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Temporal pacing of outcomes for improving patient flow: design science research in a National Health Service hospital

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Abstract

Improving patient flow in hospitals is a contemporary challenge in the UK National Health Service (NHS). When patients remain in a hospital bed for longer than clinically necessary, hospital performance is dramatically impacted, quality of care is reduced, and elective surgeries are cancelled at great cost to both hospital and patient. This research explains how one UK hospital employed design science research to improve patient flow when other process improvement techniques had failed. The work focused on improving patient flow through the creation of a set of interconnected, temporally paced routines that successfully engaged doctors and nurses in new, outcome-specific ways of working. These routines were both independent and interdependent, were relationally coordinated through time, and systematically and unambiguously engaged all levels of staff at specific temporal junctures. We discover that the successful adoption of these routines was cumulative, rather than iterative and aligned with ongoing efforts supporting the social aspects of change. Through this work, our case hospital saw performance improvements that moved them from being below average to the best in the country, combining improvements in patient care with savings of over £3 million in the first 12 months. The contribution of this research is twofold; first, we explain how the development of outcome-specific routines can facilitate process improvement, and second, we illustrate how design science research can successfully bridge theory and practice to promote swift and even flow in healthcare.

Keywords: Design science, process improvement, routines, healthcare, hospitals, patient flow

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1. Introduction

The UK health system is experiencing a humanitarian crisis (Campbell, Morris & Marsh, 2017). Cuts to social care provision, funding restraints, an increasingly elderly population, and growing demand for emergency services (Poteliakhoff and Thompson, 2011) have led to significant decline in performance in recent years. Many hospitals have been operating under a financial deficit since 2012, and performance against a number of core waiting time targets has deteriorated to levels analogous to 2007. NHS providers and commissioners ended 2015/16 with a deficit of £1.85 billion—the largest in NHS history (NAO, 2016). Accordingly, healthcare providers are being told they must redouble productivity efforts to deliver £22 billion of efficiency savings by 2021 (Alderwick, 2016).

Productivity revolves around two fundamental and interrelated principles: 1) units should flow as fast as possible through the system, and; 2) all sources of variation—quality, quantity, and timing—should be minimized (Schmenner and Swink, 1998; Schmenner, 2015). In a hospital, productivity translates broadly to the flow of patients from admission to discharge (Devaraj et al., 2013). However, policy makers' desire to redouble productivity efforts is far from unchallenged by healthcare professionals:

> "If patients were cars, we would all be used cars of different years and models, with different and often multiple problems, many of which had previously been repaired by various mechanics. Moreover, those cars would all communicate in different languages and express individual preferences regarding when, how, and even whether they wanted to be fixed." (Hartzband and Groopman, 2016, p. 107)

Moreover, physicians traditionally hold power and jurisdiction over nurses and managers (Abbot, 1988), and will commonly resist forms of managerial encroachment in order to protect their identity as an elite authority (Martin et al., 2009; Kellogg, 2010; Nancarrow, 2015). Enhancing productivity in healthcare requires attention to the social and political aspects

of change as well as the technical. Healthcare organizations must employ methods that bind these elements together, engaging managers and professionals toward the adoption of new practices that align with the values of the professional core. Here, we describe how the process of Design Science Research (DSR) led to a series of interventions and mechanisms in a UK hospital that successfully brought together a diverse set of professional and managerial perspectives to develop solutions that improved productivity. Thus, the goals of this research were:

1. To employ DSR to improve the productivity of a UK hospital, and;
2. Through DSR, address the social, political and technical aspects of productivity improvement.

We followed the 'CIMO' logic of Context-Intervention-Mechanism-Outcome (Denyer et al., 2008) to develop a set of three interventions and the mechanisms that facilitated them in order to create, implement, and embed routines to improve hospital productivity and performance against national waiting time targets.

Our research makes two contributions to healthcare operations improvement. The first is the explication of how and why outcome-specific routines support the technical aspect of process improvement. The second is an illustration of how the process of DSR can accommodate the social element of change to promote swift and even patient flow in a multijurisdictional professional service context.

The remainder of this paper is organized as follows. Section two presents our literature review. Section 3 describes the design science approach, our empirical context, and our set of three inter-related interventions. Section 4 describes the DSR project through which our interventions were deployed, the mechanisms through which the interventions were facilitated, and the performance outcomes the project achieved. In section 5 we summarize our findings

to understand why the DSR project was successful. We conclude with an outline of research limitations and implications for healthcare policy and practice.

2. Improving productivity in healthcare: Prescriptions from operations management

OM practices and process improvement methodologies can address the productivity problem faced by the NHS and other healthcare systems. However, their transfer into practice has been varied (Boyer and Provonost, 2010; Boyer et al., 2012; Kreindler, 2017).

Hospitals are analogous to: "immensely complicated processing plants, with thousands of parallel, often complex and interlocking, processes" (Rechel et al., 2010, p. 633). This structural and technical complexity is compounded by a complex social and political context that makes the operation extraordinarily difficult to manage (Glouberman and Mintzberg, 2001). Complex social systems require careful application of external and internal levers of control that can effectively mediate complex social and political systems to promote a desired operational response (Netland et al., 2015; Senot et al., 2016; Vogus and Iacobucci, 2016).

2.1 The productivity problem and patient flow

Schmenner (2015) hails productivity as the prerequisite of all economic success. The theory of swift and even flow (TSEF) was proposed by Schmenner and Swink (1998) on the basis that the productivity of any process rises with the speed by which inputs flow through the process and falls with increases in variability associated either with the demand on the process or with the steps in the process. TSEF, Schmenner argues, is "the thread tying together all productivity innovations in whatever sector*"* (2015, p. 341).

The applicability of TSEF to healthcare operations is implied in the linking of patient flow to throughput. Patient flow is influenced by a patient's length of stay (LoS), which is in turn influenced by the speed with which patients are processed (treated) toward discharge. A lack of patient flow restricts access to services by new patients, and subsequently waiting times

in the Emergency Department (ED) increase to the point of overcrowding and declining clinical outcomes. The best performing hospitals are those that have swift and even flow of patients through its system (Devaraj et al., 2013).

We reiterate that a hospital is a complex system, comprising multiple and interlocking, processes (Glouberman and Mintzberg, 2001; Rechel et al., 2010). The ED is the 'entry point' to this system: patients entering the ED are either treated (processed) within the department and discharged home, or they require further treatment involving an in-patient stay (requiring a bed) on an appropriate ward (i.e. one with specialist staff and equipment).

A patient's movement from ED to the wards is dependent on the efficacy of inter-related processes of bed management on specialist wards since patients cannot be admitted to a ward or department without an available bed. Thus, delays are caused by a lack of available bed capacity in wards other than the ED. Moreover, many patients, particularly older patients, rely on the inter-locking of processes between the hospital and external service providers such as social care, in order to facilitate a patient's discharge in a safe and timely manner. Therefore, delays can also be caused by a lack of integration with external service providers.

Internally, a patient's length of stay (LoS) is influenced by the amount of time spent waiting for the next step of treatment. Crucially, delays to the next step negatively affects patient flow, patient experience, and clinical outcomes (Devaraj et al., 2013); the additional burden upon staff and delivery cost as a direct result of non-value-adding waits are also significant (Dobrzykowski and Tarafdar, 2015).

Where patient LoS becomes protracted, beds become 'blocked' and wards are unable to accept new patients from ED. In this scenario, ED is unable to move patients to the appropriate ward and overcrowding in the ED occurs. Overcrowding impacts performance against core national targets such as the 4-hour waiting target in ED. To reduce overcrowding patients may be sent to wards that are not resourced to assist with their medical requirements

(i.e. they are medical outliers), and the overall quality of care is compromised. Moreover, elective surgery is also impacted: if beds are not available, elective operations are cancelled because there is nowhere for the patient to recover. Hence, managing bed capacity and length of stay are imperatives to improving patient flow, which is, in turn, linked to the delivery of high quality, safe patient care (Kreindler, 2017).

2.2 Barriers to process improvement in healthcare

Foundational principles of TSEF echo popular process improvement approaches. Both Lean and the Theory of Constraints (ToC) place primary emphasis upon *flow,* while Six-Sigma and Total Quality Management (TQM) emphasize reducing variation. Lean has proven to be a popular approach adopted by healthcare organizations globally (Radnor et al., 2012). However, implementation is often disjointed with improvements often reported at a functional rather than system level (Waring and Bishop, 2010; Burgess and Radnor, 2013;). Implementing a whole system approach requires significant and continued investment in process-improvement capability and continued and active participation from senior leadership, in particular the CEO.

Service delivery is also impacted by high levels of customer contact, which significantly impairs the potential for process efficiencies (Chase, 1978). Moreover, variation of inputs in terms of quality, quantity, and timing are more difficult to control in healthcare compared to manufacturing, and technological solutions do not always deliver the radical improvements in efficiency they promise (Dobrzykowski and Tarafdar, 2015). Finally, an enduring functional—as opposed to multi-disciplinary—arrangement of resources that typify most healthcare service provision means that patients do not typically flow through the system in a seamless manner (Modig and Åhlström, 2012).

2.3 Improving patient flow requires attention to Technical and Social elements

System change requires both technical and social elements. For example, Proudlove et al. (2003) prescribe technical change executed through better bed utilization with bed managers monitoring the supply and demand of beds in real time, with the aim of maintaining operational slack to cope with variation in demand. However, bed management practices are often far from rational, centralized, or planned. Typically, nursing staff take it upon themselves to manage bed utilization. For example, Allen (2015) observed the invisible work of nurses who draw upon an innate knowledge of beds, patients, and capacity requirements to continuously match patients to beds, mediating competing tensions between doctors and managers responding to wait-time targets and pressures in the ED. This skillful mediation of obstacles by nurses often requires building ad hoc systems to 'work-around' a problem (Spear and Bowen, 1999). Unfortunately, the prevalence of a work-around culture also stymies improvement since healthcare professionals become oriented towards first-order problem solving rather than understanding the root cause of the problem, and how to prevent its reoccurrence (second-order learning) (Tucker and Edmondson, 2003).

Successful approaches to enhancing patient flow commonly embody a combination of complementary interventions (Lewis and Edwards, 2013). For example, Silvester et al. (2014) outline a combination of practice changes that delivered significant improvements in patient flow and mortality without affecting re-admission rates or requiring additional resources. Focusing upon older patients, the hospital moved the bottleneck of assessing ongoing care needs from the hospital bed to the patient's home or residential place of care. This reduced patient LoS within the hospital and enhanced patient throughput. The hospital also implemented a seven-day working rule to promote an even flow of patients discharged from the hospital across the weekend and not just Monday to Friday. Finally, the hospital developed a focused approach to care delivery that cohorts patients with similar care requirements (i.e. a

frailty unit) to group resources and inputs together, creating the equivalent of a production cell, reducing variation in the quality and quantity of patient inputs through the ED.

The practices outlined above combine to achieve a common goal of expediting safe and timely discharge i.e. when a patient is declared medically fit they are transferred without delay to their residential place of care. This requires the elimination of non-value-adding activity to ensure patients are only in the hospital for the amount of time they require the specialist services of a hospital. In summary, service delivery should be designed around the needs of patients with a view to achieving patient flow (Modig and Åhlström, 2012). This requires a radical change in the way the system is designed and managed and relies on the commitment of relevant stakeholders to engage in new ways of organizing (McNulty and Ferlie, 2004; Schonberger, 2007).

2.4 Reducing variation in practice: A routines-based view

Defined as "repetitive, recognizable pattern(s) of interdependent actions, involving multiple actors" (Feldman and Pentland, 2003, p. 96), routines are analogous to processes in professional services (Lewis and Brown, 2012). Adopting a routines-based view allows insight into how we can reduce variation in the way work is performed (Pagell et al., 2015).

Routines are characterized as internally consistent practices that are often interrelated with other routines, referred to as 'bundles' (cf. Shah and Ward, 2003; 2007). Notable in Silvester et al.'s (2014) work outlined in section 2.3 is the clear labeling of the practice to clearly communicate the expected outcome. For example, the newly implemented practice 'discharge to assess' means that an assessment of ongoing care needs should take place after discharge. The importance of outcome-specificity is also captured in the work of Boyer et al. (2012) as a foundation for nurturing a safety-enabling culture.

Pagell et al. (2015) argue that the root cause of variance in the enactment of a routine

is due to the weak transmission of how a routine should be performed to align with the routine's intention. Extending Feldman and Pentland's (2003) characterization of routines as an embodiment of the ostensive (an abstract view of what the routine is expected to do) alongside the performative (how the routine is performed in practice), Bapuji et al. (2012) demonstrate the difference between a strong routine (intentions are unambiguously communicated to routine participants triggering the desired response) versus a weak routine (intentions are not clearly transmitted between participants in the routine, resulting in an ambiguous and unpredictable response).

Routine enactment is a collective activity, thus coordination and communication between actors who perform a task is essential to the emergence of a strong routine (Becker, 2004; Howard-Grenville, 2005; Boyer et al., 2012). Bapuji et al. (2012) identify the presence and movement of an intermediary (cf. Latour, 2005) as an important enabler of a strong routine. Furthermore, the successful performance of a routine is enhanced through the clear communication of the organization's broader social intention (Howard-Grenville, 2005; Bapuji et al., 2012). As such, a shared social goal may trigger a logic of complementarities (Kremser and Schreyögg, 2016), whereby participants in interrelated routines become invested in the broader social goal of the organization and work together towards its attainment.

3. Theoretical foundations for solution development

Hospitals continue to struggle with mismatches of capacity and demand, high levels of bed utilization, excessive waiting times, and other issues that are deleterious to patient flow, quality of care, patient safety, and financial steering (Dobrzykowski and Tarafdar, 2015). Despite evidence that process improvement practices can work in healthcare (Boyer and Provonost, 2010; Graban, 2012; Devaraj et al., 2013; Silvester et al., 2014), the measurable impact of these approaches is lacking (Boyer et al., 2012; Kreindler, 2017).

Reducing variation in demand in terms of the quality, quantity, and timing of inputs, alongside variation in the way that work is performed, is essential to enhance patient flow (cf. Schmenner, 2015). To be successful, a solution must consider the social complexity of healthcare, extending across multiple specialist functions and involving a diverse range of professionals (Ferlie et al., 2005). Healthcare professionals commonly resist attempts by management to implement managerial approaches (Martin et al., 2009). As such, any intervention should begin by engaging professionals toward the pursuit of a shared social goal (cf. Kremser and Schreyögg, 2016).

3.1 Design science research (DSR)

The purpose of DSR is twofold: first, to solve "authentic field problems" (van Aken et al., 2016, p. 1) and, second, to work toward generic interventions and mechanisms that can be deployed in the same and related contexts (van Aken, 2004; Denyer et al, 2008; Holmström et al., 2009). DSR is promoted as bridging the theory–practice gap by recognizing the interplay between Context, Intervention, Mechanisms, and Outcomes (CIMO). 'CIMO' logic can be used to create design propositions that contain *'information on what to do, in which situations, to produce what effect and offer some understanding of why this happens*' (Denyer et al., 2008, p. 396).

In this research, the complex nature of context necessitated interventions and mechanisms that were socio-technical (van Aken and Romme, 2012), aimed at facilitating collaboration between the different professions in healthcare.

3.2 The research site and problem to be solved

Yeovil District Hospital is a small hospital located in rural Somerset with 2,000 staff, 350 beds, and an annual budget of £120 million. It delivers most core NHS services, from maternity,

pediatrics, and the ED to elective surgery. Given its small size, the hospital is sensitive to changes in non-elective demand or any delays in discharging patients, leading to a history of significant waiting time and financial pressures, overcrowding in its ED, and cancelled operations due to a lack of available beds.

Prior to the project, the UK's four-hour waiting time standard for patients attending the ED had not been met since July 2015 and cancelled operations peaked at 126 in March 2016, costing £380,000 of income that month alone (YDH, 2016). In addition, the day-case unit, which would normally process high volumes of patients not requiring overnight stay, was routinely used as an inpatient ward generating a high number of medical outliers.

Poor waiting time performance and cancellations to elective procedures carry a substantial financial penalty to the hospital, creates a stressful working environment, alongside poor patient experience. The innate interdependency of performance outcomes in ED combined with high numbers of cancelled operations, and financial pressure meant that improving performance against key waiting time targets was a pivotal organizational concern.

From March 2016 to September 2017, the Director of Operations at Yeovil (one of the authors), led a project to improve patient flow and enhance performance against key waiting time targets. As such, DSR was employed to:

1. Develop a set of interventions (cf. Denyer et al., 2008) to improve patient flow in an acute general hospital setting;
2. Identify and implement mechanisms (cf. Denyer et al., 2008) to foster inter-professional collaboration on interventions to improve patient flow.

This research uses as its sample frame the interactions, meetings and results of the Patient Flow Project at Yeovil Hospital in the period March 2016 to September 2017. Data were collected on the efficacy and evolution of the project through several means. First, a journal (cf. Coughlan and Coghlan, 2002) was regularly populated to capture notes and reflections across

the project duration and particularly after key project events such as workshops, or after a success or failure. Where appropriate we have used this evidence in describing our research. Second, a project meeting was introduced weekly and a record kept of key events and points of note regarding either the success or otherwise of interventions. Third, quantitative data reflecting the outcomes of the project were tracked via hospital computer systems.

3.3 Identification of the Initial Interventions

The first step of the DSR project was to combine prescriptions from operations management with practice-based knowledge (cf. Holmstrom et al., 2009) and theory to create interventions I1 and I2. We adopted the CIMO logic to identify and develop interventions and mechanisms to improve performance outcomes (Denyer et al., 2008).

In the months prior to the DSR project our case study hospital failed to engage senior leaders and influential doctors in using process improvement approaches to improve patient flow. Healthcare professionals had dismissed the approach as too abstract, claiming it was a management fad, aimed at delivering operational efficiencies that did not align with their professional goals of delivering high-quality care (notes from field journal). Thus, our initial intervention prioritized the engagement of healthcare professionals towards a shared goal that aligned managerial and professional objectives. Our first intervention in the DSR project was:

I1: Connect and engage healthcare professionals toward a shared goal of improving patient flow.

This intervention pays attention to socio-cultural complexities in order to engage powerful individuals (e.g. senior physicians) to connect and work alongside those with broader process insight (e.g health professionals, nurses, and nurse managers) towards a shared goal.

Our second intervention was to facilitate clear and unambiguous communication and coordination of routines that collectively focus healthcare professionals across disparate departments towards the shared goal of improving patient flow (Becker, 2004; Howard-Grenville, 2005; Boyer et al., 2012; Silvester et al., 2014). Strong routines reduce variation in both the interpretation and enactment of a routine by participants (Bapuji et al., 2012; Pagell et al., 2015). Aligned to this, any solution should embody outcome-specific goals (cf. Boyer et al., 2012). In our case, this clearly communicated the aim of a routine, reduced variation in its enactment, and facilitated a sustained and collective focus upon swift and even patient flow. Thus, our second intervention was:

I2: Create a bundle of inter-related, outcome-specific routines that promote swift and even patient flow.

These routines emerged via an iterative problem-solving approach using mechanisms employed in relation to I1. I2 produced a bundle of six outcome-specific routines, each contributing to improving patient flow. The routines aligned to days and times of the week, representing clear and unambiguous mechanisms of communication and co-ordination across different professions and departments. With each routine successfully embedded, came the realization that the quantity of patient admissions could be reduced by enhancing the provision of treatment available via the AEC (Ambulatory Emergency Care) department.

AEC is a service that provides many of the diagnostics that patients require within just a few hours of admission through senior nurse leadership and dedicated diagnostics, thereby avoiding the need for admission to a hospital ward and a hospital bed. Prior to the project, Yeovil District Hospital had a very small AEC unit with just one trolley that was frequently used for admissions, restricting the ability of AEC to function in the manner policy makers had intended. Yeovil had created their AEC primarily to comply with national guidance (cf. RCP,

2013), but the facility was under-resourced and under-utilized by ED staff. Historically, repeated requests from the clinical team to expand AEC had not gained executive or financial support. With the implementation of I1 and I2, the potential for AEC to contribute to the collective goal of improving patient flow became a dawning reality:

> "We were aware of the concept of AEC but for various political reasons I think its potential wasn't appreciated." (Senior manager, notes from field journal)

Increasing AEC capacity facilitated the swift treatment of ambulatory patients without the need for admission, thereby reducing waiting times in the ED and reducing the number of patients being admitted to hospital wards. This unanticipated intervention suggests that complex interventions may necessitate a cumulative process of discovery, where effort directed at connecting and engaging diverse healthcare professionals towards a shared goal (I1 and I2) must be sustained in order to explore new ways of working. To conclude our identification of initial interventions, I3 was:

I3: Reduce input variation to make flow swifter and more even.

This additional intervention required a £10,000 investment in the expansion of AEC. The expansion utilized space on the day-case unit which had been used when the wards were full. This repurposing of capacity sent a clear and unambiguous message to all healthcare staff that it was no longer acceptable to use the day-case to resolve overcrowding issues in the ED.

4. The DSR project at Yeovil

4.1 The initial state

When the project began in March 2016, staff were defensive in regard to the need to improve patient flow and expedite discharges (notes from field journal). Managers at Yeovil were

enacting NHS guidance that hospital wards needed to focus their attention on discharging patients. This prompted nurses at Yeovil to direct blame towards external social care providers. For example, when asked about how flow could be improved, one senior nurse stated "the issue is social care operates in weeks rather than days or hours as we do in the hospital. Unless we fix that there's nothing much we can do"

While inefficiencies in social care processes were acknowledged to be impacting patient flow within the hospital, this initial externalization of the cause of delays made it difficult to engage teams in internal efforts to improve the rate of patient discharge. This was compounded by a lack of data analysis to understand why patients were not flowing through the wards at a rate commensurate with their recovery status. Resonating with findings in the literature (cf. Proudlove et al., 2003; Allen, 2015; Dobrzykowski and Tarafdar, 2015) we also found little evidence of a structured approach to managing bed occupancy at Yeovil.

Finally, there were cultural issues where meetings focused on improving patient flow would become dominated by a few more senior and vocal staff while more junior staff with more front-line experience remained silent. A number of instances were observed where a junior staff member made an initial suggestion but was over-ruled by their senior, and subsequently no longer contributed to the discussion. In March 2016 performance against key indicators was as follows:

i. Four-hour ED waiting time performance: 88% against a national target of 95%;
ii. Average LoS for patients was 5.7 days;
iii. Number of surgical operations cancelled in elective care (due to availability of beds) during Oct 2015 to March 2016: 253. Annualized cost of cancellations circa £2.1 million.

In the following sub-sections, we describe each of the interventions in the DSR project and the mechanisms that facilitated successful outcomes.

4.2 I1: Connect and engage healthcare professionals towards a shared goal of patient flow

The DSR project began by directing efforts towards connecting and engaging a diverse team of healthcare professionals in improving patient flow. This was taken forward via a series of frequent, informal meetings to avoid the cultural divisions that had manifested in prior attempts to formalize an approach to improving patient flow (Mechanism 1). These weekly meetings included a common core of patient flow leaders including the Director of Operations and the Head of Patient Flow, and a wider group of participants appropriate to the specific objective being discussed. Participants were selected on the basis that they were considered the most likely to influence change rather than necessarily those who were in positions of authority. Meetings focused upon the collective scrutiny of performance data to understand the problem in ways that aligned the managerial goal of enhancing patient flow to the professional goal of providing the best possible care to the patient (Mechanism 2).

In addition to the weekly meetings, daily informal meetings (huddles) built ongoing dialogue among staff and maintained focus upon the collective agreement that improving patient experience required improvements to patient flow (Mechanism 3). This led to multi-disciplinary professionals working collaboratively across jurisdictions towards the shared goal of improving patient flow (Outcome 1).

4.3 I2: Create a bundle of inter-related, outcome-specific routines that promote swift and even flow

Work towards I2 began in May 2016 and took approximately eight months. I2 was delivered by the same diverse team of professionals that formed as part of I1. Acknowledging that a clear articulation of outcome-specific objectives was valuable for engaging and coordinating diverse sets of actors, the team settled on the following three objectives:

Objective 1: Facilitate discharges before midday on Monday

Admissions to wards are variable but somewhat predictable (NHS, 2015). At Yeovil District Hospital peak demand occurs on a Monday morning when many wards are full due to a lack of discharges over the weekend, only to receive new patients around Monday lunchtime. This was validated by staff and through repeated analysis of ED data. Figure 1 shows the average breaches that occurred within the ED in the 12 months prior to the commencement of the DSR project.

Insert Figure 1 about here

Prioritizing discharge on Monday mornings enables the receiving wards to accommodate new patients sooner.

Objective 2: Address delayed transfer of care (DTOC)

Objective 2 sought to reduce the number of patients who were ready for transfer to a place of care but continued to occupy a hospital bed. At the start of the project nurses argued they were unable to discharge medically fit patients because of delays originating from the external social care provider. While managers felt these delays were only part of the problem, they recognized the importance of engaging both internal and external stakeholders in this work. This recognition demonstrated to the nurses the commitment of management to address complex issues that extended beyond the wards (Mechanism 4). Achieving this objective required nursing and managerial staff to connect and engage external social care service providers on a regular basis in order to facilitate more effective transfer of patients from the hospital to the community.

Objective 3: Increase discharges at weekends

While the majority of breaches took place at the beginning of the week, further analysis indicated that on average there were 24 fewer discharges than admissions across the weekend. Therefore, objective 3 sought process improvements to increase weekend discharges.

At this early stage there was acknowledgement by all parties of causally complex interdependence between the three problem areas identified above. For example, focusing on discharges before midday would not reduce delays in transfer of care (to social care). However, reducing internal delays to discharge would reduce the burden on available beds when a new week began.

Acknowledging the complexity of the problem and the subsequent need for coordination and collaboration among a diverse set of healthcare professionals, the Director of Operations sought ways to communicate each of the emerging routines in a clear and unambiguous manner. At this juncture it was noted that patterns in demand consistently aligned with specific days of the week and time of day. Taking inspiration from retail operations, a decision was taken to communicate each new routine in a way that aligned to pivotal days and times across the week (Mechanism 5). These routines were communicated both formally and informally through:

1. The Head of Patient Flow emphasizing the importance of the new routines at daily bed meetings;
2. The Director of Operations mentioning the routines frequently in multiple existing but unrelated meetings: “it’s Morning Monday today, how are we doing?”;
3. The Head of Patient Flow visiting wards to talk about the routines directly with ward managers.

Routine 1: Morning Monday

Initially, Monday mornings were identified as the primary capacity constraint owing to a lack of discharge over the weekend. Work toward this objective took the form of the Head of Patient Flow visiting wards every Monday at 10am (Mechanism 6). The visit from the patient flow manager produced a collaborative environment where doctors and nurses worked together to secure at least one discharge before midday. This outcome-specific routine became known as *Morning Monday.*

Routine 2: DTOC Thursday

On Thursdays, there was historically a review of the delayed transfer of care (DTOC) for patients who were medically fit and waiting to be transferred from hospital to external providers of social care. Prior to the DSR project this meeting involved the patient flow manager and the social care manager. The new routine *DTOC Thursday* presented a more rigorous approach to reducing delays caused by external care processes. The new routine involved a multi-disciplinary meeting scheduled at 10:00am, attended by the Director of Operations at Yeovil and senior external stakeholders including the Director of Social Care, Social Care Manager, Discharge Team Manager, and Community Services Lead. The primary focus of this weekly multi-jurisdictional meeting was to discuss patients experiencing delays. Within a few weeks, DTOC Thursday led to the co-creation of a 'red escalation process' that focused urgent attention on patients waiting 30 days or more.

The new process involved an internal escalation to the Director of Operations followed by a phone call with the Social Care Director to urgently examine why the patient's transfer was delayed and to expedite a plan for transfer. Previously, wards struggled to effectively communicate the urgency of delays with social care, but, with the implementation of the red escalation process, DTOC for patients waiting 30 days or more fell from 27 in April 2016 to

just one in November 2016 (see Figure 2) and ultimately led to Yeovil achieving the lowest social care delays in the region .

Insert Figure 2 about here

Routine 3: Weekend Flow

This routine involved an iterative and sustained focus on interventions at weekends to improve discharges and reduce delays, with managers and directors shadowing weekend teams to discover real issues faced in situ. Some quick-wins were redesigning staff schedules to increase medical cover on weekends facilitating the formation of a 'discharge hit squad.' The hit squad happened as it was found that junior doctors were over-worked and unable to complete discharge requirements as well as prioritize clinical care for new admissions. The discharge hit squad is made up of one senior and one junior doctor. The squad joins the morning huddle led by the Site Manager to discuss a plan for the day, before addressing a list of patients who could go home if reviewed. In short, the creation of a discharge hit squad allowed the main medical team to review new patients and those requiring medical care.

Following the introduction of the initial three outcome-specific routines it was apparent that a sense of camaraderie and competition was emerging across the wards (Outcome 2). *Morning Monday* was particularly popular since teams were incentivized by the introduction of a monthly award for the best performance – named the 'Carney Cup' after the Head of Patient Flow:

> Ward 8B were giving great banter today, I asked Jon [an F1] if he could complete a discharge summary to get a patient home by midday. He told me, as long as there's a hamper involved, he's up for it and wrote the discharge summary there and then! (Head of Patient Flow, notes from field diary)

In addition, the interventions and mechanisms developed and deployed in this stage led to reduced DTOCs and an improvement in the rate of discharge over the weekend (Outcome 3). The success of the DSR project in engaging staff in new, strong routines to improve patient flow (Outcome 4) laid the groundwork for an additional round of improvements within the wards.

A further round of improvements built upon a growing consensus between managers, senior doctors and nurses that targeting internal delays was as important as improving external delays. One ward sister stated, "there's still issues with packages of care but I recognize there's more we can do internally to reduce delays" (note from field diary). Hence the goal of the next round of improvement was to focus upon each patient's next step of treatment.

Routine 4: Next Step Tuesday

Discussing a patient's next step as opposed to a delay aligned the desire of healthcare professionals to provide high-quality patient care with a managerial desire to increase productivity. To facilitate this, walk-arounds by the patient flow manager and the Director of Operations were introduced on Tuesday mornings to review delays on wards and talk to frontline staff about issues faced. *Next Step Tuesday* formalized these walk-arounds so that the arrival of senior managers was expected and ensuing discussion to assist with barriers to a patient's next step was welcomed.

Routine 5: 14-bed Wednesday

Further data analysis revealed that long-stay patients from older age groups utilized a large proportion of beds. However, contrary to the belief of many staff, not all patients were medically fit and awaiting social care. This led to the introduction of a new routine requiring assessments of all patients that had been on the wards for longer than 14 days to determine

whether they were physically fit to move on to the next step of their care pathway. *14-day Wednesday* bridged the gap between Tuesday's focus on patients identified as ready for the next step in their hospital care pathway with Thursday's focus upon reducing delays that were caused by interlocking processes external to the hospital.

Routine 6: 30-bed Friday

While work had been initiated to improve discharges at the weekend as part of the weekend flow routine, Friday emerged as a pivotal day for ensuring sufficient capacity was available for weekend admissions. Given that the average weekend shortfall of discharges was 24, this new routine was introduced to create sufficient capacity to address this shortfall. The goal was to ensure the hospital had 30 beds available by the end of Friday's shift to correspond with demand over the weekend.

In summary, six outcome-specific routines were co-created by a diverse team of healthcare professionals working alongside senior managers and external stakeholders, toward a shared goal of improving patient flow. The daily routines were inter-related and temporally paced to maintain a consistent and sustained focus upon the shared goal. To assist with communication of the routines across the organisation, a poster (shown in figure 3) was put up across all wards and management offices. The poster provides clear, unambiguous communication of the routine's intention in the form of temporally paced, outcome-specific goals alongside the pattern of activity associated with each routine including the timing of each activity, and the routine's participants.

Insert Figure 3 about here

4.4. I3 - Reducing variation of patient inputs to enhance productivity

The final intervention of the DSR project, sought to eliminate the admission of patients to wards who could be treated without the need for a bed. I2 had made some good progress however, Yeovil were still forced to use escalation beds to cope with excess demand and there remained a need to reduce medical outliers. Discussion with the Nurse Consultant for the ED and frontline staff (facilitated by I1) led senior management to recognize the potential for an enhanced AEC service to the hospital wide patient flow endeavor; subsequently a decision was made to expand AEC capacity.

On the basis that increasing capacity of AEC will lead to fewer medical outliers (who typically ended up on the day-case unit), the hospital elected to repurpose part of the day-case unit to create a seven-bay AEC (Mechanism 7). The net financial investment in AEC was around £10,000 (factoring in staffing costs and income changes), but a commitment to reduce medical outliers on the day-case unit communicated a clear message about the hospital's commitment to supporting AEC to execute their role in reducing hospital admissions and improving patient outcomes (Outcome 5).

The AEC team had previously felt unsupported and ignored as a service. One staff member explained: "We've been here with minimal resources—just what we could spare from the ED; it's always felt like we are not seen as important." However, following the changes they noted "it's like all our dreams are coming true at once … 27 patients through AEC today alone—it's a record!*"* Further, the Head of AEC begun communicating a new mantra across the unit: "I tell staff that our patients are *'ambulatory until proven otherwise'*"; this narrative clearly enforces a change in mindset from one of admission for all who require treatment to admission only for those with acute care requirements. The impact of this change in mindset across AEC and the ED can be seen by the significant reduction in patient admissions shown in Figure 4.

Insert Figure 4 about here

4.5 Performance outcomes

Prior to the commencement of the DSR project, Yeovil's performance against the UK's four-hour waiting time target for the ED was just 88% against a target of 95%, and the number of cancellations of surgical operations in elective care were circa 500 per year.

Against the key indicators for patient flow identified at the start of the project, Figure 5 shows significant reductions in the first two indicators: number of cancellations of surgical operations (reflecting a cancelled episode of elective care due to lack of bed availability) and waiting times in the ED. Reductions in cancellations achieved annualized savings of approximately £1.75 million.

Figure 5 around here

A further indicator of success was a sustained reduction in the average LoS for non-elective patients since this would free beds for electives as well as improve patient flow. Figure 6 below shows the sustained reduction in this metric throughout the project leading to a 14% reduction in LoS comparing January 2016 to September 2017.

Figure 6 about here

In keeping with TSEF, improvements in patient flow led to substantial performance improvement and significant financial savings (Outcome 6). Investments in AEC facilitated a reduction in the quantity of inputs alongside greater standardization of the quality of inputs being admitted for acute care. This, combined with process improvements that enhanced

patient flow, subsequently enabled the closure of a ward and a reduction in escalation beds used to accommodate medical outliers during times of high demand. Table 1 outlines the total expenditure and annualized savings resulting from the project.

Table 1: Costs and savings from the patient flow DSR project

Costs	**Annualized value (£)**	**Notes**
Funding of AEC	-10,800	Cost of staff and loss of admissions income offset by increased day-case tariff for work.
Flow interventions	-151,478	The cost of increased medical input on weekends to form the discharge hit squad.
Total costs	(162,278)	
Reduced cancellations	1,750,000	Based on comparison of actual cancellations in Oct 2015-March 2016 compared to Oct 2016-March 2017 and then annualized.
Ward closure	800,000	Based on beds being reopened for four months of year to deal with winter increase in demand
Closure of 14 escalation beds	846,279	Escalation beds are high-cost due to these being staffed with agency nurses
Total savings	**3,396,279**	
Net Savings	**3,234,001**	

During 2017, Yeovil District Hospital became one of a small number of hospitals in the UK to meet the four-hour waiting time target for emergency care. The hospital saw 96.9% of all patients arriving in the ED within four hours, exceeding the national 95% target. The hospital's enhanced performance has enabled the organization to attract more qualified staff, reducing consultant emergency physician vacancies from 57% in 2016 to zero in 2017 and nurse vacancies from 23% in 2016 to 4% in 2017.

Finally, the introduction of the routines and subsequent improvements in patient flow led to a better working environment (Outcome 7). Reduced waiting times in ED alongside the increased capacity and utilization of AEC created less crowding in ED whilst patients waited for beds which in turn reduced stress for frontline staff. Following the project, Yeovil saw improvements in staff satisfaction (see Table 2).

Table 2: Staff satisfaction survey results at Yeovil before and after the DSR patient flow project

Staff survey results	**2016 (Before project)**	**2017 (After project)**
	Percent agreeing or strongly agreeing	*Percent agreeing or strongly agreeing*
Good practice is used to develop services	32%	61%
When I work I feel energized	26%	44%
I feel myself more and more engaged in my work	33%	58%
I can tolerate the pressure of my work very well	42%	78%

5. Discussion

Our research sought to improve patient flow in a busy UK hospital. Using DSR we developed a set of interventions and mechanisms that incorporated a set of six, strong routines that fostered collaboration and coordination amongst diverse professional actors, working towards a shared social goal of improving patient experience. Our routines collectively promoted swift and even flow of patients from diagnosis in ED to treatment on the wards, to safe and timely discharge. The combined outcomes of our interventions and mechanisms include improved waiting times in the ED, reduced cancellations of elective surgery, reduced length of stay, reduced costs, and increased workforce morale. Table 3 summarizes the interventions, mechanisms, and outcomes developed through this DSR project.

Table 3: Summary of Interventions, Mechanisms and Outcomes

Context	Intervention	Mechanism	Outcome
Overcrowding in ED causing significant performance issues, high cost and poor patient outcomes. Professional dominant core; senior staff over-ruling junior staff; previous approaches to improve patient flow considered too abstract and a management fad; nurses feel blamed, some staff disillusioned.	*I1: Connect and engage healthcare professionals toward a shared goal of improving patient flow*	1. Frequent and informal meetings between a diverse team of professionals; 2. Use data to understand the problem in ways that align managerial goals with professional values; 3. Build ongoing dialogue focused upon the pursuit of a shared social goal.	1. Multi-jurisdictional professionals work collaboratively towards a shared social goal of improving patient experience through enhanced patient flow.
	I2: Create a bundle of inter-related, outcome-specific routines that promote swift and even patient flow	4. Connect to and engage internal and external stakeholders to develop partnership working; 5. Communicate each of the emerging routines in a clear and unambiguous manner (i.e. outcome-specific and temporally paced); 6. Employ intermediaries to trigger successful enactment of routine.	2. Implementation of six temporally paced routines clearly connecting and communicating action towards an outcome-specific goal; 3. Collaboration and camaraderie to discharge patients and free up beds at pivotal times of the day and week; 4. Enhanced patient flow.
	I3: Reduce variation of inputs to make flow swifter and more even.	7. Invest in additional resource to cohort patients with ambulatory care needs and restrict admission to wards to those with medical needs that require an overnight stay.	5. Significant reduction in the quantity of patients admitted to the wards; 6. Enhanced performance outcomes and financial savings. 7. Enhanced staff morale and reduction in staff vacancies.

In our discussion we turn attention to understanding why this DSR project was so successful and explain how and why the development of outcome-specific routines facilitated improved patient flow.

Healthcare presents a challenging context for implementing change. Managerial terms like productivity, swift and even flow, and even patient flow have failed to gain traction within a professional dominant context. Efforts to improve patient flow are stymied by both the complexity of interlocking processes that must connect and co-ordinate activity to process patients, alongside the propensity for senior doctors to actively resist changes to their practice (Martin et al., 2009; Kellogg, 2010; Nancarrow, 2015). At Yeovil, we saw resistance at the outset of our project as a consequence of the managerial and political framing of the organizational challenge. Prior to the DSR project, meetings about patient flow involving senior staff frequently became heated, the implementation of improvement approaches were dismissed as too abstract. Nurses felt blamed for problems relating to discharge and quick to deflect the issue towards external partners on the basis that the majority of opportunities to improve flow lay with social care. I1 was an acknowledgement that successful change relies upon engagement and collaboration from a diverse team of professionals, including doctors, nurses, and managers. The approach allowed all perspectives to be shared and respected (Imison et al, 2012; Pagell et al, 2015). I1 was successful because the mechanisms that allowed the intervention to succeed were focused around fostering ongoing dialogue centered around a shared social goal (Howard-Grenville, 2005; Bapuji et al, 2012; Kremser and Schreyögg, 2016).

5.1 Establish a shared social goal to guide the creation and implementation of new routines.

I1 enabled improvements in patient experience to emerge through which professional goals aligned with the managerial goal of improving patient flow, triggering a logic of complementarities (cf. Kremser and Schreyögg, 2016). With patient flow aligned to professional values, the improvement endeavor was subsequently operationalized via regular and informal meetings through which teams on the wards and in ED, would collectively scrutinize demand data and share perspectives on the problems affecting patient flow.

The frequency and informality of these meetings not only allowed participants to understand data in real time, they also facilitated regular social interaction, lowering hierarchical barriers and fostering a climate increasingly focused upon patient experience. The clarity and constancy of focus upon a shared social goal was conducive to the rapid development and testing of new practices within a multi-jurisdictional context (cf. Boyer et al., 2012; Netland et al., 2015; Senot et al., 2016; Vogus and Iacobucci, 2016). Crucially, healthcare professionals were systematically involved in decisions about the efficacy of improvement efforts, and reflections about what more could be done. As such, they assumed ownership of the routines because they understood the reason behind it, and they were involved in the testing and implementation of each routine.

5.2 Make the change process operationally relevant, simple, and memorable to promote inter-professional collaboration

Regular and collective examination of demand data (via I1) enabled the creation of technical solutions to improve patient flow through the implementation of six outcome-specific routines (I2). Cognizant of the pressure placed upon wards, initial solutions focused on the most visible pressure points identified by staff (routines 1-3). Focusing on issues that staff considered most important was crucial to ensuring that all stakeholders feel their perspectives are listened to and thus working together to resolve these issues first was important for securing their ongoing

engagement with the work (Pagell et al, 2015). The second phase of I2 targeted delays internal to the organization.

Reflecting on the successful implementation of the new routines in relation to I2, we note that through temporal pacing of outcome-specific targets, staff at Yeovil were configured into a repetitive cycle of action learning sets that were focused on each of the six areas for improvement. This allowed rapid cycles of design, test, implement, and embed analogous to the cyclical approach to process improvement commonly employed in healthcare and other settings (Reed and Card, 2016). In being oriented to days of the week the outcome-specific routines provided predictability of interactions among the various individuals and professions (cf. March and Simon, 1993). They also served to help people remember priorities and engage with them more fully. Moreover, all staff were knowledgeable about the changes and responsibilities through the prominent display of artifacts such as that shown in Figure 3 and the pattern of action in the form of meetings and walk-arounds that triggered each element of the routine.

Incorporated into the routines, the daily meetings and walk-arounds of management staff became a notable mechanism (Mechanism 6) for triggering routines, ensuring the enactment aligned with the routine's intention. Figure 3 reveals that each routine incorporates the movement and placement of 'intermediaries' (cf. Latour, 2005; Bapuji et al, 2012) at specific times in specific places to facilitate the enactment of the routine. For example, the Patient flow manager will visit the wards as part of the *Morning Monday* routine. The anticipated presence of this individual ensures the ward manager has prepared the necessary information to facilitate enactment of the routine in the manner expected. Similarly, *Weekend Flow* was facilitated by a 'discharge hit squad,' whose presence focuses the attention of weekend staff on swiftly discharging patients when previously this had not been viewed as

important. Using human intermediaries in this way reinforces the routine and focuses attention toward the intended outcome.

Making the change process operationally relevant, simple, and memorable yielded organizational benefits. Success was due in part to the early recognition that rather than implementing vague management concepts such as ToC and lean, process change needed to be broken down into operationally relevant indicators that were memorable and simple. By making the routine outcome-specific (cf. Boyer et al, 2016), and naming a priority after each day, there were a number of instances recorded in the research diary of people becoming aware of the themes and their importance. For example, even the Chief Executive mentioned in Board meetings, "it's *14-day Wednesday* today—how are we doing against our target?". The engagement could also be seen in discussions with the broader organization on whether the targets set were appropriate. For example, initially 30-bed Friday was named 20-bed Friday as it was felt this would be sufficient to achieve targets for the weekend. However, Matrons and the Head of Patient Flow challenged this for being unambitious and suggested 30-bed Friday would be better.

In summary, I1 and I2 fostered inter-professional collaboration which I3 subsequently built upon. At Yeovil, local successes facilitated a dialogue with other departments and services about the project and how they might coordinate processes to assist with the achievement of the broader social goal of patient experience. By recognizing that some of the root causes of poor discharge performance was due to a lack of upstream and downstream integration, staff at Yeovil could collectively ensure that patients are admitted to a hospital bed only if they cannot be treated swiftly in AEC.

5.3 Reduce variability of patient inputs

Variation of inputs in terms of quality, quantity, and timing are considered more difficult to control in a healthcare context (Dobrzykowski and Tarafdar, 2015). Ambulatory care should be employed to segment patients with ambulatory needs to reduce the quantity of patients being admitted to wards who could be treated and discharged the same day (NHS, 2017). Most hospitals in England now have an ambulatory care unit, however, how they are utilized varies. At Yeovil, the AEC service had been poorly staffed and poorly equipped, indicating that the organization did not value the resource. It was only once the organization had introduced the patient flow project and had started to obtain basic stability, that staff realized many patients being admitted to wards could have been processed swiftly in AEC. This supports the river and rocks analogy employed in education around process improvement: it is only when the level of the river (i.e., inventory/patients in beds) is lowered that underlying process problems (represented by the rocks) can be solved.

We contend that the success of the AEC was an outcome of the sequence of - and specifically the cumulative nature of - the interventions. The sequence of steps that the project moved through progressed the problem from one of disillusioned staff disinterested in change, to one of expediting discharge through outcome-specific routines designed to facilitate swift and even flow, to one of reducing variation in inputs via investment in AEC.

5.4 Interventions are cumulative and sequential

Contrary to more generic process improvement approaches (Zbaracki, 1998), there was no requirement to invest resources in developing quality improvement skills, nor was there a requirement for long-term commitment of senior management. We contend that the success of the patient flow project came from ongoing investment in I1: connecting and engaging professionals in dialogue about improving patient flow. Akin to the 'sand cone' model of

improvement (Ferdows and De Meyer, 1990) we argue that continuous investment in the social aspect of change (I1) enabled the hospital to subsequently create and embed new routines that fostered swift and even flow (I2); subsequent investment in both I1 and I2 nurtured basic stability, accompanied by an improvement mindset, thereby opening up new possibilities for thinking about how we manage flow (I3).

6. Conclusions

This work employed a DSR approach to improve patient flow within a UK hospital to deliver effective care at lower cost. Over the project, the performance of the hospital went from the lower quartile to among the best in the country. Prior to the project, cancelled operations caused by poor patient flow peaked at 126 in a month (March 2016, equivalent to a loss of £380,000 of income). While patient flow within hospitals has been acknowledged as a challenge (Devaraj et al., 2013; Alderwick et al., 2016), there are few prescriptions as to how to tackle this challenge.

This research makes two important contributions to the field of process improvement in a healthcare context. The first concerns how and why outcome-specific routines support process improvement; the second concerns how and why the process of DSR successfully bridges theory and practice to produce technical solutions that engage healthcare professionals in the change endeavor.

First, we highlight the social aspect inherent in the process of routine creation. Each routine emerged through a process of ongoing and informal dialogue between a diverse team of professionals including clinicians and managers from all levels. The frequency and informality of this dialogue served to mitigate socio-cultural barriers characteristic of the healthcare profession and forged a clear link between the managerially oriented pursuit of swift patient flow with the clinically oriented value of improved patient experience. To date, research

on process improvement in healthcare has tended to marginalize its multi-jurisdictional nature (cf. Dobrzykowski and Tarafdar, 2015).

From the outset we understood that success hinged on the involvement of the various professions involved in the delivery of health services (cf. Waring and Bishop, 2010). What we did not expect was that the continued involvement of these actors would lead to the identification of further improvement activities delivering a cumulative effect. Linking improvements in patient flow with the patient experience produced a logic of complementarities (cf. Kremser and Schreyögg, 2016) that transcended socio-cultural barriers, and fostered multi-jurisdictional commitment and engagement towards the successful creation and implementation of outcome-specific routines.

Second, our outcome-specific routines were operationally relevant, memorable, and unambiguously linked the action required with the routine's intention through temporal pacing of activity. We note the problem of patient flow is causally complex, involving a diverse mix of professions operating in diverse settings both inside and outside the hospital. Temporal pacing of our outcome-specific routines clearly communicated and coordinated routine enactment across various departments in a timely and unambiguous way. This adds granularity to the work of Devaraj et al. (2013) to show *how* patient flow can be improved. Further, the clarity of the routine's intention produced a sense of camaraderie and collaboration among staff, whereby achieving the outcome specified by the routine produced a friendly and competitive improvement climate.

In considering why and how DSR successfully bridged theory with practice, we contend that our interventions were guided by theory but their enactment was secured via *practical* mechanisms. We reiterate that our interventions were cumulative in nature, with effort continuously directed at connecting and engaging professionals in the change endeavour.

By continuously focusing attention towards the social aspects of change, the technical aspects of change were supported and new opportunities for improvement were subsequently revealed.

6.1 Implications for healthcare policy and practice and limitations to research

There is a lack of prescriptions on how to actually improve patient flow within hospitals. This—we suggest—is due to the contextual and causal complexities of each ward and hospital. By employing a DSR approach, a context-specific solution can be created that focuses on the specific outcomes for each setting. Our subsequent analysis reveals a set of interventions and mechanisms that we believe are transferable to other healthcare organizations to improve patient flow and enhance productivity. However, our solution developed in Yeovil requires testing in other similar healthcare settings. Yeovil is a relatively small, acute general hospital. Thus, further research is needed to test the application of our interventions and mechanisms in other healthcare settings – for example different sizes and range of services - in order to examine the validity of our findings.

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Arrival Hour	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total
0	22	12	19	7	13	9	23	105
1	30	5	20	7	7	7	10	86
2	16	18	13	4	13	9	16	89
3	22	14	15	3	12	9	16	91
4	17	13	12	8	15	5	11	81
5	21	18	12	7	12	7	11	88
6	19	17	17	11	10	3	12	89
7	17	11	10	5	10	4	7	64
8	17	14	10	14	9	6	6	76
9	29	26	20	12	9	6	19	121
10	47	28	16	25	9	14	18	157
11	48	35	26	30	23	13	31	206
12	42	31	22	34	21	19	28	197
13	33	36	17	22	21	15	28	172
14	36	23	17	23	13	18	17	147
15	30	35	31	29	17	14	33	189
16	42	39	30	17	28	12	28	196
17	34	32	32	19	29	21	31	198
18	41	40	20	41	30	19	50	241
19	43	28	26	42	27	18	44	228
20	49	47	20	37	30	8	43	234
21	45	34	21	31	32	22	31	216
22	31	28	13	12	28	24	39	175
23	24	30	13	18	16	22	29	152
Total	755	614	452	458	434	304	581	3598
% of all breaches	21.0%	17.1%	12.6%	12.7%	12.1%	8.4%	16.1%	

Figure 1: Breaches to the ED waiting time target by day of week

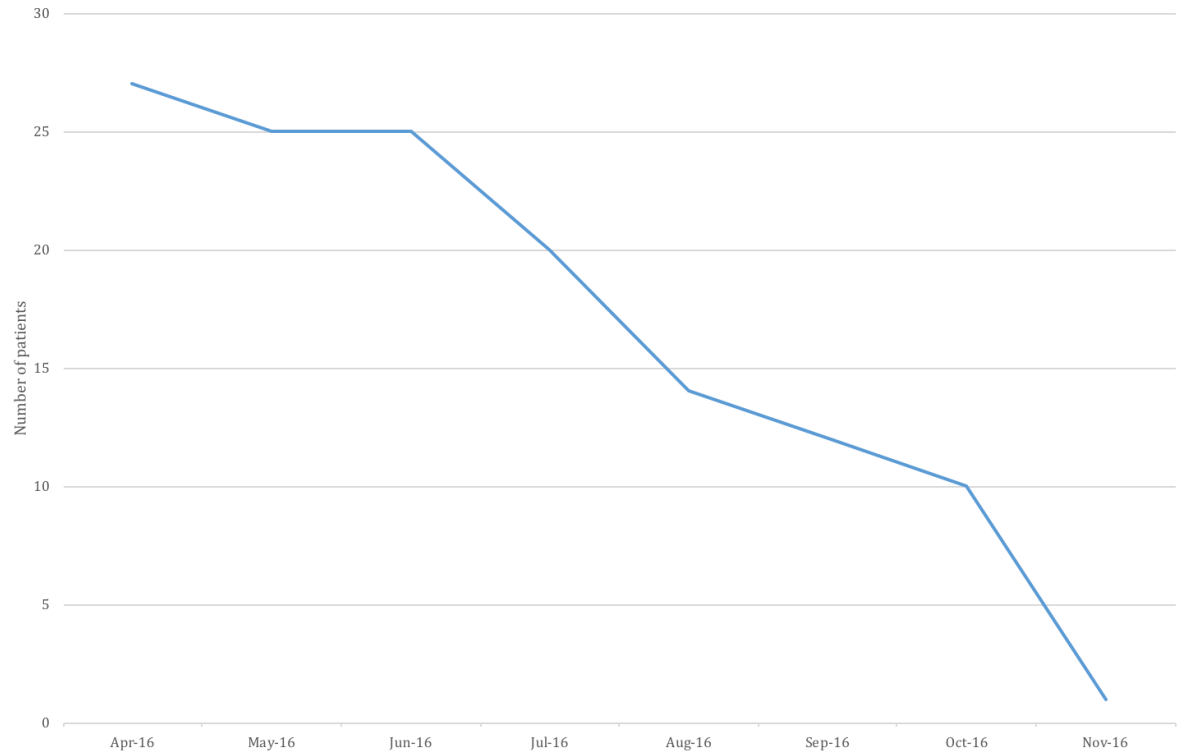

Figure 2: Number of patients waiting 30 days or more April-November 2016

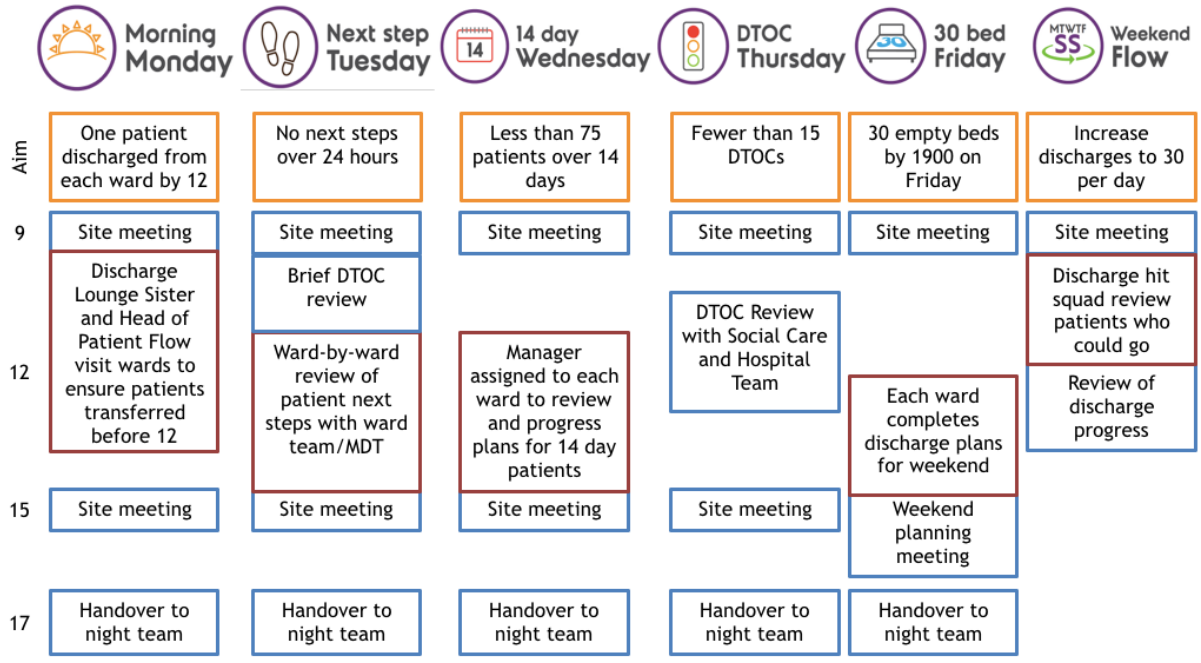

Figure 3: Temporally oriented, outcome-specific routines for improving patient flow.

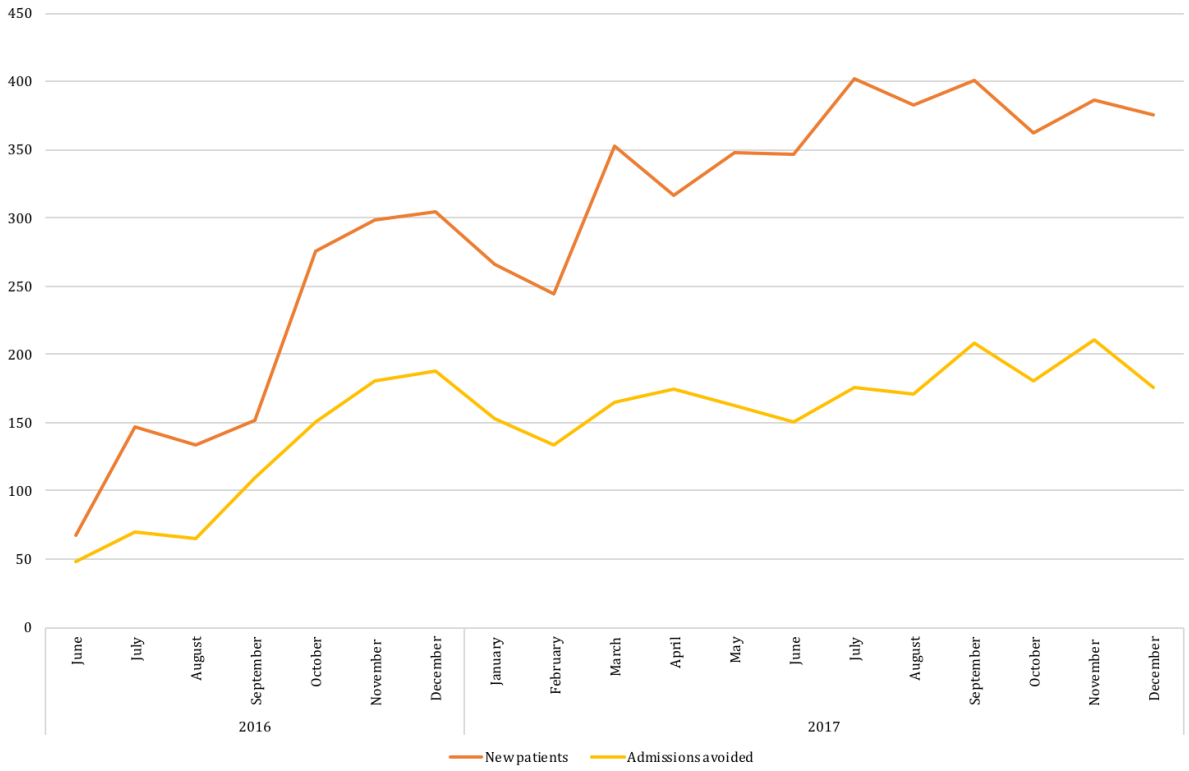

Figure 4: Increase in AEC patients seen and admissions avoided from June 2016 – December 2017

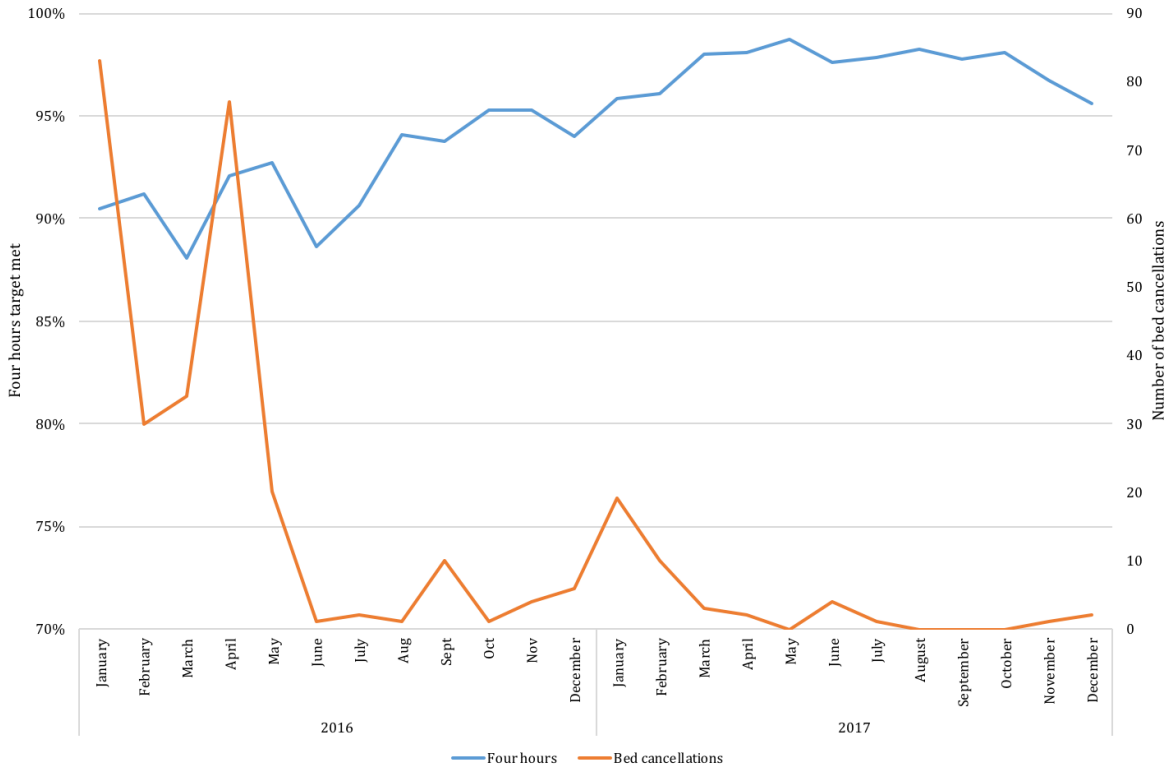

Figure 5: Cancellations of surgical operations in elective and four-hour ED performance from January 2016 to end of December 2017

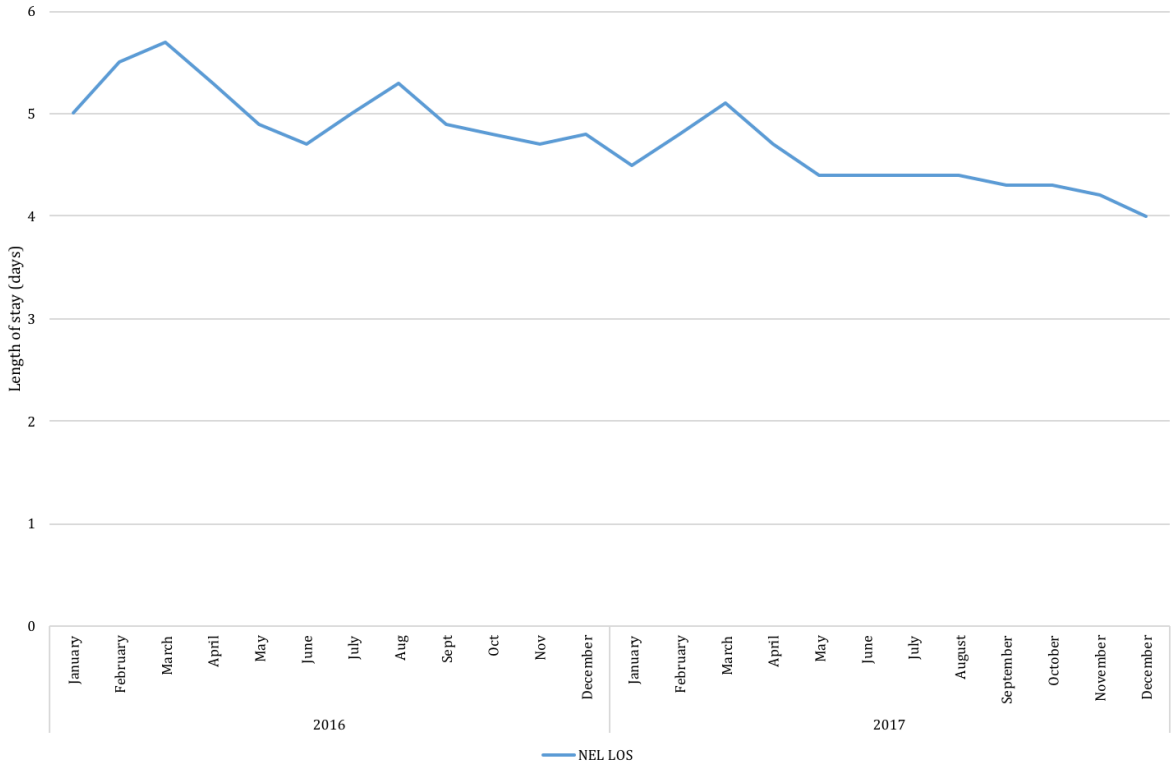

Figure 6: Improvements in patient throughput: LoS performance from January 2016 to end of December 2017