyse the government's 4-H completion time target in accident and emergency departments. *Health Care Manag Sci* 2008; 11(1):11-21.

410 Chazard E, Beuscart R. Graphical representation of the comprehensive patient flow through the hospital. *AMIA Annu Symp Proc* 2007:110-114.

411 Ward MJ, Farley H, Khare RK, Kulstad E, Mutter RL, Shesser R, Stone-Griffith S. Achieving efficiency in crowded emergency departments: a research agenda. *Acad Emerg Med* 2011; 18(12):1303-1312.

412 Silvester K, Mohammed MA, Harriman P, Girolami A, Downes TW. Timely care for frail older people referred to hospital improves efficiency and reduces mortality without the need for extra resources. *Age Ageing* (published online November 2013).

413 Khanna S, Boyle J, Good N, Bugden S, Scott M. Hospital level analysis to improve patient flow. *Stud Health Technol Inform* 2013; 188:65-71.

414 [No authors listed]. ED flow facilitators make throughput center stage, achieve decreases in LWBS, LOS, and door-to-bed times. *ED Manag* 2012; 24(9):103-105.

415 McClelland MS, Lazar D, Sears V, Wilson M, Siegel B, Pines JM. The past, present, and future of urgent matters: lessons learned from a decade of emergency department flow improvement. *Acad Emerg Med* 2011; 18(12):1392-1399.

416 Dickson EW, Anguelov Z, Vetterick D, Eller A, Singh S. Use of lean in the emergency department: a case series of 4 hospitals. *Ann Emerg Med* 2009; 54(4):504-510.

417 Mazzocato P, Holden RJ, Brommels M, Aronsson H, Bäckman U, Elg M, Thor J. How does lean work in emergency care? A case study of a lean-inspired intervention at the Astrid Lindgren Children's hospital, Stockholm, Sweden. *BMC Health Serv Res* 2012; 12:28.

418 Lin SY, Gavney D, Ishman SL, Cady-Reh J. Use of lean sigma principles in a tertiary care otolaryngology clinic to improve efficiency. *Laryngoscope* (published online March 2013).

419 [No authors listed] Barnes-Jewish Hospital applies lean methodology to acute stroke care, maximizing resources and slashing door-to-needle times. *ED Manag* 2013;25(2):13-17.

420 Yusof MM, Khodambashi S, Mokhtar AM. Evaluation of the clinical process in a critical care information system using the Lean method: a case study. *BMC Med Inform Decis Mak* 2012;12:150.

421 Kimsey DB. Lean methodology in health care. *AORN J* 2010;92(1):53-60.

422 Benson R, Harp N. Using systems thinking to extend continuous quality improvement. *Qual Lett Healthc Lead* 1994;6(6):17-24.

423 Spellman Kennebeck S, Timm N, Farrell MK, Spooner SA. Impact of electronic health record implementation on patient flow metrics in a pediatric emergency department. *J Am Med Inform Assoc* 2012; 19(3):443-447.

424 Castillo G, Wilson P. Logistics and lessons learned: ED redesign 3 years later - a follow-up to "How to create a new emergency department in 21 days or less." *J Emerg Nurs* 2012; 38(2):148-150.

425 Mabe PR, Lengacher CA. Redesigning emergency care: financial and cost analysis of services provided. *Nurs Econ* 1998; 16(2):75-82.

426 Niemeijer GC, Trip A, de Jong LJ, Wendt KW, Does RJ. Impact of 5 years of lean six sigma in a University Medical Center. *Qual Manag Health Care* 2012;21(4):262-268.

427 Pocha C. Lean Six Sigma in health care and the challenge of implementation of Six Sigma methodologies at a Veterans Affairs Medical Center. *Qual Manag Health Care* 2010;19(4):312-318.

428 Holden RJ. Lean Thinking in emergency departments: a critical review. *Ann Emerg Med* 2011; 57(3):265-278.

429 McGrath KM, Bennett DM, Ben-Tovim DI, Boyages SC, Lyons NJ, O'Connell TJ. Implementing and sustaining transformational change in health care: lessons learnt about clinical process redesign. *Med J Aust* 2008; 188(6 Suppl):S32-35.

430 Lin SY, Gavney D, Ishman SL, Cady-Reh J. Use of lean sigma principles in a tertiary care otolaryngology clinic to improve efficiency. *Laryngoscope* (Published online March 2013).

431 Evans B, Potvin C, Johnson G, Henderson N, Yuen I, Smith T, Metham S, Taylor S, Sniekers D. Enhancing patient flow in an acute care hospital: successful strategies at the Juravinski Hospital. *Healthc Q* 2011;14(3):66-74.

432 Wilson G. Implementation of Releasing Time to Care - the productive ward. *J Nurs Manag* 2009;17(5):647-654.

433 Niemeijer GC, Trip A, de Jong LJ, Wendt KW, Does RJ. Impact of 5 years of lean six sigma in a University Medical Center. *Qual Manag Health Care* 2012;21(4):262-268.

434 Pocha C. Lean Six Sigma in health care and the challenge of implementation of Six Sigma methodologies at a Veterans Affairs Medical Center. *Qual Manag Health Care* 2010;19(4):312-318.

435 Ben-Tovim DI, Bassham JE, Bennett DM, Dougherty ML, Martin MA, O'Neill SJ, Sincock JL, Szwarcbord MG. Redesigning care at the Flinders Medical Centre: clinical process redesign using "lean thinking". *Med J Aust* 2008; 188(6 Suppl):S27-31.

436 Scott IA, Wills RA, Coory M, Watson MJ, Butler F, Waters M, Bowler S. Impact of hospital-wide process redesign on clinical outcomes: a comparative study of internally versus externally led intervention. *BMJ Qual Saf* 2011; 20(6):539-548.

437 [No authors listed]. Lean-driven solutions slash ED wait times, LOS. *ED Manag* 2012; 24(12):139-141.

438 Rabin E, Kocher K, McClelland M, Pines J, Hwang U, Rathlev N, Asplin B, Trueger NS, Weber E. Solutions to emergency department 'boarding' and crowding are underused and may need to be legislated. *Health Aff* 2012; 31(8):1757-1766.

439 Hsu EB, Jenckes MW, Catlett CL, Robinson KA, Feuerstein C, Cosgrove SE, Green GB, Bass EB. Effectiveness of hospital staff mass-casualty incident training methods: a systematic literature review. *Prehosp Disaster Med* 2004; 19(3):191-199.

440 Mazzocato P, Holden RJ, Brommels M, Aronsson H, Bäckman U, Elg M, Thor J. How does lean work in emergency care? A case study of a lean-inspired intervention at the Astrid Lindgren Children's hospital, Stockholm, Sweden. *BMC Health Serv Res* 2012; 12:28.

441 Viau M, Southern B. Six Sigma and Lean concepts, a case study: patient centered care model for a mammography center. *Radiol Manage* 2007;29(5):19-28.

442 Edwards C, Seggie J, Murphy M. Redesigning the response to patients with trauma. *Nurs Manag* 2012; 19(3):31-36.

443 Nicholas J. An integrated lean-methods approach to hospital facilities redesign. *Hosp Top* 2012; 90(2):47-55.

444 Spaite DW, Bartholomeaux F, Guisto J, Lindberg E, Hull B, Eyherabide A, Lanyon S, Criss EA, Valenzuela TD, Conroy C. Rapid process redesign in a university-based emergency department: decreasing waiting time intervals and improving patient satisfaction. *Ann Emerg Med* 2002; 39(2):168-177.

445 [No authors listed]. Lean-driven solutions slash ED wait times, LOS. *ED Manag* 2012; 24(12):139-141.

446 Dickson EW, Anguelov Z, Vetterick D, Eller A, Singh S. Use of lean in the emergency department: a case series of 4 hospitals. *Ann Emerg Med* 2009; 54(4):504-510.

447 Holden RJ. Lean Thinking in emergency departments: a critical review. *Ann Emerg Med* 2011; 57(3):265-278.

448 Mabe PR, Lengacher CA. Redesigning emergency care: financial and cost analysis of services provided. *Nurs Econ* 1998; 16(2):75-82.

449 [No authors listed]. Slash diversion, improve care of boarded patients with an ED-based hospital medicine (HMED) team. *ED Manag* 2012; 24(11):124-127.

450 Henderson D, Dempsey C, Larson K, Appleby D. The impact of IMPACT on St. John's Regional Health Center. *Mo Med* 2003; 100(6):590-592.

451 Holden RJ. Lean Thinking in emergency departments: a critical review. *Ann Emerg Med* 2011; 57(3):265-278.

452 Van Dyke KJ, McHugh M, Yonek J, Moss D. Facilitators and barriers to the implementation of patient flow improvement strategies. *Qual Manag Health Care* 2011; 20(3):223-233.

453 Dickson EW, Singh S, Cheung DS, Wyatt CC, Nugent AS. Application of lean manufacturing techniques in the Emergency Department. *J Emerg Med* 2009; 37(2):177-182.

The Health Foundation is an independent charity working to improve the quality of healthcare in the UK.

We want the UK to have a healthcare system of the highest possible quality – safe, effective, person-centred, timely, efficient and equitable. We believe that in order to achieve this, health services need to continually improve the way they work.

We are here to inspire and create the space for people to make lasting improvements to health services.

We conduct research and evaluation, put ideas into practice through a range of improvement programmes, support and develop leaders and share evidence to drive wider change.

The Health Foundation
90 Long Acre
London WC2E 9RA

T 020 7257 8000
E info@health.org.uk

Registered charity number: 286967
Registered company number: 1714937

For more information, visit:
www.health.org.uk

Follow us on Twitter:
www.twitter.com/HealthFdn

Sign up for our email newsletter:
www.health.org.uk/enewsletter