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Does lean cure variability in health care?

Does lean cure variability in health care?

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Abstract

Purpose – The purpose of this paper is to investigate the roles that employee-initiated Lean improvement projects play in health care. Lean ideas are introduced to improve flow in health care. Although variability is detrimental to flow performance, it is unclear whether Lean initiatives set out to reduce this variability and the associated buffers.

Design/methodology/approach – Longitudinal field research is combined with an exploratory field-quasi-experiment. First, a large set of Lean interventions were explored and their focus classified. Semi-structured interviews with practitioners supported the initial findings regarding the focus. Second, this study investigated whether a knowledge deficiency could explain the identified focus through a quasi-experiment in which the authors' stimulated knowledge on the roles of variability and buffers and then classified subsequent interventions.

Findings – The results reflected a narrow application of Lean, with most interventions directed at reducing direct waste. A quasi-experiment demonstrated that a small investment in knowledge enables the focus to shift toward buffers and variability issues – i.e. toward a more complete Lean approach.

Research limitations/implications – This research supports the commonly held view that there is a tendency to focus on waste. Furthermore, a lengthy experience of Lean does not guarantee interventions will focus on buffers and variability, issues with arguably a higher complexity compared to obvious waste. However, small investments in knowledge can broaden the focus of practitioners' interventions.

Originality/value – This study is one of the first to research the focus of Lean interventions through a data set spanning several years. The results are based on a unique data set covering a large number of documented Lean interventions.

Keywords Health care, Continuous improvement, Lean management, Buffers, Field research, Variability

Paper type Research paper

Introduction

Process, and particularly flow, improvement has become an important aspect of healthcare activities. One of the more popular approaches to improving flow is Lean management. This popularity is reflected in the growing number of studies focusing on Lean in health care (e.g. Chiarini and Bracci, 2013; Papadopoulos *et al.*, 2011; Papadopoulos, 2012; Poksinska, 2010; Poksinska *et al.*, 2013). Most of these healthcare-oriented studies report successful outcomes (e.g. Breslin *et al.*, 2014; Chiodo *et al.*, 2012; Raab *et al.*, 2006; Yousri *et al.*, 2011). Hence, the adaptation of Lean ideas to healthcare environments seems promising.

However, next to these positive stories, we find studies that question the application of Lean in healthcare (e.g. DelliFraine *et al.*, 2010; Waring and Bishop, 2010; Mazzocato *et al.*, 2010; Curatolo *et al.*, 2014; Radnor and Osborne, 2013). Further, Hines *et al.* (2004) noted that the way Lean deals with demand variability had received particular criticism. Thus, while

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there are positive reports on the effects of Lean in health care, it appears questionable whether Lean is well understood and fully applied in healthcare environments. This raises the question of what constitutes a complete Lean approach, something which is difficult to establish given the sheer number of Lean definitions (Bhamu and Singh Sangwan, 2014).

When it comes to which aspects of Lean contribute to flow improvement, most authors tend to agree on some central issues, such as the reduction of waste and of variability and continuous improvement (e.g. De Treville and Antonakis, 2006; Shah and Ward, 2007). Hopp and Spearman (2004) make an explicit distinction between variability, which is hidden by buffers, and direct or obvious waste that can be observed directly. Some healthcare-oriented literature (e.g. Graban, 2009; Snyder and McDermott, 2009) does emphasize flow, but seems to ignore the roles of buffers and variability. These observations are surprising given that improving flow requires reduced variability (Schmenner and Swink, 1998). Studies by Jimmerson *et al.* (2005), Proudlove *et al.* (2008), and Mazzocato *et al.* (2010) indicate that, in health care, Lean is seen as a continuous improvement approach with a focus on waste.

In this research, when we speak of a complete Lean approach to flow improvement, we mean an approach that focuses on reducing both direct waste and variability through continuously improving processes. The study especially contributes to the existing literature by providing insights into the focus of continuous improvement initiatives. In doing so, the findings of this study have a relevance beyond Lean in that direct waste, variability, and consequential buffering are important in all approaches to flow improvement.

In this research, we study interventions in a hospital recognized for its pioneering use of the Lean philosophy. By classifying the interventions made as part of their Lean program over a five-year period, we determine their focus and investigate whether this has changed over time. Then, through a field experiment, we investigate whether the current focus of interventions can be attributed to a knowledge deficiency. The central research questions for this field research are:

RQ1. How should one qualify the focus of existing Lean interventions.

RQ2. Has this focus changed over time.

RQ3. Does having knowledge on buffers and variability influence the intervention focus?

Our studied case relates to one of the first hospitals in the Netherlands to adopt Lean, one that is considered to be a leader in its Lean approach. More precisely, the focus is on a medical laboratory in this large teaching hospital which has been adopting Lean principles for more than seven years and keeps meticulous records of its interventions.

Theory

Samuel *et al.* (2015) note that a general Lean theory is still lacking. However, one can identify key aspects in the literature. Reducing “unnecessary” waste in order to increase the value or “value-added” for customers is often considered central to Lean (Holden, 2011). However, many scholars, such as Hasle *et al.* (2012), argue that Lean is about more than direct or “obvious” waste reduction, and that reducing buffers and variability should be part of a Lean approach.

Direct waste refers to waste that is obviously present in the workplace and this can be linked to one of the seven types distinguished in the Lean literature (e.g. O'Neill *et al.*, 2011). Direct waste in general covers “operations that are not needed, excessive setup times, unreliable machines that can be made more reliable, rework that can be eliminated, etc.” (Hopp and Spearman, 2004, p. 145). However, waste can also result as a consequence of a causal chain, starting with a source of variability that eventually results in buffering in the form of inventory, overcapacity, or customer waiting time. Here, the original source of

the waste, that is the variability, is less obvious as it is hidden by the buffer. As such, while inventory can amount to direct waste, for example if caused by overstocking, it might also be a buffer whose root cause is variability. Thus, we posit that direct waste can be typified by its cause not being hidden by a buffer, a distinction from waste that results from variability (Hopp and Spearman, 2008). Reflecting on a range of perspectives (Hopp and Spearman, 2004, 2008; De Treville and Antonakis, 2006; Narasimhan *et al.*, 2006; Shah and Ward, 2007; Browning and Heath, 2009), we can conclude that Lean encompasses the reduction of direct waste, of variability, and of buffers. In our study, we refer to Lean as complete when all these aspects are taken into account.

Even though variability is considered an aspect of Lean, it receives limited attention in Lean-related studies. A Lean approach should include a focus on variability that is hidden behind buffers, but this seems to have been lost in translating Lean from manufacturing to service environments. Since buffers are used to cope with variability, reducing buffers implies a need to reduce variability. In our study, the works of Hopp and Spearman (2004) and Schmenner and Swink (1998) especially provide a theoretical perspective against which we evaluate our findings. Hopp and Spearman stress the importance of buffer reduction in Lean, while the “Theory of Swift and Even Flow” (Schmenner and Swink, 1998) underlines the disruptive effect of variability on a process.

We distinguish two types of variability: artificial variability and natural variability (Litvak *et al.*, 2005). Natural variability cannot, or only to a limited extent, be influenced or controlled. Conversely, artificial variability is created by one’s own actions, such as introducing rules and legislation. Artificial variability is thus controllable, and can potentially be reduced. Consequently, this is the type of variability one should focus on in Lean interventions. Despite this, we observe that reports on Lean tend not to distinguish between natural and artificial variability.

An example of natural variability concerns the different reactions of patients to treatment. Artificial variability results, for instance, from the batching activities that have been observed in health care for many years (e.g. Berwick, 1996; Vissers *et al.*, 2001). Another example of artificial variability relates to the daily ward rounds of physicians, which require multiple resources at the same moment, while decisions made during the round may cause peaks in requirements elsewhere.

In our research, we are interested in artificial variability since this is controllable and, since variability always lowers process performance (Hopp and Spearman, 2008), one should ideally minimize artificial variability. Lean interventions that focus on reducing variability can be expected to have a large impact on flow (Fredendall *et al.*, 2009; Schmenner and Swink, 1998).

The review by Mazzocato *et al.* (2010) suggests that variability is hardly addressed in Lean in healthcare. Further, studies in healthcare environments that do address variability (e.g. Allder *et al.*, 2010; Hosseini and Taaffe, 2015) tend to focus on natural variability despite it being artificial variability that can actively be reduced. Although Joosten *et al.* (2009) do make a distinction between artificial and natural variability in their study on the application of Lean in health care, it is not a central theme. A case study by McManus *et al.* (2003) observes the effects of artificial variability in an emergency care unit. The authors report that “scheduled patient flow, although theoretically controllable is, counterintuitively, more variable than the random demand of emergencies” (p. 1493). Such artificial variability will result in either patients waiting for treatment or medical personnel waiting to provide treatment. In other words, in order to cope with variability, organizations inevitably use buffers.

It is common to distinguish three different types of buffers: time, inventory, and capacity (Hopp and Spearman, 2008; Thürer *et al.*, 2014). While the different types of buffers are seen in healthcare organizations, inventory buffers are not appropriate to the healthcare process of providing patient care because it is the patients that are being transformed in the process

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(i.e. they are the inventory). Clearly, one cannot produce these “products” (i.e. cured patients) in advance of demand. Further, based on the definitions of Hopp (2008), a queue of waiting patients should be seen as reflecting the use of a time buffer, buffering by customer waiting time. As such, healthcare organizations have two viable options for coping with variability: time buffers and capacity buffers.

Coping with variability through increasing capacity buffers is costly. Similarly, coping with variability through increasing time buffers is unattractive as it results in longer patient waiting times. While ruling out inventory buffers might suggest an easier choice when it comes to choosing which buffer to apply, healthcare organizations are faced with two unattractive options. In practice, one has to balance between the patient’s and the healthcare provider’s interests in a situation where buffering is unavoidable. While creating flexibility in the capacity buffers may help reduce the required size of buffers, ultimately, the only viable option to avoid the need for buffers is to remove variability.

One would expect the reduction of variability to receive attention in Lean practices in healthcare environments. However, there seems to be a strong focus on reducing direct waste in studies on Lean in health care (e.g. Dickson *et al.*, 2009; Jimmerson *et al.*, 2005). In healthcare environments, unnecessary diagnostic procedures, medication errors, and expired supplies (Grabau, 2009) are examples of direct waste. The fact that direct waste is not hidden by buffers could explain why most organizations focus on waste – it is simply the most obvious thing to do.

Reducing direct waste, and thereby obtaining quick wins, is often the first step when organizations start their Lean journey (Radnor *et al.*, 2012). Hopp and Spearman (2004) argued that Toyota, admittedly in another sector, moved through distinct phases: first they focused on direct waste, then tried to reduce buffers and variability. This perceived transition raises questions related to Lean development over time. Specifically, can changes in the intervention focus, and a change toward a complete approach, be identified over time?

The studies that report on Lean in health care seem only to discuss waste (Mazzocato *et al.*, 2010). An initial focus on direct waste is perfectly sensible: any improvement that avoids the needless occupation of capacity could avoid congestion and waiting times. However, new opportunities to reduce direct waste will eventually become scarce. It is perhaps at this point that organizations should include the hidden causes of performance inefficiencies in seeking improvements, which amounts to a complete Lean approach with attention also given to variability and buffers.

Methodology

Our study adopted a field research approach in that it can be typified by the collection of qualitative and quantitative data from a real-life setting (Edmondson and McManus, 2007). Field research allows one to “explore the implementation of managerial norms and solutions as well as the practical validity of theoretical models” (DeHoratius and Rabinovich, 2011, p. 372) and is thus an ideal approach for exploring and validating the focus of Lean interventions. Since we were also interested in possible changes to the focus over time, we required in-depth data over several years. Further, we required numerous Lean interventions because we wanted to establish their main focus. This combination of criteria is difficult to meet, and therefore we studied a single case. This approach is generally seen as effective when the case is treated as unique, when the study is longitudinal, and when in-depth insights are required (Yin, 2009). We triangulated our study through the combination of data sources as advised by various scholars (e.g. Voss *et al.*, 2002; Barratt *et al.*, 2011).

The research had two components. First, we investigated how the Lean interventions could be categorized. We combined archival data with interview data to increase the reliability of our findings. We started by classifying Lean interventions to establish their focus. Subsequently, we conducted semi-structured interviews to investigate how Lean was

interpreted in our case organization, and to what extent practitioners were knowledgeable about the roles of buffers and variability.

In the second part of the study, we conducted an exploratory field-quasi-experiment (Pelham and Blanton, 2003; Franklin, 2005). Exploratory field experiments are useful for investigating new relationships and have been conducted by various researchers (e.g. Hui *et al.*, 2007; Shantz and Latham, 2009). The exploratory field-quasi-experiment was set up as a “knowledge session,” and this allowed us to investigate whether it had been a lack of knowledge that was inhibiting broader interventions, or if we should seek other factors that were limiting the application of Lean in health care.

Case setting

Our research setting was a medical laboratory in a clinical teaching hospital in the Netherlands. The hospital, and particularly this laboratory, was among the first to adopt a Lean philosophy. It is considered to be among the leading organizations in the Netherlands in terms of working with Lean and a national example of a successful Lean organization. New employees receive in-house Lean training and, at the time of our study, almost all the laboratory employees had received such training. The laboratory started to introduce Lean in late 2007, and there have been hundreds of both large and small interventions since. The laboratory has kept meticulous records of all its Lean interventions since 2009, providing us with a comprehensive data set. The laboratory also makes a distinction between large-scale interventions (LSIs) and small-scale interventions (SSIs). It refers to an LSI as an A3, and to SSIs as Kaizens, and both have their own format (template) within the laboratory. The formats require the user to provide information on the problem at hand, including the current state, required actions, and expected results. LSIs are projects that span periods of several weeks or more, and that require the input of multiple people, disciplines, or departments. Together, the LSIs and SSIs form the foundation of the laboratory’s approach to continuous improvement.

Part 1: categorizing lean interventions

During the first part of this research, the main objective was to gain insight into the current focus of Lean initiatives. In our classification, we distinguished four groups, namely, interventions related to direct waste, to buffers, to variability, and those not related to any of these aspects. The classification process involved three steps.

First, when classifying an intervention, we searched for explicit reference to reducing direct waste, buffers, or variability. Second, if none of these were obviously present, we studied the intervention further to see if it could logically be expected to lead to reductions in one or more of these areas. Finally, if these two steps had not enabled a focus to be established, the intervention was placed in the final group – of interventions apparently unrelated to Lean. For example, one “Lean” interventions that we attempted to classify concerned whether a specific type of bacteria could test positive under certain conditions. While this is relevant to the functioning of the laboratory, the question does not relate to a potential Lean intervention, and so we classified this specific question as unrelated to Lean. Further, within the direct waste group, we were able to recognize the seven types of waste (Womack *et al.*, 1990) and were able to identify the waste most frequently addressed.

The inputs for our classification analysis were all the Lean interventions undertaken in the laboratory during the period from 2009 through to 2013. As suggested by Miles and Huberman (1994), the interventions were entered in tables to create case displays. Here we used a two-step approach, with two independent investigators to strengthen reliability. In the first step, investigator A classified all the interventions, and investigator B classified a randomly selected 10 percent of the interventions. In step 2, the results were compared to

assess inter-assessor agreement. We measured the level of agreement using Cohen's Kappa (Cohen, 1960; Hsu and Field, 2003) and were aiming for at least a moderate agreement ($k > 0.40$). Similar two-step approaches have been used with success, including by Done *et al.* (2011).

To investigate the current interpretation of Lean in the laboratory, we conducted eight semi-structured 30 minute interviews with two participants from each of four departments, two of whom were female. The interviewees consisted of four chief analysts (department heads) and four analysts, selected because they had completed the most interventions in the past years. Before the interviews, all the interviewees signed informed consent forms. The interviewees were aged from 40 to 58, with a median of 48.5, and had been with the laboratory for between 17 and 30 years, with a median tenure of 26. All the interviewees had between five and nine years of Lean experience, with a median of 6.5. Further, all the interviewees had been trained in the Lean philosophy, completing an in-house training course plus seminars and presentations.

The interviews allowed us to explore the conceptual knowledge of Lean, and to determine whether a knowledge deficiency was the likely cause of any identified underrepresentation of certain Lean aspects during the classification. During the interviews, explicit references to "buffers" and "variability" were avoided. Rather, we asked general questions regarding the participants' personal ideas on Lean. The rationale behind the approach was that this would allow the interviewees to provide us with their understanding of the Lean concept. The interview questions are included in Table AI and were not related to specific Lean interventions. Interviews were transcribed and the information put into tables, as recommended by Miles and Huberman (1994).

If the classification process found that interventions focused on only one aspect, such as direct waste, then we would have expected professionals to only mention this aspect when asked about their ideas on Lean. However, if we had found such a focus on waste in practice, but the professionals regularly mentioned the roles of buffers and/or variability during the interviews, we would then need to investigate why these aspects were apparently not being targeted in interventions.

Part 2: exploratory field-quasi-experiment

Through the use of an exploratory field-quasi-experiment, we investigated whether the scope of the interventions was dependent on having knowledge related to managing variability and buffering. This focus was chosen based on the earlier classification showing a strong focus on direct waste reduction. This allowed us to explore the possibility that there was a knowledge deficiency, i.e. a limited understanding of the Lean concept, within our case.

The employees who had earlier participated in the interviews, and had completed the most interventions, were invited to a session on variability and buffers in Lean, which was conceived as a concise three-hour class exercise. Rather than a random sample of participants, we purposefully selected participants that would increase the likelihood of obtaining meaningful data, i.e. linked to completed interventions. The participants in the three-hour session can be considered as our "treatment group," and the "control group" as all employees who did not attend the session. The training session took place on October 3, 2014, and was facilitated by both investigators (A and B). Please note that this was not presented as an attempt to change existing improvement procedures.

The class consisted of a 30-minute introduction on the roles of variability and buffers in our daily lives, and specifically in health care, followed by a 150-minute game-playing exercise related to variability. The work of Hopp (2008) served as a starting point in explaining the different roles of direct waste, variability, and buffers. The game was aimed at increasing understanding of the effects of variability.

The exercise was an adaptation of the dice game that had been successfully used by Goldratt and Cox (1984), Umble and Umble (2005), and Knight (2014). To make it more meaningful, the focus was changed from product flows in a factory to patient flows in a hospital. Rather than thinking in terms of a build-up of inventory, we focused on patient waiting times. The game showed that large buffers increased patient waiting times, but could be used to cope with variability in patient arrivals. Further, participants experienced how low variability reduced waiting times, without any associated downsides. Each round was followed by a plenary discussion to stress the meanings of buffers and variability as identified during the game. The session ended with a short recap of the “lessons” of the day. Three days after the session, participants received an e-mail containing the slides used during the session. Two months later, participants received another e-mail as a reminder of the issues discussed.

To determine whether the exploratory field-quasi-experiment had changed the focus of interventions made, we investigated all the interventions, by both participants and non-participants that were carried out in the period between October 3, 2014 and January 13, 2015. In short, we compared the activities of our treatment group with the results from the control group.

Again we applied the classification process used in the first part of our research to determine the focus of these new interventions. We retained the two-step approach, but made alterations to boost reliability. Given the smaller number of interventions, it was practical for both investigators to classify all the interventions, rather than selecting a random subset for investigator B.

Investigator A anonymized all the interventions before handing them over to investigator B such that they no longer contained any information on date, department, or initiator. As such, there was nothing that would enable investigator B to distinguish between interventions by members of the treatment group and those by the non-treatment group. This approach has the benefit that it controls for false positives. One would expect investigator B's judgments to be the most objective and so, if the two investigators did classify an intervention differently, investigator B's decision was adopted.

Analysis and results

The raw data in the form of archival records amounted to a total of 324 Lean interventions, i.e. all the documented interventions from the laboratory in the period 2009-2013. After data cleaning, 284 (88 percent) interventions were seen as suitable for further analysis. The removed data consisted of documents that did not specifically report on interventions, e.g. double entries, undated documents, or appendices.

Results of part 1: establishing the focus

Our classification evaluation started by comparing the allocations made by investigator A with the randomly assigned subset classified by investigator B. Here, we achieved a moderate Cohen's Kappa ($k = 0.531$), and an agreement level of 88 percent, and therefore concluded that the classification was successful. Of the 30 interventions assessed by both investigators, four interventions were classified differently.

Three of these four interventions were linked to direct waste by investigator A, whereas investigator B did not consider them to be Lean-related. This was primarily due to the practical nature of the interventions, when it can be difficult to determine whether solving a practical issue should be categorized as a Lean-related direct waste reduction. The fourth disagreement was a more interesting case in that it was labeled as variability reduction by investigator A, but as direct waste reduction by investigator B. This intervention concerned the lack of a standard procedure for dealing with petri dishes that could not be fully processed during a weekend, and had to be re-inspected during the following week.

Table I.
Classification of
interventions

Investigator A felt that introducing a standard procedure implied a reduction in variability, whereas investigator B did not believe the intervention would reduce variability in such a way that it could be expected to reduce the size of buffers. After discussing the matter, and noting that the specific intervention did not explicitly mention either variability or buffer reduction, waste reduction seemed the more appropriate category. Table I provides an overview of the number of interventions related to the different categories, and covers the entire set of Lean interventions based on the classifications by investigator A.

Table I shows that interventions relating to buffers and variability reduction were rare. During the period studied, we only identified eight interventions falling into either of these categories (compared with 250 related to direct waste). In the later years of our review period, there were no interventions tackling either buffering or variability. As such, the organization did not show a transition to a more complete approach, if anything rather the opposite.

Since nearly all the interventions related to direct waste, we investigated whether there was a focus on specific types. Each intervention was attributed to one or more of the seven types of direct waste (Womack *et al.*, 1990), indicated in Table II. The results show that the most common reason (applied to 40 percent of our sample) for an intervention was to reduce the number of defects. These defect-related interventions were often not related to a specific problem that had actually occurred, rather they were preventive actions related to the possibility of a fault, which was avoided if the intervention was applied. Thus, apart from corrective improvements, we observed that the laboratory also focused on preventative actions.

Next, we investigated how Lean was perceived by the experienced practitioners and whether they were knowledgeable on the roles of buffering and variability given that these aspects were not regularly addressed in practice. Interestingly, the professionals tended to refer to personal aspects, e.g. enjoyable work, when they were asked to think about Lean rather than patient value. Further, when talking about Lean, they generally referred to direct waste reduction and process improvements. Only one of the interviewees mentioned reducing the time to obtaining results (throughput time) as an objective of Lean, but did not think in terms of buffering or variability as a way to achieve this objective: rather,

Year Group	2009		2010		2011		2012		2013		Total	
	SSI	LSI	SSI	LSI	SSI	LSI	SSI	LSI	SSI	LSI	SSI	LSI
Direct waste	53	9	16	8	41	16	65	1	41		216	34
Buffers		1	1	2	1						2	3
Variability	1		2								3	
Other	7	2	3	7	3	3	1				14	12
Total	73		39		64		67		41		284	

Table II.
Intervention focus:
waste types

Year Group	2009		2010		2011		2012		2013		Total
	SSI	LSI	SSI	LSI	SSI	LSI	SSI	LSI	SSI	LSI	
Waiting	3	2			3	1	12		18		39
Inventory	11	2	2	1	6	4	14		3		43
Defects	37	7	12	8	31	11	33	1	24		164
Overprocessing	3			1	3	1	30		20		58
Transport				1			9		5		15
Movement	6		1		9	3	22		15		56
Overproduction	2	1					4		4		11

the removal of direct waste was supposed to reduce throughput times. During the interviews, it became apparent that the professionals did not share a common definition of Lean as reflected in the following quotes:

To me, Lean stands for studying your processes, and removing the parts of your job that are undesirable. Thus, you remove waste from your processes and, as a result, the job becomes easier, better, and more enjoyable.

For me personally, it especially means improving the process and removing all types of waste.

Lean is, if I am allowed to use catchwords: process improvement, time-to-result reduction, efficiency increases, and problem-solving skills. To me personally, Lean is fun, and Lean is the reduction of waste in your processes.

Given that reduced buffers or variability are widely seen elsewhere as outcomes of Lean interventions, we were interested in the ideas of this group of professionals concerning what constituted a Lean intervention success. If process performance was seen as one of the main criteria, it would be logical to have interventions related to reducing buffers or variability. However, the healthcare professionals struggled to provide concise success criteria. They could offer practical examples of successful interventions, or they might consider an intervention successful if it resulted in positive sentiments in those involved. Overall, they were unable to give clear criteria for a successful intervention:

Eventually the result of the change you make is to have everyone working in accordance with your idea.

It is of major importance that the improvement is accepted by the people it affects. They should feel good about it. They should feel that the process was actually improved, and they should profit from it. Not in financial terms, but profit in terms of the process.

I consider every Lean intervention we have performed to be successful. Even though sometimes this is only as a learning experience, for I personally consider learning a goal of Lean.

The professionals thought about human aspects when asked for success criteria – the acceptance of suggested improvements by peers seemed of major importance. It appeared that neither buffers nor variability were a conscious part of their mindset. This suggests that the few identified interventions focused on variability and buffers, were not the result of a deliberate attempt to reduce such aspects. This reinforced our belief that there was a lack of knowledge concerning the roles of buffers and variability.

Results of part 2: exploratory field-quasi-experiment

The inputs for assessing the effect of the exploratory field-quasi-experiment were the 35 interventions initiated by the participants in the period October 2014 – January 2015 (post training). After data cleaning, 33 (94 percent) of the 35 interventions remained for the post-experiment assessment. We again applied our classification and compared the findings of investigator A with the findings of investigator B. We obtained a good Cohen's Kappa ($k = 0.704$), and an agreement level of 81 percent. The classifications by investigator B are presented in Table III.

Group	Initiator did not attend session	Initiator attended session	Total
Waste	15	6	21
Variability and buffers		3	3
Other	6	3	9
Total	21	12	33

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Table III.
Classification of interventions after the knowledge session

Of the 33 interventions, 21 were initiated by people who had not attended the session and, of these, 15 related to direct waste, and the remaining six were judged as unrelated to Lean aspects. Of the 12 interventions undertaken by people who had participated in the session, six related to direct waste, three were unrelated to Lean, and three were related to either buffers or variability. These buffer- and variability-oriented interventions explicitly mentioned time reduction as an outcome goal. Table IV provides an overview of the main findings related to these three Lean interventions, which are then further discussed.

Two of the three interventions had reduced throughput times as an explicit outcome, while the other intervention referred explicitly to reducing variety. We would expect all these interventions to eventually impact on patient waiting times.

In intervention A, we see that the laboratory decided to stop its batching activities in order to reduce artificial variability. Interventions B and C aim to reduce the number of methods and techniques applied. Although these three interventions clearly relate to variability and buffering aspects, we should remain cautious in our appraisal of these interventions and claiming the success of our knowledge-raising exercise. Most notably, these interventions never used the exact wording of “buffer” or “variability” reduction, although the interventions did indicate that throughput time reduction was an important aspect. Nevertheless, based on the findings from the experiment we do feel able to conclude that a knowledge deficiency could be the cause of the strong focus on direct waste in the earlier interventions. In the remainder of this section, we will look in more detail at the buffer- and variability-related interventions to gain a better understanding of the approach and the specific content.

Intervention A

Intervention A considered the process of incubating microorganisms (growing bacteria) in patients’ samples. During this process, laboratory equipment is used to take photographs of petri dishes containing urine samples. These pictures are then assessed by a laboratory analyst to determine whether microorganisms are present. Several dishes would be photographed at the same time; that is, they assembled batches of samples before starting the photographic step. However, this was considered as less than ideal because some microorganisms grow faster than others. The testing process for samples with a relatively rapid growth could be completed sooner. The proposed intervention was to add an additional assessment step, and this was expected to significantly reduce throughput times. In this intervention, the laboratory would reduce artificial variability in the form of batching, and this reduction should result in a smaller time buffer, leading to a reduction in patient waiting time.

Table IV.
Summary of the
variability- and buffer-
focused interventions

Intervention	Focus	Variability ^a	Actions	Results ^b
A	Microorganism incubation process	Artificial variability caused by batching	Add an additional assessment step that eliminates waiting for complete batches	Reduced throughput times
B	Set of incubation methods	Artificial variability caused by different methodologies	Avoid needless methods and protocols	Reduced variety
C	Techniques used to identify microorganisms	Artificial variability due to identification techniques used	Avoid needless techniques	Reduced throughput times

Notes: ^aIdentified by researchers; ^bidentified by intervention’s initiator

Intervention B

Intervention B related to variability and aimed to reduce the number of incubation methods used. The various incubation methods each have their own protocols to be followed by the laboratory staff. The number of different incubation methods, and their corresponding protocols, makes it difficult for practitioners to remain up-to-date on all procedures. The intervention proposal commented that practitioners have to spend considerable time reading, and re-reading, protocols. The intervention aimed to reduce the number of methodologies and protocols in use, thereby easing the burden on practitioners by reducing the variety in the applied incubation methods. In essence, the current structure was putting a strain on the available capacity, and we should expect this to have increased patient waiting time. The steps taken in the intervention should reduce this strain, allowing shorter throughput times.

Intervention C

Intervention C focused on reducing variability and hence throughput times. In the laboratory, various techniques help identify the type of microorganism present in patient samples. These techniques differ in the time they take to produce a conclusive result. Having such a large number of different techniques was identified as disruptive, and the suggestion was to adopt a standard technique. It was suggested that this new standard would reduce throughput times and costs, and result in higher quality. In proposing this intervention, the number of different techniques was seen as hindering the flow of patient samples.

Reflection

Overall, these three interventions are a promising start in encouraging the laboratory to think about variability and buffer-related improvements in future initiatives. That these three interventions were initiated after our knowledge-building exercise suggests that limited knowledge on the roles of variability and buffering might well be a factor in the limited use of interventions focused on these aspects.

There is undeniably a difference in the visibility and complexity of aspects that lead to interventions focused on direct waste and those focused on variability or buffering. Sources of variability will be obscured by buffers, whereas direct waste is usually in plain sight. Nevertheless, we have seen how a very limited amount of additional training was sufficient to facilitate practitioners in identifying and targeting variability and buffers. While the reduction of variability and buffers might arguably be more complex than reducing obvious waste, it appears that it is not the complexity itself that primarily hinders healthcare practitioners in targeting sources of variability but, rather, the lack of knowledge.

Discussion

Our main questions were how the focus of existing Lean interventions should be classified, whether and how this focus developed over time, and whether knowledge on buffers and variability influenced the focus of interventions. In terms of the first research question, we found that the interventions tended to be heavily focused on simple practical improvements that would reduce waste. This accords with the suggestions of many authors that identifying and reducing waste is the first step in a Lean transition (e.g. Hopp and Spearman, 2004; Shah and Ward, 2007). Further, the pattern in health care of improving quality and safety (Stelfox *et al.*, 2006; Weiner *et al.*, 2006) is reflected in the focus of the Lean interventions. Most of the interventions in the laboratory focused on reducing direct waste, with half linked to eradicating defects or boosting quality.

That the focus of the interventions hardly changed over time answers our second research question: we could not identify changes in the focus over time and, as

such, our results do not show a transition toward a more complete Lean approach. The continuing focus on direct waste reduction reflected a lack of attention to reducing buffers and variability. In other words, we witnessed a narrow Lean perspective despite the lengthy experience at our case site. Radnor *et al.* (2012) offered two reasons why a narrow view of Lean persists in health care. First, they saw it as difficult to influence or control services beyond the individual organization because of structures related to funding of services and the regulation of services through government targets. Second, the authors argued that Lean is generally seen as a managerial tool for waste reduction. Our findings strongly support the latter argument – that Lean is especially seen as a means to reduce waste. However, we did not find evidence to support the argument related to a lack of control beyond the specific organization. Radnor and Osborne (2013) argued that public services have over-focused on the technical tools of Lean and failed to grasp the underlying principles. However, in our study, we did not come across an overuse of tools, although we did encounter a lack of knowledge on the underlying principles regarding variability and buffers.

In response to our third research question, we can conclude that having knowledge on the effect of variability and buffers seems to influence the focus of interventions. Having a very limited knowledge on the roles of variability and buffers hinders healthcare professionals in targeting these aspects in Lean applications. The quasi-experiment showed that only a small investment in knowledge can have clear impacts in terms of the interventions made. The healthcare professionals we interviewed mainly thought of Lean as an approach for continuous improvement. Here, Radnor and Osborne (2013) argued that service organizations need to establish a logic suited to the service domain, rather than adopt one based on production environments. This could be especially relevant where buffers are concerned. Often, inventory buffers are inappropriate in service environments and, in our case, this had the consequence that variability could only be buffered by additional capacity or by increasing patient waiting times. Any such additional burden on capacity and patients could lead to a greater emphasis on reducing variability in Lean service organizations.

It is important to reflect on the implementation of Lean at a specific investigation site: are disappointing findings simply the result of a weak application of Lean? Considering the basis for selecting the case organization, this seems unlikely. The specific site is generally seen as an exemplary applier of Lean, and the hospital has its own in-house Lean training scheme that is mandatory for new personnel. In addition, employees, including physicians, travel the globe to share their views and to study Lean in other healthcare providers. The site has a well-structured continuous improvement system with daily Kaizen meetings that have resulted in hundreds of interventions.

How the interventions are set up is of interest for practice. We saw that interventions were initiated by practitioners involved in the work process. A template was available to assist practitioners during the improvement process. After an initial problem identification stage, meetings with supervisors should ensure that the potential root causes of the issue at hand are correctly identified. When all parties are confident that the correct root cause has been identified, possible solutions are posited. Here, the most promising solution will eventually be implemented. However, an important area that we identified for improvement related to following up the intervention process. A structured follow-up program was lacking at the time of our study, making it difficult to judge intervention success.

Since then, the laboratory has adopted visualization tools to continuously monitor performance. While there is no denying that the site has been successful in terms of reducing waste, and its application of Lean appears to have resulted in a smoothly running organization, overcoming the lack of variability-and buffer-related knowledge would create an opportunity for further high-impact improvements. This could be further encouraged by including variability and buffers as an explicit attention point in the intervention template.

Hopp and Spearman (2004; Hopp, 2008), when assessing Lean at Toyota, identified an attention to direct waste in the early phases of Lean adoption, and interventions related to buffers and variability in later phases. However, our findings did not identify this pattern, and thus provide no support for a Lean maturity thesis. The rare interventions related to buffers and variability occurred at different points in time, and most of these were early in the laboratory's Lean journey. It is possible, given the sheer number of interventions, that these variability- and buffer-focused interventions were mere chance since we failed to uncover any deliberate attempts to reduce variability and buffers.

An alternative explanation for the limited attention to buffers and variability could be related to the specific environment. Health care lacks an equivalent of inventory buffers. In production environments, inventory buffers can "hide" variability but, in health care, there is no equivalent natural buffer. This could make coping with variability more complex as it leads to a direct trade-off between patients waiting and excess capacity. However, as our field experiment showed, a short training exercise was able to induce variability- and buffer-focused interventions. As such, we would argue that while these interventions are more complex than those related to cutting waste, it is not the complexity itself that explains the limited focus on variability and buffer interventions.

Rather, it seems probable that the narrow focus in the Lean interventions, and the lack of attention to buffers and variability, is a manifestation of a lack of knowledge. Our findings show that, following the field experiment, buffer- and variability-related interventions were generated by people who had been part of the experiment. We saw that attention was explicitly given to variability-related issues in the later interventions, and that this was linked to the initiator's expectations related to improved throughput performance. More specifically, following the experiment, we were able to identify three interventions related to buffers and variability that took place within a period of three months, compared to just eight in the previous years. The specific interventions aimed to reduce artificial variability through batching, incubation methodologies and identification techniques. We would expect these interventions to eventually result in reduced time buffers.

It seems that a lack of variability-related knowledge could explain the focus on direct waste issues. The later variability-related interventions could be seen as interventions that require additional investigation and understanding. This could explain why the literature has struggled to demonstrate conclusive results on the effects of Lean in service industries. Our findings in the healthcare sector strengthen the suggestion by Radnor and Osborne (2013) that, in public services, there is a limited understanding of Lean's underlying principles. The empirical findings lead us to the following proposition, for which this current study has provided some initial evidence:

Healthcare industries can suffer from a deficiency of knowledge related to buffers and variability, and this hinders organizations in adopting a complete Lean approach.

In addition to our theoretical contributions, our study has implications for practice. The classification adopted was able to identify a dominant focus on waste issues in this healthcare organization. However, our experiment indicates that this focus can be shifted toward variability-related issues if managers and organizational leaders invest in boosting Lean knowledge related to the roles of variability and buffering. Through the application of a small-scale experiment, we were able to show that minimal investments could have a large impact. We would also encourage more research focused on the roles of flow in healthcare environments since this could assist practitioners in their quests for flow improvements.

Conclusions

We have executed an in-depth case study including an exploratory field-quasi-experiment to determine how the focus of Lean interventions could be classified, whether and how this focus

changed over time as Lean experience grew, and how knowledge on buffers and variability played a role in the intervention focus. Our research has made the following contributions:

- It offers support for the commonly held view that there is a tendency to focus on waste issues in Lean healthcare.
- It shows that time (our case study took place in the Dutch hospital with the longest experience of embedding Lean) does not guarantee interventions that go beyond reducing obvious waste. This contrasts with the literature that assumes that a switch to buffer and variability reduction in later stages (the key to success at Toyota) will take place.
- It supports the view that neither variability nor buffers appear to be a conscious part of the Lean mindset in the service sector.
- It suggests that providing knowledge on the role of variability will facilitate initiatives to start variability-related Lean interventions, and that only a small investment is required to instill this knowledge (a single three-hour session sufficed in our study).

Overall, this research has been a step toward a better understanding of Lean interventions in practice, and their limited impact to date on buffer reduction. The use of real-life data covering a large number of interventions is a unique feature of our research.

While our study does provide new insights, it naturally has some limitations. By selecting a single organization that can be seen as an excellent example of Lean in health care, we tried to mitigate the limitations concerning generalizability normally associated with case studies. Additionally, while our experiment was aimed at knowledge transfer, we have not focused on the sustainability of the provided knowledge and restricted ourselves to the question as to whether knowledge (or the lack thereof) could be a factor. Clearly, it was impossible to conduct a controlled experiment in our case setting, and this hinders the ability to make statements concerning causal relationships. Nevertheless, our experiment does show the importance of buffer-and variability-related knowledge when formulating Lean interventions.

Future research could benefit from our approach to classifying interventions. It would be particularly valuable to investigate the sustainability of Lean interventions and to observe differences between cases. A basic question that remains unanswered is whether reducing buffers and variability has a role in day-to-day improvement activities in other healthcare environments. It would also be useful if future studies were to consider how to boost understanding of the roles that variability plays in health care. If, as our single case suggests, reducing direct waste is virtually the only driver of Lean in health care, then there is work to do, for both business and healthcare scholars, to educate practice on other beneficial aspects of Lean.

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Appendix

Reason	Question
Establishing interviewees experience with Lean ideas, and the laboratory	What is your job in this laboratory? How long have you been working in the laboratory? Did you receive Lean training, if so which? How many years of Lean experience do you have?
Understanding of the common idea on Lean, and its main aspects	Could you describe what you understand by Lean management?
Understanding of knowledge on indicators that should prove Lean is successful	Could you indicate when you would consider a Lean improvement to be successful?
Understanding of the visibility of Lean results over time	Based on your knowledge, what effect has Lean had on the laboratory over the years?
Providing interviewees with an opportunity to add information	Would you like to add further information, or do you feel that a specific question should have been asked?

Table AI.
Interview

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