An Exploratory Study into the use of Lean Six Sigma to Reduce Medication Errors in the Norwegian Public Healthcare Context

Abstract

Purpose: Medication errors are a significant cause of injury in Norwegian hospitals. The purpose of this study is to explore how Lean Six Sigma has been utilised in the Norwegian public healthcare context to reduce medication errors.

Design/Methodology/Approach: A mixed method approach was used to gather data from participants working in the four regions served by the Norway Health Authorities. A survey questionnaire was distributed to 38 healthcare practitioners and semi-structured interviews were conducted with 12 healthcare practitioners.

Findings: The study finds that the implementation of Lean Six Sigma in the Norwegian public healthcare context is still in its infancy. This is amidst the several challenges faced by Norwegian hospitals, such as a lack of top management support, lack of LSS training and coaching and a lack of awareness around the benefits of LSS in healthcare.

Research limitations/Implications: Due to the large geographical area, it was difficult to reach participants from all health regions in Norway. However, the study managed to assess the current status of LSS implementation through the participants' perspectives. This is a fruitful area for future research whereby an action research methodology could be employed.

Originality/Value: To the best of the authors' knowledge, this is the first empirical study into the use of LSS methodology in reducing medication errors. In addition, this study is valuable for healthcare practitioners and professionals as a guideline to achieve the optimal benefit of Lean and Six Sigma implementation in order to reduce medication errors.

Keywords: Lean Six Sigma, Norwegian Public Healthcare, Medication Errors, Survey, Semi-structured interviews

1. Introduction

Improving patient safety and financial performance in the healthcare industry is of clear importance today (Dobrzykowski *et al*., 2016). Medication errors have been reported as one of the primary causes of patient mortality and morbidity, and the complexity of healthcare delivery systems could contribute to the occurrence of accidents (Marano *et al*., 2005). A medication error is a result of failure in the treatment process and a costly problem in hospitals. The errors result from the failure of the medication process itself rather than the individual performance of healthcare staff.

In 2015, medication errors and intravenous fluid incidents become the second most reported type of accident in the Australian healthcare setting (Hayes *et al.*, 2015). Medication errors remain a significant problem in North America, Canada and the UK, with a recent report by the UK government indicating that medication errors are responsible for as many as 22,000 deaths per year in the UK (Donnelly, 2018). The medication error rate in Norwegian hospitals in 2009 ranged from 0.1% to 0.7% of all adults patients who were admitted (Teigen *et al.*, 2009). Although the number of medication errors in Norwegian hospitals is relatively low, injuries resulting from such errors remain one of the most common in Norwegian hospitals (Hofstad and Kleven, 2016). In 2017, 17.3% of errors were related to the medication process, making these the second most reported incidents in Norwegian hospitals (Helsedirektoratet, 2018). Evidence shows that medication errors not only contribute to patient injury and death, but also negatively impact economic outcomes; the annual cost of medication errors worldwide is $40 billion (World Health Organization, 2017). The Norwegian Patient Injury Compensation paid 200m NOK (approximately £18.5m) to 454 patients between 2006 and 2015 as compensation for the occurrence of medication errors (NPE, 2017).

Healthcare managers have had little success in utilizing effective tools and processes to reduce medication errors (Hussain *et al.,* 2015). Nevertheless, quality in healthcare worldwide has been improved by continuous improvement (CI) methodologies (Buttigiet *et al.,* 2016). Continuous Improvement (CI) projects are aimed at improving organisational processes (Gonzalez Aleu and Van Aken, 2017). Lean and Six Sigma

are the most popular business strategies of CI applying in manufacturing and service sectors (Albiliwi *et al.,* 2015). LSS is a powerful business strategy, which aims to reduce variation and eliminate defects in the process, resulting in business process excellence (Snee, 2010). Although LSS has been widely implemented in many Western healthcare sectors, the application of LSS to reduce medication errors in the Scandinavian context has not yet been reported. Therefore, the purpose of this paper is to investigate how LSS has been applied in the Norwegian public healthcare context to reduce medication errors, in order to address the following research question: *'How has Lean Six Sigma been implemented in Norwegian Public Hospitals to reduce medication errors?'*. In order to answer to the research question, the following objectives have been set.

1) To understand the common types of medication errors found in Norwegians hospitals
2) To understand the common continuous improvement methodologies that hospitals are using
3) To understand the challenges and difficulties, benefits and readiness factors of Lean Six Sigma implementation that have led to a reduction in medication errors
4) To know tools and techniques of Lean Six Sigma that have used to reduce medication errors in Norwegian Hospitals

2. Literature review of LSS in reducing medication errors

Lean is a philosophy that focuses on the elimination of waste and non-value added activities from the process, thus improving speed and the reduction of operational costs. Importantly, the concept of lean focuses on understanding value from the customers' perspective, with activities that do not serve customers' needs considered for elimination from the process (Womack and Jones, 2003). Lean was first applied in the manufacturing industry, and has since commanded attention in healthcare delivery. As Radnor (2010) showed, 51% of process improvement methodologies used in service sectors focuses on Lean and 35% on health services. The implementation of Lean is favoured by healthcare managers worldwide as it potentially combines cost reduction with an outstanding standard of healthcare to the patient (Matthias and Brown, 2016), is easy to understand and straightforward to use by healthcare staff (Curatolo *et al.,* 2014).

The concept of Six Sigma was introduced by Bill Smith, a senior engineer and scientist within the Motorola communication division in the mid-1980s (Antony, 2006). Six Sigma was popularized by the General Electric (GE) and their former CEO Jack Welch (Furterer, 2014). GE capital introduced Six Sigma to the financial service industry and the R&D operation in the form of design for Six Sigma (DFSS) (Snee, 2010). The ultimate goal of Six Sigma is to improve process performance by reducing variation within the process, resulting in a reduction of defects or errors. The integration of Lean and Six Sigma can contribute to better outcomes than those gained by the separate implementation of each methodology (Bhat *et al*., 2014). The combination of Lean and Six Sigma is important because Lean cannot conduct a process under statistical control and Six Sigma is not able to accelerate the speed of all processes without Lean (George, 2002). LSS also addresses the root cause of the problems related to process flow and waste and reduces variation within a process (Bhat *et al*., 2014). LSS uses appropriate tools from both philosophies through the implementation of Define-Measure-Analyze-Improve-Control (DMAIC) methodology (Albiliwi *et al*., 2015) and, as such, LSS has the potential to contribute within healthcare industries as much as it has contributed in manufacturing industries (Laureani *et al*., 2013). In the UK, both Lean and Six Sigma have been implemented by the National Health Service (NHS) (Laureani *et al*., 2013). After this first example of LSS being successfully employed in healthcare sectors, several LSS projects have been applied in different areas of healthcare to improve their processes. This has not been without its challenges and, for example, Laureani *et al.* (2013) affirmed that the implementation of LSS in the healthcare sector has encountered the same barriers as in other industries. However, successful projects have been widely cited by several studies, for example, the reduction of patient waiting time in a registration process (Bhat *et al*., 2014), a tertiary care otolaryngology clinic (Lin *et al.,* 2013), an audiology clinic (Huddle *et al.,* 2016), and the reduction of turnaround time in a medical records department (Bhat *et al.,* 2016). Trakulsunti and Antony (2018) further mention that LSS is a powerful improvement methodology that could be applied to reduce medication errors, increase patient safety and reduce operational costs.

At the same time, Lean, Six Sigma, and LSS are not the only improvement methodologies available to healthcare practitioners. Table I depicts a variety of such methodologies, and how they have been used in healthcare. While each of these is worthy of further investigation, the scope of this research is limited to LSS in order

that the specific challenges to and benefits of LSS implementation in relation to mediation errors can be understood in clear detail.

Table I CI methodologies applied in healthcare

CI methodologies in healthcare	Example studies	Context	Example outcomes
Total Quality Management (TQM)	Chiarini & Baccarani (2016)	Italy	Organisational performance improvement
	Neetha *et al.* (2016)	India	Increased patient satisfaction Cost saving
Lean	Chiarini (2013)	Italy	Reduced average lead time
	Miller & Chalapati (2015)	India	Reduced outpatient patient waiting time
	White *et al.* (2015)	the USA	Reduced emergency department laboratory (ED) turnaround times
Six Sigma	Ortiz Barrios & Felizzola Jiménez (2016)	Columbia	Reduced average appointment lead time Increased patient safety
	Elbireer (2013)	Uganda	Reduction in data entry errors
	Gijo *et al.* (2013)	India	Cost saving Reduced patient waiting time in a pathology department
Lean Six Sigma	Bhat *et al.* (2016)	India	Reduced turn-around-time (TAT) Reduced work-in-process inventory
	Niemeijer *et al.* (2013)	the Netherlands	Reduced average length of stay (LOS) for hip fractures and average duration of surgery
	Sanders & Karr (2015)	the USA	A 50 percent decrease in vials used for testing

Medication errors have been defined by researchers as errors that occur at any stage of the medication process, whether they stem from prescribing, transcribing,

dispensing or administration by the nurse (Franklin *et al.*, 2005; Lisby *et al.*, 2005; Baril *et al.*, 2014). Franklin *et al.* (2005) further pointed out that a medication error may or may not cause harm to the patient, but it is still considered to be preventable. Healthcare staff have endeavoured to control the number of medication errors in their organisations, but have been unsuccessful in using effective tools to reduce medication errors (Hussain *et al.*, 2013). It is therefore important for healthcare sectors to employ an appropriate process excellence methodlogy to reduce the number of medication errors. A study by Chan (2004) first adopted Six Sigma to improve the medication dispensing process in a pharmacy department in Taiwan. The following year, Six Sigma was applied to a mid-sized hospital in the US to reduce medication order entry mistakes (Esimai, 2005). This study has yielded a dramatic reduction in estimated labour costs of $550,000. Similarly, a study conducted by Hintzen *et al.* (2009) showed that the hospital can save the inpatient pharmacy $82,650 annually by reducing the number of errors and missing doses (Hintzen *et al.,* 2009)

There is a noticeable increase in interest regarding the application of LSS to reduce medication errors. According to Trakulsunti *et al.* (2018), the USA is the leading country reporting Lean, Six Sigma and LSS implementation to eliminate medication errors in hospitals. However, there has been little evidence of implementation to reduce medication errors in the European public healthcare sector, and none in the public Scandinavian healthcare sector, including Norway. This shows the need for more research to be undertaken to understand the current status of LSS implementation in Norwegian hospitals. Therefore, the purpose of this paper is to explore how LSS has been implemented to reduce medication errors in Norwegian public hospitals.

3. Research Methodology

In order to address the research question: 'How has Lean Six Sigma been implemented in Norwegian Public Hospitals to reduce medication errors?', the study adopted a mixed approach involving survey and semi-structured interviews. The survey method is traditionally associated with a quantitative positivist approach. However, as a design it has also been used to collect qualitative data (Neuman, 2014). It is a structured way of asking different respondents the same questions (O'Gorman and MacIntosh, 2015) in order to understand the situation being studied without intervening. A mixed methods approach using a questionnaire and semi-structured

interviews was employed to collect the primary data in order to avoid single source bias and improve validity (Manville *et al.,* 2012). The combination of both methods of data collection can provide a greater understanding of the research questions than that gained by relying on one approach (Creswell, 2014).

To obtain qualitative data, semi-structured interviews with open-ended questions were conducted. The researcher can prepare questions and may also have a set of subquestions, sometimes referred to as follow-up questions or prompts, which can be used to explore answer further and gain more information. This method was suitable for this study because the researcher could gather in-depth data from the participants to elicit their opinions and thinking about the implementation of LSS in the Norwegian hospitals. The protocol for the interviews was created based on the report "Preparing for Interview Research: The Interview Protocol Refinement Framework" by Castillo-Montoya (2016). Each interview lasted approximately 45 minutes and was recorded. The interview protocol began with an explanation of the research purpose, followed by several broad questions, more specific and then detailed questions (Voss *et al*., 2002).

Nurses, doctors, pharmacists and quality advisors were interviewed, aligning with Lean's emphasis on including all stakeholders (Womack and Jones, 2003). All the participants worked directly or indirectly in Norwegian hospitals. The interviews were conducted in Norwegian to ensure that data were captured in the best possible way by motivating participants to speak freely in their native language. The interviews were audio-taped, transcribed, translated into English by the principal investigator for this research (Moxham *et al.,* 2010). The authors read the transcribed information for become familiar with it. The data from the transcribed interviews were coded and subsequently classified into themes.

To obtain quantitative data, a questionnaire was used as a survey instrument. The survey design and structure is explained in Table II. The target population for the survey were all the healthcare practitioners who were working in the four regional health authorities (RHA) in Norway: Northern Norway RHA; Western Norway RHA; Central Norway RHA and South-Eastern Norway RHA (Ringard *et al.*, 2013). The questionnaire consisted of three main parts. The first part of the survey aimed to understand general information about the participant's demographics by series of multiple-choice questions. The second part employed multiple-choice and close questions to ascertain the challenges and difficulties, benefits gained, and tools and

techniques of LSS implementation. The third part was designed to capture data regarding the extent to which the Norwegian public hospitals were ready to implement LSS to reduce medication errors. The questions were piloted by five leading academics and five practitioners to ensure that they were able to address the research questions (Antony *et al.,* 2007). The academics who have piloted the questionnaire have published peer-reviewed papers on Lean and Six Sigma topic over the past ten years. The practitioners included Master Black Belt and Black Belt who have carried out a number of Lean and Six Sigma projects in a hospital setting. The authors have carefully chosen these people from countries outside Norway. These ten people have provided some constructive feedback on a number of questions in the survey instrument and the authors have made amendment on such questions. The survey data were entered into spreadsheets for validation and coding using Microsoft Excel 2015 spreadsheets, Qualtrics software and analysed using SPSS.

Table II Survey design

Survey Design	
Element	**Explanation**
Questions	The questionnaire used close-ended questions with a multiple-choice format which was derived from the systematic review to capture aspects of LSS implementation in the Norwegian hospitals. In addition, a Likert rating scale was adopted, allowing respondents to indicate the level of agreement with the statements related to readiness factors and the difficulties of adopting LSS in Norwegian hospitals
Quality Assurance	The questionnaire was piloted based on the Norwegian language to ensure the appropriate length and structure and to detect possible errors (Collis and Hussey, 2013). Those involved in the pilot who did not fit the demographic requirements for the study were excluded from the main study subsequently.
Sampling	Snowball sampling was used to identify the participants for the study. It was difficult to define the exact sample size, since potential respondents may have shared it with their colleagues or other appropriate respondents (Saunders *et al*., 2009).

4. Key Findings

Research findings are organized into two main sections. The first section presents the data from the questionnaires and the second provides the qualitative data gathered through semi-structured interviews using the themes retrieved from the thematic analysis. In the survey and interview, the respondents have been asked the same questions such as demographic information, types of medication errors, common continuous improvement methodologies, challenges and difficulties and benefits for LSS implementation etc.

4.1 Survey results

The survey results are presented in two parts including background information of the respondents and a number of characteristics: types of medication errors; common continuous improvement methodologies; challenges and difficulties; benefits; LSS tools and techniques and readiness factors for LSS implementation.

4.1.1 Demographic information

The questionnaire have been distributed to 200 people which included nurses, doctors, quality chiefs, specialist advisors, social workers, amedical secretaries and managers in hospitals. 38 out of 200 have been completed the questionnaire. The highest proportion of respondents worked in the Western Norway RHA (63.2%), with 26.2 % from the South-Eastern Norway RHA, 7.9 % respondents from Northern Norway RHA and 2.6% from Central Norway RHA. Further participant demographic is presented in Table III.

Table III Survey Participant Demographics

Gender	
Male	23.7%
Female	76.3%
Profession	
Nurse	76.3%
Doctor	13.2%
Quality Chief/Specialist/Advisor	2.6%
Social Worker	2.6%
Medical Secretary	2.6%
Manager	2.6%
Health Region	
Northern Norway RHA	7.9%
Western Norway RHA	63.2%
South-Eastern Norway RHA	26.2%
Central Norway RHA	2.6%

4.1.2 Types of medication errors

Medication errors can occur at every stage of the medication process, stemming from prescription, transcribing, dispensing and administration, monitoring and reporting. According to the literature, it is important to ensure that the correct phase of the medication process has been targeted for improvement (Bhat et al., 2016). The majority of participants were involved in the administration phase, and 65.8 % of the participant agreed that medication errors frequently occurred in this phase. This clearly indicates that the administration process needs to be improved in order to reduce errors occurring in this phase. Relatively few participants identified that the errors occurred in the monitoring and reporting phases. This could be explained by the lack of data collection strategies in these phases.

4.1.3 LSS Methodologies

Several methodologies could be used for the implementation of continuous quality improvement, such as DMAIC (define, measure, analyse, improve, control) or PDCA (plan, do, check, act) (Albliwi *et al.,* 2017). Interestingly, for this study, the majority of respondents (80 per cent) had no knowledge of any continuous improvement methodologies such as these. Smaller numbers of participants had some knowledge of Lean (18%) and total quality management (TQM) (10.5%) and only a few participants acknowledged Six Sigma. This shows a clear lack of training and education regarding LSS methodology in the Norwegian healthcare context. The participants who had any knowledge of continuous improvement methodologies were questioned further about the use of particular methodologies in their organisations. The results show that four participants used TQM, three participants used PDCA and only two participants used Six Sigma. Focusing on the implementation of methodologies to reduce medication errors, two participants used PDCA and one each used TQM and Lean. Due to a lack of awareness of the need for LSS, Norwegians hospitals have not widely used LSS to reduce medication errors. When implementing LSS to reduce medication errors, the organisation encountered several challenges and difficulties, as explained in the next section.

4.1.4 Challenges and difficulties of LSS implementation

The list of challenges presented to the respondents was extracted from the published literature regarding the problems encountered by service sectors when implementing

LSS. The top issues experienced when implementing continuous improvement methodologies in the Norwegians hospitals were resistance to change, lack of time, lack of top management involvement and commitment and lack of LSS training or coaching. These insights are similar to the findings from the literature of leading Six Sigma practitioners and academics (Antony *et al.,* 2007; Albliwi, 2017). Challenges related to lack of time could be overcome with improvements in the management process (Kokkranikal *et al*., 2013). Furthermore, resistance to change could be ameliorated by changing the culture and employees' mind-set. Linking LSS to organisational strategy could encourage top management involvement in LSS implementation in the organisation.

4.1.5 Benefits for LSS implementation

The results showed that a potential benefit achieved from the employment of continuous improvement methodologies was an increased openness surrounding medication errors. Implementing LSS projects requires data to measure the baseline performance of the process. Therefore, in a culture of openness, participants are not afraid to disclose errors. Increased patient safety and more effective communication were also the top ranked perceived benefits. Interestingly, effective communication is a key success factor in helping the project to run smoothly. These findings differ slightly from those found in the published literature because two participants suggested they had not experienced any benefits from implementing improvement methodologies, and none of the participants mentioned the key benefit of a reduction in potential errors in the medication process

4.1.6 LSS tools and techniques in the context of medication errors

Understanding the tools and techniques of Lean Six Sigma, as well as its philosophy, plays a significant role in the successful implementation of LSS. The top three tools and techniques used in the Norwegian public healthcare context to reduce medication errors were Standard Operating Procedure (SOP), flow chart and process mapping. However, it is important to note that half of the participants did not know if any LSS tools and techniques had been used in their organisations. The results of the survey show that the most commonly used tools and techniques are those that are non-statistical and are easy to apply by healthcare practitioners. Standard operating procedure is a step by step set of instructions, helping healthcare practitioners to perform the work correctly such as standardizing pharmacy order entry process

(Critchley, 2015). Process mapping tools can help healthcare practitioners to understand the current problems in the medication process such as poor flow, rework loops and delays. These can be used to compare and contrast the actual flow and the ideal flow to identify the opportunities for improvement (Antony *et al.,* 2016).

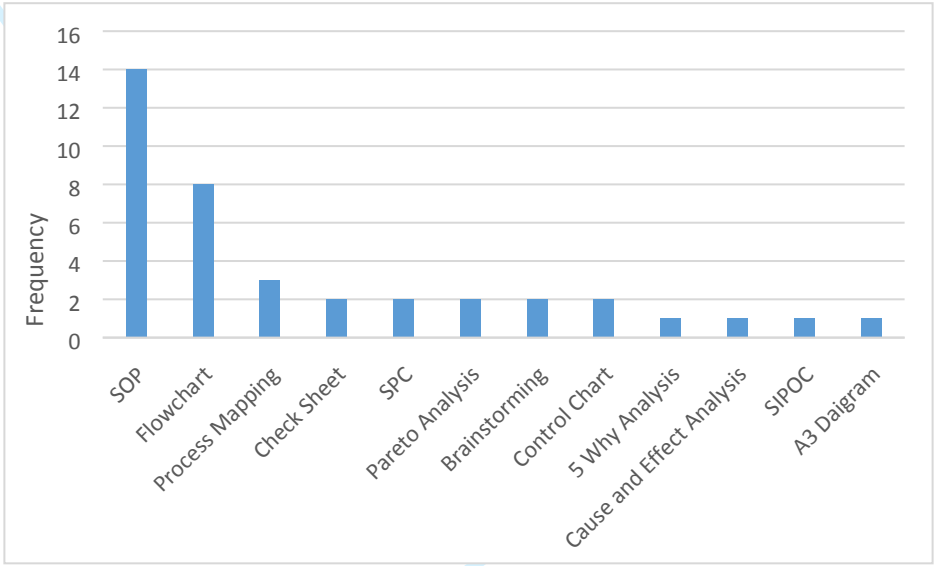

Figure 1 LSS tools and techniques used to reduce medication errors.

4.1.7 Readiness factors for LSS implementation

Readiness factors were investigated to ascertain if Norwegian public hospitals are ready to implement LSS in order to reduce medication errors. Readiness factors are required for the successful introduction and development of an LSS initiative (Antony, 2014). To investigate readiness factors, the participants were asked to rate the readiness factors of LSS implementation on a Likert scale from 1-7 (1= highly disagree, 2 = disagree, 3 = slightly disagree, 4= I don't know, 5 = slightly agree, 6 =agree, 7= highly agree). The analysis found that 'employees show the need for process improvement to reduce medication errors' was the highest ranked readiness factor. The next most important was 'effective communication at all levels of organisation'. The mean score of each readiness factors is presented in Table IV.

Table IV. Readiness factor for LSS implementation

Readiness factors	**Mean**
Employees	5.36

show the need for process improvement	5.30 5.20
Effective communication at all levels	4.2
Errors are viewed as an opportunity for improvement	
Open culture for improvement	

4.2 Interviews Results

4.2.1 Demographic Information

A sample of 12 people were interviewed, 11 female and one male. The sample comprised seven nurses, four quality chief, quality advisors and specialist advisors and one pharmacist. With regards to numbers of respondents in different regional health authorities, the majority of participants worked in the Western Norway RHA (eight people), with two each from Northern Norway RHA and South-Eastern Norway RHA. All of the interviews were conducted in Norwegian to ensure that respondents were able to use their native language. The participant demographic is further presented in Table V.

Table V Interview Participant Demographics

Gender	
Male	8.3%
Female	91.7%
Profession	
Nurse	58.3%
Pharmacist	8.3%
Quality Chief/Specialist/Advisor	33.3%

Health Region	
Northern Norway RHA	16.7%
Western Norway RHA	66.7%
South-Eastern Norway RHA	16.7%

4.2.2 Types of medication errors

According to the Institute of Medicine (2007), different stakeholders are part of the different medication phases, depending on their job in the hospital. The thematic analysis revealed that the majority of participants identified that most errors occurred in the administration phase. This was probably because almost half of the participants were involved in this phase. However, the other participants agreed that the errors mostly occurred in the prescribing, transcribing and dispensing phases. The transcribing phase and monitoring and reporting phase were not emphasised nor frequently mentioned by the participants. This indicates a clear need to reduce the number of errors in the administration phase.

4.2.3 LSS methodologies

The participants were asked about their knowledge of Lean, Six Sigma and other methodologies such as Kaizen and TQM. The majority of respondents (7) lacked knowledge of any improvement methodologies, and none of the nurses recognised any continuous improvement methodologies. The findings demonstrate that employees are not involved when implementing improvement methodologies in the hospitals. Participants who were working in relation to quality assurance from Northern Norway RHA, South-Eastern Norway RHA and Western Norway RHA did mention that Lean had been implemented to some extent. However, it did not appear that Lean has been implemented to reduce medication errors. The findings further revealed that whilst Six Sigma had also not been applied in both the general Norwegian healthcare context and to reduce medication errors, PDCA was being used for process improvement in this context. It could be suggested that LSS had not been implemented to reduce medication errors due to lack of training and coaching.

4.2.4 Challenges and difficulties for LSS implementation

Table VI shows that the top challenges for LSS implementation in the Norwegian Hospitals were focus on lack of time, resistance to culture change, lack of data

availability, a fragmented approach and lack of effective communication between IT systems. The majority of participants agreed that lack of time was the challenge for the employment of LSS. The potential difficulties encountered when trying to implement LSS was lack of baseline data on current process performance. Resistance to change in the culture change was one of the challenges faced by the Norwegian hospitals as mentioned by half of the participants. Therefore, hospitals should gradually attempt to change their culture in order to successfully deploy LSS (Albiwi *et al,* 2014). Poor communication within the hospitals was also a major problem. The hospital hierarchy could affect the culture which contributes to increased unevenness of workload and hospitals staff tending to work in silos. Establishing clear and effective channels of communication could help healthcare organisations to solve this problem (Antony *et al.,* 2007).

Table VI The top five challenges of LSS implementation to reduce medication errors

List of challenges
1. Lack of time (n=9)
2. Resistance to change (n=6)
3. Lack of data (n=5)
4. Fragmentation (n=4)
5. Lack of effective communication between IT systems (n=4)

4.2.5 Benefits of LSS implementation

The three greatest benefits achieved from continuous improvement methodologies were decreased medication errors, increased patient safety and increased internal collaboration. These benefits are similar to those identified in the systematic literature review by Trakulsunti *et al.* (2018). This review found that the key benefits of such interventions using process excellence methodologies were the reduction of errors in the medication process such as missing medication (Hintzen et *al.*, 2009), expired medication errors (Hussain *et al.,* 2015) and order entry errors by the pharmacy (Benitez *et al*., 2007; Esimai, 2005), mostly occurring in the pharmacy department in hospitals. However, one third of participants had no experience of the benefits arising from LSS implementation because their organisations were not aware of LSS.

4.2.6 Lean Six Sigma tools and techniques in the context of medication errors

The literature identifies that one of the success factors for LSS implementation is the integration of statistical and non-statistical tools and techniques. Conversely, the results from the study clearly demonstrated that the majority of tools and techniques used in the reduction of medication errors were SOP and checklists which are non-statistical tools. This appears to be due to a lack of training and coaching for project teams to understand the application of LSS tools and techniques. These results are in line with the previous study by Antony *et al.* (2007) which states that many service organisations commonly apply simple tools for process improvement such as process mapping, Pareto analysis and cause and effect diagrams.

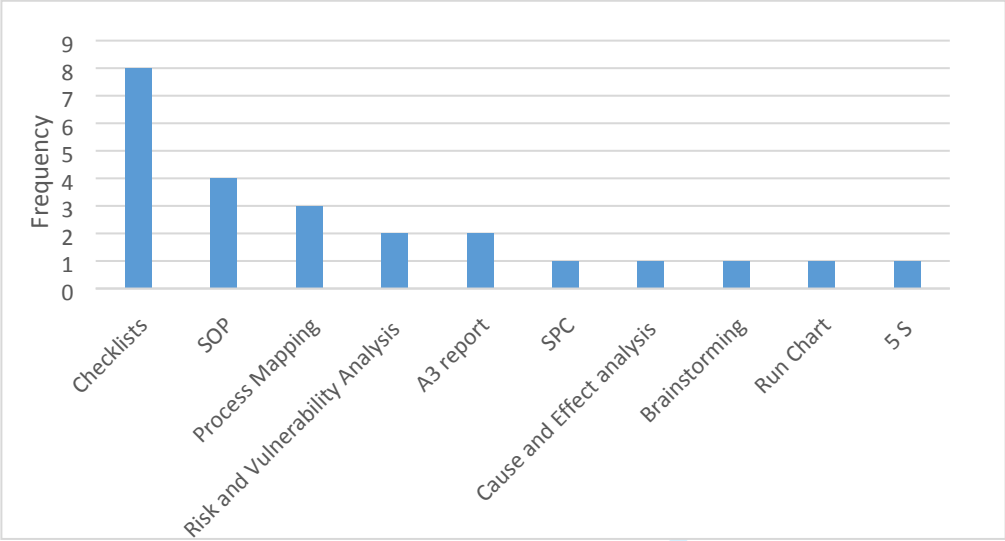

Figure 2 LSS tools and techniques to reduce medication errors.

4.2.7 Readiness factors for LSS implementation

Top management should determine whether the organisation is ready to start an LSS project (Alibiwi *et al.,* 2014). A lack of readiness factors could lead to resistance to change at all organizational levels (Antony, 2014). However, the study identified that the key readiness factor was not mentioned by most of the participants. Other significant factors such as leadership involvement, linking LSS to the hospitals' strategy and customer focus were not identified.

5. Discussion, implications and limitations

The results of the survey indicate that participants who were working directly or indirectly with the medication distribution process believed that most errors occurred in the administration phase. Most participants had been involved in an administration error. The findings are aligned with a report from the Norwegian Directorate of Health which reveals that out of 1676 medication errors, 68.4% of the errors were administration errors (Helsedirektoratet, 2018). There is a clear need to acknowledge, address, and reduce administration errors as they pertain to medication. This concurs with findings from Trakulsunti *et al.* (2018), which indicate that administration errors are the most dominant type that should be targeted by healthcare practitioners in an effort to reduce errors.

LSS methodologies, the challenges and difficulties, benefits, tools and techniques and readiness factors were all explored in the study. The study highlights that PDCA has been widely applied to reduce medication errors in the Norwegian healthcare context. Lean or Six Sigma have not been fully implemented to reduce medication errors due to a lack of LSS knowledge. The key benefits elicited from the mixed methods data were improved patient safety, a reduction in the number of medication errors and increased openness surrounding medication errors. This finding is similar to studies carried out by Hintzen *et al.* (2009), Hussain *et al.* (2015) Benitez *et al.* (2007) and Esimai (2005). However, other key benefits such as increased financial gains and improved staff working performance were not mentioned in the study.

The main challenges and difficulties faced by Norwegian hospitals relate to leadership vision, LSS training and coaching, and management attention. These result in resistance to change, perceived lack of time, insufficient data, and a lack of top management involvement and commitment. As mentioned by Antony *et al.* (2007), these challenges are commonly encountered by several service organisations. The findings further showed that the LSS tools and techniques mostly used to reduce medication errors in Norwegian hospitals are non-statistical tools such as SOP, process mapping and checklist. Notwithstanding, LSS has not been fully implemented by Norwegian hospitals, but several tools and techniques have been used to reduce medication errors. LSS tools and techniques have not been implemented across DMAIC methodology due to the lack of LSS training and coaching.

The results of the study revealed several aspects regarding the application of LSS in Norwegian public hospitals to reduce medication errors. Albiliwi *et al*. (2015) claimed that Six Sigma training is costly for many organizations, yet researchers argue that it is necessary for Norwegians hospital to invest in training staff before the implementation of the LSS project. However, training alone cannot guarantee a successful project. In addition, coaching and mentoring by champions and experts are needed. Furthermore, challenges and benefits when implementing LSS have been established, an awareness of which can help healthcare practitioners to be prepared before LSS is put in place.

This study is valuable and beneficial for quality advisors and managers in hospitals, as it provides a clear understanding of the current state of LSS in the Norwegian healthcare context. The study clearly indicates that LSS is a methodology that is capable of reducing medication errors, which is the second most problematic issue reported in Norwegian hospitals (Helsedirektoratet, 2018). Senior managers could apply the findings to improve the probability of project success and cost reductions when implementing LSS and other quality improvement methodologies.

Some limitations of the study should be taken into account. Most of the interview participants were from West Norway RHA and none from Central Norway RHA. However, quality advisors from three of the four health regions were interviewed to ensure that the data would cover as much of the healthcare context in Norway as possible. Further, a snowball sampling technique was used whereby a third-party with expertise was contacted to distribute the survey to the appropriate personnel, as well as to identify eligible interview participants. This type of sampling makes it difficult for researchers to have overall control over who is asked and who chooses to participate. Nevertheless, as the target population (that is, relevant clinicians and those with a role in medicines management) was quite specific, the total number of 38 people who completed questionnaires and 12 who agreed to be interviewed was felt to provide considerable insight regarding the topic of the research.

6. Leadership for Lean Six Sigma

When companies decide to introduce and implement a LSS initiative, there are several building blocks required for a successful venture. One of those building blocks is Leadership. Leadership is absolutely crucial from the development of strategy for LSS

to identification of strategic projects which are directly aligned with the corporate objectives of the business. Both transformational and transactional leadership styles are proved to be beneficial in the successful deployment of LSS (Laureani and Antony, 2017). Existing theory suggests that in order to implement a quality improvement methodology successfully, an organization needs to have transformational leaders at the top (Waldman, 1993) that create the culture and objectives, which must be carried out from transactional leaders in the middle management ranks (Waldman et al., 1998). So what are the roles and responsibilities of leaders in hospitals for making the application of LSS successful? The authors suggest the following key points to be very beneficial.

- *Lean Six Sigma transformation is a journey that does not happen overnight: successful leaders are those that can see through the difficult moments and inspire employees to keep going*
- *Able to establish an organizational culture that accelerates Lean Six Sigma implementation*
- *Leaders have a crucial role in selecting the right and top talented employees for the training and execution of projects and ensuring that the projects are aligned with the corporate strategic goals and objectives*

A recent study has identified 10 leadership characteristics which are more conducive to success in Lean Six Sigma deployment in any setting and this list includes: visibility, communicative, inspirational, consistent, targeted, leading by example, flexible, perceive Lean Six Sigma as a philosophy, clearly define roles and responsibilities-and able to build.

7. Conclusion and directions for further research

The findings of the study revealed that the most of medications errors in Norwegian hospitals occur in the administration phase, and thus this phase should be targeted for improvement. The study found that Lean and Six Sigma has not been widely applied as complete methodologies to reduce medication errors in the Norwegian healthcare context though PDCA was identified as a popular improvement methodology. It is suggested that LSS is a powerful methodology that could be used to solve the problems in the medication process, resulting in a reduction of medication errors.

Therefore, this is a potential opportunity to establish LSS as a methodology to reduce such errors in the Norwegian healthcare context. Additionally, healthcare practitioners should consider the challenges and difficulties of LSS before beginning the LSS project. Project team members (which include all level of practitioners who are involved with the medication process) should understand the purpose of the Lean and Six Sigma philosophy and its tools and techniques as well as undergoing the training. Moreover, before the LSS project commences, the hospital should consider readiness factors to determine whether the organisation is ready to employ LSS.

This research could be applied in similar contexts (such as other Scandinavian countries) to investigate similarities and differences and ascertain if they are able to draw on each other's experiences. Whilst the scope of this study was limited to the Norwegian public hospital sector, a comparison between healthcare providers could also be beneficial. Finally, this could be a fruitful area for future research to apply action research methodology.

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