

Developing a maturity model to facilitate the sustainability of Lean implementations in hospitals

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ABSTRACT

The implementation of Lean principles in healthcare has been a topic of research since the early 2000s and it has been increasingly implemented by healthcare providers. Although Lean principles have been implemented in a growing number of hospitals, their implementation is not always maintained. It is important to understand that the successful initial implementation of Lean principles in healthcare does not ensure that the implementation is sustainable. In the healthcare environment, especially in hospitals, an improvement project is only deemed successful if the implementation ensures reforms that permanently better the quality of service and level of patient satisfaction. Healthcare organisations often fail to meet this goal due to an implementation gap. Lean implementation in healthcare environments has seen failure rates of up to 90%. Therefore, a Lean strategy that is set to improve an organisation's performance will not result in improved performance unless it is properly planned and implemented with sustainability as end goal. The problem this study aims to address is the lack of sustained Lean implementations in hospital environments. The aim of this study is to design a Lean implementation roadmap that will contribute towards sustainable Lean implementations. The study is conducted within the problem-solving paradigm of design science research, following a maturity model development procedure model. The developed sustainable Lean implementation roadmap (SLIR) was designed in the form of a prescriptive maturity model. The SLIR's development was informed by factors that influence successful Lean implementation in hospitals and an implementation science framework, namely the quality implementation framework. The SLIR consists of four maturity levels and seven capability dimensions. It was evaluated by means of a survey sent to respondents with experience in Lean implementations in hospitals. There was consensus among the respondents that the SLIR contributes towards sustainable Lean implementation in a hospital environment.

Key terms: Lean healthcare, Lean implementation, maturity model, design science research, success factors, systematic literature review, implementation science, survey

LIST OF ACRONYMS

DSR	Design science research
SLIR	Sustainable Lean implementation roadmap
SLR	Systematic literature review
IT	Information technology
IS	Information systems
QUOROM	Quality Of Reporting Of Meta-analysis
PRISMA	Preferred Reporting Items for Systematic reviews and Meta-Analyses
ENTREQ	Enhancing Transparency in Reporting the synthesis of Qualitative research
QIF	Quality implementation framework
DP	Design principle
DR	Design requirement
PDCA	Plan do check act

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CHAPTER 1

INTRODUCTION TO THE STUDY

This chapter aims to address the following research question:

- Research question 1.1 – What information does the current body of literature offer with respect to the identified research problem?
-

This chapter fits into the methodological steps as follows:

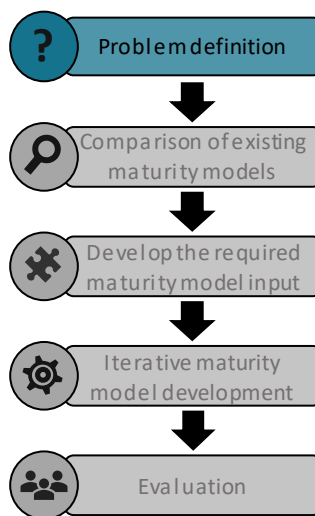


Figure 1: Chapter 1 research methodology step

CHAPTER 1 INTRODUCTION TO THE STUDY

1.1 Background to study

According to Section 27 of the Constitution (1996) every South African should have access to healthcare services. The Government Gazette (2017) refers to this government-funded healthcare sector as the public healthcare sector. This government publication further describes that South African citizens also have the option to purchase health insurance and receive healthcare services from privately owned healthcare organisations. This study does not focus on either one of these two sectors, but rather on the hospital environment in general. Healthcare organisations worldwide are not only faced with the pressures of an increase in demand due to aging populations and lifestyle diseases such as cancer and diabetes requiring long-term care, but also with a decrease in state spending on public healthcare services (Al-Balushi *et al.*, 2014). Due to the rising pressures, healthcare organisations are forced to both improve and sustain their performance and their customer satisfaction (Van Rossum *et al.*, 2016). Therefore, healthcare organisations have to achieve more with less (Al-Balushi *et al.*, 2014).

Bicheno and Holweg (2016) provide a simplified definition for Lean as “doing more with less”. The current body of knowledge is in agreement that the Lean thinking philosophy has the potential to help healthcare environments achieve more with less (D'Andreanmatteo *et al.*, 2015; Hung *et al.*, 2015; Steed, 2012). Although the Lean philosophy originated in the automotive industry (Liker, 2004), healthcare environments, such as hospitals, share a common goal with the automotive industry: they have to use their resources efficiently to perform their core business effectively (Daniels *et al.*, 2005). There are various publications that have applied quality improvement practices, such as Lean principles, to the service sector and Lean implementation was the focus in 51% of these publications (Al-Balushi *et al.*, 2014). Ben-Tovim *et al.* (2008) state that just as it is appropriate to implement Lean in both the manufacturing and service sector, it is appropriate to implement it in the healthcare (service) sector. The following definition of the Lean philosophy shows that it offers possibilities for assisting healthcare providers with the challenges they encounter (Grabau, 2016):

“Lean is a set of concepts, principles and tools used to create and deliver the most value from the customer’s perspective while consuming the fewest resources and fully utilizing the knowledge and skills of the people performing the work.”

Lean implementation in healthcare has been a topic of research since the early 2000s and healthcare providers are implementing it more frequently (D'Andreamatteo *et al.*, 2015). Van Rossum *et al.* (2016) state that, as a result of the increase in Lean in healthcare implementation, the term “Lean healthcare” has emerged when referring to the implementation of Lean principles in healthcare.

Fixsen *et al.* (2005) list the final stage of any implementation as sustainability. Although Lean healthcare is implemented in an increasing number of hospitals, its implementation is not always maintained (Van Rossum *et al.*, 2016). Akugizibwe and Clegg (2014) confirm that healthcare providers struggle to sustain the success achieved after initial Lean implementation. D'Andreamatteo *et al.* (2015) conclude that Lean implementation research needs to be broadened in terms of the country in which it is implemented. Linking to their conclusion, the struggle of maintaining initial Lean implementation success is also experienced in South Africa. In a 2018 eHealth News article the CEO of Groote Schuur Hospital in South Africa, Dr B Patel, stated that Lean principles had been introduced to the hospital prior to her appointment, but that they were “...short lived...” and that the results were not sustained (Chowles, 2018). It is important to understand that the successful initial implementation of Lean healthcare does not ensure that the implementation is sustainable. In the healthcare environment an improvement project is only seen as successful if the implementation of Lean healthcare ensures changes that permanently better the quality of service and the patient satisfaction (Stelson *et al.*, 2017). Thus, even if the initial implementation is successful, it cannot be deemed a success unless the improvements are permanent – thus sustainable.

The implementation of Lean principles in healthcare is complicated because of the complexity of healthcare organisations (Aherne & Whelton, 2010; Al-Balushi *et al.*, 2014; Stanković, 2008). Due to this complexity, healthcare organisations have to pay attention to success factors that should be in place as part of the initial stage of Lean implementation (Al-Balushi *et al.*, 2014). Success is defined as “the accomplishment of an aim or purpose” (Garner, 2016b). Pinto and Slevin (1987) define success factors as factors that are predictive of project success. Therefore, success factors can be defined as factors that influence the change process (Rich & Bateman, 2003). In terms of healthcare, success factors are factors that enable employees to successfully adapt Lean thinking in their everyday routines (Maijala *et al.*, 2018). These success factors can be seen as part of a change-implementation strategy that influences the sustainability of the change (Al-Balushi *et al.*, 2014). It is therefore critical to incorporate success factors into a Lean healthcare implementation.

D'Andreamatteo *et al.* (2015) state that, although the topic of success factors has been established in literature, the sustainability of Lean healthcare requires attention. They agree with Fixsen *et al.* (2005) that the final stage of Lean healthcare implementation should be sustaining the change. They summarise the Lean transformation process as follows: understanding the as-is state, defining the to-be state, implementing Lean principles and sustaining the implementation. Since success factors are critical to the success, and thus, the sustainability, of the Lean transformation process (Van Rossum *et al.*, 2016), insufficient attention to success factors could place the success of the final stage of the Lean transformation process at risk (Al-Balushi *et al.*, 2014).

Although Lean implementation has the potential to improve a healthcare organisation's performance, this goal cannot be reached if the implementation of the Lean initiative is not thoroughly planned with sustainability as the end goal (Van Rossum *et al.*, 2016). Van Rossum *et al.* (2016) further state that healthcare organisations often fail to meet their implementation goal due to an implementation gap. They further state that some studies conclude there is a Lean healthcare failure rate of up to 90%. Therefore, having a Lean strategy that will improve your organisation's performance does not mean that it will result in improved performance unless it is implemented properly. A sustainable Lean implementation can be reached by closing the gap between strategy and execution (Van Rossum *et al.*, 2016).

While discussing their findings, D'Andreamatteo *et al.* (2015) conclude their literature review by stating that two of the main issues that require further research is the implementation process of Lean principles in healthcare as well as its sustainability. To address the first issue namely the implementation process of Lean principles a relatively new field of research, called implementation science, is used to inform this study. Eccles and Mittman (2006) define this science in the first publication of the *Journal of Implementation Science* as follows:

"Implementation research is the scientific study of methods to promote the systematic uptake of research findings and other evidence-based practices into routine practice, and, hence, to improve the quality and effectiveness of health services and care."

Fitzgerald (2018) describes that 66% of organisations' efforts to implement some form of change fail due to implementation failure. Nilsen (2015) explains that implementation science should investigate and develop theories and frameworks to help researchers and practitioners understand the mechanisms that will ensure successful implementation. This may then assist in reducing the failure rate described by Fitzgerald

(2018). These investigated mechanisms can contribute to closing the gap between research and practice. Since implementation is a common and transdisciplinary concept, implementation researchers develop implementation frameworks to act as a knowledge-communication bridge between disciplines (Tabak *et al.*, 2012). Bauer *et al.* (2015) state that quality improvement approaches, such as Lean, and implementation science both aim to improve healthcare. However, these improvements do not increase a company's performance and customer satisfaction if they are not sustained.

Although the body of research on Lean healthcare has been growing over the past 20 years (Graban, 2016) and Lean's potential to assist hospitals in achieving their goals with the use of less resources has been proven hospitals still often experience a trial and error process when implementing Lean (Van Rossum *et al.*, 2016). To reduce these "trial and error" processes, it is vital to not only focus on the Lean initiative but to also focus on the implementation process of implementing Lean in a hospital environment.

1.2 Problem statement

From the literature discussed above, the following research problem is derived: *Lean implementations in hospital environments are not sustained.*

1.3 Research opportunity

A maturity model comprises various maturity levels that guide organisational transformation from an initial to a desired state (Becker *et al.*, 2009; De Bruin *et al.*, 2005). Maturity can be defined as "...the state of being complete..." (Stevenson, 2010b). Therefore, a maturity model can be seen as an implementation framework (Van Dyk, 2013). A maturity model can be designed to guide the implementation of a certain innovation, such as Lean principles, through various predefined maturity stages, with the final stage being the sustainment of the implementation. Therefore, the research opportunity to use a maturity model as a mechanism to develop an implementation framework towards sustainable Lean implementation in hospitals arises.

Maturity models are applied for several purposes, one of these purposes is to be "...a roadmap for improvement" (De Bruin *et al.*, 2005). These maturity models are referred to as prescriptive maturity models (Pöppelbuß & Röglinger, 2011). A prescriptive maturity model with incorporated Lean healthcare success factors and an implementation science framework has the potential to address the sustainability of implementing Lean in hospitals. Based on a preliminary literature review, that is further discussed in Chapter 2, a similar prescriptive maturity model has not yet been researched. Therefore, the

study's research aim, of developing such a maturity model, encapsulates this possible solution.

1.4 Research aim and objectives

The following research aim and objectives arise from the problem statement and research opportunity:

1.4.1 Research aim

The aim of this study is to design a Lean implementation roadmap, in the form of a prescriptive maturity model, that will contribute towards sustainable Lean implementations in a hospital environment. The aim of the maturity model is to guide sustainable Lean implementation in a hospital environment by incorporating Lean success factors and implementation science into the model. This model is referred to as the SLIR (sustainable Lean implementation roadmap) throughout the rest of the study.

1.4.2 Research objectives

In order to reach the aim of the study, the research objectives are defined as follows:

1. To explore sustainable Lean implementation in hospital environments as a relevant research problem;
2. To investigate maturity models and determine whether a maturity model that address the aim of this study exists in the current body of knowledge;
3. To define and develop the input required for the development of the SLIR;
4. To develop the SLIR;
5. To verify that the SLIR adheres to all its design requirements; and
6. To validate the SLIR.

1.5 Research questions

The research objectives discussed in the previous section give rise to the following research questions respectively:

1. Explore sustainable Lean implementation in hospital environments as a relevant research problem:
 - 1.1. What information does the current body of literature offer with respect to the identified research problem?

2. Investigate maturity models and determine whether a maturity model that address the aim of this study exists in the current body of knowledge:
 - 2.1. What are the definitions, constructs and paradigms relevant to maturity models?
 - 2.2. What maturity models relevant to Lean healthcare are available?
3. Define and develop the input required for the development of the SLIR:
 - 3.1. What are the factors that influence the success of Lean implementation within a hospital environment?
 - 3.2. Which implementation science framework is the most appropriate to incorporate into the development of the SLIR?
 - 3.3. What are the design requirements that the SLIR must satisfy?
4. Develop the SLIR:
 - 4.1. What approach should be followed during the SLIR development process?
 - 4.2. How should the various development inputs inform the development of the SLIR?
5. Verify that the SLIR adheres to all its design requirements:
 - 5.1. Does the model adhere to each of the specified design requirements?
6. Validate the SLIR:
 - 6.1. Did the study address a valid research problem?
 - 6.2. Was a valid research design followed to address the research problem?
 - 6.3. Does the SLIR address the research problem that was identified in this study?

1.6 Research design

The study's research problem is addressed within the problem-solving paradigm of design science research (DSR). Literature suggests that maturity models should be developed within this paradigm (Becker *et al.*, 2009; Mettler & Rohner, 2009; Pöppelbuß & Röglinger, 2011). The paradigm is further discussed in Chapters 2 and 3. The research design followed in this study can be seen in Figure 3. Figure 2 acts as a key to understand Figure 3's composition. The research design is further discussed in Chapter 3.

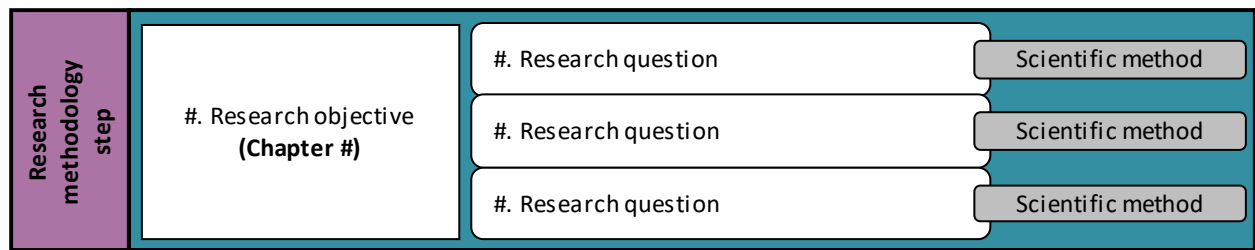


Figure 2: *Research design key*

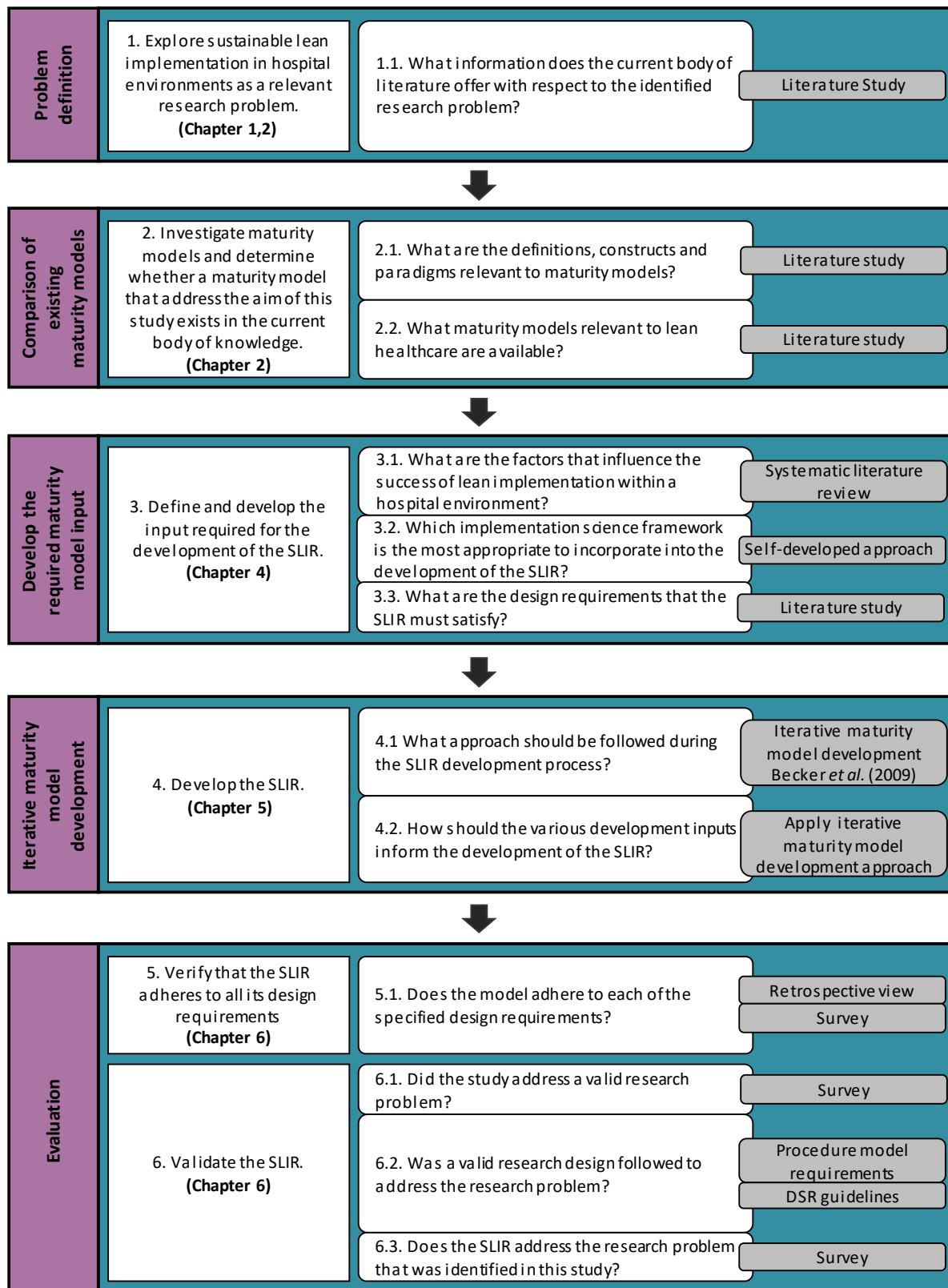


Figure 3: Research design

1.7 Chapter division

Table 1 below outlines the chapter division of this study. The table indicates in which chapter the various research objectives and research questions are addressed.

Table 1: Chapter division

Chapter	Research Objective	Research Question
1 Introduction	1. Explore sustainable lean implementation in hospital environments as a relevant research problem.	1.1. What information does the current body of literature offer with respect to the identified research problem?
2 Literature review	1. Explore sustainable lean implementation in hospital environments as a relevant research problem. 2. Investigate maturity models and determine whether a maturity model that address the aim of this study exists in the current body of knowledge.	1.1. What information does the current body of literature offer with respect to the identified research problem? 2.1. What are the definitions, constructs and paradigms relevant to maturity models? 2.2. What maturity models relevant to lean healthcare are available?
3 Research design		
4 Model input	3. Define and develop the input required for the development of the SLIR.	3.1. What are the factors that influence the success of lean implementation within a hospital environment? 3.2. Which implementation science framework is the most appropriate to incorporate into the development of the SLIR? 3.3. What are the design requirements that the SLIR must satisfy?
5 Model development	4. Develop the SLIR.	4.1. What approach should be followed during the SLIR development process? 4.2. How should the various development inputs inform the development of the
6 Model evaluation	5. Verify that the SLIR adheres to all its design requirements. 6. Validate the SLIR.	5.1. Does the model adhere to each of the specified design requirements? 6.1. Did the study address a valid research problem? 6.2. Was a valid research design followed to address the research problem? 6.3. Does the SLIR address the research problem that was identified in this study?
7 Conclusions and recommendations		

1.8 Chapter conclusion

This chapter served as an introduction to the rest of the study. The research problem was stated as follows: Lean implementations in hospital environments are not sustained. The research aim and objectives were formulated and the research design that is followed, within the design science research problem-solving paradigm, to reach the research aim was explicated. Finally, the layout of the document, in terms of chapter division and research questions was presented. The next chapter reviews the literature relevant to this study.

CHAPTER 2

LITERATURE REVIEW

This chapter aims to address the following research questions:

- Research question 1.1 – What information does the current body of literature offer with respect to the identified research problem?
 - Research question 2.1 – What are the definitions, constructs and paradigms relevant to maturity models?
 - Research question 2.2 – What maturity models relevant to Lean healthcare are available?
-

This chapter reports on the following step of the research methodology:

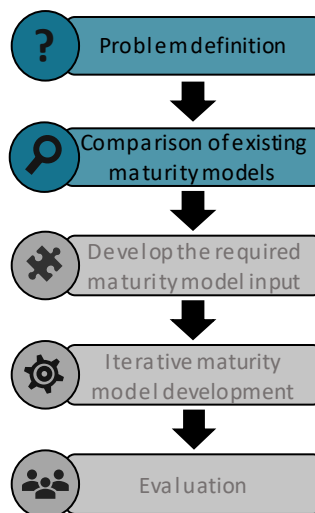


Figure 4: Chapter 2 research methodology steps

CHAPTER 2 LITERATURE REVIEW

2.1 Chapter introduction

The purpose of this chapter is to investigate the literature pertaining to the main themes of this study. These themes emerge from the study's aim and research design. Figure 5 illustrates the orientation of this chapter. The themes are indicated in the light blue blocks, while the content to be covered is presented in the white blocks. The study's aim gave rise to the following themes: Lean, systematic literature review (SLR), implementation science and maturity models. The themes of DSR and the evaluation strategies were derived from the study's research design.

Firstly, Lean is discussed as the application domain of the study. Since design is such an integral part of this study DSR is the next topic of discussion in the literature review. More specifically DSR is discussed as the problem-solving paradigm within which this study is executed. Subsequently SLRs and implementation science is explored since their respective outputs serves as inputs for the development of the SLIR. Next maturity models are explored with the purpose of understanding the solution domain of the study and to ensure that there exists no maturity model, similar to the SLIR, in the current body of knowledge. Finally, in correlation with the final step in the research methodology, evaluation strategies are discussed.

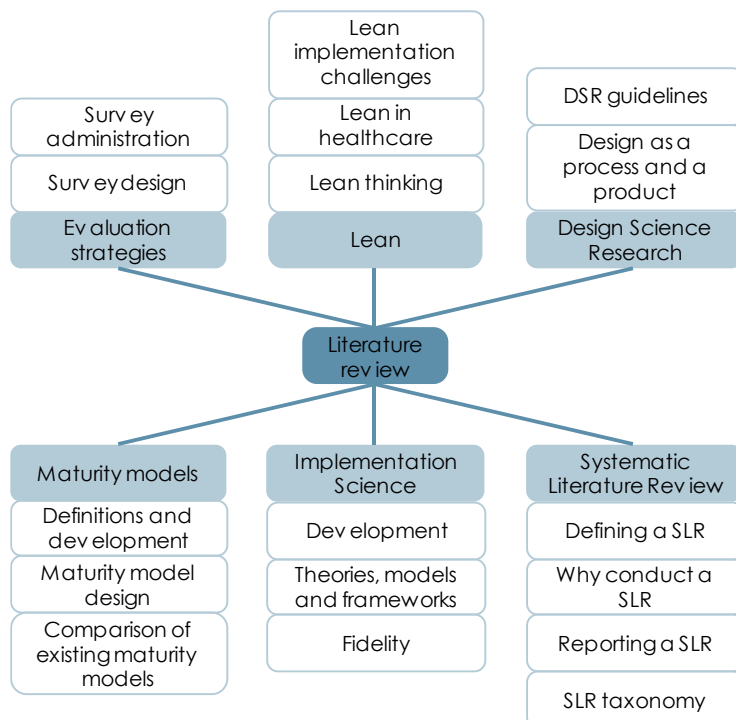


Figure 5: Chapter 2 orientation

2.2 Lean

2.2.1 Section introduction

Lean is a well-known concept. However, it is sometimes challenging to capture a single, exhaustive definition for Lean (Grabau, 2016). Its definitions varies based on factors such as the sources discussing Lean, its application domain, the reason a company wants to implement Lean, and finally, during what time was Lean discussed (Akugizibwe & Clegg, 2014). One of the simplest definitions of Lean is that it aims to reduce waste in order to increase customer value (Bicheno & Holweg, 2016). The rest of this section firstly discusses Lean thinking and its basic concepts. It then discusses the application of Lean in healthcare, more specifically in hospitals. Finally, the section explores the challenges that arise when implementing Lean in healthcare.

2.2.2 Lean thinking

Toyota, inspired by the work of among others Henry Ford and Edwards Demming, developed the famous Toyota Production System (Grabau, 2016; Kim *et al.*, 2009). The continuous improvement methodology that is known as Lean was adapted from Toyota's Production System (Eriksson *et al.*, 2016). Although various definitions for Lean exist, Grabau (2016) defines it as follows:

“Lean is a set of concepts, principles and tools used to create and deliver the most value from the customer’s perspective while consuming the fewest resources and fully utilizing the knowledge and skills of the people performing the work.”

Although there is a “toolbox” of Lean tools that can be used to improve an environment, Lean is a way of thinking. That is why it is referred to as the Lean philosophy. Instead of thinking about the short term Lean is aimed at a long-term, holistic thinking about production or delivering service (Dickson *et al.*, 2009; Kim *et al.*, 2009; Noori, 2015a). Aij and Lohman (2016) refer to it as a “permanent approach”. Within this approach one must be careful not to focus too much on production or service delivery at the cost of the human component of Lean. Grabau (2016) states that the philosophy on which Lean is based has two elements, namely continuous improvement and respect for people. The “people” Lean implementation affect are usually reluctant to change (Coetzee, 2019) and they have to be taken along the Lean implementation journey carefully (Liker, 2004).

As mentioned earlier, the Lean journey is focused on increasing customer value by reducing waste (Akugizibwe & Clegg, 2014). There are eight types of waste: defects,

overproduction, transportation, waiting, inventory, motion, over-processing and non-utilised talent (Graban, 2016). There are five Lean principles that guide the operationalisation of its overall goal of increasing customer value through reduction of waste. These five principles are (Bicheno & Holweg, 2016):

1. Define customer value
2. Capture the value stream
3. Establish pull
4. Establish flow
5. Continuously strive for perfection

Although Lean thinking was developed in the automotive industry, it is also applicable and valuable in service sectors such as the healthcare sector (Patri & Suresh, 2018).

2.2.3 Lean in healthcare

Similar to the automotive industry, hospitals must use their resources efficiently to perform their core business, treating their patients, effectively (Daniels *et al.*, 2005). Noori (2015a) confirms that Lean has the potential to improve the processes at a hospital. Hospitals often have high quality doctors and high quality treatments, but broken processes (Graban, 2016). Yet, hospitals cannot afford to have “broken” processes, for they are increasingly pressured to achieve more with less (Bicheno & Holweg, 2016). Lean has the potential to relieve healthcare providers of this increasing pressure. Literature provides ample evidence of Lean implementation in healthcare (Akugizibwe & Clegg, 2014; Harrison *et al.*, 2016; Noori, 2015a).

Frank (1868–1924) and Lilian (1878–1972) Gilbreth are often referred to as the parents of industrial engineering (Kruger, 2014). Although Lean has formally been utilised by hospitals since the 1990s (Graban, 2016), two of the first instances where industrial engineering thinking was applied to healthcare occurred at the hand of the Gilbreths. The first application was shortly after the First World War when they improved the efficiency of rehabilitation and surgery procedures for soldiers (Kruger, 2014). The second was when Frank recommended that surgeons should be assisted by surgical nurses with the purpose of handing the surgeons their tools as they need it (Graban, 2016). Further, in 1922, Henry Ford also wrote about his attempts to introduce their production methods in a hospital environment (Graban, 2016).

Holden (2011) developed a model indicating the effects of Lean when applied to the healthcare environment. This model is provided in Figure 6. Lean is successful if it

improves performance and patient satisfaction (van Rossum *et al.*, 2016). The model presented in Figure 6 depicts how Lean affects these two aspects.

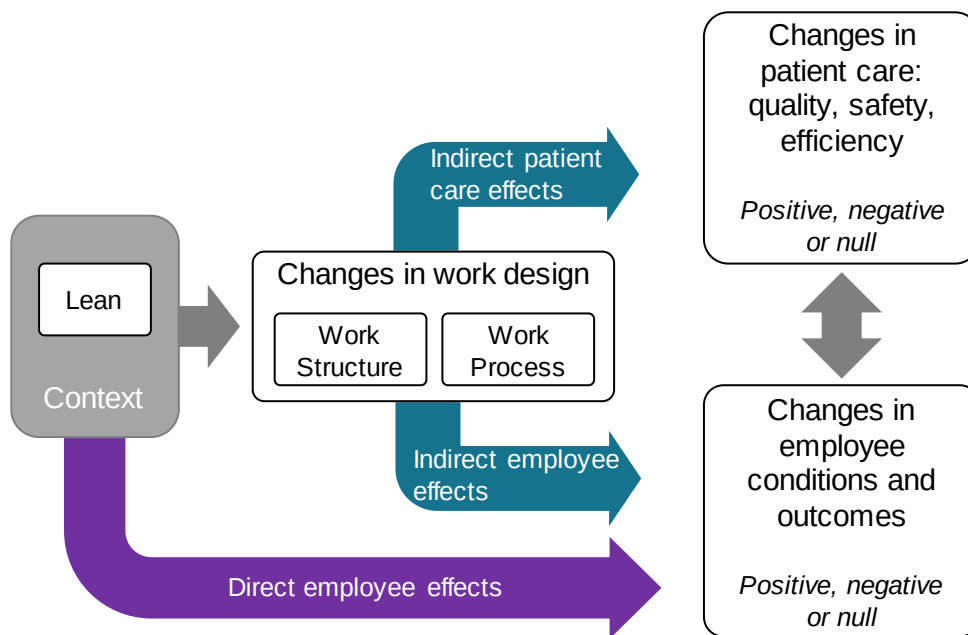


Figure 6: *Applying Lean in healthcare model reproduced from Holden (2011)*

2.2.4 Lean implementation challenges

Steed (2012) confirms that the Lean philosophy is a worthwhile and sustainable answer to the challenges inherent to the healthcare environment. Yet, healthcare providers struggle to sustain the success achieved after initial Lean implementation (Akugizibwe & Clegg, 2014). Although Lean implementation in hospitals is complex because of the complex environment, the implementation process is critical for the success and sustainability of the change (Hung *et al.*, 2015). A hospital environment has high process variability (Grove *et al.*, 2010) and its traditional hierarchical staff structure often hinders the teamwork Lean requires (Aij *et al.*, 2013). Additionally, staff struggle to see why Lean is required, since they are not a production line. Such misconceptions often lead to staff resistance (Ul Hassan *et al.*, 2013). Different healthcare environments tend to share the same type of challenges when it comes to Lean implementation. Steed (2012) lists the following challenges as the most often reported:

- Implementation sustainability
- Competition from other initiatives

- Top management commitment
- Readily available resources

However, these challenges do not take away the value Lean has to offer to healthcare environments.

2.2.5 Section conclusion

Although implementation challenges will often occur, the Lean philosophy and its capability to improve patient satisfaction and organisational performance remains (Bicheno & Holweg, 2016). Thoroughly planning the implementation of Lean with sustainability as the end goal (van Rossum *et al.*, 2016) will ensure these challenges are addressed and Lean becomes part of healthcare providers' everyday way of doing things.

2.3 Design science research

2.3.1 Section introduction

Peppers *et al.* (2007) suggest that after 15 years of design science research (DSR), a well-accepted definition would be that design science aims to solve certain identified organisational problems by creating and evaluating information technology (IT) artefacts (Hevner *et al.*, 2004). The DSR paradigm guides the development and evaluation of IT artefacts (Hevner *et al.*, 2004; Walls *et al.*, 2004). Although DSR initially played a key role in information systems (IS) research (Gregor & Hevner, 2013), design is a fundamental activity that occurs not only in IS research, but also in fields such as engineering and architecture (March & Smith, 1995). Hevner *et al.* (2004) state that the field of engineering contributes greatly to literature on design. Subsequently, DSR is applicable to engineering research and has been applied in the fields of engineering and IS (Gregor & Hevner, 2013). The research aim of this study states that a roadmap to facilitate sustainable Lean implementation needs to be designed. Therefore, DSR is used as the paradigm to guide this design process. Key aspects of DSR is further discussed in this section.

Since DSR originated in the IS discipline, it is important to understand the dual nature of IT research (March & Smith, 1995). March and Smith (1995) describe the dual nature of IT research as a "natural science – design science distinction". According to Simon (1996a), natural science is "...knowledge about natural objects and phenomena". March and Smith (1995) state that design science "...attempts to create things that serve human

purpose”. Hevner *et al.* (2004) describe the dual nature of IT as two paradigms, namely behavioural science and design science, where behavioural science originated from natural science. The purpose of behavioural science is to create and justify theories. Therefore, its purpose is truth. Design science originated from both engineering and the science of the artificial (Simon, 1996a). Its purpose is to create effective innovations, or to create utility (Hevner *et al.*, 2004). Each of the two paradigms, behavioural science and design science, consists of two respective research activities. Natural science involves discovering theories that explain certain phenomena and justifying the validity of the discovered theory (March & Smith, 1995). Design science builds an artefact and evaluates the performance of the artefact (March & Smith, 1995). Hevner *et al.* (2004) argue that truth and utility are inseparable. Hevner (2007) further states that “Design science is poised to take its rightful place as an equal companion to natural science research in the IS field”.

Although these two paradigms of behavioural science and design science differ, it is important to understand their interaction with one another (March & Smith, 1995). Figure 7 depicts a simplified version of how Walls *et al.* (2004) understand these interactions. The complete view of the interrelationships, as is described by Walls *et al.* (2004), can be seen in Annexure A.

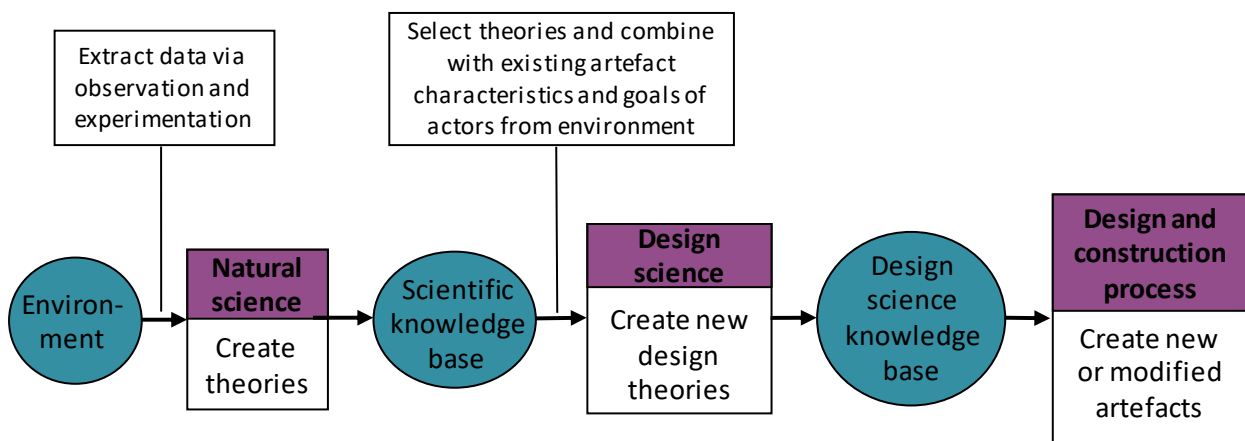


Figure 7: *Simplified depiction of relationship between natural science, design science and design theory*

As stated earlier, DSR is a paradigm that solves identified problems by means of creating artefacts. An artefact is any object that is crafted by human activities. The word originates from the Latin words *ars* and *facio* which translates to “skill” and “to make” respectively (Walls *et al.*, 2004). Although these artefacts are man-made, natural laws still apply to

them (Hevner *et al.*, 2004). Not only do natural laws apply to artefacts, but also social laws. These laws are called kernel theories (Walls *et al.*, 2004). Kernel theories inform the development of artefacts (Gregor & Jones, 2007; Walls *et al.*, 2004) and therefore justify the development and evaluation of the artefact (Gregor & Hevner, 2013).

2.3.2 Design as a process and a product

Hevner *et al.* (2004) state that an important dichotomy with respect to design science is that design is both a verb and a noun. Therefore, design is both a process and a product. Walls *et al.* (2004) further explain this by stating that the output of the design process must be the designed product. DSR consists of four research outputs and two design processes (March & Smith, 1995). In order to describe design as process, the DSR cycle is discussed next. The DSR cycle, which is based on the IS research framework, can be seen in Figure 8 (Hevner, 2007; Hevner *et al.*, 2004).

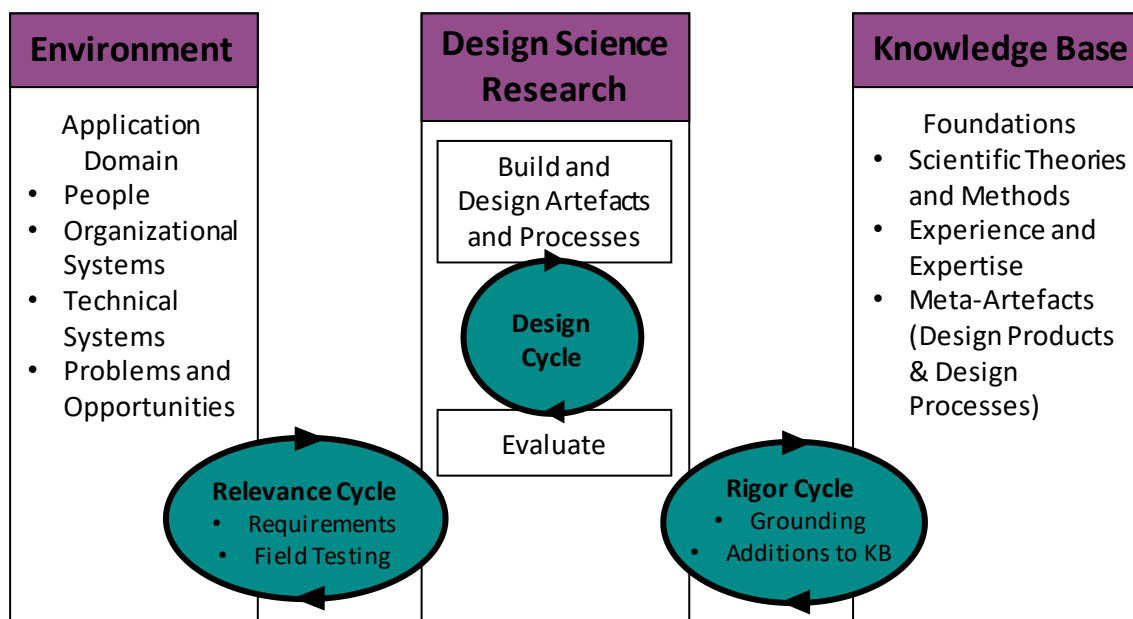


Figure 8: *Design science research cycles compiled from Hevner (2007)*

The research problem and opportunities of a DSR study lies within the environment (Hevner *et al.*, 2004; Simon, 1996a). As can be seen in Figure 8, the application domain (environment) consists of people, organisational systems and technical systems that work together to achieve a certain solution or to reach a certain goal (Hevner, 2007). The knowledge base is made up of foundations that are used during DSR to perform research (Hevner, 2007). These foundations can be described as the “raw materials” required to perform research (Hevner *et al.*, 2004). As stated earlier, design science’s purpose is to

create effective innovations that address the problem(s) identified in the application domain (Hevner *et al.*, 2004). As seen in Figure 8, the relevance cycle iterates between the environment and DSR. Hevner (2007) states that the relevance cycle “...initiates design science research...”. The requirements of the DSR study and the final evaluation criteria (field testing) for the design cycle is defined within the application domain. The rigour cycle connects the knowledge base and the DSR. The rigour cycle provides the research with the required knowledge to ensure rigorous research (Hevner, 2007). Since the purpose of design science is to create innovative artefacts, “the internal design cycle is the heart of any design science research project” (Hevner, 2007). In order to ensure that an effective and innovative artefact is created, the design cycle iterates between building and evaluation. Although the design cycle is the heart of a DSR project, it is important to note that it is also dependant on the other two DSR cycles (Coetzee, 2019).

As stated earlier, design is a process and a product. In order to understand design as a product, the four research outputs described by March and Smith (1995) are briefly discussed:

- Constructs – Constructs are specific concepts that are used to define the problems and solutions within a specific domain.
- Model – A model is a representation of the relationship between constructs. Models describe certain scenarios with problem and solution statements.
- Method – A method guides the reader to perform a certain task. In DSR a method is grounded in certain relevant constructs and in a model of the solution space.
- Instantiations – Instantiations are the realisation of the created artefacts within its application domain. Instantiations demonstrate the feasibility of the above-mentioned research outputs by operationalising them within their application domain.

2.3.3 DSR guidelines

In order to assist researchers in following a rigorous and relevant design process, resulting in a sound artefact that solves the relevant problem Hevner *et al.* (2004) developed a set of seven guidelines. Thus, the purpose of these guidelines is to guide researchers to conduct and evaluate sound DSR. Hevner *et al.* (2004) state that the fundamental DSR principle on which these seven guidelines are based are as follows: “...knowledge and understanding of a design problem and its solution are acquired in the building and application of an artefact”. These guidelines together with their descriptions can be seen in Table 2.

Table 2: DSR guidelines reproduced from Hevner *et al.* (2004)

Guideline	Description
Guideline 1: Design as an Artefact	DSR must produce a viable artefact in the form of a construct, a model, a method or an instantiation.
Guideline 2: Problem Relevance	The objective of DSR is to develop technology-based solutions to important and relevant business problems.
Guideline 3: Design Evaluation	The utility and efficacy of a design artefact must be rigorously demonstrated by means of well-executed evaluation methods.
Guideline 4: Research Contributions	Effective DSR must provide clear and verifiable contributions in the areas of the design artefact, design foundations and/or design methodologies.
Guideline 5: Research Rigour	DSR relies on the application of rigorous methods in both the construction and evaluation of the design artefact.
Guideline 6: Design as a Search Process	The search for an effective artefact requires utilising available means to reach desired ends while satisfying laws in the problem environment.
Guideline 7: Communication of Research	DSR must be presented effectively both to technology-oriented as well as management-oriented audiences.

2.3.4 Contribution to knowledge

March and Smith (1995) explain that design science researchers do not produce general theoretical knowledge, they rather apply certain knowledge to create artefacts that solve problems. Hevner *et al.* (2004) explain that there is a crucial difference between routine design and design research. Routine design is the use of existing artefacts to solve organisational problems, whereas design research creates new and innovative artefacts in order to solve certain identified unsolved problems. A criterion that can be used to distinguish between these two designs is the contribution to the knowledge base. Gregor and Hevner (2013) further state that this is the primary criterion for research. Figure 9 depicts the DSR knowledge contribution framework. As can be seen in the bottom left quadrant, routine design does not greatly contribute to the knowledge base since you apply known solutions to known problems. Gregor and Hevner (2013) further confirm this by stating that routine design usually does not require any research methods to solve the problem.

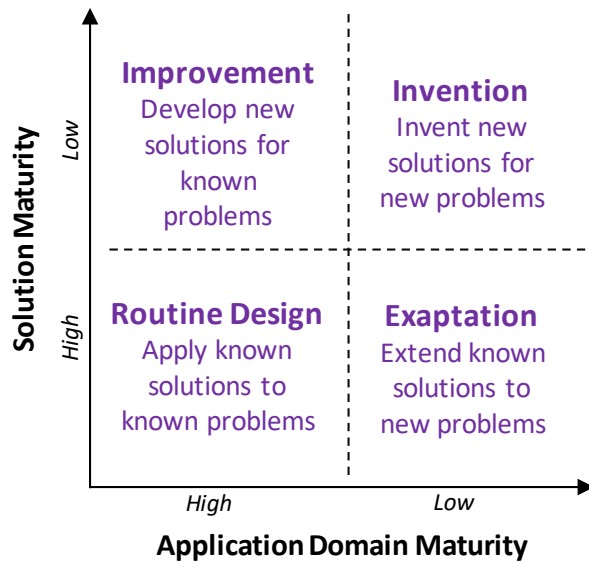


Figure 9: *DSR knowledge contribution framework reproduced from Gregor and Hevner (2013)*

The remaining three quadrants are discussed based on the arguments of Gregor and Hevner (2013). In contrast to routine design lies the top right quadrant – invention. This can be described as a radical breakthrough. The environment in which the problem lies is complex and insightful knowledge that stretches over various domains is required to find a possible solution. If existing artefacts are bettered so that it is more effective and efficient, the contribution to knowledge can be seen as an improvement. Gregor and Hevner (2013) state that it should “...genuinely advance on previous knowledge”. The last quadrant of the framework is the exaptation quadrant. As can be seen in Figure 9, this is when known solutions are extended to new problems. “New problems” include problems in new application areas. It differs from routine design in that the research conducted is not trivial but “...nontrivial and interesting” Gregor and Hevner (2013)

Within the IT context, research can be divided into descriptive and prescriptive research (March & Smith, 1995). The purpose of descriptive research is to understand the nature of IT while the purpose of prescriptive research is to better IT performance. Design research is prescriptive in nature (Walls *et al.*, 2004).

2.3.5 Section conclusion

As stated earlier, DSR guides the process of developing innovative artefacts as a solution to an identified problem (Hevner *et al.*, 2004). Although DSR is rooted in IT, it is applied in various fields, since design is a fundamental activity in various fields, such as

engineering. Since this research paradigm originated in IT, it is important to understand and explain the dual nature of IT in this literature study. Not only were the differences between natural science and design science discussed, but also the interactions between these sciences. Design science creates innovative artefacts to solve problems. It can also be seen as a product with four possible outputs (artefacts) as explained in this chapter. Design science was also discussed as a process with research activities as part of the DSR cycles. The seven guidelines developed by Hevner *et al.* (2004) were discussed. They are further discussed in the Chapter 3 since the research methodology of this study is based on the seven guidelines. Finally, the section elaborated on the possible contribution to the knowledge base.

2.4 Systematic literature review

2.4.1 Section introduction

It is important to understand the difference between a literature review and reviewing literature (Siddaway *et al.*, 2019). The purpose and method of a literature review, and therefore also the purpose and method of this section, is to select relevant literature and to discuss it in order to introduce a topic and to explain the rationale of why a study will contribute to the knowledge sector (Siddaway *et al.*, 2019). This usually serves as an introduction to a study. The purpose of reviewing literature is to draw conclusions by synthesising existing literature while following a systematic research design (Siddaway *et al.*, 2019).

The purpose of this section is therefore to provide background to the SLR by explaining the relevant theory by considering the concepts, definitions and terminology. The rest of the section defines an SLR, explaining why an SLR should be conducted, how it should be presented, and finally elaborating on the taxonomy of SLRs.

2.4.2 Defining a systematic literature review

To further explain the difference between a literature review and an SLR, one can think of a literature reviewer as a lawyer and a systematic literature reviewer as a judge and jury (Siddaway *et al.*, 2019). A lawyer defends one side of the argument, while the judge and jury critically listen to and weigh all evidence (Liberati *et al.*, 2009) to ensure that they reach a fair and unbiased conclusion (Baumeister, 2013; Siddaway *et al.*, 2019).

One can conclude that a literature review becomes an SLR when you approach it systematically. Booth *et al.* (2012) describe systematic approaches to literature reviews

as “...those elements of a literature review that, either individually or collectively, contribute to its methods being both explicit and reproducible.” Cochrane (2019), a network of among other researchers in healthcare, further define an SLR in their glossary of terms as follows:

“A review of a clearly formulated question that uses systematic and explicit methods to identify, select, and critically appraise relevant research, and to collect and analyse data from the studies that are included in the review.”

Siddaway *et al.* (2019) characterise an SLR based on two characteristics. Firstly, it is *methodical* and secondly it is *replicable*. Another important characteristic of an SLR, which in essence is a result of the first two characteristics, is that an SLR minimises the bias of a researcher (Liberati *et al.*, 2009; Petticrew & Roberts, 2006; Siddaway *et al.*, 2019). Tong *et al.* (2012) further state that an SLR’s reproducibility and its comprehensiveness distinguish it from other methods.

2.4.3 Why researchers should conduct a systematic literature review

The previously mentioned characteristics of an SLR is the reason why this research method is desirable and advantageous. Booth *et al.* (2012) similarly describe that the three main reasons why one would conduct an SLR is its clarity, auditability and validity.

Clarity:

O’Brien and Mc Guckin (2016) summarise the aim of an SLR as providing “...a clear, targeted answer to specific research questions...”

This corresponds with the first characteristic that Siddaway *et al.* (2019) allocate to an SLR, namely that it is methodical. By following a clear methodology consisting of, among other things, a specifically formulated focused research question and a structured search strategy, the researcher can produce clear and reliable results (Booth *et al.*, 2012; Liberati *et al.*, 2009).

In order for research to contribute and advance a specific field of the knowledge sector, it is vital to know what the existing work in that sector is (Xiao & Watson, 2019). The only way to truly understand such vast amounts of knowledge is to work through it systematically and methodically. In doing so one can collate, make sense of and summarise these vast amounts of knowledge (Liberati *et al.*, 2009; O’Brien & Mc Guckin, 2016; Petticrew & Roberts, 2006). The SLR allows a researcher to understand the

“whole” instead of only the “sum of its parts”. The researcher has to zoom out and take the “whole” into consideration, not only individual studies (Siddaway *et al.*, 2019).

Auditability:

O’Brien and Mc Guckin (2016) further summarises the aim of an SLR as providing “...a clear, targeted answer to specific research questions and to allow for replication...”

In order to ensure that a researcher did not purposefully reach a conclusion for the benefit of his/her research, it is important the research must be transparent (Booth *et al.*, 2012). The research must also be reproducible. Therefore, as the word “auditability” implies, a fellow researcher must be able to “audit” the work and if they follow the same method as you, they should reach the same conclusion.

If the latter is not possible, there is a “...replication crisis...”, meaning that researchers have found that some key scientific findings in literature do not replicate if the research process is repeated (Siddaway *et al.*, 2019). Due to the methodical nature of an SLR, its results are replicable and therefore auditable (Siddaway *et al.*, 2019).

Validity:

O’Brien and Mc Guckin (2016) finally summarises the aim of an SLR as providing “...a clear, targeted answer to specific research questions and to allow for replication in a way which minimises bias.”

If researchers follow a systematic method to perform an SLR, they will produce valid results (O’Brien & Mc Guckin, 2016). However, there is no room for bias in this method. If a researcher is biased during any stage in the research process, the results will not be replicable.

One of the main advantages of conducting an SLR is that it reduces the possibility of conscious or unconscious bias. However, one must take into account that it does not eliminate the risk of bias, but only minimises it (Liberati *et al.*, 2009; O’Brien & Mc Guckin, 2016; Siddaway *et al.*, 2019).

Booth *et al.* (2012) warn of several forms of bias that should be considered. A few of these are selection bias, publication bias and the language of publication bias. Not only must the SLR be conducted in an unbiased manner, the results must be presented in an unbiased manner (Siddaway *et al.*, 2019). The SLR report must convince the reader of the validity of the study (Holopainen *et al.*, 2008).

2.4.4 The reporting of an SLR

Siddaway *et al.* (2019) place an SLR at the top of the evidence hierarchy. However, Booth *et al.* (2012) state that the evidence not only lies in how the systematic review is conducted, but also how it is presented. Thus, not only is an SLR characterised by a methodical and replicable execution, but also by a methodical and replicable presentation of the results (Siddaway *et al.*, 2019).

The presentation or reporting of an SLR study is not merely assumed as part of the research process as with other research methods, but rather receives explicit mention in the majority of the SLR literature, therefore, presenting the results is seen as the final step of the research process (Holopainen *et al.*, 2008; Xiao & Watson, 2019). Xiao and Watson (2019) further state that it is the third major stage of an SLR, after planning and conducting the review as the first two stages.

The SLR report should guide the reader through the realisation of each stage (Holopainen *et al.*, 2008). Siddaway *et al.* (2019) summarise the reporting of an SLR, based on general principles, as having to consist of the following main sections:

- Introduction: This section clarifies the topic, scope and rationale of the study.
- Method: This section describes every step of the method used to conduct the review, as well as the rationale behind it.
- Results: This section is the essence of the review as it evaluates and integrates your findings and presents it in a logical structure.
- Discussion: This section discusses the summarised findings relevant to the previous knowledge.

Since reporting the SLR is such an important stage in the SLR process, various guides on how to report an SLR have been developed. These guides not only help researchers report SLR studies according to a certain standard, they also set standards in terms of conducting the SLR (Tong *et al.*, 2012). These guides are usually categorised as guides for either synthesising quantitative studies or synthesising qualitative studies. An example of reporting guidelines for the synthesis of quantitative studies is the QUOROM (Quality Of Reporting Of Meta-analysis) statement, published in 1999, and later the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) statement, based on the QUOROM and published in 2009 (Liberati *et al.*, 2009; Moher *et al.*, 2000; Moher *et al.*, 2009). The PRISMA statement consists of a 27-item checklist (Liberati *et al.*, 2009). It also suggests the use of an information flow diagram to act as a

visual representation of the stages used to determine the final included primary studies. An example of reporting guidelines for the synthesis of qualitative studies is the ENTREQ (ENhancing Transparency in REporting the synthesis of Qualitative research) statement developed by Tong *et al.* (2012). This framework has 21 items that are divided into five stages in accordance with the main stages of an SLR. Since this study's SLR focuses on synthesising qualitative data, the ENTREQ statement with the 21-item checklist can be found in Annexure B.

In order to better understand the difference between synthesising qualitative data and synthesising quantitative data, the following sections elaborates on the taxonomy of SLRs.

2.4.5 The taxonomy of systematic literature reviews

When referring to a taxonomy, the aim is to elaborate on various types of classifications that can be allocated to an SLR based on certain attributes of the SLR (Stevenson, 2010c). Although there have been various attempts to create an SLR taxonomy, it is a very challenging task due to the various domains across which it can be characterised (Booth *et al.*, 2012). Tong *et al.* (2012) also state that the inconstant use of terminology leads to confusion among SLR researchers. The next section provides a high-level taxonomy of SLRs. Figure 10 illustrates the taxonomy “sections” of an SLR that are discussed in this section.

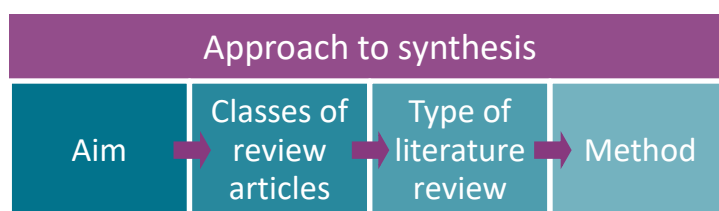


Figure 10: *Systematic literature review taxonomy*

As established earlier, the purpose of an SLR is to draw conclusions by synthesising existing literature while following a systematic research design (Siddaway *et al.*, 2019). As seen in Figure 10, the overarching characterisation of an SLR is the researcher's approach to synthesis. There are two approaches: aggregative or interpretive (Booth *et al.*, 2012; Korhonen *et al.*, 2013). Aggregative synthesis refers to synthesising studies on a similar topic (Booth *et al.*, 2012). However, this is not merely vote counting where a research finding is validated based on the fact that the majority of studies reach a similar

conclusion (Siddaway *et al.*, 2019). Aggregative synthesis assign weights to certain predetermined criteria to avoid mere vote counting (Booth *et al.*, 2012). Interpretive synthesis aims to interpret various studies in order to understand a certain phenomenon (Booth *et al.*, 2012; Hannes & Lockwood, 2011). The approach followed depends on the overall aim of the study (Figure 10, first block).

Xiao and Watson (2019) distinguish between four study aims:

- Describe – The aim of this review is to analyse the current state of literature relevant to a research question.
- Test – The aim of this review is to answer/ test a specific research hypothesis.
- Extend – This review not only synthesises literature but aims to build on it.
- Critique – This review aims to compare studies against predetermined (standard) criteria.

The aim of an SLR not only determines the overall synthesising approach, but also determines the class of review articles that is synthesised (Figure 10, second block). There are two classes of review articles, namely quantitative and qualitative (Siddaway *et al.*, 2019). If an SLR is seen as research about research (Whittemore, 2005), it can be seen as secondary research and the primary articles (Weed, 2005; Whittemore, 2005; Xiao & Watson, 2019) that it reviews can be classified as either qualitative (researching qualities) or quantitative (researching quantities) data.

In the past, SLRs have mostly reviewed quantitative literature (Siddaway *et al.*, 2019). However, recently the number of qualitative SLRs have increased (Hannes & Lockwood, 2011). In the healthcare environment the studies are often qualitative in nature due to the aim of research often being the measurement of intervention implementation (Korhonen *et al.*, 2013). Tong *et al.* (2012) state that the synthesising of qualitative studies results in valuable evidence within the healthcare environment. Based on the class of literature to be synthesised, the type of literature review can be classified (Figure 10, third block). It is imperative that the type of SLR "...logically fit the aims of the review" (Siddaway *et al.*, 2019).

Siddaway *et al.* (2019) distinguish between three types of SLRs. The first type is a meta-analysis review, which synthesises quantitative data – studies that empirically examined a similar theory. Often, the aim of meta-analyses is to estimate the effectiveness of a certain phenomenon (Korhonen *et al.*, 2013; Siddaway *et al.*, 2019). The second type is a narrative review that synthesises quantitative studies with varying methodologies.

However, the results of these reviews are qualitative, not quantitative. They therefore do not refer to the statistical significance of the primary studies (Siddaway *et al.*, 2019). The third type of SLR is a meta-synthesis review, which synthesises qualitative data with the purpose of determining “...key themes, concepts or theories...”.

As can be seen in Figure 10, the final block of the SLR taxonomy is the method to be used to conduct the SLR. Various SLR methods exist, but it is dependent on the aim of the review and the primary studies (class of review articles) involved in the review (Holopainen *et al.*, 2008). For instance, when the primary studies are qualitative, the SLR methods fall under the “umbrella” of meta-synthesis (Korhonen *et al.*, 2013; Xiao & Watson, 2019). Researchers tend to use the terms SLR *methods* and *type* varyingly. For example, Siddaway *et al.* (2019) state that the review type “meta-synthesis” can also be referred to as meta-ethnography, while Korhonen *et al.* (2013) and Tong *et al.* (2012) place meta-ethnography as a method under meta-synthesis. Whitemore (2005) states that SLR methods develop rapidly to increase the rigour of the review process and this leads to methodological confusion. However, what all these methods share is that they have to adhere to the methodological requirements of research and meet the same methodological rigour that primary research should adhere to (Holopainen *et al.*, 2008; Whitemore, 2005).

Therefore, although the taxonomy of SLRs are complicated, it is imperative that all SLRs follow the commonly accepted research process (Hannes & Lockwood, 2011; Holopainen *et al.*, 2008; Korhonen *et al.*, 2013; Pearson, 2004; Whitemore, 2005). Holopainen *et al.* (2008) state that the common accepted process is defining the aim and research question of an SLR, searching for literature, evaluating and analysing the data extracted from the literature and presenting the results. Xiao and Watson (2019) summarise this process as planning, conducting and reporting the SLR.

Figure 11 summarises the SLR taxonomy as discussed in this section.

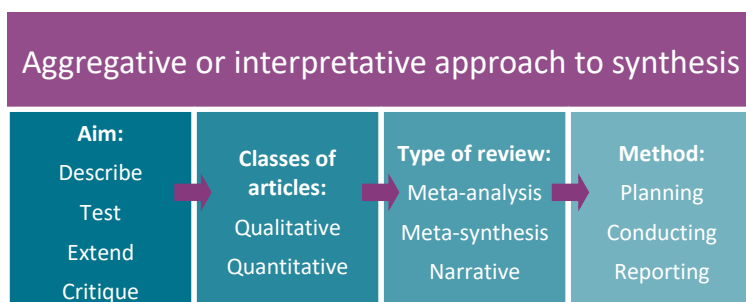


Figure 11: Summary of SLR taxonomy

2.4.6 Section conclusion

SLRs are at the top of the evidence hierarchy (Siddaway *et al.*, 2019). An SLR aims to provide "...a clear, targeted answer to specific research questions and to allow for replication in a way which minimises bias" (O'Brien & Mc Guckin, 2016). The only way of making sense and synthesising large bodies of literature is to do so systematically (Liberati *et al.*, 2009; O'Brien & Mc Guckin, 2016; Petticrew & Roberts, 2006).

Although these reviews and their taxonomies are intimidating and challenging, an SLR that follows the commonly accepted process in a methodical and replicable manner will still rank at the top of the evidence hierarchy.

2.5 Implementation science

2.5.1 Section introduction

Implementation is a common and transdisciplinary concept (Fitzgerald, 2018). Many organisations, disciplines and countries face the challenge of ineffective implementation (Eccles & Mittman, 2006; Nilsen, 2015). Literature suggests that it takes an average of 17 years for a research findings to be integrated into the everyday practices of a healthcare setting (Bauer *et al.*, 2015; Fitzgerald, 2018). Fitzgerald (2018) further states this is not even the case for all initiatives, since only 14% of these findings end up changing patient care in some way. Therefore, there is a rather large gap between research and implementation. This is the gap that implementation science, as a discipline, aims to reduce (Balas & Boren, 2000).

The rest of this section firstly defines implementation science and its development. Secondly, it discusses the theories, models and frameworks that have been developed to put into effect implementation science. The section lastly discusses implementation fidelity and its importance.

2.5.2 Implementation science development

There is consensus among researchers on the definition of implementation science. Eccles and Mittman (2006) provide this definition in the first edition of the *Implementation Science Journal*:

"Implementation research is the scientific study of methods to promote the systematic uptake of research findings and other evidence-based practices into

routine practice, and, hence, to improve the quality and effectiveness of health services.”

Implementation science is, therefore, primarily concerned with the implementation of healthcare-related research findings. However, as mentioned above, it is a transdisciplinary concept that can be applied in any environment. May *et al.* (2009) further define implementation, in terms of applying the term, as a deliberate effort to introduce something new to an environment with the purpose of bringing about change. Implementation is not the only concept relevant to the spread of research findings. It falls onto the diffusion-dissemination-implementation continuum (Nilsen, 2015). The aim of this continuum is to enhance the spread of research findings that can improve a healthcare environment (Tabak *et al.*, 2012).

Although the three concepts on this continuum have a common goal, it is important to understand the differences between them. Diffusion is the inactive part of disseminating knowledge about these new practices (Nilsen, 2015). The action can be simplified as “letting it happen” (Greenhalgh *et al.*, 2004). The next “step” on the continuum namely dissemination requires more action. New practices are actively communicated to the target group for which it is intended (Tabak *et al.*, 2012). Greenhalgh *et al.* (2004) simplify this action as “helping it happen.” Finally, as defined above, implementation is a deliberate action of ensuring the research findings are incorporated into the environment’s everyday practices (Nilsen, 2015), in other words “making it happen” (Greenhalgh *et al.*, 2004). This study focusses on the concept of deliberate implementation. This is very important since research findings cannot add value to a healthcare environment if the findings are not integrated into the everyday practices.

Fitzgerald (2018) provides an example of this: penicillin was not used to treat infections for nearly 17 years after it was discovered. Bauer *et al.* (2015) further defend the need for implementation science by stating that there was a “need for research that more directly impacts public health”. Since these implementation challenges are universal, implementation science rapidly progressed. In order to address these challenges, implementation researchers increasingly ensured the use of theoretical approaches to inform their research (Nilsen, 2015). These theoretical approaches, such as theory concerning change and behaviour, created a better understanding of why certain implementations fail or succeed (Tabak *et al.*, 2012). How these theoretical approaches are put into practice, is discussed in the next section.

2.5.3 Theories, models and frameworks

Strategies should be developed to close this research-to-practice gap (Bauer *et al.*, 2015). These strategies take the shape of theories, models and frameworks. These three terms are often used interchangeably, but they are three different concepts. The three “strategies” can be distinguished as follows:

- Theories influence how certain phenomena, such as implementation failures and success, are understood (Tabak *et al.*, 2012).
- Nilsen (2015) describes models as the simpler version of certain phenomena. Therefore, a model can be describes as the enactment of a theory (Bauer *et al.*, 2015).
- Tabak *et al.* (2012) further describe a framework as a model’s “action plan”. It therefore describes and guides the implementation.

As the field of implementation science grows, the number of available theories, models and frameworks also expands (Tabak *et al.*, 2012). In order to address the confusion associated with this expansion of available resources, Nilsen (2015) developed a taxonomy of the these theories, models and frameworks. This taxonomy, together with the aim of the respective categories, are presented in Figure 12.

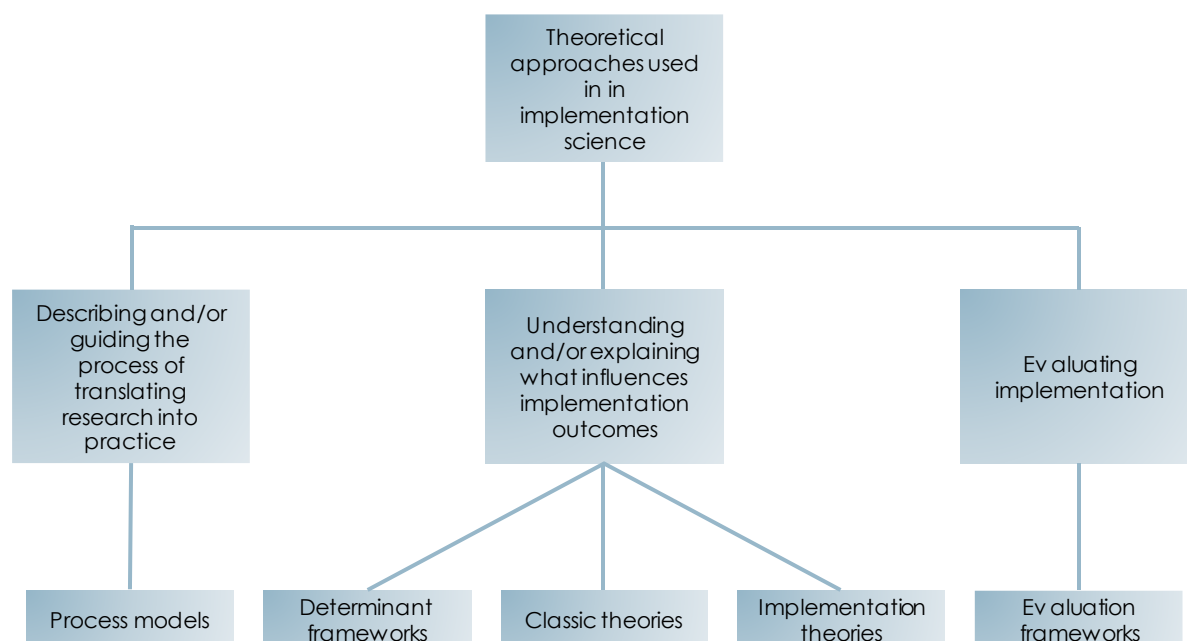


Figure 12: *Five categories of theories, models and frameworks together with their aims reproduced from Nilsen (2015).*

Nilsen (2015) further comments on this taxonomy by saying that although these models, theories and frameworks share common goals and characteristics across the different categorisations, it is important to realise that they do differ and it is very important to select an appropriate framework to use. After selecting an appropriate framework, it can either be adapted or used as is (Tabak *et al.*, 2012). This depends on the context of the implementation. However, it is important to keep in mind that the outcome should be a quality implementation of the research findings.

As can be seen in Figure 12 process models aim to guide an implementation process. Similarly, the aim of this study is to develop a Lean implementation roadmap for a hospital environment. Therefore, a process model is used to inform the SLIR's development. Chapter 4 elaborates on how an appropriate implementation science process model is selected.

2.5.4 Fidelity

Fixsen *et al.* (2009) define the formula for a quality implementation outcome as a combination of an effective innovation and an effective implementation plan. Fitzgerald (2018) elaborates on this formula by defining the elements of a successful implementation as follows:

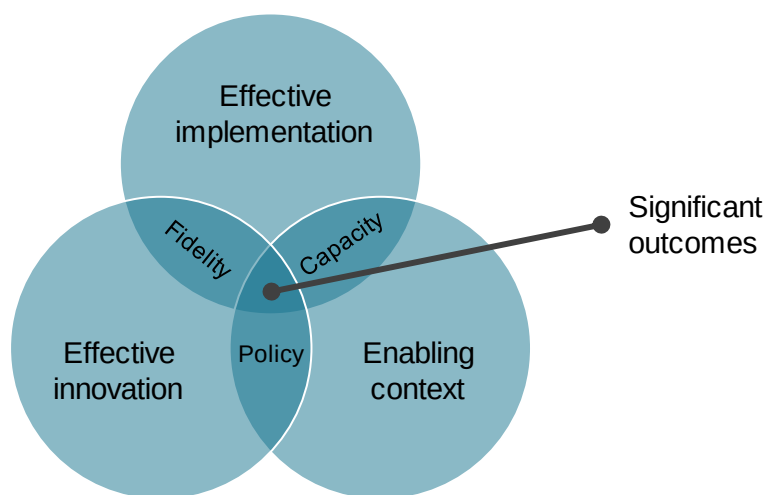


Figure 13: *Elements of a quality implementation reproduced from Fitzgerald (2018)*

As can be seen in Figure 13, the result of an effective innovation that is implemented in an effective way is fidelity. Fidelity can be defined as “faithfulness” or “degree of exactness...copied or reproduced” (Stevenson, 2010a). Therefore, did the innovation

stay “faithful” to itself during the implementation, or was the end result and adapted version of the original innovation? (Bauer *et al.*, 2015). Although there should be an enabling context to reach significant outcomes, it is vital to ensure fidelity during implementation. Research findings might not have the same effect on patient care if it is not adopted into everyday practices as intended.

Fidelity should be maintained in terms of a few aspects (Fitzgerald, 2018):

- Operational fidelity: The innovation is not adapted (altered) after implementation.
- Theoretical fidelity: Adapting the innovation to fit the context without influencing its fidelity.
- Population fidelity: The innovation improves healthcare at the point in healthcare where it was intended to bring improvement.
- Sustained fidelity: Sustainability is the end goal of the implementation.

2.5.5 Section conclusion

“The business case for implementation science is clear: As healthcare systems work under increasingly dynamic and resource-constrained conditions, evidence-based strategies are essential in order to ensure that research investments maximize healthcare value and improve public health” (Bauer *et al.*, 2015). Fidelity is ensured by means of effective innovation and implementation (Fitzgerald, 2018; Fixsen *et al.*, 2009). The innovation used in this study is the Lean methodology. Lean has proven to be effective in improving a hospital’s performance and patient satisfaction (van Rossum *et al.*, 2016). The implementation of Lean is seen as an opportunity to broaden the application of implementation science (Eriksson *et al.*, 2016). Therefore, by focusing on an effective implementation plan, the shared goal of implementation science and Lean, which is to improve the quality of service delivery in a healthcare environment (Bauer *et al.*, 2015), can be reached while fidelity of the innovation is maintained.

2.6 Maturity models

2.6.1 Section introduction

The aim of this study is to develop the SLIR in the form of a prescriptive maturity model to facilitate the implementation of Lean in a hospital environment. This section reviews maturity model literature. First, the relevant definitions and development of maturity models are discussed. Secondly, aspects surrounding the design of a maturity model

are examined. Finally, the existing maturity models relevant to this study's context is explored.

2.6.2 Definitions and development

2.6.2.1 Defining maturity models

Bate *et al.* (1995) define a maturity model as follows:

“A model of the stages through which organisations progress as they define, implement, evolve, and improve their processes. This model serves as a guide for selecting process improvement strategies by facilitating the determination of current process capabilities and identification of the issues most critical to quality and process improvement.”

Becker *et al.* (2009) summarise this definition by stating that a maturity model guides organisational transformation from an initial to a desired state. However, before an organisation can move towards a desired goal, they need to know where they are moving from. Maturity models not only act as transformation guides but also as an evaluation tool to determine the organisation's current state of maturity (Essmann, 2009; Van Dyk, 2013). A maturity model can thus further be defined as a tool that firstly evaluates an organisation and accordingly determines what the most appropriate path is towards the desired maturity (Jami Pour & Jafari, 2019).

2.6.2.2 Defining maturity

In order to fully comprehend maturity models, it is important to understand what maturity entails. Van Dyk (2013) points out that the term “maturity” is often not defined in maturity model literature. Maturity is defined as “the state, fact, or period of being mature” (Stevenson, 2010b). This is a very general definition, since how maturity is defined depends greatly on the context in which it is used. Van Dyk (2013) concludes that maturity is a psychological attribute that is used to describe certain dimensions within an organisation. The maturity of the following three dimensions are generally measured in maturity models (Mettler, 2011; Poeppelbuss *et al.*, 2011):

- Process – This maturity refers to the efficiency of activities or work practices.
- Object – This maturity, for instance, refers to technology or other objects within a process or organisation.
- People – This maturity refers to the culture in a company and measures the employees' ability to create knowledge or develop their skills.

Many maturity models pay attention to only one of the three dimensions, namely the process dimension. These are referred to as fixed-level maturity models (Steenbergen, 2011). However, the majority of the activities that are performed within an organisation include all three of the dimensions (Henning, 2017). Models that measure maturity in terms of all three these dimensions are referred to as focus area maturity models (Mettler & Rohner, 2009).

2.6.2.3 Maturity model development

Pöppelbuß and Röglinger (2011) state that some of the first examples of maturity models are Maslow's well-known hierarchy of human needs (Maslow, 1943) as well as the economic growth theory (Kuznets, 1955). Almost four decades after one of the first maturity models were published by Maslow (1943), the capability maturity model was developed to address issues within the United States' military (Van Dyk, 2013). The capability maturity model "provides software organisations with guidance on how to gain control of their processes for developing and maintaining software" (Paulk *et al.*, 1993). Although this maturity model was developed specifically for software organisations, literature suggests that maturity model development increased drastically due to the capability maturity model's development (De Bruin *et al.*, 2005; Mettler, 2011; Pöppelbuß & Röglinger, 2011; Van Dyk, 2013).

2.6.3 Maturity model design

2.6.3.1 Designing maturity models

A maturity model is often defined in terms of the maturity levels it offers to guide organisational transformation (Becker *et al.*, 2009; De Bruin *et al.*, 2005). However, a maturity model consists of much more than maturity levels. Literature indicates that maturity models usually comprise of the following six components (Henning, 2017; Mettler & Rohner, 2009; Steenbergen, 2011):

1. Maturity levels
2. A short description of each maturity level
3. Characteristics of each maturity level
4. Capability dimensions/capability areas
5. Capability activities within each dimension forming a maturity path
6. Further descriptions of each capability activity

Pöppelbuß and Röglinger (2011) indicate that various information system researchers view the design of maturity models as something that should occur within the DSR paradigm. As discussed in the DSR literature review section, design can be seen as both a product and a process (Hevner *et al.*, 2004). Therefore, in terms of the design of a maturity model, it is important to think about both the process of design and the maturity model as a product of the design process. In order to ensure that a quality maturity model is designed (Hevner *et al.*, 2004), Pöppelbuß and Röglinger (2011) developed a list of design principles that should guide the development of a maturity model. These principles are further discussed in Chapter 4 when the SLIR design requirements are defined. Various researchers have proposed maturity model development procedures (Becker *et al.*, 2009; De Bruin *et al.*, 2005; Pöppelbuß & Röglinger, 2011).

One of the steps in the procedure model developed by Becker *et al.* (2009) is iterative design. This procedure model is further discussed in Chapter 3 as part of this study's research methodology. The iterative design step requires that each design level, in other words each maturity model component, is designed separately. These components can either be designed by following a top-down approach or a bottom-up approach (Van Dyk, 2013). A top-down approach refers to starting with defining the maturity levels and moving towards additional descriptions of the capability activities (De Bruin *et al.*, 2005). The inverse process is followed with a bottom-up approach. Maier *et al.* (2012) suggest using a top-down approach when maturity in the field in question has not yet been fully defined due to the field being "young". In a well-established field, research capturing the necessary activities to reach maturity is usually well defined and can be used as a starting point while following the bottom-up approach.

2.6.3.2 Application purposes

Maturity models are generally applied for two possible reasons. The first reason is to determine the current maturity level of an environment (Röglinger *et al.*, 2012). Since these maturity models evaluate and describe the as-is situation of an environment, they are referred to as descriptive maturity models (Maier *et al.*, 2012). Linking to the maturity model definitions discussion, these models determine where in the journey towards the desired state a certain environment lies. The second reason a maturity model is applied is to guide the organisation on this journey to the desired state. These maturity models typically include detailed actions that are developed based on historical data to prescribe the organisational transformation (Maier *et al.*, 2012). Such models are referred to as prescriptive maturity models (Pöppelbuß & Röglinger, 2011). Once these models have been applied in various application areas, they allow for a third reason of application.

Authors refer to these as comparative maturity models (De Bruin *et al.*, 2005; Pöppelbuß & Röglinger, 2011), seeing as they enable benchmarking between organisations (De Bruin *et al.*, 2005).

2.6.4 Comparison of existing maturity models

This section of the literature review addresses the second step of this study's research methodology. Since maturity models were originally developed in the IS discipline, various maturity models relevant to the maturity of IS in the healthcare domain have since developed. Carvalho *et al.* (2016) conducted an SLR to determine which maturity models relevant to IS and technology management have been developed. They identified 14 maturity models. However, they concluded that a more holistic maturity model that addresses all the sub-systems of a healthcare organisation should be developed (Carvalho *et al.*, 2016). Two years later, Gomes and Romão (2018) also conducted an SLR to determine what the capability dimensions are that are generally defined in maturity models pertaining the IS in a healthcare environment. They identified and analysed 26 maturity models (Gomes & Romão, 2018).

However, none of the 40 maturity models identified in these two reviews addressed Lean in healthcare implementation. The following section reports on the results obtained when searching for maturity models that involve Lean in healthcare in the current body of knowledge.

2.6.4.1 Lean healthcare maturity models

There is currently little literature concerning Lean healthcare maturity models. The following five databases were searched:

- Web of Science
- Emerald Insight
- ProQuest Dissertations & Theses Global
- Scopus
- EBSCOhost with the following selected databases within EBSCOhost:
 - AHFS Consumer Medication Information
 - Applied Science & Technology Source
 - Business Source Premier
 - CINAHL with Full Text
 - eBook Collection (EBSCOhost)
 - EconLit

- E-Journals
- Health Source - Consumer Edition
- Health Source: Nursing/Academic Edition
- International Pharmaceutical Abstracts
- MasterFILE Premier
- MEDLINE
- OpenDissertations

The following search terms were used to search the above-mentioned databases:

(TITLE-ABS-KEY ("maturity model") AND TITLE-ABS-KEY ((health* OR medic* OR hospital* OR clinic*)) AND TITLE-ABS-KEY (lean))*

Web of Science and Emerald Insight yielded no results. Although ProQuest yielded 21 results when the search term “lean” was omitted, it yielded no results when “lean” was included in the above-mentioned search terms.

Scopus yielded five results. Based on the abstracts, three of the five results were not studies concerned with the use of or development of a maturity model pertaining to Lean in healthcare. The fourth result did not develop a new maturity model, but merely applied an existing maturity model from the information research sector to implement ways of assessing the quality of the service the institution delivers (Nashawati *et al.*, 2018). The final Scopus result applied a maturity model at a medical device manufacturing facility (Stout, 1995) and was therefore not considered due to the application not being in a healthcare service environment.

EBSCOhost yielded one result. The purpose of the study was to analyse the effect Lean implementation has on the culture of a healthcare organisation and how this culture changes as a result of the Lean implementation (Guimarães & Carvalho, 2015). These authors also present a maturity model “as a starting point for developing a healthcare Lean assessment (HLA) instrument.”

Although the maturity model developed by Guimarães and Carvalho (2015) addresses the implementation of Lean in healthcare, it only addresses the culture aspect of this implementation. Therefore, a maturity model addressing all aspects of Lean implementation in a hospital environment, with sustainability as end goal, needs to be developed.

2.6.5 Section conclusion

Today's organisations are constantly under pressure to increase their performance and decrease their costs (Henning, 2017). These goals are not achieved overnight and requires some form of an improvement journey. Maturity models are valuable tools that can assist organisations in achieving these goals. Similar to the purposes of maturity models, Jami Pour and Jafari (2019) describe the advantages of maturity models as being that they firstly assist in systematically capturing the current situation and further acting as a roadmap to the desired state of maturity.

Based on the literature search conducted relevant to this section, there is no maturity model that meets the aim of this study. Lasrado *et al.* (2015) similarly conclude that researchers tend to develop maturity models from scratch to address a specific research question in a specific domain. Since maturity models guide organisational transformation from its initial state to its desired state, it has the potential to guide a hospital's Lean transformation towards a sustained Lean implementation.

2.7 Evaluation strategies

2.7.1 Section introduction

Nordin *et al.* (2012) describe the validation process as a process that is followed to evaluate whether a designed tool/artefact is fit for the purpose for which it was designed. It therefore asks whether the tool/artefact addresses the research problem that was identified. According to Inglis (2008), there are six possible validation methods. These methods are as follows:

- By means of literature
- Input from experts on the matter
- Empirical research
- Conducting a survey
- Case studies/pilot studies

In this study, the artefact is validated by means of a survey sent to respondents with experience in implementing Lean in a hospital environment. A survey is an evaluation approach where the population is usually pre-selected based on inclusion criteria to extract data relating to a specific topic (Kelley *et al.*, 2003). They state that surveys can be used to confirm the effect of some form of change or implementation. Therefore, this

section briefly discusses surveys and important practices that must be taken into consideration in the development and administering of a survey.

2.7.2 Survey design

A survey usually requires the respondents to answer multiple closed-ended questions (Bryman & Bell, 2014; Kelley *et al.*, 2003; Sinkowitz-Cochran, 2013). This typically includes a 7-point or 5-point Likert scale, from strongly disagree to strongly agree (Bryman & Bell, 2014; Fanning, 2005). It is important to carefully design a survey and its questions as this contributes to a respondent's likeliness to complete the survey (Fanning, 2005). It is vital that the purpose of the survey be kept in mind throughout its design. This is to ensure that all the survey questions contribute to the research questions that it was designed to answer (Kelley *et al.*, 2003; Sinkowitz-Cochran, 2013).

Since a survey is usually sent via email without any personal contact or guidance from the researcher, it is vital that the questions must be simple in format and easy to answer (Bryman & Bell, 2014). An important design consideration is to present questions in sections according to topics and to remain consistent with the format of the questions (Fanning, 2005; Kelley *et al.*, 2003).

2.7.3 Survey administration

Kelley *et al.* (2003) suggest the following three methods to identify respondents for a survey aimed at gathering qualitative data about a specific topic:

- Convenience sampling
- Purposive sampling
- Snowball sampling

Researchers should use the method best suited to the context of their study and they should clearly communicate all relevant instructions to the respondents. This includes information like the completion deadline, how respondents should return the completed survey to the researcher and what the respondents should do if they have any questions or queries (Fanning, 2005).

Although surveys tend to have a lower response rate than other evaluation methods, it is still a valuable evaluation method if the researcher can justify that the respondents are representative of the targeted evaluation group (Bryman & Bell, 2014). Bryman and Bell (2014) suggest the following to increase the response rate:

- Include an explanatory cover letter
- Follow up on the initial email sent to the respondents
- Provide instructions
- Pay attention to the survey layout
- Minimise the use of open-ended questions

The average accepted response rate for a survey is between 60% (Sinkowitz-Cochran, 2013) and 65% (Kelley *et al.*, 2003).

2.7.4 Section conclusion

A survey is a useful and common approach to evaluating qualitative research (Fanning, 2005). It should be carefully developed and administered. Both the layout and the content play a role in the likeliness of a respondent completing the survey. Questions should be unambiguous (Sinkowitz-Cochran, 2013) and contribute to the purpose of the survey (Kelley *et al.*, 2003). The administration of the survey should be done in a professional and ethical manner.

2.8 Chapter conclusion

This chapter reviewed literature relevant to two aspects of this study. The first aspect was reviewing literature relevant to the problem-solving paradigm within which this study is conducted together with the relevant methods applied as part of the research design. The second aspect was reviewing literature relevant to fields of research that informed this study. Two fields of research that informed this study, and therefore contributed to reaching the study's aim, was researched namely implementation science and maturity models.

Table 3 provides an orientation regarding model-related concepts discussed throughout the literature review. The first concept in Table 3 is relevant to the research design aspect of the study. The remaining three concepts in Table 3 is relevant to the research fields that informed this study.

The remaining chapters of the study report on the application of the reviewed literature with the purpose of developing an artefact to address the identified research question.

Table 3: Model-related concepts' orientation

Concept	Description	Relevant section in Chapter 2
Procedure model	A maturity model development methodology developed within the DSR problem-solving paradigm	Section 2.6.3.1
Implementation science framework/model	Implementation science aims to reduce the research to practice gap by developing theories, models and frameworks to assist healthcare providers in implementing research findings into everyday practice	Section 2.5.3
Process model	Implementation science theories, models and frameworks can be divided into five categories where process models is the category of implementation theories, models or frameworks that provide detailed implementation guidance to healthcare providers	Section 2.5.3
Maturity model	A maturity model guides organisational transformation from its initial state to its desired state by defining various levels of maturity that leads to the desired state	Section 2.6

CHAPTER 3

RESEARCH DESIGN

This chapter discusses the study's research design.

CHAPTER 3: RESEARCH DESIGN

3.1 Chapter introduction

A study's research design can be seen as the blueprint used to guide the researcher to solve the identified research problem (Burns & Grove, 2005). In Chapter 1 the research aim was defined as designing a roadmap in the form of a prescriptive maturity model to address the low rate of sustainable implementations of Lean in hospitals. As discussed in the literature review, literature suggests that maturity models be developed within the DSR problem-solving paradigm since DSR guides the process of developing innovative artefacts as a solution to a certain identified problem (Hevner *et al.*, 2004). Therefore, the problem-solving paradigm within which this research falls is DSR.

Clough and Nutbrown (2007) distinguish, as follows, between methodology and method: a method is a research tool used as part of a study whereas the methodology is the reason for using the respective methods. Therefore, the research methodology justifies the research methods. Burns and Grove (2005) define a research methodology as the complete approach or strategy of the study. Figure 14 provides a visual representation of this study's research design. The grey cube indicates the DSR paradigm that encapsulates this study's research design. The research design, or strategy, is indicated by the blue sheet. This strategy consists of a research methodology (the purple blocks) and the research methods (turquoise blocks). Each research method is a tool that is used to address a research objective within the research methodology. The dark grey curved arrows indicate that the selected research methodology is informed by the DSR paradigm.

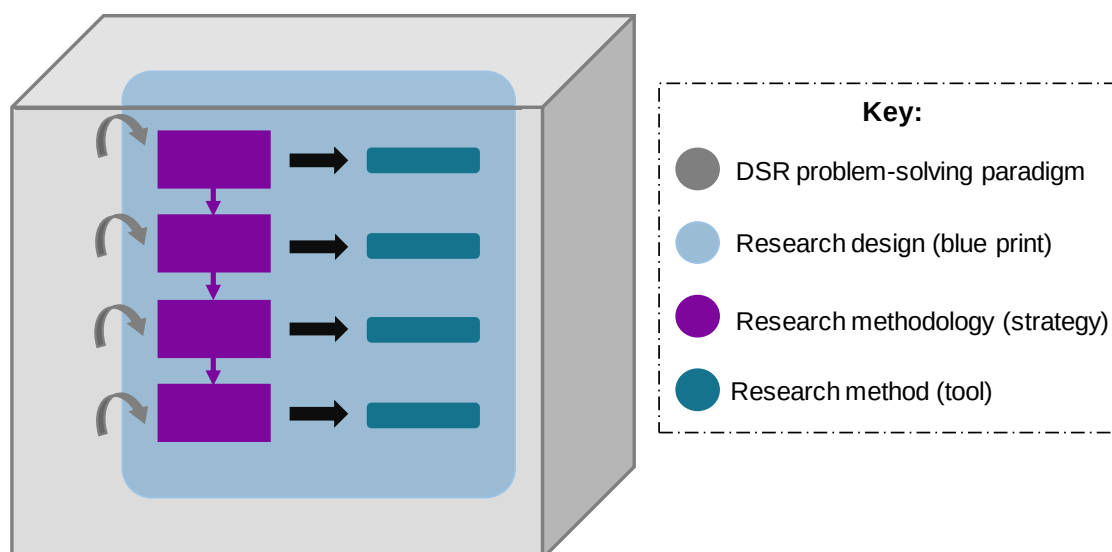


Figure 14: Visual representation of research design

In the sections that follow, the overall research methodology and the methods that are used to satisfy each research objective is discussed. In the last section the knowledge contribution of this study according to the DSR paradigm is discussed.

3.2 Research methodology

3.2.1 Introduction

The research methodology of this study is based on a procedure model that was developed to guide the design of maturity models. The procedure model can be seen in Figure 15. As stated in Chapter 1 literature strongly suggest that maturity models should be developed within the DSR paradigm (Becker et al., 2009; Mettler & Rohner, 2009; Pöppelbuß & Röglinger, 2011). Subsequently the development of the procedure model (Figure 15), more specifically its design requirements, were based on the seven DSR guidelines (Becker et al., 2009) as discussed in the literature study. These seven DSR guidelines were developed to guide researchers and to ensure good DSR is practiced (refer to Table 2). Therefore, by using a procedure model, informed by the seven DSR guidelines, to guide the development of this study's aimed maturity model will contribute towards conducting rigorous and relevant research. The eight procedure model design requirements together with the seven DSR guidelines, that these design requirements were based on, can be seen in Table 4. The procedure model with the relevant design requirements (R1 to R8) can be seen in Figure 15. The argument behind each requirement is further discussed in the next section.

Table 4: Procedure model requirements vs DSR guidelines compiled from Becker et al. (2009)

Becker et al. (2009) maturity model development requirements	DSR guideline
R1: Comparison with existing maturity models	G1: Design as an artefact G4: Research contributions
R2: Iterative procedure R3: Evaluation	G6: Design as a search process
R4: Multi-methodological procedure	G3: Evaluation G5: Research rigour
R5: Identification of problem relevance R6: Problem definition	G2: Problem relevance
R7: Targeted presentation of results R8: Scientific documentation	G7: Communication of research

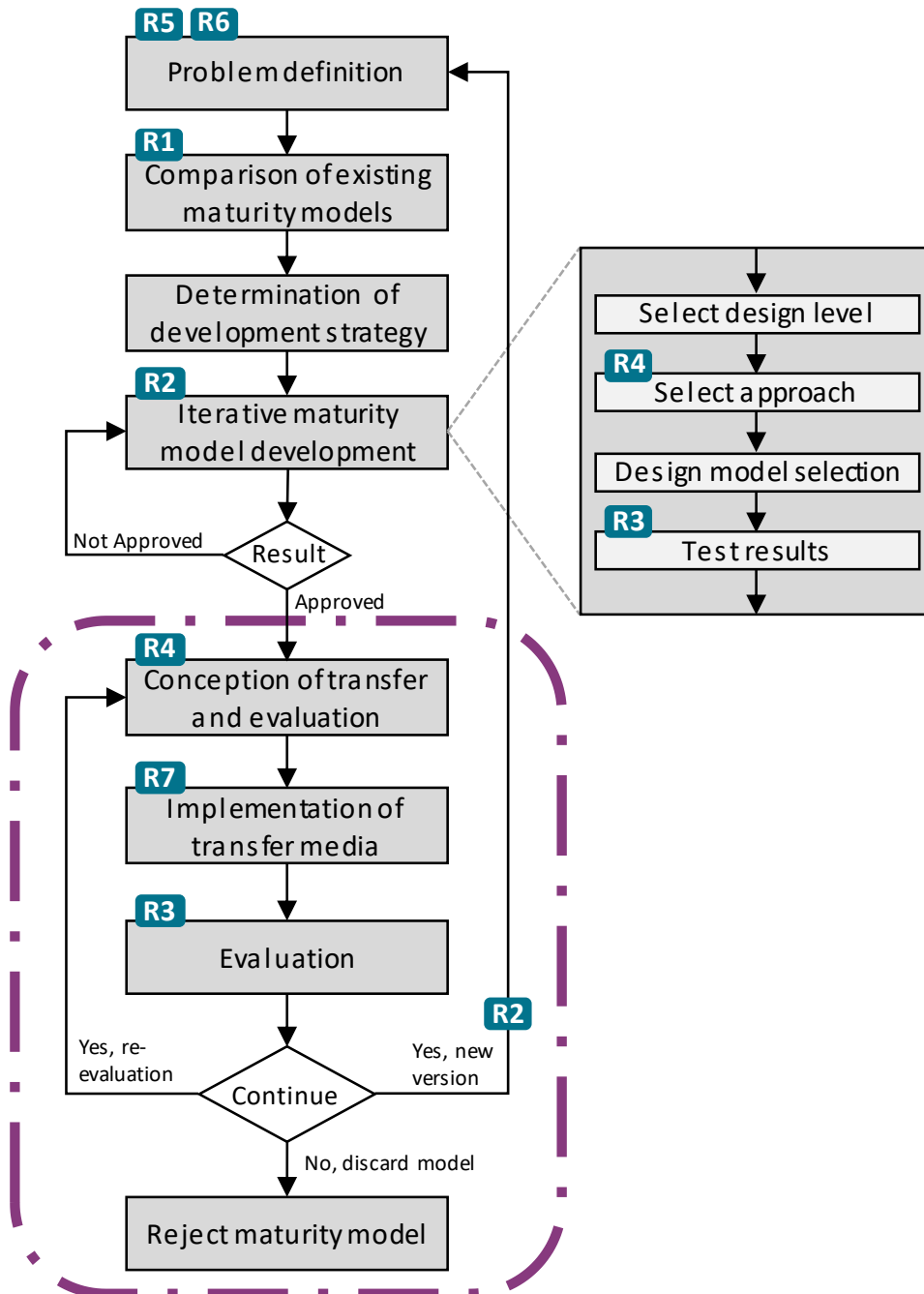


Figure 15: Procedure model compiled from Becker et al. (2009)

3.2.2 Adaptation of research methodology

Similar to a study conducted by Neff et al. (2014), the procedure model developed by Becker et al. (2009) is simplified to fit the context of this study. The third step in the procedure model, determination of development strategy, is adapted to develop the required maturity model input seeing as this aligns with the study's research objectives and questions. Since implementation of the developed artefact does not fall within the

scope of this research, the last four steps of the procedure model (circled in purple in Figure 15) are merged into one step, evaluation. The final, simplified research methodology of this study can be seen in Figure 16.

In order to ensure the validity of the research design, the DSR guidelines must be followed throughout the study. The adherence to the seven DSR guidelines and eight procedure model requirements, referred to as verification, is discussed in Chapter 6. Section 6.2.1 elaborates on the difference between validation and verification. Although steps of the original procedure model are merged into one step (evaluation) the procedure model requirements are still taken into account during the development of the SLIR.

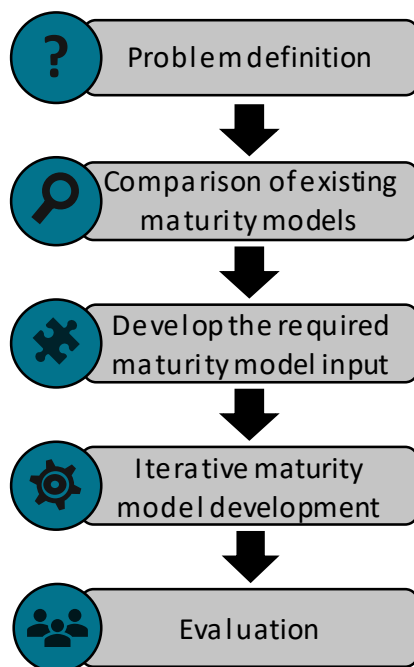


Figure 16: *Final research methodology*

3.3 Research method

In the following section each step in the research methodology (refer to Figure 16) is discussed in detail.

3.3.1 Problem definition

This step in the research methodology is concerned with the following research objective: *Explore sustainable Lean implementation in hospital environments as a relevant research problem. (Objective 1).*

According to Becker *et al.* (2009), the following should be defined as part of problem identification:

- Problem relevance
- Target domain
- Target group

The following research question encapsulates these three requirements: *What information does the current body of literature offer in terms of the identified research problem (Research question 1.1)?* All three requirements are established in the background discussion of Chapter 1. Problem relevance was further discussed in the literature study reported in Chapter 2.

3.3.2 Comparison of existing maturity models

The next step in the research methodology addresses the following research objective: *Investigate maturity models and determine whether a maturity model that address the aim of this study exists in the current body of knowledge (Objective 2).*

According to Becker *et al.* (2009) the following should be researched as part of this step:

- The possibility of improving/adapting an already existing maturity model
- Possible existing models that address the research problem

Subsequently, the following two research questions were defined:

- What are the definitions, constructs and paradigms relevant to maturity models (Research question 2.1)?
- What maturity models relevant to Lean healthcare are available (Research question 2.2)?

Both research questions are addressed in the literature review reported in Chapter 2.

3.3.3 Develop the required maturity model input

This step in the research methodology addresses the following research objective: *Define and develop the input required for the development of the SLIR (Objective 3).*

According to Becker *et al.* (2009), no requirement is linked to this methodology step. However, the requirements of this step is based on the output of the previous step (Neff *et al.*, 2014). Seeing as there were no maturity models that address this study's research

aim, a new maturity model had to be developed. This maturity model has three inputs. The following three research questions related to the three SLIR development inputs were defined:

- What are the factors that influence the success of Lean implementation within a hospital environment (Research question 3.1)?
- Which implementation science framework is the most appropriate to incorporate into the development of the SLIR (Research question 3.2)?
- What are the design requirements that the SLIR must satisfy (Research question 3.3)?

Research question 3.1 is addressed by conducting an SLR. Although there are various variants of the SLR method, literature refers to a commonly accepted method (Hannes & Lockwood, 2011; Holopainen *et al.*, 2008; Korhonen *et al.*, 2013; Pearson, 2004; Whitemore, 2005). The SLR method to be followed in this study is based on a general method proposed by Siddaway *et al.* (2019). Their method applies to all types of SLR studies and adheres to the commonly accepted SLR method. This method can be seen in Figure 17. The commonly accepted stages can be seen on the left of Figure 17 and the detailed steps of the method can be seen on the right of Figure 17. The execution and output of the SLR is discussed in Chapter 4.

Research question 3.2 is addressed by means of a self-developed implementation science framework selection method. In order to select an appropriate framework that fits this study's context, a method was developed based on current implementation science literature. The development of this method, together with the application of this method is discussed in Chapter 4.

Research question 3.3 is addressed based on literature. Pöppelbuß and Röglinger (2011) developed design principles to guide the development of quality maturity models. These design principles are used to inform the development of the SLIR design requirements. The development of these design requirements is discussed Chapter 4.

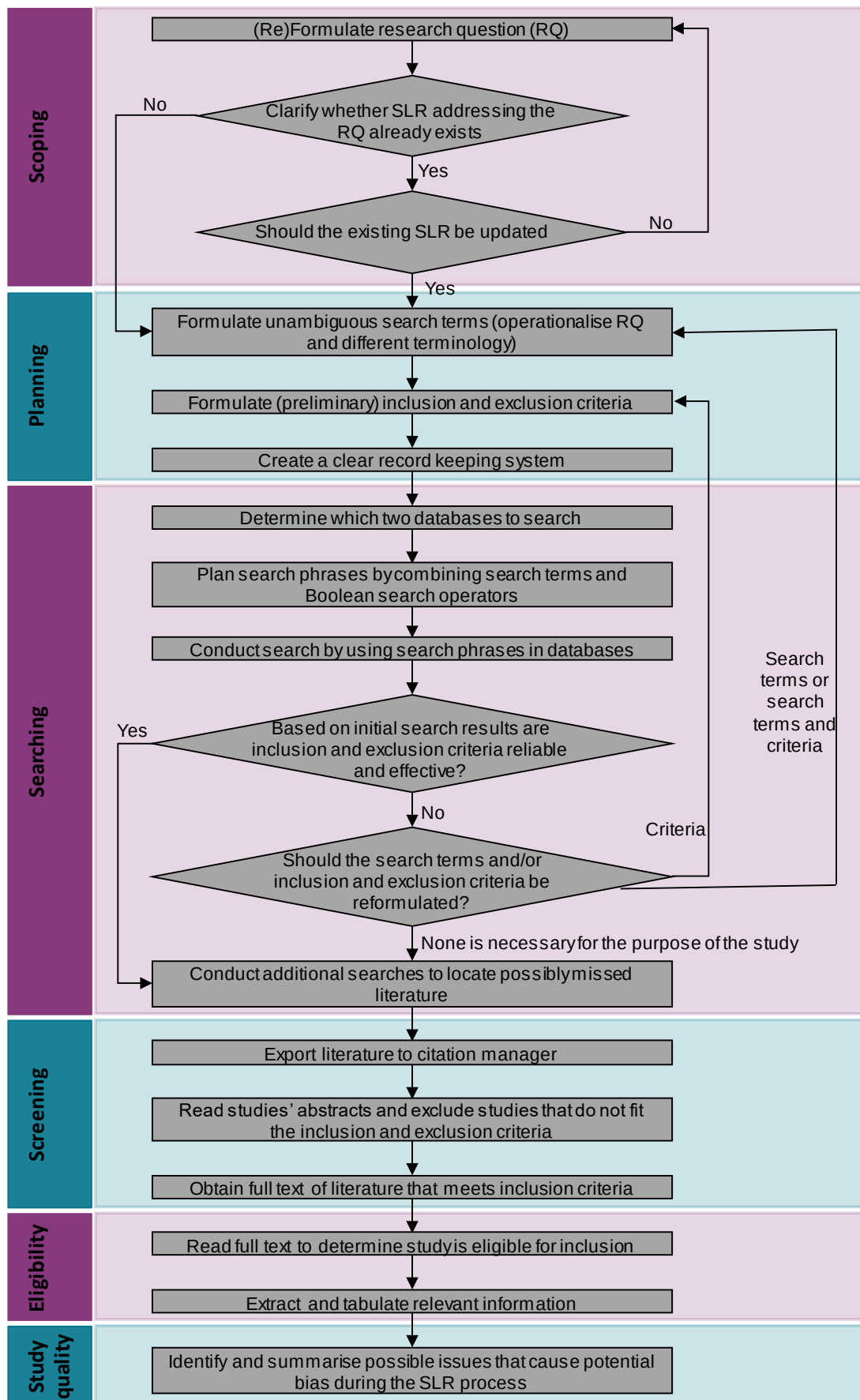


Figure 17: SLR method

3.3.4 Iterative maturity model development

This step in the research methodology addresses the following research objective: *Develop the SLIR (Objective 4).*

Becker *et al.* (2009) state that this is the central phase of the development process. The four sub-steps used to guide this step in the research methodology is displayed on the right-hand side of Figure 15. The following two research questions were developed to guide the execution of this methodology step:

- What approach should be followed during the SLIR development process (Research question 4.1)?
- How should the various development inputs inform the development of the SLIR (Research question 4.2)?

Research question 4.1, together with the four sub-steps of the iterative maturity model development step guides the development of a detailed approach to develop the SLIR. This is thoroughly discussed in Chapter 5. Research questions 4.2 is addressed by using the three inputs developed in Chapter 4 (Research objective 3), to inform the development of the SLIR. The development process together with the developed SLIR is discussed in Chapter 5.

3.3.5 Evaluation

This step in the research methodology addresses the following research objectives:

- Verify that the SLIR adheres to all its design requirements (Objective 5).
- Validate the SLIR (Objective 6).

The various outcomes that Becker *et al.* (2009) describe for the simplified evaluation step (merging of the last four procedure model steps) are as follows:

- The communication of the model to various audiences should be defined.
- The communication of the model should include the possibility of evaluation and thus feedback from the specified audiences.
- The developed model should be accessible to the end user.
- Whether the model is a solution to the research problem should be confirmed.

All these outcomes, together with the methods that were selected to address each research question, are discussed in answer to the following four research questions:

Does the model adhere to each of the specified design requirements (Research question 5.1)?

Adherence to the design requirements is determined by means of a retrospective view and a survey that is sent to respondents with experience in implementing Lean in hospitals.

Did the study address a valid research problem? (Research question 6.1)?

The validity of the research problem is confirmed by determining its relevance based on literature and by means of a survey sent to respondents with experience in implementing Lean in hospitals.

Was a valid research design followed to address the research problem (Research question 5.2)?

In order to ensure that a valid research design was followed throughout the study, the process is measured against the seven DSR guidelines and the eight design requirements used to develop the procedure model presented in Figure 15. This is done by means of a retrospective view.

Does the SLIR address the research problem that was identified in this study (Research question 6.3)?

The survey sent to respondents with experience in Lean implementation in hospitals is used to validate whether the SLIR is a solution to the research problem.

The evaluation of the SLIR is reported in Chapter 6.

3.4 Knowledge contribution

According to the knowledge contribution framework that is proposed by Gregor and Hevner (2013), the contribution that this study will make to the knowledge base falls in the “exaptation” quadrant, as can be seen in Figure 18. The solution space of this study is the Lean methodology and more specifically Lean healthcare as discussed in Chapter 1. The Lean methodology is very “mature” and well-known and applied all over the world. The application domain of Lean healthcare (applying Lean in a healthcare setting) is also a reasonably well-known solution. However, the application has a very low success rate. Since this application domain is not equally mature to the solution space, this study is

seen as an exaptation that will extend the known solution of Lean to a new problem: the healthcare application domain.

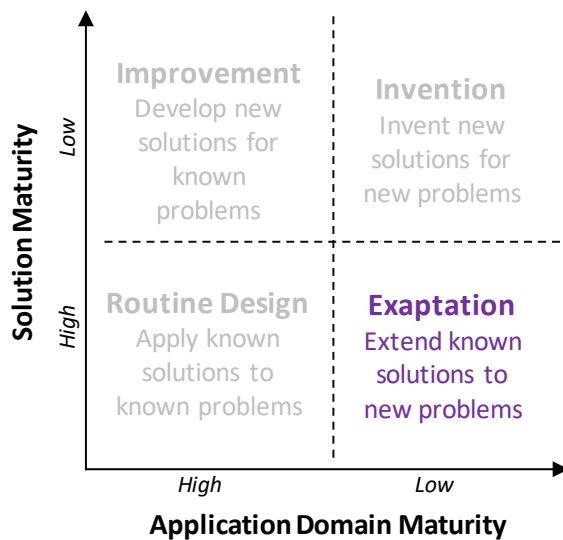


Figure 18: Knowledge contribution of this study (Gregor & Hevner, 2013)

3.5 Chapter conclusion

This chapter discussed the blueprint that guide this study. First the research paradigm within which this study is conducted was discussed. Then the research methodology, which is based on the seven DSR guidelines, was discussed. The various methods/tools suitable for the research methodology were also mentioned in this chapter. Applying these methods and answering the research questions, which will in turn meet the research objectives, will ensure that the aim of this study is achieved.

CHAPTER 4

MODEL INPUT

This chapter aims to address the following research question:

- Research question 3.1 – What are the factors that influence successful Lean in healthcare implementation?
 - Research question 3.2 – Which implementation science framework is the most appropriate to incorporate into the development of the SLIR?
 - Research question 3.3 – What are the design requirements that the SLIR must satisfy?
-

The chapter addresses the following step of the research methodology:

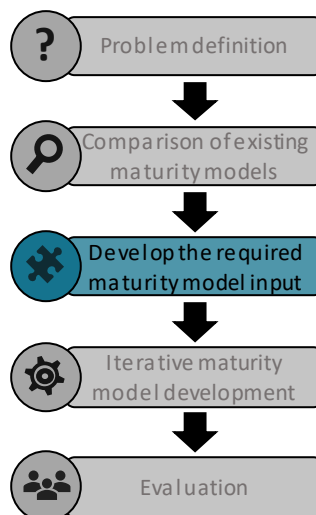


Figure 19: Chapter 4 research methodology step

CHAPTER 4: MODEL INPUT

4.1 Chapter introduction

This chapter reports on the various SLIR inputs. The inputs are used to inform the development of the SLIR. The first input that is discussed are factors that influence successful Lean implementation within a hospital environment. The second input discussed is the quality implementation framework (QIF) developed by Meyers *et al.* (2012). The third input is the design requirements. The first two inputs are used to inform the SLIR due to their positive influence on the change process that takes place during the implementation of Lean. Factors influencing successful Lean implementations are derived from literature by means of an SLR. The QIF is selected from implementation science literature by following a self-developed selection method. Finally, this chapter discusses the development of the design requirements to which the SLIR must adhere. A visual orientation of the layout of this chapter can be seen in Figure 20.

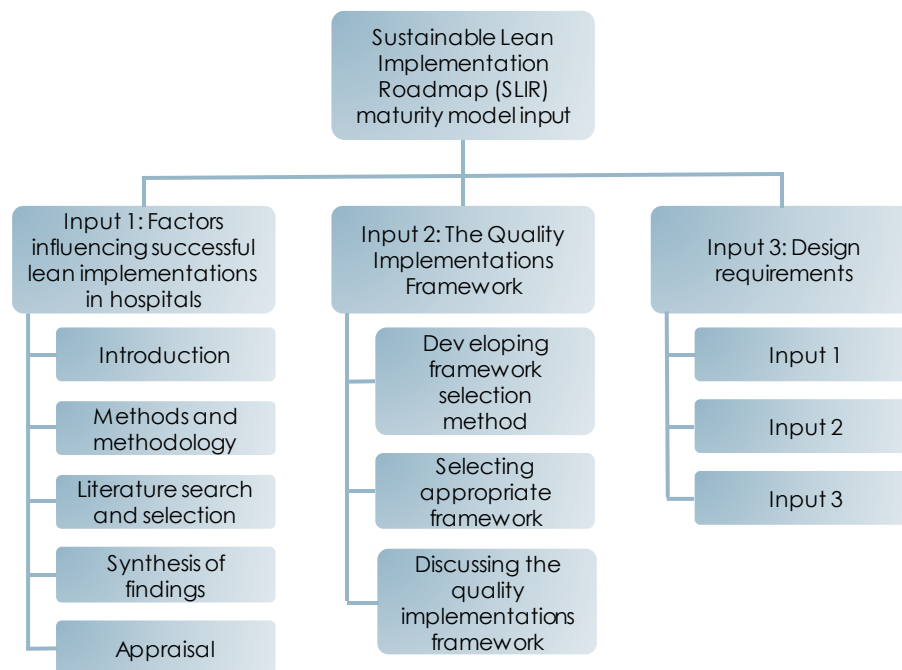


Figure 20: Chapter 4 orientation

4.2 Factors influencing successful Lean implementations in hospitals

This section reports on the first input of the SLIR, namely the SLR that was conducted to address the following research question: *What are the factors that influence the*

success of Lean implementation within a hospital environment? During the reporting of the SLR, there is often reference to the method followed to conduct the SLR, as is described in Figure 17 (Chapter 3: Research design). A summary of this method's phases is depicted in Figure 21.



Figure 21: SLR method main phases

As discussed, the reporting of an SLR, just like the review itself, should be methodical and repeatable (Siddaway *et al.*, 2019; Tong *et al.*, 2012). As discussed in the literature review, there are various methods for reporting SLRs. Since this SLR integrated qualitative research, the reporting is based on the ENTREQ statement developed by Tong *et al.* (2012). Tong *et al.* (2012) suggest complementing the ENTREQ statements with the PRISMA statement's information flow diagram (Liberati *et al.*, 2009), as can be seen in Figure 23. The ENTREQ statement suggests the following five stages: introduction, methods and methodology, literature search and selection, appraisal and the synthesis of findings (Tong *et al.*, 2012). However, in order to align the five stages of reporting with the six phases of the SLR method, the appraisal stage is reported last due to its corresponding method phase, study quality, which is the final phase in this study's SLR method. Figure 22 shows which SLR phase (white blocks) is discussed in which ENTREQ statement stage (grey blocks).

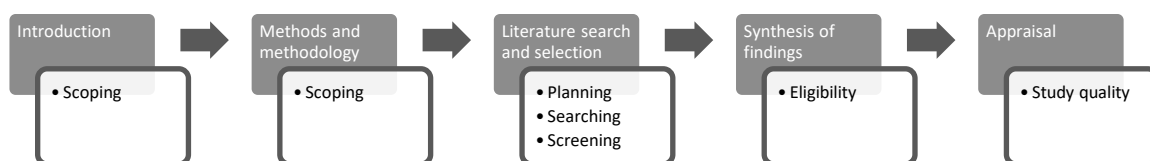


Figure 22: Aligning ENTREQ statement stages with SLR method phases

4.2.1 Introduction

Many organisations have achieved an increase in performance by adopting the Lean philosophy. However, unsuccessful Lean implementations often occur (Noori, 2015a). The Lean implementation process plays a big role in not only the success, but also the sustainability of Lean implementations (Hung *et al.*, 2015). Yet, it still remains one of the

main Lean in healthcare issues (D'Andreanmatteo *et al.*, 2015). The current body of literature is rife with articles discussing various factors that influence Lean implementation. These factors are, among other things, described as barriers, facilitators, challenges, readiness factors, success factors, inhibitors and managerial attributes (Aij *et al.*, 2013; De Souza & Pidd, 2011; Grove *et al.*, 2010; Mazur *et al.*, 2011; Sobek, 2011; Steed, 2012). The purpose of this SLR is to integrate these factors by addressing the following research question: What are the factors that influence the success of Lean implementation within a hospital environment?

When referring to successful Lean implementations within a healthcare context, the improvements achieved should be sustained (Stelson *et al.*, 2017). Change within a complex environment, such as healthcare, is a complicated process (Van Rossum *et al.*, 2016). It is important that healthcare providers properly plan the Lean implementation process by incorporating factors that influence the change process (Rich & Bateman, 2003) into the planning of the implementation strategy. Van Rossum *et al.* (2016) indicate that this will help healthcare providers in closing the research-to-strategy gap and contribute to the sustainability of the implementation improvements.

Although the words implementation and deployment are often used interchangeably, it is important to understand how they differ in meaning. Machado Guimarães and Crespo de Carvalho (2014) define the Lean deployment journey as reaching various Lean maturity levels. Maturity levels guide organisational transformation from an initial to a desired state where the desired state can be defined as being complete (Becker *et al.*, 2009; De Bruin *et al.*, 2005). Nilsen (2015) defines implementation as all the activities that are executed from the point in time when an organisation commits to a certain “change”, to the point in time that the “change” is part of the organisation’s routine or the “change” is abandoned. “Implement” is further defined as “to take practical steps towards the fulfilment of...” (Garner, 2016a). Therefore, implementation is the process of reaching full deployment. Since these two words are often used interchangeably, both terms are included in the search terms to ensure that all relevant articles are included in the study.

Various studies have been conducted on the respective factors that influence Lean implementation. However, based on the literature included in this review, no SLR that integrates all factors influencing Lean implementation has been conducted.

Based on the four study aims described by Xiao and Watson (2019), the aim of this SLR is to analyse the current state of literature relevant to the defined research question.

According to Xiao and Watson (2019), the aim is to “describe” all factors that influence the success of Lean implementation in a hospital environment.

4.2.2 Methods and methodology

Before starting an SLR, it is important to not only ensure that there is no existing study that addresses the research question, but also to decide which type of review to conduct (Siddaway *et al.*, 2019). The type of review will determine the method followed to conduct the SLR. The aim of this review is to analyse and integrate qualitative studies in order to address the defined research question. The defined research question is concerned with successful implementation within a hospital environment. Since this is a service environment, human behaviour plays a big role in implementation success. Synthesising qualitative studies enables the researcher to better understand human behaviour (Tong *et al.*, 2012). Therefore, a meta-synthesis SLR is conducted. Siddaway *et al.* (2019) clearly state that all SLRs must adhere to a commonly accepted process. Although a meta-synthesis review is conducted, the method followed in this study is based on the commonly accepted SLR process.

This review consists of six phases: scoping, planning, searching, screening, eligibility and study quality. Each of these phases with its outcomes are discussed briefly within the ENTREQ statement stages. A summary of the SLR method can be seen in Figure 17.

As discussed in the previous section, the purpose of the first phase of an SLR, scoping, is to clearly define the research question and determine whether an SLR that addresses the same research question does not already exist. Although the latter was not the case in this review, if such a review does exist, the reviewer can decide whether to update the existing review, if applicable. Since no similar SLR exists, the study was continued.

4.2.3 Literature search and selection

As part of the planning phase, the research question was operationalised by dividing it into four key terms. These terms are influencing factors, healthcare, Lean and implementation. During this phase of the review, the focus was more on finding as many relevant articles as possible rather than specifically ensuring that only relevant articles are selected (Siddaway *et al.*, 2019). In order to do this, alternative terminology for the respective key terms were identified and included in the search terms. As indicated in the SLR method, Figure 17, the search phrases (searching phase) and inclusion and exclusion criteria (planning phase) can be reformulated based on the initial search results

not being satisfactory. This was the case in this review. The revised inclusion and exclusion criteria that were used for the final screening, were formulated as follows:

Inclusion criteria:

- Studies must be available in full text and in English
- Studies must be published in accredited journals or in an established conference's proceedings
- Lean implementation in a hospital environment must be the main aim of the study or "method" to achieve the aim of the study
- Studies must explicitly mention any form of factor that influence Lean implementation

Exclusion criteria:

- Book chapters were excluded
- Studies were excluded if they were not conducted in a hospital environment
- Studies were excluded if they were concerned with the implementation of Lean in a non-service part of the hospital
- Studies were excluded if they were concerned with the implementation of Lean in combination with another methodology

The final step of the planning phase was to create a clear record-keeping system. EndNote was used as record-keeping software. Furthermore, an excel spreadsheet was used to assist the author in recording the various outputs of each methodology step.

The search phase was initialised by determining, based on a detailed discussion with the librarian for engineering, that Scopus and EBSCOhost would be used as the search databases. The following databases were selected under EBSCOhost:

1. Academic Search Premier
2. AHFS
3. Applied Science and Technology
4. Business Premier
5. EconLit
6. CINAHL with Full Text
7. E-Journals
8. Health Source - Consumer Edition
9. Health Source: Nursing/Academic Edition

10. MasterFILE Premier

11. MEDLINE

In order to locate the articles, the key terms were combined with Boolean search operators. The revised search phrases, after being adapted based on the initial search results, was as follows:

```
( TITLE ( ( lean OR "continu* improvement*" ) ) AND TITLE ( ( implement* OR deploy*  
OR adopt* OR adapt* OR appl* OR conscious* OR integrat* ) ) AND ABS ( (   
"health care" OR healthcare OR hospital* OR clinic* OR "health cent*" OR "medical  
service" OR "medical care environment" OR "medical facilit*" OR "medical cent*" ) )  
AND ALL ( ( "success factor*" OR "critical factor*" OR "change factor*" OR driver*  
OR "important factor*" OR success* OR facilitat* OR sustain* OR "long term" OR  
longterm OR "read* factor*" OR "failure factor*" OR challeng* OR barrier* OR  
lesson* OR issue* ) ) )
```

The flow of records that is described in this phase can be seen in Figure 23. After revising the search phrases and inclusion and exclusion criteria, a final search in the databases was conducted. The searches resulted in 287 records. Additional searches based on the included studies' references were conducted and these studies were included for screening in the next phase. The additional searches resulted in 33 records. Due to the scope of this study, unpublished and grey literature was not considered during the searching phase.

The 320 studies were screened based on their title and abstracts and 171 records were excluded. The remaining 146 studies were exported to EndNote where its function to identify and remove duplicate records were used. After removing the duplicate records 106 records remained. These remaining records' full text were obtained and screened to determine whether they are eligible for inclusion. Eighty-seven full text articles were excluded. The remaining 19 studies were studied, and the relevant factors were extracted, tabulated and synthesised. These results are discussed in the next section.

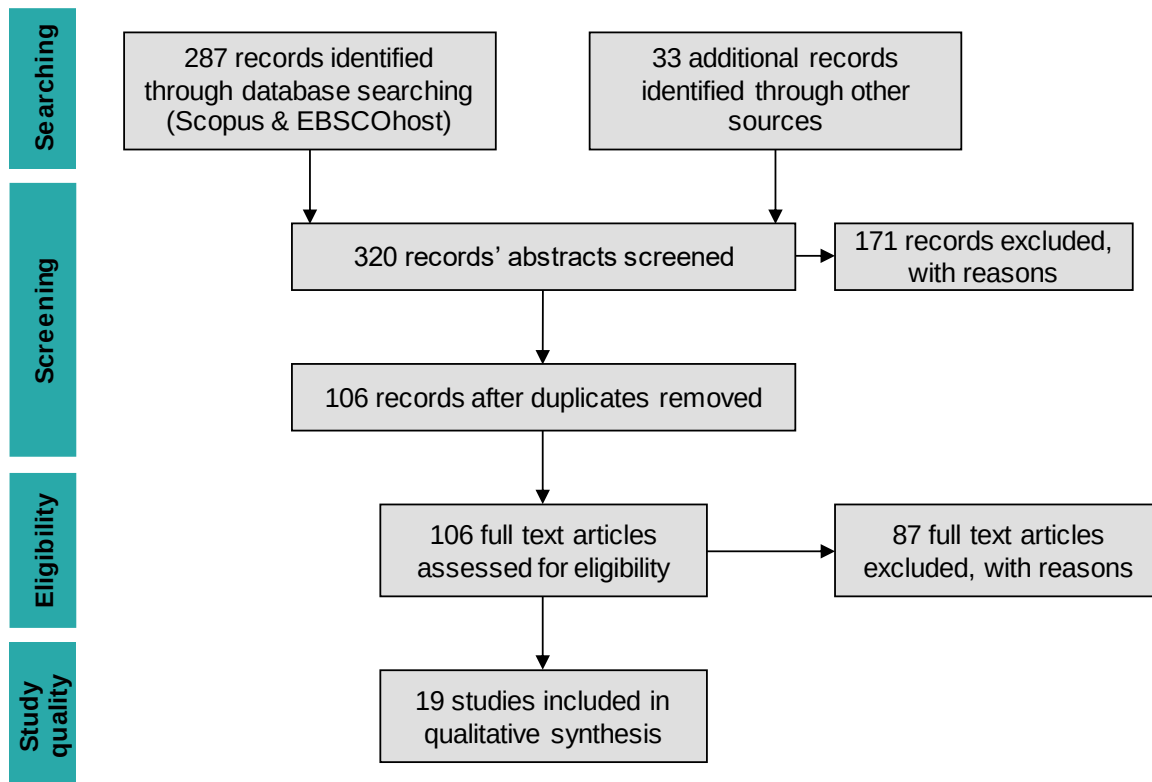


Figure 23: *Flow of records through SLR phases compiled from Liberati et al. (2009)*

The meta-data of the 19 studies that were included in the final phase of this review is captured in Table 5.

Table 5: Summary of SLR articles information

	Author (year)	Country	Article title	Journal/Conference proceeding	Healthcare environment
1	Harrison et al. (2016)	USA	Effects of organizational context on Lean implementation in five hospital systems	Health Care Management Review	Hospital
2	Jain & Ajmera (2018)	India	Modelling of the factors affecting lean implementation in healthcare using structural equation modelling	International Journal of Systems Assurance Engineering and Management	Hospital
3	Steed (2012)	USA	An exploration of the leadership attributes and methods associated with successful lean system deployments in acute care hospitals	Quality Management in Health Care	Hospital
4	Noori (2015b)	Iran	Identifying critical issues in lean implementation in hospitals	Hospital Topics	Hospital
5	de Souza & Pidd (2011)	UK	Exploring the barriers to lean health care implementation	Public Money and Management	Hospital
6	Grove et al. (2010)	UK	UK health visiting: challenges faced during lean implementation	Leadership in Health Services	Hospital
7	Mazur et al. (2011)	USA	Measuring and understanding change recipients' buy-in during lean program implementation efforts	61st Annual IIE Conference and Expo Proceedings	Hospital
8	Maijala et al. (2018)	SLR	Successful implementation of lean as a managerial principle in health care: a conceptual analysis from systematic literature review	International Journal of Technology Assessment in Health Care	Healthcare
9	Ajmera & Jain (2018)	India	A fuzzy interpretive structural modeling approach for evaluating the factors affecting lean implementation in Indian healthcare industry	International Journal of Lean Six Sigma	Healthcare
10	Sobek (2011)	USA	Lean healthcare implementation: critical success factors	61st Annual IIE Conference and Expo Proceedings	Hospital
11	Poksinska (2010)	SLR	The current state of Lean implementation in health care: literature review	Quality Management in Health Care	Healthcare
12	Ulhassan et al. (2013)	Sweden	Antecedents and characteristics of lean thinking implementation in a Swedish hospital: a case study	Quality Management in Health Care	Hospital
13	Aij et al. (2013)	Netherlands	Experiences of leaders in the implementation of Lean in a teaching hospital—barriers and facilitators in clinical practices: a qualitative study	BMJ Open	Hospital
14	Régis et al. (2018)	Brazil	Lean healthcare implementation: experiences and lessons learned from Brazilian hospitals	RAE Revista de Administracao de Empresas	Hospital
15	Noori (2015a)	Iran	The critical success factors for successful lean implementation in hospitals	International Journal of Productivity and Quality Management	Hospital
16	Patri & Suresh (2018)	India	Factors influencing lean implementation in healthcare organizations: An ISM approach	International Journal of Healthcare Management	Healthcare
17	Lorden et al. (2018)	Texas	Measure of success: the role of human factors in lean implementation in healthcare	Quality Management Journal	Healthcare
18	D'Andreanmatteo et al. (2015)	Italy	Lean in healthcare: a comprehensive review	Health Policy	Healthcare
19	Holden (2011)	Sweden	Lean thinking in emergency departments: a critical review	Annals of Emergency Medicine	Emergency department

4.2.4 Synthesis of findings

In accordance with the inclusion criteria – *studies must explicitly mention any form of factor that influence Lean implementation* – any explicit mention of factors that have an influence on the success of Lean implementation within a healthcare environment was extracted from the included literature. Factors extracted from the 19 included studies were tabulated. These factors were grouped under eight themes that were derived with

inductive reasoning. These factors, together with the relevant sources, can be seen in Table 6. A more detailed summary can be seen in Annexure B.

Table 6: Factors influencing successful Lean implementation

Theme	Factor	Source(s)
Planning	Define strategy	Jain & Ajmera (2018), Noori (2015b), Grove et al. (2010), Mazur et al. (2011), Ajmera & Jain (2018), Sobek (2011), Aij et al. (2013), Régis et al. (2018), Noori (2015a), Patri & Suresh (2018), Lorden et al. (2018), D'Andreamatteo et al. (2015), Harrison et al. (2016)
	Define value	Jain & Ajmera (2018), Grove et al. (2010), Mazur et al. (2011), Ajmera & Jain (2018), Poksinska (2010), Régis et al. (2018)
	Implementation timeline	Jain & Ajmera (2018), Ajmera & Jain (2018), Patri & Suresh (2018), Sobek (2011)
	Implementation team	Noori (2015b), Mazur et al. (2011), Régis et al. (2018), Noori (2015a), Holden (2011)
	Implementation process	Noori (2015b), Mazur et al. (2011), Noori (2015a), Lorden et al. (2018), D'Andreamatteo et al. (2015), Harrison et al. (2016), Sobek (2011), Régis et al. (2018), Ulhassan et al. (2013)
	Contextualisation	Ulhassan et al. (2013), Régis et al. (2018), Holden (2011), Noori (2015b), Noori (2015a)
	Learn from mistakes	D'Andreamatteo et al. (2015), Holden (2011)
Engagement	Patient engagement	Jain & Ajmera (2018), Ajmera & Jain (2018), Holden (2011)
	Employee engagement	Jain & Ajmera (2018), Mazur et al. (2011), Ajmera & Jain (2018), Sobek (2011), Patri & Suresh (2018), Harrison et al. (2016), Holden (2011), Lorden et al. (2018)
	Physician engagement	Sobek (2011), Holden (2011), Ulhassan et al. (2013)
	Management engagement	Lorden et al. (2018), Noori (2015b), Sobek (2011), D'Andreamatteo et al. (2015), Lorden et al. (2018), Maijala et al. (2018), Harrison et al. (2016)
Management	Management commitment	Jain & Ajmera (2018), Noori (2015b), Grove et al. (2010), Mazur et al. (2011), Ajmera & Jain (2018), Poksinska (2010), Ulhassan et al. (2013), Aij et al. (2013), Noori (2015a), Patri & Suresh (2018), Lorden et al. (2018), D'Andreamatteo et al. (2015), Holden (2011)
	Follow-up	Jain & Ajmera (2018), Noori (2015b), de Souza & Pidd (2011), Ajmera & Jain (2018), Sobek (2011), Noori (2015a), D'Andreamatteo et al. (2015), Harrison et al. (2016), Maijala et al. (2018), Mazur et al. (2011)
	Organisational momentum	de Souza & Pidd (2011), Aij et al. (2013)
	Leadership style	Steed (2012), Maijala et al. (2018), Aij et al. (2013), Sobek (2011)
Environment	Healthcare staff structure	de Souza & Pidd (2011), Sobek (2011), Poksinska (2010), Ulhassan et al. (2013), Noori (2015a), Lorden et al. (2018), Noori (2015b)
	Data collection	de Souza & Pidd (2011)
	Process variability	Grove et al. (2010), D'Andreamatteo et al. (2015)
	Defining waste	D'Andreamatteo et al. (2015), Grove et al. (2010)
Training	Employee trianing	Jain & Ajmera (2018), Noori (2015b), Grove et al. (2010), Mazur et al. (2011), Ajmera & Jain (2018), Sobek (2011), Poksinska (2010), Aij et al. (2013), Noori (2015a), Patri & Suresh (2018), D'Andreamatteo et al. (2015), Harrison et al. (2016)
	Lean philosophy	Jain & Ajmera (2018), Grove et al. (2010), Ajmera & Jain (2018), D'Andreamatteo et al. (2015)
	Facilitator training	Mazur et al. (2011), Noori (2015a), Noori (2015b), Sobek (2011), Harrison et al. (2016), Holden (2011)
Resources	Financial resources	Jain & Ajmera (2018), Ajmera & Jain (2018), Sobek (2011), Holden (2011)
	Supporting resources	Sobek (2011), Harrison et al. (2016), Holden (2011), Aij et al. (2013)
	Expertise	Sobek (2011), Régis et al. (2018), D'Andreamatteo et al. (2015), Harrison et al. (2016), Holden (2011)
Communication	General communication	Noori (2015b), Sobek (2011), Noori (2015a), Lorden et al. (2018), Harrison et al. (2016)
	Interdepartmental cooperation	Jain & Ajmera (2018), de Souza & Pidd (2011), Grove et al. (2010), Ajmera & Jain (2018), Sobek (2011), Poksinska (2010), Aij et al. (2013)
	Progress communication	Jain & Ajmera (2018), Ajmera & Jain (2018), Aij et al. (2013)
	Terminology	de Souza & Pidd (2011)
Culture	Supportive culture	Jain & Ajmera (2018), Noori (2015b), Ajmera & Jain (2018), Noori (2015a), Patri & Suresh (2018), D'Andreamatteo et al. (2015), Sobek (2011), Holden (2011)
	Readiness and resistance	Jain & Ajmera (2018), de Souza & Pidd (2011), Ajmera & Jain (2018), Ulhassan et al. (2013), Aij et al. (2013), Patri & Suresh (2018), Lorden et al. (2018), D'Andreamatteo et al. (2015), Harrison et al. (2016), Holden (2011)
	Normalisation of initiative	de Souza & Pidd (2011), Sobek (2011), Ulhassan et al. (2013), Régis et al. (2018), Poksinska (2010), Harrison et al. (2016), Holden (2011), Noori (2015b), Noori (2015a)

Discussion of synthesised findings

Based on themes that repeatedly emerged from the literature the success factors were grouped under the following eight themes: planning, engagement, leadership, environment, resources, communication, culture and training. Each theme, with its relevant factors, are discussed in this section.

Planning

As discussed, in the introduction chapter of the study, sustainable Lean implementation will not be reached if the implementation process is not thoroughly planned (Van Rossum *et al.*, 2016). Therefore, all the factors included in the planning theme are of vital importance to a successful Lean implementation. The first planning factor is to clearly define the organisational vision and strategy. The organisation's vision and improvement strategy should be carefully planned and aligned with the organisation's overall strategy (D'Andreamatteo *et al.*, 2015; Harrison *et al.*, 2016; Lorden *et al.*, 2014; Noori, 2015a; Noori, 2015b; Régis *et al.*, 2018). The strategy should be clearly communicated to all the relevant employees as this will contribute to their realisation of the importance of and commitment to the implementation initiative (Aij *et al.*, 2013; Jain & Ajmera, 2019; Mazur *et al.*, 2011; Régis *et al.*, 2018). A clearly defined vision is a factor with strong drive power (Ajmera & Jain, 2019). Management must also clearly define and communicate quantifiable goals that will assist in reaching the organisation's vision (Ajmera & Jain, 2019; Grove *et al.*, 2010; Jain & Ajmera, 2019; Patri & Suresh, 2018; Sobek, 2011). As part of the vision and goal communication, management must clearly communicate what they expect from the employees and what they can expect, in turn, from the organisation (Jain & Ajmera, 2019; Sobek, 2011).

The first principle of the Lean philosophy is to define value from the customer's perspective (Graban, 2016). Accordingly, the second planning factor is to clearly define value within a hospital environment (Ajmera & Jain, 2019; Grove *et al.*, 2010; Jain & Ajmera, 2019). In an effort to further define value in terms of the customer, the healthcare organisation should define who the customer is within their hospital environment (Grove *et al.*, 2010; Poksinska, 2010). Another Lean principle is to capture the value stream throughout the organisation (Graban, 2016). By developing a value stream map, the value-adding processes can be identified.

The third planning factor is to plan and manage the implementation timeline. Implementing Lean is a timeous activity (Ajmera & Jain, 2019; Jain & Ajmera, 2019).

Therefore, management should carefully plan the implementation timeline by taking into account how much time they can spend on the initiative (Patri & Suresh, 2018), as well as what they can realistically expect from their employees (Sobek, 2011).

The fourth planning factor is planning the implementation team. The implementation team must be carefully selected together with champions to lead the implementation (Holden, 2011; Mazur *et al.*, 2011; Noori, 2015a; Noori, 2015b; Régis *et al.*, 2018). As discussed as part of the training theme, it is also vital that the selected team and team leaders receive the necessary respective training (Noori, 2015a; Noori, 2015b).

The fifth planning factor is to properly plan the Lean implementation process (D'Andreamatteo *et al.*, 2015; Harrison *et al.*, 2016; Lorden *et al.*, 2014; Ulhassan *et al.*, 2013). Part of planning the implementation process is planning which processes within the hospital should be prioritised (Noori, 2015a; Noori, 2015b; Régis *et al.*, 2018; Sobek, 2011). These processes can be selected based on the value stream map results as discussed as part of the second planning factor (Mazur *et al.*, 2011).

The sixth planning factor is to contextualise the Lean intervention. Although all hospitals have patient, material and information flow, each organisation must take their internal context into account when planning how to implement Lean within their environment (Régis *et al.*, 2018; Ulhassan *et al.*, 2013). Similarly, all organisations have customers and suppliers, but within the internal context, Lean must be linked to both these stakeholders (Noori, 2015a; Noori, 2015b; Ulhassan *et al.*, 2013).

The seventh and final planning factor is to incorporate “lessons learned” into the planning process (D'Andreamatteo *et al.*, 2015). Holden (2011) elaborates by explaining that managers can either learn from their own experience or their colleagues' experience or they can learn from literature case studies.

Engagement

Patient, employee, physician and leadership engagement plays a role in the success of Lean implementation. Although patient engagement does not greatly influence the system (Ajmera & Jain, 2019), it is important to make them feel valued and recognise the value that their opinion can add to the implementation process (Ajmera & Jain, 2019; Holden, 2011). Jain and Ajmera (2019) further elaborate on this by stating that a healthcare organisation is likely to get better results when patients participate in the design of the implementation initiative since actual patient experience is integrated into the planning of the initiative. In an effort to ensure a better initial Lean implementation

results employees, especially frontline staff (Patri & Suresh, 2018; Sobek, 2011), should be engaged in the entire implementation process (Holden, 2011; Lorden *et al.*, 2014). Ajmera and Jain (2019) categorise employee engagement as a priority factor. One way in which employees can be engaged is by having awareness sessions (Mazur *et al.*, 2011). During such sessions, employees must be engaged in decision making and the execution of the implementation initiative (Patri & Suresh, 2018). Another topic that must be covered in such sessions is how the initiative will affect the employees' daily work, patient safety, and the quality of service provided to the patients (Patri & Suresh, 2018; Sobek, 2011). Although it is important to engage employees in the entire implementation process, Harrison *et al.* (2016) argue that management should be careful not to expect too much time-consuming activities from their employees in relation to the implementation initiative. Physician engagement early in the implementation process will minimise their resistance to the initiative and will prepare them for any time and effort expected of them in relation to the initiative (Holden, 2011; Sobek, 2011; Ulhassan *et al.*, 2013). Leadership engagement, on all levels (D'Andreamatteo *et al.*, 2015), plays a big role in not only the implementation of Lean, but also in the execution of patient, employee and physician engagement. Although employee engagement ensures better initial implementation results, leadership engagement translates to successful long-term implementation results. Majjala *et al.* (2018); Sobek (2011) and Harrison *et al.* (2016) clearly state that leaders should be actively involved in the implementation process, without forcing solutions on the employees, but guiding them through the process and the activities that form part of the implementation process.

Management

Management commitment, at all levels, is a factor that emerges in the majority of literature (D'Andreamatteo *et al.*, 2015; Grove *et al.*, 2010; Noori, 2015a; Noori, 2015b; Poksinska, 2010). Management commitment plays a pivotal role in implementation success (Aij *et al.*, 2013; Mazur *et al.*, 2011; Ulhassan *et al.*, 2013) and the opposite is also true – a lack of management commitment is a hurdle in the success of Lean implementation (Grove *et al.*, 2010; Lorden *et al.*, 2014). Management commitment does not only play a pivotal role in implementation success, but also in the sustainment of the implementation (Jain & Ajmera, 2019; Patri & Suresh, 2018). Ajmera and Jain (2019) further state the importance of this factor by concluding that it has a strong drive, in terms of the implementation process, and it is the foundation of the other factors. However, management cannot solely ensure the success of Lean implementation. They have to motivate employees to understand the importance and effectiveness of Lean in a

healthcare environment (Holden, 2011). Another important factor is the commitment to certain strategies, such as Lean, to ensure organisational momentum (Aij *et al.*, 2013; De Souza & Pidd, 2011). Management should be careful not to constantly change their strategy to improve, as this hinders the organisational momentum.

Another vital role of management is to measure both performance and progress. Management should evaluate and measure employee performance (De Souza & Pidd, 2011; Maijala *et al.*, 2018; Noori, 2015a; Noori, 2015b; Sobek, 2011). This will assist them in determining whether employees have fallen back to their habits prior to Lean implementation (Sobek, 2011). D'Andreamatteo *et al.* (2015) argue that management should give employees who perform well incentives to motivate further involvement. In order to motivate employees, managers should provide them with clarity in terms of the Lean implementation progress (Ajmera & Jain, 2019; Harrison *et al.*, 2016; Jain & Ajmera, 2019). This factor greatly influences the entire implementation and creates a positive attitude towards the initiative (Ajmera & Jain, 2019). As part of the training theme, Mazur *et al.* (2011) specifically mentions the fact that Lean leaders should receive training on how to measure and communicate improvements.

Management should be role models in terms of exhibiting behaviour that is favourable for Lean implementation (Aij *et al.*, 2013). Management style and behaviour is a factor that greatly reduces employees' resistance to change (Mazur *et al.*, 2011). Steed (2012) and Maijala *et al.* (2018) conducted studies to determine exactly what these management styles and behaviours must be. Their respective results can be seen in Annexure B.

Environment

A factor that becomes a barrier in Lean implementation is the traditional hierarchical structure of staff (De Souza & Pidd, 2011; Poksinska, 2010; Ulhassan *et al.*, 2013). Poksinska (2010) and Sobek (2011) describes the reason for this as that Lean implementation requires teamwork between all levels. If the hierarchical structure of healthcare staff is not managed or considered during Lean implementation, it might influence the success of Lean implementation. The hierarchy of the leadership should be managed during the introduction of Lean (Lorden *et al.*, 2014; Noori, 2015a; Noori, 2015b; Sobek, 2011). Another factor that should be addressed as part of the initial Lean implementation is the fire-fighting mentality that healthcare staff tend to have. They have to adopt a more analytic mentality, including not only focusing on taking care of patients, but also on collecting data while doing so (De Souza & Pidd, 2011). A further factor that

is unique to the hospital environment is the high process variability (D'Andreanmatteo *et al.*, 2015; Grove *et al.*, 2010). As discussed earlier, one of the five Lean principles is to determine the value stream of service transformation. High process variability makes it difficult for healthcare staff to capture a common process of service transformation. A final environmental factor is identifying waste within a hospital environment (D'Andreanmatteo *et al.*, 2015; Grove *et al.*, 2010). This links well with the training theme where employees must be trained to identify waste within their environment.

Training

More often than not, employees have no prior experience in terms of Lean (Harrison *et al.*, 2016) or their perception of Lean is only what they hear from the manufacturing sector (De Souza & Pidd, 2011). Since Lean is a new or vague concept to healthcare employees, they should receive training that equips them to apply Lean in their environment (Aij *et al.*, 2013; D'Andreanmatteo *et al.*, 2015; Jain & Ajmera, 2019; Patri & Suresh, 2018; Sobek, 2011). These training sessions should also address the factor of distinguishing between waste and value-adding steps in their environment, as discussed under environment (Grove *et al.*, 2010; Mazur *et al.*, 2011). This can be done by ensuring that healthcare-related examples are used during the training (Poksinska, 2010). Equipping staff with the required knowledge is a very important factor with strong drive power (Ajmera & Jain, 2019). This not only empowers employees (Noori, 2015a; Noori, 2015b), but also contributes to another influencing factor – ensuring that employees understand the overall Lean philosophy (Grove *et al.*, 2010).

Healthcare staff should not only understand the tools and techniques used in Lean implementations, but also how Lean can improve the organisation as a whole (D'Andreanmatteo *et al.*, 2015; Grove *et al.*, 2010; Jain & Ajmera, 2019). This factor, once again, has a strong drive and will greatly affect implementation success (Ajmera & Jain, 2019). The final environmental factor is empowering the Lean implementation facilitators (Harrison *et al.*, 2016) by equipping them with the necessary skills to lead the Lean transformation (Mazur *et al.*, 2011). The facilitators must receive the necessary project management skills and be equipped to convey the necessary information to the rest of the employees (Holden, 2011; Noori, 2015a; Noori, 2015b; Sobek, 2011).

Resources

Ajmera and Jain (2019) clearly state that healthcare organisations require the necessary financial resources to successfully implement Lean. Harrison *et al.* (2016), Holden

(2011), Jain and Ajmera (2019) and Sobek (2011) agree that financial ability to invest in training and expertise is required. Similar to what D'Andreamatteo *et al.* (2015) suggest in terms of rewarding employees with incentives, Jain and Ajmera (2019) and Sobek (2011) state that management should budget for some form of a reward system. Ensuring that the necessary supporting resources is available greatly influences the success of Lean implementation (Holden, 2011). These resources include software (Jain & Ajmera, 2019; Sobek, 2011) and time and personnel resources (Aij *et al.*, 2013; Harrison *et al.*, 2016; Holden, 2011).

An important factor that is widely recognised is hiring external expertise to assist the organisation with implementing Lean (D'Andreamatteo *et al.*, 2015; Harrison *et al.*, 2016; Holden, 2011; Régis *et al.*, 2018; Sobek, 2011). If possible, it will be even more beneficial to make use of in-house expertise (Harrison *et al.*, 2016). Holden (2011) points out that if a healthcare organisation makes use of external expertise, it can only be temporary, and the organisation's staff would have to be equipped to later guide the implementation themselves.

Communication

General communication within an organisation is an important factor when implementing Lean (Harrison *et al.*, 2016; Noori, 2015a; Noori, 2015b). Sobek (2011) further states that there should be frequent communication with both individual employees and departments who are part of the implementation initiative. Lorden *et al.* (2014) point out that it is prudent to consider what type of medium is used for communication. The medium used must not hinder communication, but rather contribute to its effectiveness. Another factor that De Souza and Pidd (2011) note is the terminology used during communication. Although new terminology can be a barrier at first, if employees receive no training and do not understand the terminology, their attitude to the new way of doing things may be negative.

In terms of communication within an organisation, Ajmera and Jain (2019) conclude that it is an important factor with a strong drive. Both interdepartmental (Jain & Ajmera, 2019) and multidisciplinary (Aij *et al.*, 2013) communication must be effective to ensure that Lean is implemented successfully within a hospital environment. Another communication factor that often emerges from literature is the barrier of professional and functional silos. These silos hinder flow (an important Lean principle) within the hospital and greatly affects the success of Lean implementation (De Souza & Pidd, 2011). Organisations, specifically management, must ensure that this barrier is removed, resulting in effective

communication throughout the entire organisation (Aij *et al.*, 2013; Grove *et al.*, 2010; Poksinska, 2010; Sobek, 2011). The factor of communicating progress, both vertically and horizontally, throughout the organisation, assists in creating a positive drive in the employees (Jain & Ajmera, 2019). Linking to the first planning factor that was discussed, it is important to not only communicate the results, but also the strategy (Aij *et al.*, 2013).

Culture

Part of the Lean implementation goals should be to aim for a culture change (Holden, 2011; Noori, 2015a; Noori, 2015b). An encouraging and supportive culture will affect the employees' attitude towards the implementation initiative (Jain & Ajmera, 2019; Sobek, 2011). It is important to create a supportive and encouraging culture, since, in contrast with the manufacturing environment, the healthcare environment deals with people, not machines (Patri & Suresh, 2018). Since "people" play such an important role within Lean healthcare implementation, D'Andreamatteo *et al.* (2015) suggest that management communicate Lean to the employees in such a way that an emotional bond forms between them and the initiative. Ajmera and Jain (2019) emphasise that a supportive and encouraging professional culture is foundational to the rest of the factors influencing the success of Lean implementation.

The next culture factor has two elements: managing resistance to change and managing misconceptions of Lean. Before Lean implementation is introduced to the staff, management must ensure that they are receptive to change and willing to change their way of thinking (D'Andreamatteo *et al.*, 2015; Harrison *et al.*, 2016; Holden, 2011; Ulhassan *et al.*, 2013). More often than not employees will be resistant to change and management must carefully manage this as it is a factor that is greatly dependent on other factors (Aij *et al.*, 2013; Ajmera & Jain, 2019; Harrison *et al.*, 2016; Lorden *et al.*, 2014; Patri & Suresh, 2018). It is also vital that management addresses misconceptions that employees might have about Lean. These misconceptions include that Lean is merely a cost cutting initiative that will result in either an increase in workload or result in layoffs (Harrison *et al.*, 2016; Holden, 2011; Jain & Ajmera, 2019; Patri & Suresh, 2018). Further misconceptions might stem from manufacturing – that Lean is only appropriate in a manufacturing environment, or that, similar to a manufacturing environment, patients are going to be handled like "products" instead of patients. Addressing the following and final culture factor will also contribute to managing employees' resistance to change. Management must not only cultivate a supporting and encouraging culture, as discussed above, but also a continuous improvement culture (Régis *et al.*, 2018; Ulhassan *et al.*, 2013). In order to cultivate such a culture, employees must understand that continuous

improvement is necessary within an organisation and that Lean is a continuous improvement strategy that can be applied in a hospital environment (Harrison *et al.*, 2016; Holden, 2011; Poksinska, 2010; Régis *et al.*, 2018; Ulhassan *et al.*, 2013). Poksinska (2010) concludes that such a culture will ensure that employees are committed to partake in the implementation initiative. Management's aim, in terms of culture change, must be that employees incorporate Lean into their everyday routines (De Souza & Pidd, 2011; Sobek, 2011). Therefore, Lean must be the "normal" way of doing their job.

4.2.5 Appraisal

The final phase of the SLR method is to ensure the quality of the study by identifying and summarising any possible issues that can cause potential bias during the review process. The inclusion criteria specified in a study (Siddaway *et al.*, 2019) and in the case of this study specifically the inclusion criteria "studies have to be published in accredited journals or published in an established conference's proceedings", is the first step to ensuring that quality and relevant articles are included in the study. However, the quality of the included studies will still differ. Tong *et al.* (2012) summarise three main approaches to appraising primary studies as assessing the method, the reporting, and the value of the study results.

One of the appraisal tools suggested by Tong *et al.* (2012) is a list of questions developed by Mays and Pope (2000) to assess the quality of qualitative studies. These questions, derived from specified criteria (see Table 7), assist the researcher in assessing the relevance and validity of the studies (Mays & Pope, 2000). A 5-point Likert scale was used to rate the studies by perusing the primary studies. Therefore, for each of the 19 primary studies a value between 1 and 5, with 5 being the highest, was awarded to each of the seven criteria developed by Mays and Pope (2000). The results of this process can be seen in Table 7.

Eight of the 19 primary studies were awarded a rating of 4 or 5 for each of the seven criteria. The remaining 11 primary studies received ratings below 4 for at least one of the criteria. These 11 studies are categorised in two categories. The first category is studies that, despite receiving rating(s) below 4, still yielded an average rating above 3.75. The second category is studies that, together with receiving rating(s) below 4, yielded an average rating below 3.75. The eleven studies within the 2 categories are as follows:

Studies with rating of 3 for at least one criterion (average rating **above** 3.75)

- Steed (2012)
- Mazur *et al.* (2011)
- Ulhassan *et al.* (2013)

Studies with rating of 3 for at least one criterion (average rating **below** 3.75)

- Noori (2015a)
- Noori (2015b)
- De Souza & Pidd (2011)
- Ajmera & Jain (2018)
- Sobek (2011)
- Poksinska (2010)
- Régis *et al.* (2018)
- Lorden *et al.* (2018)

Although assessing the quality of primary studies is important, Siddaway *et al.* (2019) warn that researchers differ in what they perceive as “quality”. They further warn not to exclude studies from qualitative synthesis based on the results of the assessment. Based on their recommendation and possible bias the studies of a poorer quality were not excluded from the study. However, these studies should not be the only source that justifies a factor (Table 6). The two factors for which this was the case – data collection under the theme environment, and terminology under the theme communication – can thus be defined as non-critical factors in the implementation of Lean.

As a final step to ensure study quality, a table listing borderline cases that were excluded from the review is included in Annexure B. This is provided to contribute to the repeatability of the study, as this is one of the characteristics of an SLR.

Table 7: Primary studies appraisal ratings

	Criteria	Worth or relevance	Clarity of research question	Appropriateness of design of question	Context	Sampling	Data collection and analysis	Reflexivity of the account	
	Question	Does study contribute usefully to knowledge?	Is research question clear at some stage in study?	Is the method appropriate or would a different method have been more appropriate?	Is context adequately described so that reader can relate it to other setting?	Does sample include full range of possible cases?	Were data collection and analysis procedures systematic (repeatable)?	Were sufficient data included in the reports? Did researcher self consciously assess the impact of the chosen method on the obtained data?	Average rating:
S o u r c e	Harrison et al. (2016)	5	4	4	5	4	4	4	4.29
	Jain & Ajmera (2018)	4	5	4	4	4	4	5	4.29
	Steed (2012)	4	5	3	4	4	3	4	3.86
	Noori (2015b)	3	3	4	4	3	4	3	3.43
	de Souza & Pidd (2011)	4	4	3	4	4	2	3	3.43
	Grove et al. (2010)	5	5	4	4	4	5	4	4.43
	Mazur et al. (2011)	4	4	4	4	3	4	5	4
	Majjala et al. (2018)	5	4	5	5	5	5	4	4.71
	Ajmera & Jain (2018)	4	4	4	3	3	4	4	3.71
	Sobek (2011)	4	3	4	3	4	3	2	3.29
	Poksinska (2010)	3	4	3	4	3	2	3	3.14
	Ulhassan et al. (2013)	4	4	4	5	3	4	5	4.14
	Aij et al. (2013)	4	4	4	4	4	5	4	4.14
	Régis et al. (2018)	3	4	4	4	3	4	4	3.71
	Noori (2015a)	3	3	4	3	3	2	3	3
	Patri & Suresh (2018)	5	4	4	4	4	5	5	4.43
	Lorden et al. (2018)	3	4	3	4	3	3	3	3.29
	D'Andreamatteo et al. (2015)	5	5	5	4	4	5	4	4.57
	Holden (2011)	4	4	4	4	4	5	4	4.14

4.2.6 Section conclusion

A list of factors influencing the success of Lean implementation within a hospital environment was developed by systematically reviewing literature on Lean healthcare implementation. These factors were categorised according to eight themes: engagement, leadership, environment, resources, communication, culture, training and planning. The eight themes and 32 factors are the first SLIR input. The inclusion of these factors into the development of the SLIR contributes towards maintaining the fidelity of the Lean methodology throughout its implementation.

4.3 The quality implementation framework

Although ways to improve healthcare environments are researched on a regular basis, they do not add value if they are not adopted into the healthcare environment's everyday practice (Eccles & Mittman, 2006). Implementation science is concerned with bridging this gap between research and practice (Wandersman *et al.*, 2008). As discussed in Section 2.5 this is achieved by the development of theories, models and frameworks to facilitate the systematic adoption of these research findings into everyday practices (Bauer *et al.*, 2015). The majority of these developed frameworks are applicable to any implementation and act as bridges between implementation science and implementation studies in various fields (Damschroder, 2019). However, researchers in all fields struggle to determine which one of these multiple developed implementation science frameworks are the most appropriate for their study (Birken *et al.*, 2017; Damschroder, 2019; Nilsen, 2015; Tabak *et al.*, 2012). Various studies have been conducted to help researchers and healthcare practitioners select the most appropriate framework for the relevant study (Birken *et al.*, 2017; Damschroder, 2019; Lynch *et al.*, 2018). Although there is implementation science literature that guides framework selection, a selection method was developed specifically for this study's context.

The first aim of this section is to report on how existing literature for selecting studies were combined to develop the selection method tailored to this dissertation's context. This is discussed in Section 4.3.1. The second aim is to report on how an appropriate framework, the QIF, was selected by following this self-developed selection method. This is discussed in Section 4.3.2.

4.3.1 Developing a framework selection method

Figure 24 offers a visual representation of the self-developed implementation science framework selection method. This figure serves as a guide to discuss the development of this selection method. Firstly, the various sources used to develop a list of frameworks, as a starting point for the appropriate framework selection, are identified (Box 1). Secondly, the questions used in the selection process are formulated (Box 2). Finally, the selection process and its steps are expounded (Box 3).

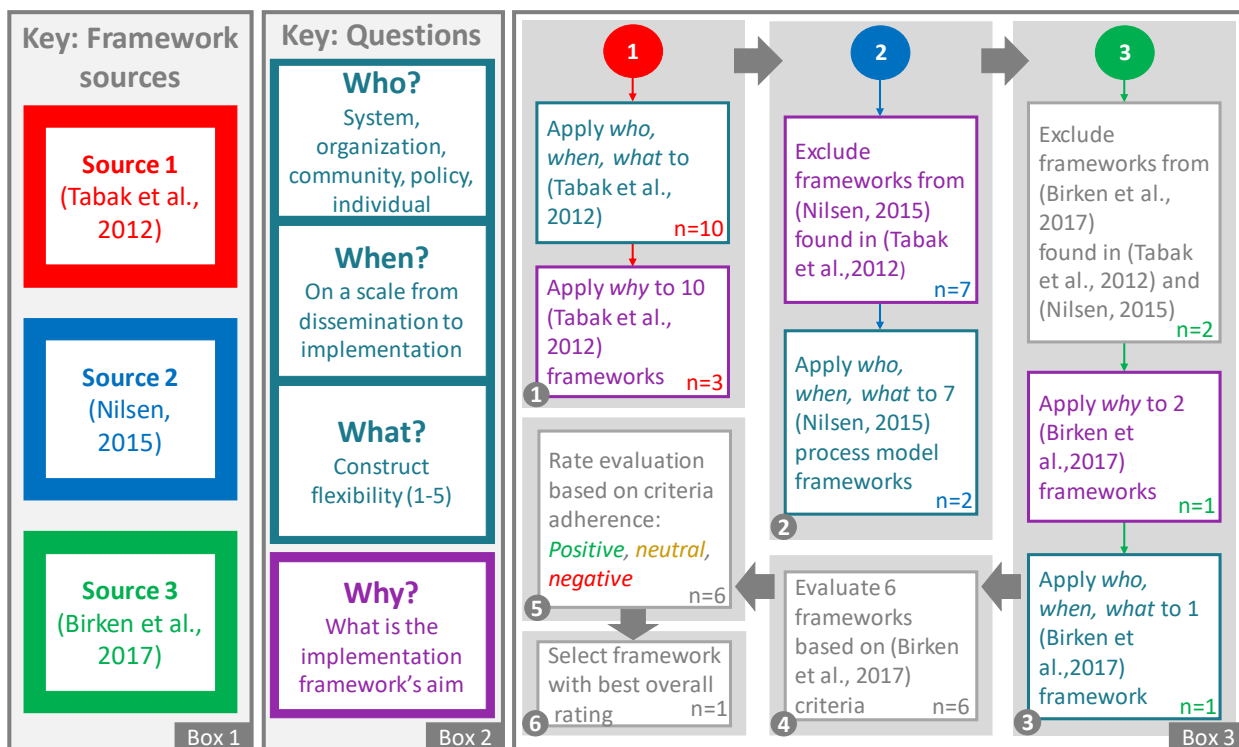


Figure 24: Visual representation of self-developed implementation science framework selection method

4.3.1.1 Framework sources

As mentioned earlier, there are multiple implementation science frameworks (Birken et al., 2017; Damschroder, 2019; Nilsen, 2015; Tabak et al., 2012). The listed frameworks from three sources were used as the starting point to select the most appropriate implementation framework for this study (Box 1). These three sources, distinguished by their authors, are Tabak et al. (2012), as indicated by the red block in Figure 24, Nilsen (2015), as indicated by the blue block in Figure 24, and Birken et al. (2017), as indicated by the green block in Figure 24. Damschroder (2019) recommends a few online tools that can be used to assist a researcher in selecting a framework. One of these tools is an online version of the frameworks listed in Tabak et al. (2012). Damschroder (2019) further states that the suggested online tools “do not cover the full range of theories but rather provide a starting point”. Therefore, the frameworks listed in Nilsen (2015) was selected as the second source to inform the starting point of frameworks from which to select. Nilsen (2015) lists frameworks based on five categories: process models, determinant frameworks, classic theories, implementation theories and evaluation frameworks. Since the aim of this study is to develop an implementation roadmap, the

specific list of process models, of which the purpose is to guide the implementation of research into practice, was used as the second framework source. In an effort to ensure an exhaustive list of frameworks at the starting point of the selection process, a third source was used. Birken *et al.* (2017) compiled a list of 23 frameworks that emerged from a survey as most often used in the application of implementation science.

4.3.1.2 Selection questions

Once a comprehensive list of framework sources have been compiled, the next step is to select the most appropriate framework for this study. Lynch *et al.* (2018) recommend five questions that can be used to select the most appropriate framework for a specific study. These questions, as listed by Lynch *et al.* (2018), can be seen in Figure 25. Lynch *et al.* (2018) further suggest that it is ideal not to base the selection of an appropriate framework on the available data, but rather to gather the necessary data after a framework has been selected. Therefore, the “how” question is eliminated from the selection process, as it is assumed that all necessary data will be available when applying the SLIR. These final four selection questions used to guide the selection of an appropriate implementation science framework is indicated in Box 2 in Figure 24.

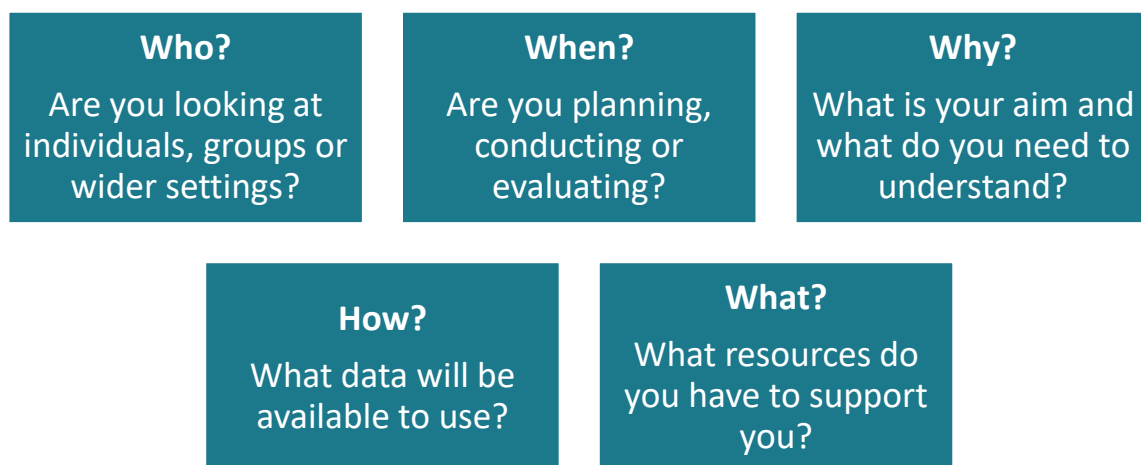


Figure 25: *Framework selection questions reproduced from Lynch et al. (2018)*

The criteria to which the appropriate framework should adhere are specified for each of the remaining four questions. These criteria, as discussed below, are summarised in Figure 26. They were derived from Tabak *et al.* (2012) and Nilsen (2015). Nilsen (2015) categorises implementation frameworks into five categories. One of these categories is process models. The aim of the process models is “to describe and/or guide the process

of translating research into practice” (Nilsen, 2015). This aim was used as the criteria for the “why” question. Therefore, the appropriate framework to be selected should adhere to this requirement in terms of its aim.

Tabak *et al.* (2012) define three categories that they used to categorise their list of implementation frameworks in their study. These three categories are used to inform the criteria for the “who”, “when” and “what” questions. These categories are described in Table 8.

Table 8: Categories used to categorise list of implementation frameworks reproduced from Tabak *et al.* (2012)

Category	Variable definition	Anchor definitions
Construct flexibility	Definition/flexibility of model constructs	1=Broad: loosely outlined and defined constructs; allows researchers greater flexibility to apply the model to a wide array of D&I activities and contexts 5=Operational: detailed, step-by-step actions for completion of D&I research processes
Dissemination and/or implementation (D/I)	Focus on dissemination and/or implementation activities	D-only: Focus on active approach of spreading evidence-based interventions to the target audience via determined channels using planned strategies D=I: Equal focus on dissemination and implementation I-only: Focus on process of putting to use or integrating evidence-based interventions within a setting
Socioecologic framework	Level of the framework at which the model operates	Individual: Personal characteristics Organization: Hospitals, service organizations, factory Community: Local government, neighborhood System: Hospital system, government

The criteria for the “who” question are derived from the socioecologic framework category. From the four listed levels, the specific applicable criteria are determined to be the organisational and system level frameworks. These two levels are selected seeing as Lean is a way of thinking that needs to be adopted by an entire organisation (Aij & Lohman, 2016). Similarly, Tabak *et al.* (2012) also lists hospitals under these two levels in Table 8. The “when” question’s criteria are derived from the dissemination and/or implementation category. Nilsen (2015) refers to this as the “diffusion-dissemination-implementation continuum”. Both dissemination and implementation consist of deliberately taking action to introduce new research to an environment. However, dissemination focuses on introducing knowledge, while implementation focuses on integrating the research with the environment (Nilsen, 2015). Since the focus of this study is on implementation activities, the criteria, in correlation with Tabak *et al.*’s (2012)

criteria, are selected to be I>D and I-only. The “what” question’s criteria are derived from the construct flexibility category. Lynch *et al.* (2018) recommend that researchers who are novices in implementation science should work with frameworks that are more structured, less flexible and have little room for interpretation. Therefore, the construct flexibility deemed fit for this study is a construct flexibility of four and five.

Who?	When?	Why?	What?
•System •Organisation	•I>D •I-only	•Aim: guide implementation process by describing stages/phases	•Construct flexibility = 4 •Construct flexibility = 5

Figure 26: *Four selection question's specified criteria*

4.3.1.3 Selection process

As seen in Figure 24, Box 3, each of the four selection questions (Box 2) were applied to the three framework sources (Box 1). Although the application of the four selection questions reduces the list of possible appropriate frameworks, this reduced list of possible frameworks had to be further evaluated in order to select the most appropriate framework. This was achieved by incorporating a list of evaluation criteria derived from Birken *et al.* (2017). Birken *et al.* (2017) developed an exhaustive list of criteria, derived from other researchers’ experience, that can be used to determine which framework best suits the need of a study. They further state that on average researchers use seven of the 19 criteria. Similarly, the seven criteria most relevant to this study’s context were selected from the exhaustive list. The selected criteria are presented in Table 9.

Table 9: Implementation framework selection criteria reproduced from Birken *et al.* (2017)

Criteria	Description
Generalisability	Applicability to various disciplines, settings, and populations
Inclusion of change strategies/techniques	Provision of specific method(s) for promoting change in implementation-related processes and/or outcomes
Inclusion of a diagrammatic representation	Elaboration in a clear and useful figure representing the concepts and their interrelations
Process guidance	Provision of a step-by-step approach for application
Disciplinary approval	Frequency of use, popularity, acceptability, and perceptions of influence among a given group of scholars or reviewers, country, funding agencies, etc.; endorsement or recommendation by credible authorities in the field
Application to a specific setting	Developed for a specific environment (e.g. hospitals, schools) or population (e.g. cancer patients) (should not be selected)
Explanatory power/testability	Ability to provide explanations around variables and effects; generates hypotheses that can be empirically tested

Once again, these criteria assisted in reducing the list of possible appropriate frameworks. As a final evaluation the seven awarded criteria from the list compiled by Birken *et al.* (2017) were rated based on the extent to which the frameworks met the criteria. Each framework was awarded a positive, neutral or negative rating in terms of adherence to a criterion. This is further explained in the next section when the application of the entire self-developed selection process presented in Figure 24 is reported.

4.3.2 Selecting an appropriate framework

This section aims to report on the application of the developed implementation science framework selection method. The application of the four selection questions to each of the three framework sources are discussed. Finally, the application of the list of criteria, compiled by Birken *et al.* (2017), is discussed.

4.3.2.1 The four selection questions applied to Source 1

The first three selection questions – “who”, “when” and “what” – were applied first to Tabak *et al.* (2012). The criteria listed below, which were derived from Table 8 and presented in Figure 26, were applied to the online database of implementation science frameworks listed by Tabak *et al.* (2012). The ten implementation science frameworks that met the criteria listed below can be seen on the left-hand side of Table 10.

- “Who”: system and organisation

- “When”: I>D, I-only
- “What”: construct flexibility = 4,5

To answer the “why” question, the ten implementation frameworks that met the criteria were further evaluated by classifying their respective aims based on five possible framework aims developed by Nilsen (2015). These aims were discussed in Section 2.5.3 and can be summarised as follows:

- Process models: “...guide the process of translating research into practice.”
- Determinant frameworks: “...explain influences on implementation outcomes.”
- Classic theories: “Theories that originate from fields external to implementation science...”
- Implementation theories: “...explanation of aspects of implementation.”
- Evaluation theories: “...determine implementation success.”

The classification of the ten frameworks’ respective aims are indicated on the right-hand side of Table 10. The ARC model was categorised as a determinant framework, since its objective is addressing how the implementation of service technology is affected by the social context in which it is implemented (Glisson & Schoenwald, 2005). The Centre for Disease Control’s HIV/AIDS prevention division’s research-to-practice model was categorised as a process model as it specifies phases that provide implementation guidance (Sogolow *et al.*, 2000). Although the conceptual model of evidence-based practice implementation in public service sectors specifies four phases, guiding implementation, they also focus on discussing factors that influence the implementation process (Aarons *et al.*, 2011). Therefore, it was categorised as a determinant framework. The consolidated framework for implementation research consists of five defined domains that integrate to positively influence implementation success (Damschroder *et al.*, 2009). It was therefore also placed in the determinant framework category. The contextual frameworks for research on the implementation of complex systems aim to determine which aspect of implementation influences the achievement of the desired outcomes (Rojas Smith *et al.*, 2004). As this correlates with the aim of implementation theories, these frameworks were placed into this category.

The framework developed by Michie (2005) uses psychological theory and is relevant to implementation science as it explains the behaviour changes associated with implementation of evidence-based practices (French *et al.*, 2012). Since this framework originated in an external research field, it is categorised as a classic theory. Intervention mapping aims to assist in the development of an intervention to be implemented

(Bartholomew *et al.*, 1998). It provides step-by-step guidance (Bartholomew *et al.*, 1998) and is, therefore, categorised as a process model. The PRISM framework is concerned with factors influencing implementation success (Feldstein & Glasgow, 2008) and is categorised as a determinant framework. The framework developed by Kilbourne *et al.* (2007) was categorised as a process model, since it guides implementation by means of its four phases and descriptions under each phase. The theoretical domains framework uses both organisational and psychological theory to analyse the changes in employees' behaviour during an implementation (French *et al.*, 2012). Therefore, it was categorised as a classic theory.

The three frameworks from Source 1 that met the four selection question's criteria were determined and is presented in Table 10. The following section reports on the application of the selection questions to Source 2.

Table 10: Applying implementation science framework selection method to source 1 (Tabak *et al.*, 2012)

Frameworks from Tabak <i>et al.</i> (2012)		Aim according to Nilsen (2015) categories ("How" question)				
Framework name	Source author	Process models	Determinant frameworks	Classic theories	Implementation theories	Evaluation frameworks
Availability, Responsiveness & Continuity (ARC): An organisational & Community Intervention Model	Glisson & Schoenwald (2005)		X			
CDC DHAP's Research-to-Practice Framework	Sogolow <i>et al.</i> (2000)	X				
Conceptual Model of Evidence-based Practice Implementation in Public Service Sectors	Aarons <i>et al.</i> (2011)		X			
Consolidated Framework for Implementation Research	Damschroder <i>et al.</i> (2009)		X			
Contextual Frameworks for Research on the Implementation of Complex System Interventions	Rojas Smith <i>et al.</i> (2014)				X	
Explaining Behavior Change in Evidence-Based Practice	Michie (2005)			X		
Intervention Mapping	Bartholomew <i>et al.</i> (1998)	X				
Practical, Robust Implementation and Sustainability Model (PRISM)	Feldstein & Glasgow (2008)		X			
Replicating Effective Programs Plus Framework	Kilbourne <i>et al.</i> (2007)	X				
Theoretical Domains Framework	French <i>et al.</i> (2012)			X		

4.3.2.2 The four selection questions applied to Source 2

Apart from the definition of process models, Nilsen (2015) also provides a list of process model examples. This list of examples was used as the second framework source.

Before applying the four selection questions to this list of process models, any framework that featured in Tabak *et al.* (2012), as can be seen in Table 10, was excluded from this step, since these frameworks have already been evaluated against the criteria of the four selection questions.

Seeing as this source of frameworks automatically meets the “why” selection question criteria, the seven (of 14) remaining frameworks were allocated the criteria listed within each of the “who”, “when” and “what” selection questions respectively. This allocation can be seen in Table 11. These seven frameworks are applicable to be applied on a system or organisational level, as per the requirements defined for the “who” category in Figure 26. Subsequently, as can be seen in Table 11 the seven frameworks were allocated both system and organisation for the “who” question.

Since the frameworks are all process models with the aim of guiding researchers by defining stages, all the frameworks scored between three and five for their construct flexibility. The final allocation of construct flexibility was done based on the detail provided for each stage, in other words, the extent of the unguided interpretation that is required from the researcher during the implementation of the respective framework. Scores between three and five were allocated where a score of three meant little detail was provided and a score of five for the most detailed framework.

Considering the first four frameworks listed in Table 11 are focused on the transfer of knowledge, linking to the first two steps of the “diffusion-dissemination-implementation continuum” (Nilsen, 2015), these frameworks were allocated with either a D=I, D>I or D-only under the dissemination and/or implementation category (Landry *et al.*, 2001; Majdzadeh *et al.*, 2008; Smylie *et al.*, 2004; Stevens, 2013). The final decision between D=I, D>I or D-only was made based on the ratio of the defined stages between dissemination or implementation (Landry *et al.*, 2001; Majdzadeh *et al.*, 2008; Smylie *et al.*, 2004; Stevens, 2013).

The 10-step model for inducing change in professional behaviour addresses the facilitation of changing the behaviour of professionals within the implementation setting (Grol & Wensing, 2004). Therefore, it focuses more on implementation than dissemination. Hence, I>D was awarded to this framework. The QIF describes detailed steps to be followed during the implementation process to ensure a quality implementation (Meyers *et al.*, 2012). Therefore, I<D was also awarded to this framework. The knowledge-to-action process framework consists of both a knowledge

creation cycle and an action cycle, therefore it focuses equally on dissemination and implementation. Hence, D=I was awarded to this framework (Graham *et al.*, 2006).

The two frameworks from Source 2 that met the selection question's criteria have been determined. The following section reports on the application of the selection questions to Source 3.

Table 11: Applying implementation science framework selection method to source 2 (Nilsen, 2015)

Framework name	Source author	Socioecologic framework ("Who" question)	Construct flexibility ("What" question)	Dissemination and/or implementation ("When" question)
The Ladder of Knowledge Utilization	Landry et al. (2001)	System, Organisation	3	D=I
Knowledge Translation Cycle	Majdzadeh et al. (2008)	System, Organisation	4	D-only
CIHR Knowledge Translation Model	Smylie et al. (2004)	System, Organisation	3	D>I
ACE Star Model of Knowledge Transformation	Stevens (2013)	System, Organisation	4	D=I
10-Step Model for Inducing Change In Professional Behaviour	Grol & Wensing (2004)	System, Organisation	4	I>D
Quality Implementations Framework	Meyers et al. (2012)	Organisation, System	5	I>D
Knowledge to Action Process	Graham et al. (2006)	System, Organisation	3	D=I

4.3.2.3 The four selection questions applied to Source 3

To firstly ensure an exhaustive list of frameworks, as a starting point, and secondly to ensure no possible appropriate framework is omitted, the list of most popular frameworks used by implementation researchers as compiled by Birken *et al.* (2017) is used as the third and final framework source. Before applying the four selection questions to this list of popular frameworks, any framework that featured in Tabak *et al.* (2012), as can be seen in Table 10, or in Nilsen (2015), as can be seen in Table 11, was excluded from this step, seeing as these frameworks have already been evaluated against the four selection questions' criteria.

Two frameworks that have not been evaluated remained.

After studying the two frameworks, it was clear that they are applicable on a system or organisation level, as per the requirements defined for this category in Figure 26. Table 12 presents the two frameworks' "who" allocations as system and organisation.

The implementation drivers framework does not contain much detail as it merely lists drivers influencing implementation categorised as one of three types of drivers: competency, organisational and leadership drivers (Fixsen *et al.*, 2005). Seeing as interpretation will be necessary to use this framework, a construct flexibility of three was awarded to the framework. However, the drivers focus on influencing the implementation (Fixsen *et al.*, 2005), therefore the criteria of I-only, under the “when” question, was awarded to the framework. The positive behaviour interventions and support framework provides a description of each stage as part of their framework (Kincaid & Horner, 2017), and it was allocated a construct flexibility of four. Since implementation is the focus of this framework, I-only was allocated to this framework under the “when” question.

Table 12: Applying implementation science framework selection method to source 3 (Birken *et al.*, 2017)

Framework name	Source author	Socioecologic framework ("Who" question)	Construct flexibility ("What" question)	Dissemination and/or implementation ("When" question)
Implementation Drivers Framework	Fixsen et al. (2005)	System, Organisation	3	I-only
Positive Behavior Interventions and Support	Kincaid & Horner (2017)	System, Organisation	4	I-only

One framework from Source 3 met the selection question’s criteria. The following section reports on the final evaluation of the list of possible appropriate sources taken from each of the three framework sources.

4.3.2.4 Final evaluation of possible appropriate frameworks

By applying steps one to three, indicated in grey circles in Figure 27, six frameworks were identified to meet the criteria specified under each of the four selection questions.

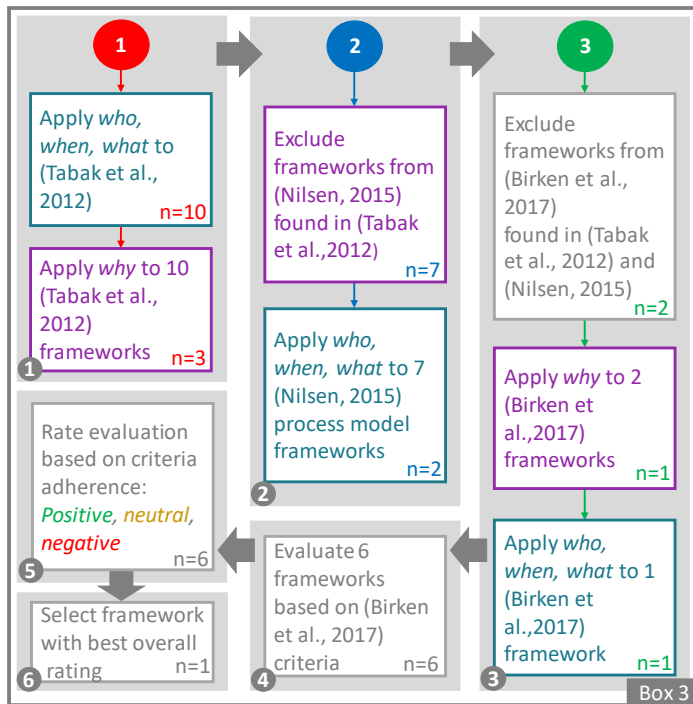


Figure 27: Self-developed implementation science framework selection method steps

As discussed in Section 4.3.1.3 based on the context of this study, seven criteria were selected from the 19 model evaluation criteria specified by Birken *et al.* (2017). The selected criteria can be seen in Table 13. Each of the six frameworks were evaluated against this list of criteria (Step 4 in Figure 27). After this evaluation was done, the results were rated based on their adherence to the criteria (Step 5 in Figure 27). Table 14 presents the six frameworks' evaluation and ratings. The evaluation results were rated positive (green) if they adhered fully to the criteria, neutral (yellow) if they somewhat adhered to the criteria and negative (red), if they did not adhere to the criteria. The rest of the section reports on how the frameworks were evaluated based on the criteria in Table 13 and their respective ratings.

Table 13: Evaluation criteria adapted from Birken *et al.* (2017)

Criterion number	Criteria
1	Application to a specific setting (e.g., hospitals, schools) or population (e.g., cancer) (should not be selected if too specific)
2	Generalisability, i.e., applicability to various disciplines, settings, and populations
3	Inclusion of change strategies/techniques, i.e., provision of specific method(s) for promoting change in implementation-related processes and/or outcomes
4	Inclusion of a diagrammatic representation, i.e., elaboration in a clear and useful figure representing the concepts within and their interrelations
5	Process guidance, i.e., provision of a step-by-step approach for application
6	Disciplinary approval, i.e., frequency of use, popularity, acceptability, and perceptions of influence among a given group of scholars or reviewers, country, funding agencies, etc.; endorsement or recommendation by credible authorities in the field
7	Explanatory power/testability, i.e., ability to provide explanations around variables and effects; generates hypotheses that can be empirically tested

The first criterion evaluated the application area discussed in each of the original sources of the six frameworks. Birken *et al.* (2017) recommend not using frameworks that are developed for a specific environment. Since the application area of this study is hospitals, the frameworks developed for the healthcare system were further evaluated, while the CDC DHAP's research-to-practice framework and the positive behaviour intervention and support frameworks were not evaluated further due to their environment-specific development. To award a level of generalisability, Criterion 2, a 5-point scale was defined and used:

1. Extremely difficult
2. Possible with relative difficulty
3. Possible
4. Possible with relative ease
5. Extremely easy

If 1 was awarded to a framework it was rated "negative" and indicated in red. If 2 or 3 was awarded, it was rated "neutral" and indicated in yellow. If 4 to 5 was awarded to a framework, it was rated "good" and indicated in green. For Criterion 3, specific mention of change, as is required for this criterion according to Birken *et al.* (2017), was identified in frameworks. If there was explicit mention of a change process, it was rated "positive" and indicated in green. If change was not explicitly mentioned, but steps towards change are specified, it was rated "neutral" and indicated in yellow.

In order to evaluate the frameworks based on Criterion 4, the criterion description provided by Birken *et al.* (2017) was used to develop a mini-assessment rubric. Each of the following four questions contributes 25% to the total score awarded to each framework:

- Is a visual diagram present?
- Is the diagram straightforward and useful?
- Does the figure contain the relevant concepts?
- Are the relationships between the various concepts clear?

The two Nilsen (2015) frameworks scored 100% and was rated “positive”. The two remaining Tabak *et al.* (2012) frameworks only lack being straightforward and useful, and therefore scored 75% with a “neutral” rating. If detailed process steps were provided, frameworks scored a 3 and a “positive” rating for Criterion 5. If vague process steps were provided, frameworks scored a 2 and a “neutral” rating. If no process steps were provided, frameworks scored a 1 and a “negative” rating for Criterion 5. The results of this criterion can be seen in Table 14. In order to determine the approval of frameworks within the implementation science discipline, Criterion 6, a ratio of cites per year was determined based on Google Scholar statistics. Since the two Nilsen (2015) frameworks’ annual citations were more than double that of the two Tabak *et al.* (2012) frameworks, they were rated “positive” and the latter two “neutral”. Criterion 7 aims to evaluate whether sufficiently explained process steps are included in the framework (Birken *et al.*, 2017). As is indicated in the last row of Table 14, the intervention mapping framework and replicating effective programme plus framework do elaborate on their steps and were rated “positive”. The 10-step model for inducing change in professional behaviour does not elaborate on its steps and received a rating of “negative”. The QIF provides detailed descriptions of each of its steps and, as is indicated in green, received a rating of “positive”.

Table 14: Final evaluation of frameworks based on criteria specified by Birken *et al.* (2017) (colour view is important)

Criterion number	Tabak et al. (2012) frameworks			Nilsen (2017) frameworks		Birken et al. (2017) framework
	CDC DHAP's Research-to-Practice Framework	Intervention Mapping	Replicating Effective Programs Plus Framework	10-Step Model for Inducing Change In Professional Behaviour	Quality Implementation Framework	Positive Behavior Interventions and Support
1	HIV/Aids prevention	Health education	Non academic health services (community)	General change in practice	General implementation	School system
2	1	2	2	4	5	1
3	-	Yes	Yes (barriers/enablers)	Yes (barriers/enablers)	Yes, steps towards implementation outcomes are defined	-
4	-	75	75	100	100	-
5	-	2	3	3	3	-
6	-	cited by 775 since 1998 (37 cites/year)	cited by 313 since 2007 (26 cites/year)	cited by 1294 since 2004 (86 cites/year)	cited by 521 since 2012 (74 cites/year)	-
7	-	Elaborates on process steps	Elaborates on process steps	Does not elaborate on process steps	Detailed elaboration on process steps	-

From Table 14 the QIF is the most appropriate implementation science framework to use to inform the development of the SLIR. The next section elaborates on this framework and its content.

4.3.3 The content of the quality implementation framework

The QIF lists the steps that are critical to execute during any implementation (Meyers *et al.*, 2012). The QIF was informed by the interactive systems framework (Meyers *et al.*, 2012). The interactive systems framework in turn demonstrates the interaction between three systems that encapsulate the required areas of focus during implementation (Meyers *et al.*, 2012; Wandersman *et al.*, 2008). Wandersman *et al.* (2008) list these three systems as “the prevention synthesis and translation system”, “the prevention support system” and “the prevention delivery system”. The QIF aimed to further the work of Wandersman *et al.* (2008) by listing all the critical aspects that contribute towards a quality implementation where fidelity of the innovation is maintained throughout the implementation process (Meyers *et al.*, 2012). The QIF is therefore a framework that encapsulates critical steps to be executed across three systems.

The QIF consists of 14 steps that are grouped in four phases and are critical to the quality of an implementation (Meyers *et al.*, 2012). The framework further provides questions under each critical step to guide the researcher in using the QIF. Table 14 presents the framework consisting of 14 critical steps grouped in the relevant phases.

Table 15: Quality implementation framework reproduced from Meyers *et al.* (2012)

Phase one (a): Initial considerations regarding the host setting
Assessment strategies
1. Conducting a needs and resources assessment:
Why are we doing this?
What problems or conditions will the innovation address (i.e., the need for the innovation)?
What part(s) of the organization and who in the organization will benefit from improvement efforts?
2. Conducting a fit assessment:
Does the innovation fit the setting?
How well does the innovation match the:
Identified needs of the organization/community?
Organization's mission, priorities, values, and strategy for growth?
Cultural preferences of groups/consumers who participate in activities/services provided by the organization/community?
3. Conducting a capacity/readiness assessment:
Are we ready for this?
To what degree does the organization/community have the will and the means (i.e., adequate resources, skills and motivation) to implement the innovation?
Is the organization/community ready for change?
Decisions about adaptation
4. Possibility for adaptation
Should the planned innovation be modified in any way to fit the host setting and target group?
What feedback can the host staff offer regarding how the proposed innovation needs to be changed to make it successful in a new setting and for its intended audience?
How will changes to the innovation be documented and monitored during implementation?
Phase one (b): Initial considerations regarding the host setting
Capacity Building Strategies (may be optional depending on the results of previous elements)
5. Obtaining explicit buy-in from critical stakeholders and fostering a supportive community/organizational climate:
Do we have genuine and explicit buy-in for this innovation from:
Leadership with decision-making power in the organization/community?
From front-line staff who will deliver the innovation?
The local community (if applicable)?
Have we effectively dealt with important concerns, questions, or resistance to this innovation? What possible barriers to implementation need to be lessened or removed?
Can we identify and recruit an innovation champion(s)?
Are there one or more individuals who can inspire and lead others to implement the innovation and its associated practices?
How can the organization/community assist the champion in the effort to foster and maintain buy-in for change?
Note. Fostering a supportive climate is also important after implementation begins and can be maintained or enhanced through such strategies as organizational policies favoring the innovation and providing incentives for use and disincentives for non-use of the innovation

6. Building general/organizational capacity:
What infrastructure, skills, and motivation of the organization/community need enhancement in order to ensure the innovation will be implemented with quality?
Of note is that this type of capacity does not directly assist with the implementation of the innovation, but instead enables the organization to function better in a number of its activities (e.g., improved communication within the organization and/or with other agencies; enhanced partnerships and linkages with other agencies and/or community stakeholders).
Phase one (c): Initial considerations regarding the host setting
7. Staff recruitment/maintenance:
Who will implement the innovation?
Initially, those recruited do not necessarily need to have knowledge or expertise related to use of the innovation; however, they will ultimately need to build their capacity to use the innovation through training and on-going support
Who will support the practitioners who implement the innovation?
These individuals need expertise related to (a) the innovation, (b) its use, (c) implementation science, and (d) process evaluation so they can support the implementation effort effectively
Might roles of some existing staff need realignment to ensure that adequate person-power is put towards implementation?
8. Effective pre-innovation staff training
Can we provide sufficient training to teach the why, what, when, where, and how regarding the intended innovation?
How can we ensure that the training covers the theory, philosophy, values of the innovation, and the skill-based competencies needed for practitioners to achieve self-efficacy, proficiency, and correct application of the innovation?
Phase two: Creating a structure for implementation
Structural features for implementation
9. Creating implementation teams:
Who will have organizational responsibility for implementation?
Can we develop a support team of qualified staff to work with front-line workers who are delivering the innovation?
Can we specify the roles, processes, and responsibilities of these team members?
10. Developing an implementation plan:
Can we create a clear plan that includes specific tasks and timelines to enhance accountability during implementation?
What challenges to effective implementation can we foresee that we can address proactively?
Phase three: Ongoing structure once implementation begins
Ongoing implementation support strategies
11. Technical assistance/coaching/supervision:
Can we provide the necessary technical assistance to help the organization/community and practitioners deal with the inevitable practical problems that will develop once the innovation begins?
These problems might involve a need for further training and practice in administering more challenging parts of the innovation, resolving administrative or scheduling conflicts that arise, acquiring more support or resources, or making some required changes in the application of the innovation
12. Process evaluation
Do we have a plan to evaluate the relative strengths and limitations in the innovation's implementation as it unfolds over time?
Data are needed on how well different aspects of the innovation are being conducted as well as the performance of different individuals implementing the innovation

13. Supportive feedback mechanism
Is there an effective process through which key findings from process data related to implementation are communicated, discussed, and acted upon?
How will process data on implementation be shared with all those involved in the innovation (e.g., stakeholders, administrators, implementation support staff, and front-line practitioners)?
This feedback should be offered in the spirit of providing opportunities for further personal learning and skill development and organizational growth that leads to quality improvement in implementation
Phase four: Improving future applications
14. Learning from experience
What lessons have been learned about implementing this innovation that we can share with others who have an interest in its use?
Researchers and innovation developers can learn how to improve future implementation efforts if they critically reflect on their experiences and create genuine collaborative relationships with those in the host setting
Collaborative relationships appreciate the perspectives and insights of those in the host setting and create open avenues for constructive feedback from practitioners on such potentially important matters as: (a) the use, modification, or application of the innovation; and (b) factors that may have affected the quality of its implementation

4.4 Design requirements

This section reports on the development of the design requirements used to guide and continuously evaluate the SLIR. In order to ensure that a quality maturity model is developed, it is necessary to define the design requirements to which the model must adhere. Three inputs were used to inform the development of the design requirements:

- The factors influencing successful Lean implementation identified during the SLR
- The QIF identified in the previous section
- Maturity model design requirements as described in the current body of literature

Each of these inputs and the design requirements generated from their input are discussed in the rest of this section.

4.4.1 Input 1: Factors influencing successful Lean implementation

By conducting an SLR, 32 success factors grouped under eight themes were identified. These factors and themes should inform the development of the SLIR. Therefore, the following design requirement was formulated:

- **Design requirement 1:** The model must include all the factors influencing successful Lean implementations as identified during the SLR.

4.4.2 Input 2: Quality implementation framework

By developing and applying a selection method, the QIF was identified as the most appropriate implementation science framework to inform the development of the SLIR. Therefore, the following design requirement was formulated:

- **Design requirement 2:** The model must include each of the 14 critical steps listed in the QIF.

4.4.3 Input 3: Literature on maturity model design requirements

The development and use of maturity models have increased (Becker *et al.*, 2009; De Bruin *et al.*, 2005; Pöppelbuß & Röglinger, 2011), but Pöppelbuß and Röglinger (2011) doubt that there is a correlation between quantity and quality. They further state that although researchers like De Bruin *et al.* (2005) and Becker *et al.* (2009) addressed the development process of quality maturity models, they aimed to further address the development of quality maturity models by developing design principles to which quality maturity models must adhere. The design principles Pöppelbuß and Röglinger (2011) developed that are relevant to this study are listed in Table 16. The SLIR's remaining design requirements were defined based on these listed design principles (DP) and are as follows:

In order to ensure that the model is applicable in the relevant domain (DP1.1a), the following design requirement was formulated:

- **Design requirement 3:** The model must be applicable to any hospital environment with the necessary contextualisation.

In order to ensure that the model adheres to the purpose for which it was developed (DP1.1b), the following design requirement was formulated:

- **Design requirement 4:** The model must facilitate sustainable Lean implementation.

The principles stated in Table 16: DP1.1c and DP1.4 both relate to the target group of the maturity model and they are captured in the following two formulated design requirements:

- **Design requirement 5:** Staff members from all (relevant) levels should be able to interpret and apply the model.

- **Design requirement 6:** Staff members from various (relevant) disciplines should be able to interpret and apply the model.

The principles stated in Table 16: DP1.2a, DP1.2b, DP1.2c and DP1.3 all relate to the various maturity model elements and their contribution to reaching maturity. Similarly, DP1.1d specifies that the maturity model should measure the maturity relevant to the application domain. These DPs are captured in the following two formulated design requirements:

- **Design requirement 7:** Maturity and the steps to achieve maturity in each maturity level must be clearly defined.
- **Design requirement 8:** The maturity levels must form a logical maturation path towards sustainable Lean implementation.

Table 16: Basic maturity model design requirements adapted from Pöppelbuß and Röglinger (2011)

Basic design principles	
1.1	Basic information a) Application domain and prerequisites for applicability b) Purpose of use c) Target group d) Class of entities under investigation e) Differentiation from related maturity models f) Design process and extent of empirical validation
1.2	a) Maturity and dimensions of maturity b) Maturity levels and maturation paths c) Available levels of granularity of maturation d) Underpinning theoretical foundations with respect to evolution and change
1.3	Definition of central constructs related to the application domain
1.4	Target group-oriented documentation

Three of the DPs in Table 16 were not used to formulate design requirements for the SLIR. These DPs are DP1.1e, DP1.1f and DP1.2d. These three DPs relate to the process followed to develop a maturity model rather than being requirements to which the maturity model, as an artefact, must adhere. The three principles and where in the development process they are adhered to are as follows:

- DP1.1e – As per the requirements listed by Becker *et al.* (2009), part of the research methodology is to compare existing maturity models and to ensure that

the SLIR contributes to the body of literature. DP1.1e was addressed during the comparison of existing maturity models in the literature review.

- DP1.1f – Seeing as one of the maturity model development processes (Becker *et al.*, 2009) mentioned by Pöppelbuß and Röglinger (2011) is followed in this study, the “design process” part of this principle is addressed during the completion of this study. Part of the development process according to Becker *et al.* (2009) is the evaluation of the SLIR. This is done by means of a survey sent to respondents with experience in implementing Lean in hospitals. Therefore, the “evaluation” part of this design principle is addressed during the final stage of this study.
- DP1.2d – By using the Lean success factors and the QIF to inform the development of the maturity model, theoretical foundations relating to change are incorporated into the SLIR.

4.4.4 Chapter conclusion

This chapter reported on the three SLIR inputs. 32 factors influencing the success of Lean implementation in a hospital environment were identified by synthesising 19 qualitative studies. By developing and applying a selection method, the QIF consisting of 14 critical steps was identified as the most appropriate implementation science framework to inform the development of the SLIR. Finally, the design requirements to which the SLIR should adhere were developed. The development of the SLIR using these three inputs is discussed in the next chapter.

CHAPTER 5

MODEL DEVELOPMENT

This chapter aims to address the following research questions:

- Research question 4.1 – What approach should be followed during the process of developing an SLIR?
 - Research question 4.2 – How should the various development inputs inform the development of the SLIR?
-

The chapter addresses the following step in the research methodology:

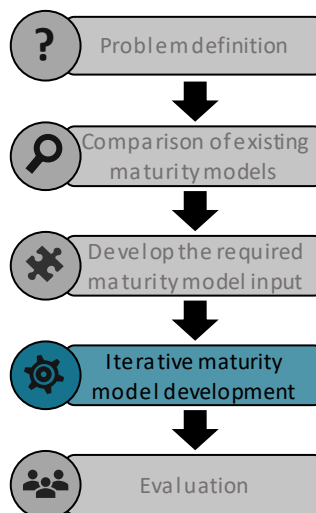


Figure 28: Chapter 5 research methodology step

CHAPTER 5: MODEL DEVELOPMENT

5.1 Chapter introduction

This chapter reports on the development of the SLIR. As discussed in Chapter 1, the aim of the SLIR is to address the problem of Lean implementations not being sustained over a period of time. The aim of the study is to develop a Lean implementation roadmap in the form of a prescriptive maturity model to facilitate sustainable Lean implementations. Prescriptive maturity models act as a guide for an organisation's transformation to the desired state (Poeppelbuss *et al.*, 2011; Van Dyk, 2013). This chapter starts by reporting on the development approach that was followed to develop the SLIR. The chapter further reports on the development of the SLIR in the form of a prescriptive maturity model. Finally, the SLIR is discussed in more detail. The layout of the chapter can be seen in Figure 29.

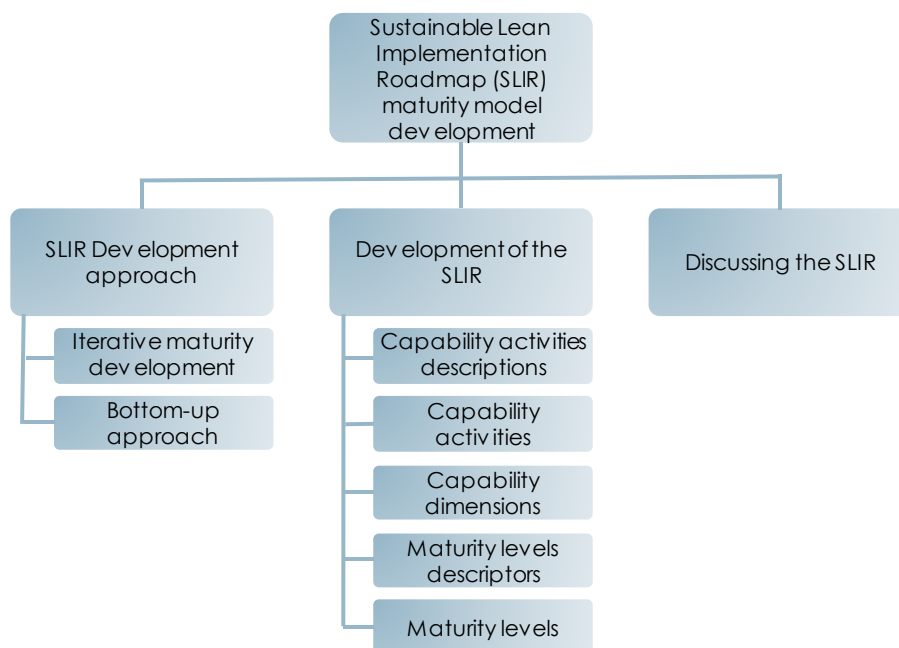


Figure 29: Chapter 5 orientation

5.2 Development approach

This section describes the iterative maturity model development approach followed to develop the SLIR. It also describes why a bottom-up approach instead of a top-down approach is followed. Lastly, the various inputs for the development of the SLIR are explicated.

5.2.1 Iterative maturity model development approach

As discussed in Chapter 3, the research problem identified in this study is approached within the DSR problem-solving paradigm. The research methodology guiding this study is an adapted version of a maturity model development procedure developed by Becker *et al.* (2009). One step in this research methodology is the iterative development of a maturity model (Figure 30). This step was used to guide the development of the SLIR.

The procedure model is also rooted in the DSR problem-solving paradigm. Becker *et al.* (2009) achieved this by developing eight design requirements for their procedure model as shown in Figure 15 based on the seven DSR guidelines. These design requirements, R1 to R8, are denoted on their procedure model (Figure 15). The three design requirements relevant to the iterative maturity model development step in the research methodology can be seen in Figure 30.

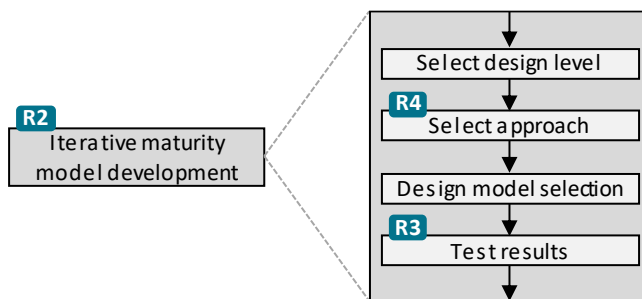


Figure 30: *Iterative maturity model development approach reproduces from Becker et al. (2009)*

The rest of this section briefly elaborates on each step of the iterative maturity model development approach.

Step 1: Select the design level

As discussed in Chapter 2, literature suggests that a maturity model usually comprises of the following components (Henning, 2017; Mettler & Rohner, 2009; Steenbergen, 2011):

1. Maturity levels
2. A short description of each maturity level
3. Characteristics of each maturity level
4. Capability dimensions/capability areas

5. Capability activities within each dimension forming a maturity path
6. Further descriptions of each capability activity

A visual depiction of a general maturity model, consisting of these components, can be seen in Figure 31.

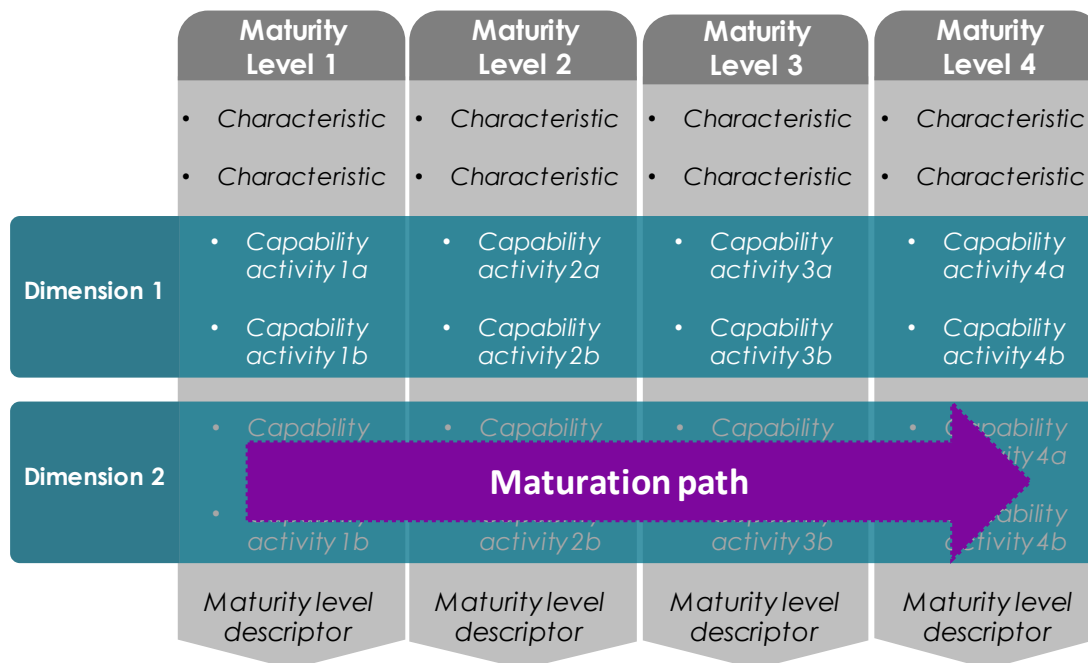


Figure 31: Typical maturity model consisting of six maturity model components

These components were used as the various design levels of each iteration of the development approach. Components 1, 2, 4, 5, and 6 were respectively developed during each iteration. Component 3 is encompassed in Component 2 and was not developed separately.

Step 2: Select approach

In order to develop each design level (maturity model component), a specific approach in this step should be selected (Becker *et al.*, 2009). As part of the procedure model discussion, Becker *et al.* (2009) suggest a few possible approaches that can be considered to design the selected design level. The first suggested approach is a literature analysis. Literature analysis refers to the use of literature, for example “success factors and typical developments” (Becker *et al.*, 2009) to define certain maturity model components (Marshall & Mitchell, 2003). The second suggested approach is creativity

techniques (Becker *et al.*, 2009; Lahrmann *et al.*, 2011). Although this approach, as suggested by the name, leaves room for a certain level of creativity, Becker *et al.* (2009) provide an example of utilising this technique by applying deductive reasoning to consolidate aspects from literature to define certain maturity model components.

A third approach is the application of thematic analysis. It entails approaching qualitative data in an inductive way with the purpose of identifying certain themes. Inductive reasoning refers to reaching general conclusions based on specific instances (Simon, 1996b). Guest *et al.* (2012) and Braun and Clarke (2006) agree that a thematic analysis is a very popular method of analysing qualitative data.

Step 3: Design model selection

In order to design each of the respective design levels (maturity model components), the above-mentioned approaches were applied. The following list indicates which method was used at each of the design levels:

- Maturity levels – applied thematic analysis and literature analysis
- A short description of each maturity level – creativity technique
- Capability dimensions/capability areas – applied thematic analysis
- Capability activities, within each dimension, forming a maturity path – literature analysis and creativity techniques
- Further descriptions of each capability activity – literature analysis

Step 4: Test results

The last step in the iterative maturity model development approach is to test the design level (maturity model component). The SLIR was tested by means of a survey sent to respondents with experience in implementing Lean in healthcare. In order to test each maturity model component, the results were tested for adherence to the specified design requirements.

5.2.2 Bottom-up approach

There are a further two approaches that must be considered in terms of the order in which the respective design levels (maturity components) are developed. These approaches are either a top-down or a bottom-up approach. A top-down approach refers to starting by defining the maturity levels and working down towards the explanations of each within the maturity path (De Bruin *et al.*, 2005; Van Dyk, 2013). A bottom-up

approach refers to starting with detailed explanations of each activity and working upwards towards defining the maturity levels (De Bruin *et al.*, 2005; Van Dyk, 2013).

Maier *et al.* (2012) recommend a top-down approach if the application domain of the maturity model is a new domain with little knowledge as to how maturity should be defined. Referring to the discussion of this study's knowledge contribution in Chapter 3, the maturity of this study's application domain is relatively low as can be seen in Figure 18. Since the detailed activity explanations provided in the QIF can be used to inform the development of the maturity path capability activity explanations (maturity model Component 6) and the relative low maturity of the application domain, a bottom-up approach was followed to develop the SLIR.

5.3 Development of the SLIR

This section reports on the application of the iterative maturity model development approach. The resources used as the input for the development of the SLIR was as follows:

- Factors influencing sustainable Lean implementation in a hospital environment (Chapter 4)
- The QIF (Chapter 4)

The final input to the development of the SLIR was the formulated design requirements. As mentioned above, these requirements were used in the final step of the iterative development approach, namely the step of testing results.

Following the bottom-up approach, the application of the four iterative development approach steps (Figure 30) to each design level (maturity model component) is discussed separately.

5.3.1 Descriptions of the capability activities

Step 1: Select the design level

The descriptions of the activities (maturity model Component 6), that form the maturation path towards maturity, was the first design level that was selected. The QIF's detailed questions listed under each of the 14 critical steps (Table 15) were used to inform the development of this design level.

Step 2: Select approach

The approach selected to develop this design level was a literature analysis. The literature used to inform this development iteration was the QIF developed by Meyers *et al.* (2012). The first design requirement requires that the factors influencing successful Lean implementations in hospital environments must be included in the model. This was ensured by mapping the 32 identified Lean success factors next to the QIF's detailed questions. All 32 factors featured in the QIF. A table indicating this result can be found in Annexure C, Table 44. Since the QIF's detailed questions were listed under each of the 14 critical steps, the SLIR also includes the 32 Lean success factors identified in the SLR.

Step 3: Design model selection

The QIF's detailed questions listed under each of the 14 critical steps were analysed and adapted, where applicable, to better provide explanations regarding Lean implementation in a hospital environment. This was firstly achieved by contextualising the wording of the activities from a general context to a hospital context and secondly by adapting the wording to better portray the 32 Lean success factors. In order to better convey certain explanations, some of the questions listed in the QIF were either consolidated or split into more than one statement. The questions were changed to statements to guide the user of the SLIR to perform the activity that is being explained. The questions were also altered to reduce confusing terminology in the explanations.

The output of this design level is a list of activity explanations that resulted in the following capability explanations:

- Ensure premature use of Lean terminology does not cause a resistance to Lean implementation.
- Determine what process improvements hospital wants to accomplish based on, amongst other, patient engagement.
- Determine whether Lean will address these hospital needs.
- Determine how Lean currently fits within the hospital operating context.
- Align the hospital's mission, priorities and strategy for growth with the Lean implementation strategy.
- Ensure organisational momentum is not hindered due to regular changes in strategy.

- Determine whether Lean implementation aligns with the cultural preferences of the hospital staff.
- Determine hospital staff's readiness to implement Lean in their working environment.
- Ensure the required supporting resources are available for a quality implementation of Lean.
- Determine whether Lean should be adapted to fit hospital operating context.
- Contextualise Lean to fit in hospital operating context.
- Ensure adaptations are documented and monitored during implementation.
- Ensure relevant management is committed and willing to engage during implementation process.
- Engage with all employees, including physicians, during Lean implementation preparation.
- Ensure implementation barriers, such as employee resistance, are addressed.
- Appoint all participants, from the implementation operational area, who will form part of the implementation team.
- Ensure a supportive culture is cultivated among all participants.
- Ensure employees know and feel free to use the managerial support team when necessary.
- Ensure implementation area's culture is transforming to a "Lean thinking" culture.
- Ensure hierarchical staff structure does not hinder the teamwork and communication required for Lean implementation.
- Train staff to implement Lean and identify waste amidst their variable processes.
- Provide additional training required for Lean to become a normal part of everyday routine in area of implementation.
- Ensure Lean becomes normal part of everyday routine in implementation area.
- Create a follow-up plan to evaluate strengths and limitation within the Lean implementation.
- Collect data on how well Lean is being implemented and how well the staff is performing in this regard.
- Ensure all involved staff receive continuous support after implementation.
- Develop feedback system where managers can communicate key findings and progress updates to the necessary participants.
- Ensure all participants receives feedback and implementation progress updates.
- Ensure implementation feedback leads to further training and skill development.

- Ensure a collaborative relationship between the implementation participants from different departments exists.
- Evaluate participants' performance based on their commitment to Lean and the improvement Lean implementation has brought to their working environment.
- Ensure, if necessary, the feedback leads to further training and skill development that leads to quality improvement in the implementation of Lean.
- Ensure the purpose of Lean implementation is carefully communicated to all participants.
- Identify Lean champions based on whether they can lead and inspire.
- Ensure a supportive culture from the managerial team is maintained throughout the implementation process.
- Provide the implementation facilitators with additional training to empower them to lead the implementation process.
- Specify the roles, processes and responsibilities of the Lean implementation managerial support staff.
- Create a plan that includes specific tasks relating to the implementation process linked to an implementation timeline.
- Determine whether there are any implementation challenges that needs to be addressed proactively.
- Research and learn from previous successful/failed Lean implementations from other environments.
- Ensure the implementation process, including lessons learned are properly documented to enable knowledge transfer.
- Determine whether hospital has necessary supporting resources to implement Lean (finance, infrastructure, technology).
- Determine which additional supporting resources must be acquired to ensure a quality implementation of Lean.
- Ensure the necessary expertise is available to support the entire implementation process.
- Ensure the availability of an in-house expert support team, if necessary, they need to be developed through training.
- Ensure the supporting resources does not get outdated.
- Build all the participants' capacity through training on the principles of Lean.
- Provide sufficient training regarding the overall Lean thinking philosophy.
- Determine to what extent the Lean champions have been exposed to Lean.
- Obtain Lean in healthcare experts to provide all participants with Lean training.

Step 4: Test results

The list of capability activity explanations was tested for adherence to the applicable design requirements and yielded the results depicted in Table 17.

Table 17: Test design requirement adherence – capability activities descriptions

	Design requirement	Adherence (Yes/No)
1	The model must include all the factors influencing successful Lean implementations, as identified during the SLR	Yes
2	The model must include each of the 14 critical steps listed in the QIF	Yes
3	The model must be applicable to any hospital environment, with the necessary contextualisation	N/A
4	The model must facilitate sustainable Lean implementation	N/A
5	Staff members from all (relevant) levels should be able to interpret and apply the model	Yes
6	Staff members from various (relevant) disciplines should be able to interpret and apply the model	Yes
7	Maturity and the steps to achieve maturity within each maturity level must be clearly defined	N/A
8	The maturity levels must form a logical maturation path towards sustainable Lean implementation	N/A

Due to the fact that only one component of the SLIR is developed in this iteration, and not the completed SLIR, some of the design requirements cannot be tested for adherence during this design level. These requirements are indicated with a “N/A” on the right-hand side of Table 17. Since the rest of the design requirements are adhered to the next maturity model component, capability activities were developed along the maturation path.

5.3.2 Capability activities

Step 1: Select design level

The capability activities (maturity model component 5) that form the maturation path within each dimension, was the next design level that was selected to be designed. The 32 identified Lean success factors was the primary input for this design level. The descriptions of the capability activities, that was designed in the previous iteration, do not feature in the SLIR but are provided to the SLIR user as additional information to use as part of the SLIR. The development of a summarised version of each capability activity description, resulting in a capability activity, is discussed in this section.

Step 2: Select approach

Since most of the capability activity descriptions listed in the results of the previous iteration links with one of the 32 Lean success factors, literature analysis could be applied by taking the success factors as the summarised version of each description. This process then results in the capability activities.

However, not all the capability activity descriptions linked with a Lean success factor. Therefore, a creativity technique as suggested by Becker *et al.* (2009) and Lahrmann *et al.* (2011) had to be applied to develop a summarised version of these activity descriptions. A creativity technique was further applied by consolidating certain activity descriptions, resulting in a single activity (to feature in the SLIR) with multiple descriptions (to feature in the additional activity descriptions).

Step 3: Design model selection

The allocated summarised capability activities, as they appear in the SLIR, can be seen in Table 18.

Table 18: Capability activity allocation results

Capability activity	Capability activity description
<i>Ensure communication contributes to initial acceptance of lean</i>	Ensure premature use of lean terminology does not cause a resistance to lean implementation. Ensure the purpose of lean implementation is carefully communicated to all participants.
<i>Determine hospital's improvement needs</i>	Determine what process improvements hospital wants to accomplish based on, amongst other, patient engagement. Determine whether lean will address these hospital needs.
<i>Assess operating environment context</i>	Determine how lean currently fits within the hospital operating context.
<i>Define implementation strategy</i>	Align the hospital's mission, priorities and strategy for growth with the lean implementation strategy.
<i>Ensure organisational momentum by maintaining the strategy</i>	Ensure organisational momentum is not hindered due to regular changes in strategy
<i>Assess hospital culture</i>	Determine whether lean implementation aligns with the cultural preferences of the hospital staff.
<i>Assess employee readiness</i>	Determine hospital staff's readiness to implement lean in their working environment.
<i>Put necessary resources in place</i>	Ensure the required supporting resources are available for a quality implementation of lean.
<i>Plan lean adoptions</i>	Determine whether lean should be adapted to fit hospital operating context.
<i>Contextualise lean</i>	Contextualise lean to fit in hospital operating context.
<i>Document and monitor adoptions</i>	Ensure adoptions are documented and monitored during implementation.
<i>Obtain and ensure management commitment</i>	Ensure relevant management is committed and willing to engage during implementation process.
<i>Engage with employees</i>	Engage with all employees, including physicians, during lean implementation preparation.
<i>Manage employee resistance to change</i>	Ensure implementation barriers, such as employee resistance, are addressed.

<i>Appoint implementation team</i>	Appoint all participants, from the implementation operational area, who will form part of the implementation team.
<i>Establish a supportive culture</i>	Ensure a supportive culture is cultivated between all participants.
<i>Provide implementation support</i>	Ensure employees know and feel free to use the managerial support team when necessary.
<i>Assess culture transformation</i>	Ensure implementation area's culture is transforming to a "lean thinking" culture.
<i>Adapt staff structure</i>	Ensure hierarchical staff structure does not hinder the teamwork and communication required for lean implementation.
<i>Empower implementation team and employees for implementation</i>	Provide the implementation facilitators with additional training to empower them to lead the implementation process.
<i>Provide continuous training to implementation team</i>	Train staff to implement lean and identify waste amidst their variable processes.
	Ensure implementation feedback leads to further training and skill development.
	Provide additional training required for lean to become a normal part of everyday routine in area of implementation.
<i>Normalise lean culture in area of implementation</i>	Ensure lean becomes normal part of everyday routine in implementation area.
<i>Follow up on implementation</i>	Create a follow-up plan to evaluate strengths and limitation within the lean implementation.
	Collect data on how well lean is being implemented and how well the staff is performing in this regard.
<i>Normalise supportive culture</i>	Ensure all involved staff receive continuous support after implementation.
<i>Develop organisational feedback system</i>	Develop feedback system where managers can communicate key findings and progress updates to the necessary participants.
<i>Provide implementation feedback throughout implementation area</i>	Ensure all participants receives feedback and implementation progress updates.
<i>Establish interdepartmental cooperation</i>	Ensure a collaborative relationship between the implementation participants from different departments exists.
<i>Performance evaluation of implementation team participants</i>	Evaluate participants' performance based on their commitment to lean and the improvement lean implementation has brought to their working environment.
<i>Ensure feedback system triggers remedial action</i>	Ensure, if necessary, the feedback leads to further training and skill development that leads to quality improvement in the implementation of lean.
<i>Identify lean champions</i>	Identify lean champions based on whether they can lead and inspire.
<i>Support implementation process</i>	Ensure a supportive culture from the managerial team is maintained throughout the implementation process.
<i>Ensure support team availability</i>	Specify the roles, processes and responsibilities of the lean implementation managerial support staff.
<i>Create implementation plan</i>	Create a plan that includes specific tasks relating to the implementation process linked to an implementation timeline.
<i>Research and evaluate past lean implementations</i>	Research and learn from previous successful/failed lean implementations from other environments.
	Determine whether there are any implementation challenges that needs to be addressed proactively.
<i>Document implementation process</i>	Ensure the implementation process, including lessons learned are properly documented to enable knowledge transfer.
<i>Perform resource assessment</i>	Determine whether hospital has necessary supporting resources to implement lean (finance, infrastructure, technology).
<i>Determine resource needs</i>	Determine which additional supporting resources must be acquired to ensure a quality implementation of lean.
<i>Use experts to guide implementation</i>	Ensure the necessary expertise is available to support the entire implementation process.
<i>Ensure in-house experts are developed</i>	Ensure the availability of a in-house expert support team, if necessary, they need to be developed through training.
<i>Stay updated on resource development</i>	Ensure the supporting resources does not get outdated.
<i>Introduce lean principles</i>	Build all the participants' capacity through training on the principles of lean.
<i>Introduce lean philosophy</i>	Provide sufficient training regarding the overall lean thinking philosophy.
<i>Assess current lean footprint</i>	Determine to what extent the lean champions have been exposed to lean.
<i>Use experts to provide employees with training</i>	Obtain lean in healthcare experts to provide all participants with lean training.

Step 4: Test results

The list of capability activities was tested for adherence to the applicable design requirements, yielding the results depicted in Table 19.

Table 19: Test design requirement adherence - capability activities

	Design requirement	Adherence (Yes/No)
1	The model must include all the factors influencing successful Lean implementations, as identified during the SLR	Yes
2	The model must include each of the 14 critical steps listed in the QIF	Yes
3	The model must be applicable to any hospital environment, with the necessary contextualisation	N/A
4	The model must facilitate sustainable Lean implementation	N/A
5	Staff members from all (relevant) levels should be able to interpret and apply the model	Yes
6	Staff members from various (relevant) disciplines should be able to interpret and apply the model	Yes
7	Maturity and the steps to achieve maturity within each maturity level must be clearly defined	N/A
8	The maturity levels must form a logical maturation path towards sustainable Lean implementation	N/A

Similar to the previous component, due to the fact that the completed SLIR had not yet been developed, some of the design requirements could not be tested for adherence during the development of this design level. These requirements are indicated with a “N/A” on the right-hand side of Table 19.

5.3.3 Capability dimensions

Step 1: Select design level

The capability dimensions were developed next. During the SLR, eight themes were identified, and the 32 Lean success factors were grouped under these themes. These eight themes were used to inform the development of this design level. They included planning, engagement, management, environment, training, resources, communication and culture.

Step 2: Select approach

An applied thematic analysis technique was followed to develop this design level. As described in Section 5.2.1, the applied thematic analysis refers to approaching qualitative data in an inductive way with the purpose of identifying certain themes (Coetzee, 2019; Guest *et al.*, 2012). As implied by inductive reasoning, the specific instances analysed to reach a “general conclusion” is the various capability activities. The “general conclusions” relate to which one of the eight SLR themes each capability activity resorts under. Therefore, a thematic analysis was not applied to identify themes, but rather to allocate activities to the eight predetermined SLR themes.

Step 3: Design model selection

After allocating the capability activities to the eight predetermined SLR themes, the results were tested for adherence to the design requirements. However, after studying the maturation path of each dimension, indicated by the various capability activities, it became clear that they do not form a logical maturation path (design requirement 8). To address this issue, three changes were made to initial result:

- The capability activities listed under the theme “engagement” were allocated to other themes, seeing as engagement with different stakeholders was required to perform various other capability activities.
- Similarly, the capability activities listed under the theme “management” were allocated to other themes, since management were the stakeholders that had to perform several of the capability activities.
- The “planning” theme had multiple capability activities listed under it and the theme was split into two dimensions to simplify the maturation path formed within each dimension. These two dimensions were “planning people” and “planning implementation”.

The results of the thematic analysis, including the three changes made to the initial results, can be seen in Table 20.

Table 20: Capability dimensions with allocated capability activities

Planning Implementation
<i>Determine hospital's improvement needs</i>
<i>Define implementation strategy</i>
<i>Ensure organisational momentum by maintaining the strategy</i>
<i>Follow up on implementation</i>
<i>Support implementation process</i>
<i>Create implementation plan</i>
<i>Research and evaluate past lean implementations</i>
<i>Document implementation process</i>
Environment
<i>Assess operating environment context</i>
<i>Plan lean adoptions</i>
<i>Contextualise lean</i>
<i>Document and monitor adoptions</i>

Resources
<i>Put necessary resources in place</i>
<i>Perform resource assessment</i>
<i>Determine resource needs</i>
<i>Use experts to guide implementation</i>
<i>Ensure in-house experts are developed</i>
<i>Stay updated on resource development</i>
<i>Assess current lean footprint</i>
<i>Use experts to provide employees with training</i>
Planning people
<i>Obtain and ensure management commitment</i>
<i>Engage with employees</i>
<i>Appoint implementation team</i>
<i>Adapt staff structure</i>
<i>Establish interdepartmental cooperation</i>
<i>Performance evaluation of implementation team participants</i>
<i>Identify lean champions</i>
<i>Ensure support team availability</i>
Training
<i>Provide continuous training to implementation team</i>
<i>Empower implementation team and employees for implementation</i>
<i>Introduce lean principles</i>
<i>Introduce lean philosophy</i>
Communication
<i>Ensure communication contributes to initial acceptance of lean</i>
<i>Develop organisational feedback system</i>
<i>Provide implementation feedback throughout implementation area</i>
<i>Ensure feedback system triggers remedial action</i>
Culture
<i>Assess hospital culture</i>
<i>Assess employee readiness</i>
<i>Manage employee resistance to change</i>
<i>Establish a supportive culture</i>
<i>Provide implementation support</i>
<i>Assess culture transformation</i>
<i>Normalise lean culture in area of implementation</i>
<i>Normalise supportive culture</i>

Step 4: Test results

Following the adaptations made during the previous step of this design level, the results adhere to the relevant design requirements, including design requirement 8, as shown in Table 21.

Table 21: Test design requirement adherence - capability dimensions

	Design requirement	Adherence (Yes/No)
1	The model must include all the factors influencing successful Lean implementations, as identified during the SLR	Yes
2	The model must include each of the 14 critical steps listed in the QIF	Yes
3	The model must be applicable to any hospital environment, with the necessary contextualisation	Yes
4	The model must facilitate sustainable Lean implementation	N/A
5	Staff members from all (relevant) levels should be able to interpret and apply the model	Yes
6	Staff members from various (relevant) disciplines should be able to interpret and apply the model	Yes
7	Maturity and the steps to achieve maturity within each maturity level must be clearly defined	N/A
8	The maturity levels must form a logical maturation path towards sustainable Lean implementation	N/A

5.3.4 Maturity levels

Step 1: Select design level

Although the next design level, following the bottom-up approach, is the maturity level descriptors, the maturity levels were defined first to ensure that the descriptors align with the maturity levels and help the SLIR user to understand what is expected at each maturity level.

Step 2: Select approach

A maturity model typically has between four and six maturity levels (Henning, 2017; Mettler & Rohner, 2009; Steenbergen, 2011). Aligning with the emphasis this study, which is thoroughly planning the implementation of the Lean initiative with sustainability as the end goal (Van Rossum *et al.*, 2016), the maturity levels of the SLIR had to meet the following two requirements:

- Have sustainability as end goal
- Guide proper planning of implementation of Lean

The QIF is divided into four phases (Meyers *et al.*, 2012):

1. Initial considerations regarding the host setting
2. Creating a structure for implementation
3. Ongoing structure once implementation begins
4. Improving future applications

After adapting these four stages to ensure they meet the requirements specified for the maturity levels, the SLIR's maturity levels were defined as prepare, plan, implement and sustain.

Step 3: Design model selection

After performing a literature analysis to define the SLIR's four maturity levels, an applied thematic analysis was conducted to allocate the capability activities to these four maturity "themes". Each capability dimension, with its relevant capability activities, was analysed. This yielded the following tabulated results (Table 22):

Table 22: Maturity level allocation results

Planning Implementation	
Prepare	Determine hospital's improvement needs
	Research and evaluate past lean implementations
Plan	Define implementation strategy
	Create implementation plan
Implement	Support implementation process
	Follow up on implementation
Sustain	Ensure organisational momentum by maintaining the strategy
	Document implementation process
Environment	
Prepare	Assess operating environment context
Plan	Plan lean adaptations
Implement	Contextualise lean
Sustain	Document and monitor adaptations
Resources	
Prepare	Perform resource assessment
	Assess current lean footprint
Plan	Determine resource needs
	Use experts to provide employees with training
Implement	Put necessary resources in place
	Use experts to guide implementation
Sustain	Stay updated on resource development
	Ensure in-house experts are developed
Planning People	
Prepare	Obtain and ensure management commitment
	Engage with employees
Plan	Identify lean champions
	Adapt staff structure
Implement	Appoint implementation team
	Establish interdepartmental cooperation
Sustain	Ensure support team availability
	Performance evaluation of implementation team participants
Training	
Prepare	Introduce lean philosophy
Plan	Introduce lean principles
Implement	Empower implementation team and employees for implementation
Sustain	Provide continuous training to implementation team

Communication	
Prepare	<i>Ensure communication contributes to initial acceptance of lean</i>
Plan	<i>Develop organisational feedback system</i>
Implement	<i>Provide implementation feedback throughout implementation area</i>
Sustain	<i>Ensure feedback system triggers remedial action</i>
Culture	
Prepare	<i>Assess employee readiness</i>
	<i>Assess hospital culture</i>
Plan	<i>Manage employee resistance to change</i>
	<i>Establish a supportive culture</i>
Implement	<i>Provide implementation support</i>
	<i>Assess culture transformation</i>
Sustain	<i>Normalise supportive culture</i>
	<i>Normalise lean culture in area of implementation</i>

Step 4: Test results

It was difficult to accurately test each result's adherence to design requirement 7 and 8 due to the tabulated way in which the results are presented. In order to address this and ensure adherence to these two design requirements, the content of the results in

Table 22 was presented in a more logical manner. The result is presented in Figure 32.

	Level 1 Prepare	Level 2 Plan	Level 3 Implement	Level 4 Sustain
Planning Implementation	☐ Determine hospital's improvement needs ☐ Research and evaluate past lean implementations	☐ Define implementation strategy ☐ Create implementation plan	☐ Support implementation process ☐ Follow up on implementation	☐ Ensure organisational momentum by maintaining the strategy ☐ Document implementation process
Environment	☐ Assess operating environment context	☐ Plan lean adoptions	☐ Contextualise lean	☐ Document and monitor adoptions
Resources	☐ Perform resource assessment ☐ Assess current lean footprint	☐ Determine resource needs ☐ Use experts to provide employees with training	☐ Put necessary resources in place ☐ Use experts to guide implementation	☐ Stay updated on resource development ☐ Ensure in-house experts are developed
Planning People	☐ Obtain and ensure management commitment ☐ Engage with employees	☐ Identify lean champions ☐ Adapt staff structure	☐ Appoint implementation team ☐ Establish inter-departmental cooperation	☐ Ensure support team availability ☐ Performance evaluation of implementation team participants
Training	☐ Introduce lean philosophy	☐ Introduce lean principles	☐ Empower implementation team and employees for implementation	☐ Provide continuous training to implementation team
Communication	☐ Ensure communication contributes to initial acceptance of lean	☐ Develop organisational feedback system	☐ Provide implementation feedback throughout implementation area	☐ Ensure feedback system triggers remedial action
Culture	☐ Assess employee readiness ☐ Assess hospital culture	☐ Manage employee resistance to change ☐ Establish supportive culture	☐ Provide implementation support ☐ Assess culture transformation	☐ Normalise supportive culture ☐ Normalise lean culture in area of implementation

Figure 32: *Adapted maturity level allocation results*

The adapted maturity level allocation results met design requirement 8. Although maturity had not yet been described, the results also adhered to design requirement 7. The description of maturity is added in the next and final iteration of the iterative maturity model development process.

Table 23: Test design requirement adherence – maturity levels

	Design requirement	Adherence (Yes/No)
1	The model must include all the factors influencing successful Lean implementations, as identified during the SLR	Yes
2	The model must include each of the 14 critical steps listed in the QIF	Yes
3	The model must be applicable to any hospital environment, with the necessary contextualisation	Yes
4	The model must facilitate sustainable Lean implementation	N/A
5	Staff members from all (relevant) levels should be able to interpret and apply the model	Yes
6	Staff members from various (relevant) disciplines should be able to interpret and apply the model	Yes
7	Maturity and the steps to achieve maturity within each maturity level must be clearly defined	Yes
8	The maturity levels must form a logical maturation path towards sustainable Lean implementation	Yes

5.3.5 Maturity level descriptors

Step 1: Select design level

The final maturity model component that had to be designed was the descriptor for each maturity level. This was to ensure that the user of the SLIR understands when maturity is achieved at each level.

Step 2: Select approach

The creativity technique was applied here to capture/consolidate the shared purpose of all the capability activities at each respective maturity level.

Step 3: Design model selection

The descriptor for each maturity level was defined as follows:

- Level 1, Prepare – Obtain the necessary information for planning
- Level 2, Plan – Plan all elements of implementation process
- Level 3, Implement – Execute planned implementation process
- Level 4, Sustain – Continuously improve implementation

These descriptors were added to the results shown in Figure 32. This resulted in the developed SLIR. Therefore, in accordance with the study's aim, the developed Lean implementation roadmap that contributes to sustainable Lean implementation, designed in the form of a prescriptive maturity model, by incorporating Lean success factors and an implementation science framework is presented in Figure 33.

Step 4: Test results

The testing of the developed SLIR is discussed in the next chapter as part of the verification of the SLIR.

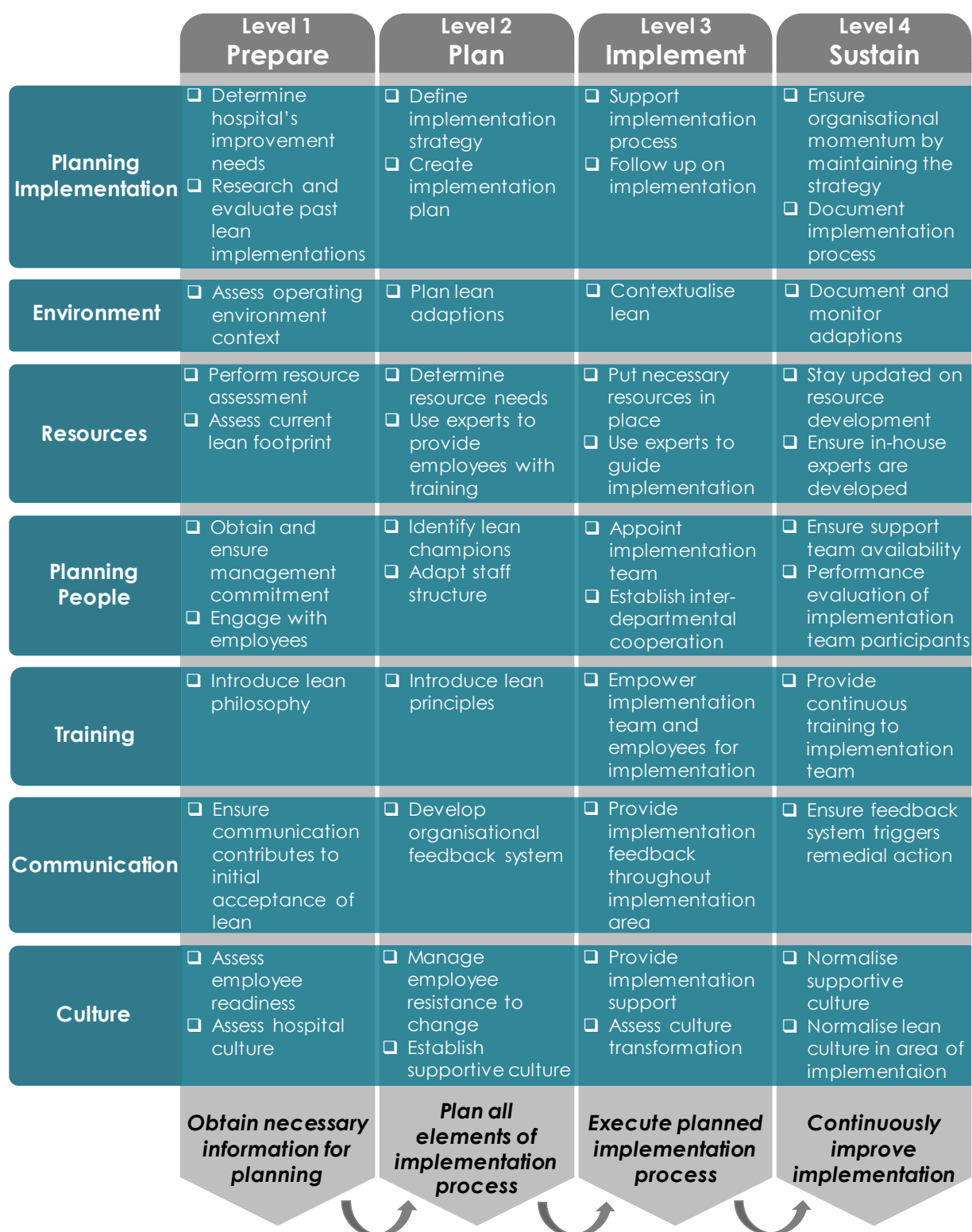


Figure 33: The sustainable Lean implementation roadmap (SLIR)

5.4 Discussing the SLIR

This section discusses the SLIR presented in Figure 33. The SLIR was developed in the form of a prescriptive maturity model. Subsequently, the SLIR's purpose, in accordance with the purpose of any maturity model, is to guide hospitals in their transformation from their initial state to their desired state. In this case, the desired state is a sustained implementation of Lean. Not only a successful initial implementation of Lean, but an implementation that is sustained over period of time. The SLIR therefore aims to ensure the fidelity of Lean is not compromised during its implementation. In Section 2.5.4 fidelity was defined as implementing an effective innovation in an effective manner to ensure that the original innovation (Lean) is not altered due to the implementation process. The SLIR therefore aims to ensure that a true version of the Lean philosophy is sustainably implemented in a hospital environment.

Since thoroughly planning the implementation with sustainability as the end goal (Van Rossum *et al.*, 2016) is vital to a sustainable implementation, a Level 1 maturity is reached if a hospital has successfully executed all the preparation activities and had obtained all the information they require to start the planning process. Although planning is a vital step in reaching a sustainable implementation, it does not serve its purpose if the planning is based on inaccurate information and the necessary people are not committed to the implementation. Therefore, the capability activities listed in the first maturity level should be performed before moving on to planning the implementation, which is the second maturity level. As often stated, planning the implementation is key to a sustainable implementation. Therefore, hospital management must use the capability activities listed within at the second maturity level to ensure that every element of the implementation process is thoroughly planned prior to the implementation process. During the implementation process, it is important to follow the guidelines developed during the planning of the implementation. This should be done to ensure that the hospital is not under a false sense of successful implementation. If all the capability activities within the implement maturity level is not performed, it might result in an implementation of Lean that is not sustained. The final maturity level, sustain, is aligned with the purpose of Lean – which is to continuously improve an environment by eliminating activities that do not add value (Eriksson *et al.*, 2016). The Lean implementation should be continuously assessed and improved.

The seven capability dimensions of the SLIR have been placed in a logical order, moving from planning the implementation to ensuring Lean is part of the hospital's culture. This is indicated by the grey pentagon arrow shape that is used in Figure 33 to depict each

maturity level (top to bottom). However, these dimensions do not have to be conducted from top to bottom for it to be successful. It was designed as such to make the flow of performing the various capability activities within at each maturity level as logical as possible. Even though the capability activities do not have to be performed in any specific order, it is important that the capability activities in a maturity level is performed and maturity within the respective maturity level is reached before performing the subsequent maturity level's capability activities. This is indicated by the dark grey curved arrows at the bottom of the SLIR in Figure 33.

The remainder of the section discusses the maturation paths within each of the seven capability dimensions. Part of these discussions are tables containing the additional descriptions of the relevant capability activities. These descriptions of the capability activities were not included in the SLIR to keep the roadmap from becoming complex and overpopulated. However, the SLIR is complemented by these descriptions and they will help the user understand how to apply the SLIR.

5.4.1 Planning implementation

The planning implementation dimension contains two maturation paths. The first path captures the maturation of the hospital's implementation strategy/vision. The second path captures the maturation of the implementation plan. The detailed descriptions of these paths' capability activities are summarised in Table 24.

It is important to not only clarify the strategic goal of the Lean implementation, but to also align this with the hospital's organisational vision (Grove *et al.*, 2010; Patri & Suresh, 2018). However, before management can define their strategic goal, they must understand what areas they aim to improve with the Lean implementation. Management must engage with patients to ensure these improvement areas are aligned with the patient needs and to them understand which parts of the hospital require improvement (Holden, 2011). This is the preparation required for planning and aligning their implementation strategy with the hospital's strategy (Noori, 2015a). This includes the hospital's strategy for growth/improvement. During the implementation of the strategy, therefore the implementation of Lean as part of the hospital's growth strategy, managers have to ensure that the employees who are actively involved in the implementation process have the necessary support to ensure quality implementation of Lean (Meyers *et al.*, 2012). Finally, by sustaining and continuously improving the implementation strategy (Eriksson *et al.*, 2016), managers contribute towards organisation momentum, as opposed to hindering progress due to often changing the strategy (Aij *et al.*, 2013; De

Souza & Pidd, 2011). It is very important not to dampen employees' buy-in by continuously changing the approach of implementing Lean in the specific hospital setting.

D'Andreamatteo *et al.* (2015) comment that discussions on the topic of Lean in healthcare and its implementation have increased since the early 2000s. Thus, healthcare providers have access to ample literature on implementing Lean in hospitals. They should research past implementations to assist them in developing their implementation plan. This research will also benefit them by preparing for any implementation challenges that might arise during the implementation of Lean. Healthcare providers can develop a detailed implementation plan as part of reaching maturity in the second level based on lessons learned from previous implementations (Holden, 2011) and their understanding of what needs have to be addressed (Meyers *et al.*, 2012). This implementation plan must include specific tasks that should be performed (Meyers *et al.*, 2012), who would be responsible for each task (Grove *et al.*, 2010), as well as a timeline for when the tasks must be complete (Jain & Ajmera, 2019). This implementation plan then acts as a guide to reach maturity at the third maturity level. Part of reaching maturity at this level is to regularly follow up on the implementation. Managers must evaluate and communicate the implementation progress to the implementation team (Sobek, 2011). Part of this progress evaluation can be the evaluation of employees' performance relevant to the Lean implementation. Finally, to enable knowledge transfer and ensure sustainability of this dimension, healthcare providers must document their implementation process together with the do's and don'ts learned after the implementation.

Table 24: Planning implementation dimension – capability activities descriptions

Planning Implementation		
Prepare	Determine hospital's improvement needs	Determine what process improvements hospital wants to accomplish based on, amongst other, patient engagement. Determine whether lean will address these hospital needs.
	Research and evaluate past lean implementations	Research and learn from previous successful/failed lean implementations from other environments. Determine whether there are any implementation challenges that needs to be addressed proactively.
Plan	Define implementation strategy	Align the hospital's mission, priorities and strategy for growth with the lean implementation strategy.
	Create implementation plan	Create a plan that includes specific tasks relating to the implementation process linked to an implementation timeline.
Implement	Support implementation process	Ensure a supportive culture from the managerial team is maintained throughout the implementation process.
	Follow up on implementation	Create a follow-up plan to evaluate strengths and limitation within the lean implementation. Collect data on how well lean is being implemented and how well the staff is performing in this regard.
Sustain	Ensure organisational momentum by maintaining the strategy	Ensure organisational momentum is not hindered due to regular changes in strategy
	Document implementation process	Ensure the implementation process, including lessons learned are properly documented to enable knowledge transfer.

5.4.2 Environment

Although Lean has the potential to increase a hospital's performance and patient satisfaction, it is important to understand that every implementation environment has its own context (Van Rossum *et al.*, 2016). Meyers *et al.* (2012) dedicate eight of their 14 critical QIF steps to “considerations regarding the host setting”.

Seeing as the QIF informed the development of the SLIR, it also contains capability activities relevant to the “host setting”. Therefore, the preparation required in this maturation path is to assess the context of the operating environment in which Lean would be implemented. Whether it is assessing an entire hospital or only a relevant department, healthcare providers must determine how Lean fits in with the current state of the operating context (Meyers *et al.*, 2012). Meyers *et al.* (2012) further state that this assessment must be followed by planning the necessary adaptations that must be made to the generic Lean methodology. Maturity of the implementation level is achieved when these adaptations are put into place and the Lean initiative is contextualised for implementation in the planned implementation area. Finally, to enable knowledge transfer and ensure sustainability, the adaptations must be documented and monitored. The detailed descriptions of the capability activities forming this maturation path is summarised in Table 25.

Table 25: Environment dimension - capability activities descriptions

Environment		
Prepare	Assess operating environment context	Determine how lean currently fits within the hospital operating context.
Plan	Plan lean adaptations	Determine whether lean should be adapted to fit hospital operating context.
Implement	Contextualise lean	Contextualise lean to fit in hospital operating context.
Sustain	Document and monitor adaptations	Ensure adaptations are documented and monitored during implementation.

5.4.3 Resources

“Without the material and nonmaterial resources needed to do a thorough job, Lean will not succeed.” (Holden, 2011). The resources dimension contains two maturation paths. The first path involves the maturation of the hospital’s material resources, while the second path involves the maturation of nonmaterial resources. The detailed descriptions of the capability activities within these two paths are summarised in Table 26.

The first maturation path of this dimension starts by performing a resources assessment (Meyers *et al.*, 2012). These material resources include financial-, technology- and infrastructure-related resources. Without these supportive resources “...lean will not succeed.” (Holden, 2011). Healthcare providers can research past Lean implementations to help them determine which resources they lack. Therefore, during the second maturity level, the healthcare providers must plan the procurement of the resources that were identified as lacking during the resource assessment. Healthcare providers further have to ensure all the resources are in place prior to the implementation of Lean to ensure these resources support the implementation process (Aij *et al.*, 2013; Harrison *et al.*, 2016). Lastly, as part of sustaining these resources, the healthcare providers have the responsibility of staying updated on possible advancements in the material resources the hospital has in place.

The second maturation path’s nonmaterial resources refer to expertise to assist with the implementation of Lean. The purpose of this maturation path is to move from using external consultants’ expertise to the development of in-house expertise (Holden, 2011). These experts can also assist the healthcare providers to determine which resources are required to support a successful Lean implementation. The first capability activity that must be performed is to determine to what extent the implementation team has been exposed to Lean. The next activity is then to use external expertise to provide the implementation team with the necessary Lean training (Harrison *et al.*, 2016). The external expertise is then further used at the third maturity level when they support and guide the implementation process. However, the implementation cannot be sustained if

it is dependent on external expertise. The maturation path is therefore completed when in-house expertise has been developed through training and experience (Harrison *et al.*, 2016).

Table 26: Resource dimension – capability activity descriptions

Resources		
Prepare	<i>Perform resource assessment</i>	Determine whether hospital has necessary supporting resources to implement lean (finance, infrastructure, technology).
	<i>Assess current lean footprint</i>	Determine to what extent the lean champions have been exposed to lean.
Plan	<i>Determine resource needs</i>	Determine which additional supporting resources must be acquired to ensure a quality implementation of lean.
	<i>Use experts to provide employees with training</i>	Obtain lean in healthcare experts to provide all participants with lean training.
Implement	<i>Put necessary resources in place</i>	Ensure the required supporting resources are available for a quality implementation of lean.
	<i>Use experts to guide implementation</i>	Ensure the necessary expertise is available to support the entire implementation process.
Sustain	<i>Stay updated on resource development</i>	Ensure the supporting resources does not get outdated.
	<i>Ensure in-house experts are developed</i>	Ensure the availability of a in-house expert support team, if necessary, they need to be developed through training.

5.4.4 Planning people

The planning people dimension firstly contains a maturation path for management and secondly for employees. The activities along these two paths are summarised in Table 27.

Ample literature sources indicate the importance of obtaining management commitment and ensuring they are committed during the entire implementation process (Grove *et al.*, 2010; Jain & Ajmera, 2019; Mazur *et al.*, 2011; Patri & Suresh, 2018). This important capability activity should be conducted as part of the preparation maturity level. Management must then plan who to first involve in the Lean implementation. These “first” involved employees are referred to as Lean champions and must be selected based on whether they can lead and inspire (Meyers *et al.*, 2012). “Implementation maturity” is reached during the subsequent capability activity, which requires the identification and appointment of the implementation team who will be involved in implementing Lean in the selected operational environment (Holden, 2011; Mazur *et al.*, 2011; Régis *et al.*, 2018). Finally, aligning with the “resource” dimension discussed above, management must ensure the availability of some form of support team to assist the implementation team (Meyers *et al.*, 2012).

Seeing as employees form the majority of the implementation team, it is important to properly plan their role in the implementation process. Literature strongly suggests

engaging with them during the early stages of implementing Lean. They have to be involved (engaged) during all of the capability activities listed within the prepare maturity level. This includes engaging them in the decision making that occurs at the first maturity level (Jain & Ajmera, 2019). Seeing as physicians might be affected by the implemented changes, it is also important to engage with them during the early stages (Holden, 2011; Sobek, 2011; Ulhassan *et al.*, 2013). The healthcare environment is a unique and complex environment (D'Andreamatteo *et al.*, 2015). Part of this environment's complexity is the hierarchical structure of employees (Ulhassan *et al.*, 2013). Meyers *et al.* (2012) suggest that the staff structure of the intended implementation area be adapted should the current structure hinder teamwork. Not only must teamwork be made possible by the structure of a department, there should also be interdepartmental cooperation. Such collaboration forms part of the third maturity level. Finally, employee engagement and commitment must be sustained by continuously following up on employee progress. D'Andreamatteo *et al.* (2015) suggest that managers consider incentives to reward employees who perform well with regard to Lean.

Table 27: Planning people dimension - capability activities descriptions

Planning People		
Prepare	Obtain and ensure management commitment	Ensure relevant management is committed and willing to engage during implementation process.
	Engage with employees	Engage with all employees, including physicians, during lean implementation preparation.
Plan	Identify lean champions	Identify lean champions based on whether they can lead and inspire.
	Adapt staff structure	Ensure hierarchical staff structure does not hinder the teamwork and communication required for lean implementation.
Implement	Appoint implementation team	Appoint all participants, from the implementation operational area, who will form part of the implementation team.
	Establish interdepartmental cooperation	Ensure a collaborative relationship between the implementation participants from different departments exists.
Sustain	Ensure support team availability	Specify the roles, processes and responsibilities of the lean implementation managerial support staff.
	Performance evaluation of implementation team participants	Evaluate participants' performance based on their commitment to lean and the improvement lean implementation has brought to their working environment.

5.4.5 Training

The current body of Lean in healthcare literature strongly advises that training influences the success of Lean implementations (D'Andreamatteo *et al.*, 2015; Grove *et al.*, 2010). Literature often refers to Lean as "Lean thinking" as it is more than just a set of tools to use in an environment. It is a way of thinking about the management of an environment (Kim *et al.*, 2009). Ensuring all participants understand this way of thinking, the Lean philosophy (Jain & Ajmera, 2019) is the first step in the training maturation path. The

second step, in the second maturity level is to further employees' understanding of Lean thinking by introducing them to the five principles of Lean (Noori, 2015b).

The third step is to empower the involved employees to apply Lean in their environment. Firstly, the employees have to be equipped to apply Lean and thus identify waste amidst the variable processes that are typical in a healthcare environment (D'Andreamatteo *et al.*, 2015; Grove *et al.*, 2010). Secondly, the Lean champions and the support team should receive additional training to empower them to lead the implementation process (Holden, 2011). The final step in the maturity path is to sustain the training by firstly regularly providing training to address any identified gaps during implementation (Meyers *et al.*, 2012) and secondly using training as a tool to ensure that Lean becomes a normal part of the employees' everyday routine (Ul Hassan *et al.*, 2013).

The descriptions of the capability activities forming this maturation path is captured in Table 28.

Table 28: Training dimension - capability activities descriptions

Training		
Prepare	Introduce lean philosophy	Provide sufficient training regarding the overall lean thinking philosophy.
Plan	Introduce lean principles	Build all the participants' capacity through training on the principles of lean.
Implement	Empower implementation team and employees for implementation	Provide the implementation facilitators with additional training to empower them to lead the implementation process.
		Train staff to implement lean and identify waste amidst their variable processes.
Sustain	Provide continuous training to implementation team	Ensure implementation feedback leads to further training and skill development.
		Provide additional training required for lean to become a normal part of everyday routine in area of implementation.

5.4.6 Communication

Table 29 summarises the communication dimension's maturation path. Healthcare staff often display resistance towards Lean due to misconceptions about what it entails (Patri & Suresh, 2018). Therefore, the initial Lean communication must be well thought out. It must not contain too much Lean terminology, resulting in resistance from the employees (De Souza & Pidd, 2011). They must furthermore avoid their communication resulting in resistance from the employees by clearly explain Lean and the purpose of the planned implementation. A feedback system enabling managers to communicate key findings and progress updates to all relevant participants can be helpful as part of the plan maturity level. This aligns with the "follow-up on the implementation" capability statement within the planning implementation dimension. Using this feedback system is the third step in this maturation path. It is therefore the "implementation" of the feedback system.

Finally, in order to reach full maturity within this dimension, managers must ensure that the feedback they receive and provide is acted upon (Meyers *et al.*, 2012). For instance, the feedback can lead to further training and skills development. This in turn will result in the quality implementation of Lean.

Table 29: Communication dimension - capability activities descriptions

Communication		
Prepare	<i>Ensure communication contributes to initial acceptance of lean</i>	Ensure premature use of lean terminology does not cause a resistance to lean implementation. Ensure the purpose of lean implementation is carefully communicated to all participants.
Plan	<i>Develop organisational feedback system</i>	Develop feedback system where managers can communicate key findings and progress updates to the necessary participants.
Implement	<i>Provide implementation feedback throughout implementation area</i>	Ensure all participants receives feedback and implementation progress updates.
Sustain	<i>Ensure feedback system triggers remedial action</i>	Ensure, if necessary, the feedback leads to further training and skill development that leads to quality improvement in the implementation of lean.

5.4.7 Culture

The culture capability dimension consists of two maturation paths. The first path is aimed at reaching maturation in terms of the culture among the employees. The second path is aimed at reaching maturation in terms of the general culture within the hospital setting. Both these paths and their subsequent capability activity descriptions are presented in Table 30.

The first path starts with assessing the employees' readiness to implement Lean in their operating environment (Jain & Ajmera, 2019). This relates to determining what exposure they have had to Lean. This in turn leads to the next step, which is managing implementation barriers relevant to the employee culture, such as resistance to change. Employees' previous exposure to Lean might have resulted in misconceptions regarding the philosophy (Patri & Suresh, 2018). This should be addressed prior to implementing Lean in the selected implementation area. The third step is to ensure that reaching out for support from the support team is part of the employees' culture. As a final step, this supportive culture should be sustained and continuously available to the employees after initial implementation.

The second path starts with assessing the current hospital culture and determining whether the Lean implementation aligns with the cultural preferences of the staff (Meyers *et al.*, 2012). After this preparation has been done, a supportive culture among employees must be established by performing the various capability activities that have been discussed up until now. Nearing the end of the maturation path, and seeing as

various capability activities have been performed, management must assess the hospital's cultural transformation to determine whether it is transforming into a "Lean thinking" culture. Finally, in order to sustain this culture, management must ensure and evaluate that the Lean culture becomes part of the normal everyday routine (Poksinska, 2010), in other words that the implementation is the "normal" way of doing things (May & Finch, 2009).

Table 30: Culture dimension - capability activities descriptions

Culture		
Prepare	<i>Assess employee readiness</i>	Determine hospital staff's readiness to implement lean in their working environment.
	<i>Assess hospital culture</i>	Determine whether lean implementation aligns with the cultural preferences of the hospital staff.
Plan	<i>Manage employee resistance to change</i>	Ensure implementation barriers, such as employee resistance, are addressed.
	<i>Establish a supportive culture</i>	Ensure a supportive culture is cultivated between all participants.
Implement	<i>Provide implementation support</i>	Ensure employees know and feel free to use the managerial support team when necessary.
	<i>Assess culture transformation</i>	Ensure implementation area's culture is transforming to a "lean thinking" culture.
Sustain	<i>Normalise supportive culture</i>	Ensure all involved staff receive continuous support after implementation.
	<i>Normalise lean culture in area of implementation</i>	Ensure lean becomes normal part of everyday routine in implementation area.

5.5 Chapter conclusion

This chapter discussed the development of the SLIR by using the three model inputs discussed in Chapter 4 and applying the iterative maturity model development approach with a bottom-up design approach. The SLIR can be seen in Figure 33. A summarised presentation of which input informed which part of the developed SLIR can be found in Annexure F, Figure 39.

Although the various capability activities descriptions are not included in the SLIR, a consolidated version of Table 24 to Table 30 is provided, together with the SLIR, to contribute towards the sustainable implementation of Lean within a hospital setting.

CHAPTER 6

MODEL EVALUATION

This chapter aims to address the following research questions:

- Research question 5.1 – Does the model adhere to each of the specified design requirements?
 - Research question 6.1 – Was a valid research problem addressed in this study?
 - Research question 6.1 – Was a valid research design followed to address the research problem?
 - Research question 6.1 - Does the SLIR address the research problem that was identified in this study?
-

The chapter addresses the following step of the research methodology:

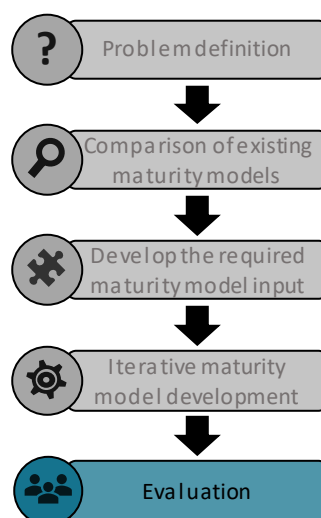


Figure 34: Chapter 6 research methodology step

CHAPTER 6: MODEL EVALUATION

6.1 Chapter introduction

The previous chapter reported on the development of the SLIR. This chapter reports on the evaluation of the SLIR. The SLIR was primarily evaluated by means of a survey. The first section of this chapter discusses the survey and the respondents to whom this survey was sent. The remainder of the chapter discusses the verification and validation of the study. The orientation of this chapter can be seen in Figure 35.

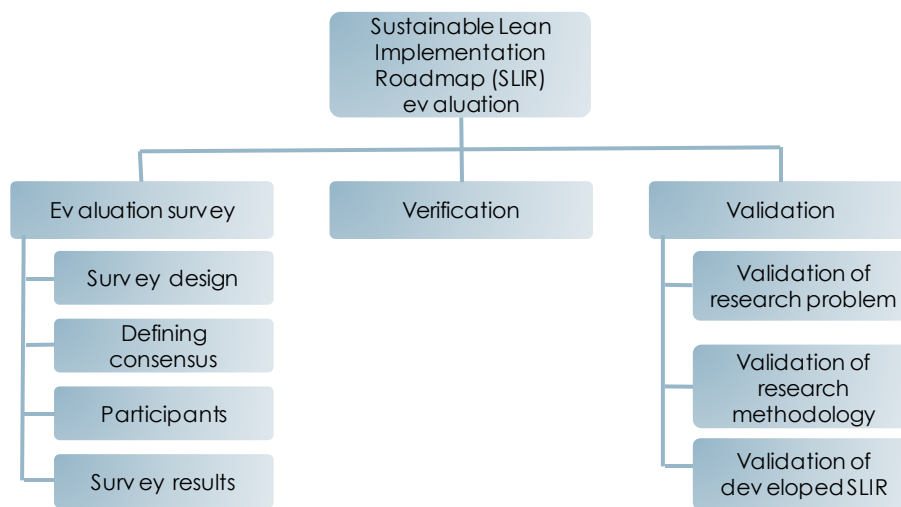


Figure 35: Chapter 6 orientation

6.2 Evaluation survey

This section reports on the survey that was administered to evaluate the SLIR. The various survey aspects that are discussed throughout the rest of the section can be seen in Figure 35. The main purpose of the evaluation is to ensure there is consensus (Hsu *et al.*, 2007) among respondents with experience in implementing Lean in hospital environments on the validity of the SLIR. The goal was therefore to determine whether they agree (validate) that the SLIR contributes towards solving the problem of sustainable Lean implementations in hospital environments. Another purpose is to verify that the SLIR adheres to the design requirements formulated in Chapter 4.

6.2.1 Survey design

The survey was developed in Google Forms and consisted of three sections. The survey had two aims in terms of evaluating the SLIR. The first aim was verification and the

second validation. The first two sections of the survey were devoted to validation and the remaining section to verification. Each section consisted of multiple statements. Respondents had to indicate their agreement with these statements based on a Likert scale (Likert, 1932). However, instead of using the traditional 7-point Likert scale, a simplified 5-point Likert scale was used (Babakus & Mangold, 1992). The 5-points from which the respondents could select were as follows (Bryman & Bell, 2014):

1. Strongly disagree
2. Disagree
3. Undecided
4. Agree
5. Strongly agree

The complete survey can be seen in Annexure D.

6.2.1.1 Verification section

According to Coetzee (2019), verification is the process of determining whether a designed artefact adheres to its specified design requirements. Six of the eight design requirements were evaluated by means of the survey. The remaining two design requirements (1 and 2) required a simple “yes or no” answer and were rather verified by means of a retrospective view than being included in the survey. The six included design requirements were adapted to be appropriate survey statements. The six design requirements (DR) statements included in the survey’s verification section were as follows:

- DR3: The model is applicable to any hospital environment with the necessary contextualisation
- DR4: The model facilitates sustainable Lean implementation
- DR5: Staff members from all (relevant) levels will be able to interpret and apply the model
- DR6: Staff members from various (relevant) disciplines will be able to interpret and apply the model
- DR7: Maturity and the steps to achieve maturity within maturity levels are clearly defined
- DR8: Maturity levels form a logical maturation path towards sustainable Lean implementation

6.2.1.2 Validation sections

According to Nordin *et al.* (2012), validation is the process of determining whether a designed artefact is fit for its purpose. The purpose for which the SLIR was designed was to address the research problem identified in this study. The first validation section was devoted to validating the identified research question. The second validation section aimed to validate whether the SLIR addressed this identified research problem.

Three statements derived from Chapter 1 were used to validate the research problem. These three statements appeared in the first validation section of the survey as follows:

- Lean implementation in healthcare environments has increased over the past two decades
- Lean has the capability to increase a hospital's quality of service and performance
- Although initial Lean implementations might be successful, it is not sustained in the long run

The two statements used to evaluate the validity of the SLIR appeared in the second validation section as follows:

- The SLIR contributes towards the sustainability of Lean implementations in a hospital environment
- The seven dimensions of the SLIR represents critical areas where maturity should be achieved for Lean implementations to be sustained

6.2.2 Defining consensus

Similar to a Delphi process being used to reach consensus on certain statements (Hsu *et al.*, 2007), the aim of this survey was also to reach consensus on the 11 statements included in the survey. In agreement with various previous studies (Coetzee, 2019; Nordin *et al.*, 2012), consensus is defined as 75%. Therefore, consensus was achieved if an average rating of 3.75 or above was achieved for each statement.

6.2.3 Respondents

Respondents were selected to complete the survey based on their experience in implementing Lean in hospital environments. Skulmoski *et al.* (2007) recommend, based on a book written on the Delphi techniques (Adler & Ziglio, 1996), that the inclusion criteria should not only include knowledge and experience, but also the following:

- Being willing to be a respondent
- Having time available to complete the survey
- Having the necessary communication skills

These three criteria, together with experience in implementing Lean in healthcare, were defined as the inclusion criteria for the respondents.

Following the inclusion criteria, respondents were not identified with the goal of forming a sample group that is statistically representative (Coetzee, 2019; Skulmoski *et al.*, 2007), but rather based on whether they adhere to these criteria. This was achieved by means of purposive expert sampling (Trochim & Donnelly, 2008). This sampling technique was complemented by using snowball sampling (Trochim & Donnelly, 2008), which entailed that the respondents to the survey were requested to forward the survey to other potential respondents that adhere to the inclusion criteria. Apart from the inclusion criteria, respondents were identified with the purpose of forming a heterogeneous group in terms of their application domains. Hence, respondents with experience in academia, public healthcare and private healthcare were identified.

6.2.4 Survey results

An email providing the necessary background and ethical information was sent to the identified respondents. The respondents were requested to watch a 5-minute introductory video that provided the study background and explained how the SLIR had been developed. The email contained the following:

- The SLIR
- The capability activity descriptions (Table 24 – Table 30)
- A link to the survey
- A link to the 5-minute introductory video

The email was initially sent to 14 possible respondents. One of these respondents felt that he/she did not have enough experience in the field to answer the survey (this respondent was excluded from the response rate calculation). Due to snowball sampling, a further 14 respondents received the initial email. After seven working days, a reminder email was sent to the respondents. Fourteen respondents completed the survey, yielding a 52% response rate. One of the few limitations of a survey is a lower response rate (Bryman & Bell, 2014). The average accepted response rate for a survey is between 60% (Sinkowitz-Cochran, 2013) and 65% (Kelley *et al.*, 2003). However, although a relatively low response rate was obtained, the responses are still assumed to be

representative (Bryman & Bell, 2014) due to the respondents' equal distribution over the three application domains and the majority of respondents having more than five years' experience.

The distribution of the respondents' experience (in years) is provided in Table 31. More than 70% of the respondents had more than five years' experience, with 43% falling in the more than 10 years' experience category. The number of respondents who indicated they have experience in the respective application domains is provided in Table 32. Each application domain is sufficiently represented by the 14 respondents as illustrated in Table 32.

Table 31: Respondents' experience (years) distribution

Experience (years)	Frequency	%
0-2	2	14.3
2-5	2	14.3
5-10	4	28.6
10+	6	42.9

Table 32: Respondents' experience in various application domains

Application domain	Number of respondents
Academics	7
Public healthcare	10
Private healthcare	9

The respondents' ratings of the different statements are discussed in the remaining two sections.

6.3 Verification

This section reports on the verification of the SLIR. Eight DRs were specified earlier in the study. The SLIR should adhere to these DRs for it to be verified. This adherence was evaluated by means of a retrospective view and the evaluation survey.

The SLIR's adherence to the first two DRs were verified by means of a retrospective view. Table 33 presents the retrospective confirmation of each DR, together with the corresponding SLIR component(s).

Table 33: Design requirements 1 and 2 retrospective view verification

Design requirement		Confirmation	Corresponding SLIR component(s)
1	The model must include all the factors influencing successful Lean implementations, as identified during the SLR	Annexure C, Table 44, indicates how each Lean success factor is represented in the QIF. The QIF informed the development of the SLIR's capability activities and therefore the Lean success factors are included in the SLIR.	·Capability activities descriptions ·Capability activities
		Additionally, the eight themes identified during the SLR was used to inform the development of the SLIR's capability dimensions.	·Capability dimensions
2	The model must include each of the 14 critical steps listed in the QIF	The detailed questions listed under each of the 14 QIF critical steps were used to inform the capability activities and their descriptions. Therefore, each of the 14 critical steps are included in the SLIR.	·Capability activities descriptions ·Capability activities

The remaining six DRs were tested for adherence by means of the evaluation survey. The results for DRs 3 to 8 are presented in Table 34. As seen in Table 34, DRs 3, 4, 7 and 8 received an average rating above 3.75 and is therefore verified. However, DRs 5 and 6 did not receive an average rating above 3.75. Their respective average ratings were 3.07 (61%) and 3.21 (64%). Although these ratings are not far below 3.75, they are still not verified according to the defined consensus.

Table 34: Design requirement 3 to 8 verification – survey results

Respondents	Design requirements (DR) with their received survey rating					
	The model is applicable to any hospital environment with the necessary contextualisation (DR3)	The model facilitates sustainable lean implementation (DR4)	Staff members from all (relevant) levels will be able to interpret and apply the model (DR5)	Staff members from various (relevant) disciplines will be able to interpret and apply the model (DR6)	Maturity and the steps to achieve maturity within maturity levels is clearly defined (DR7)	Maturity levels form a logical maturation path towards sustainable lean implementation (DR8)
R1	4	4	2	4	4	2
R2	4	4	4	4	4	4
R3	4	4	2	2	2	4
R4	4	4	4	4	3	4
R5	5	4	4	3	4	4
R6	4	4	2	2	3	4
R7	3	3	4	3	4	3
R8	4	4	4	4	4	4
R9	5	5	5	5	5	5
R10	4	2	2	2	4	3
R11	5	4	3	4	4	4
R12	3	4	3	3	4	4
R13	4	4	2	3	4	4
R14	4	3	2	2	4	4
Average score	4.07	3.79	3.07	3.21	3.79	3.79

Based on the respondents' ratings and additional feedback (comments), DRs 5 and 6 were not verified for two possible reasons. The first reason is the wording of the two statements and the second reason is the requirements being unrealistic.

The wording of the two statements were too ambiguous. This is confirmed by respondent 10's comment regarding his/her ratings for these two requirements: "...you will see that my assessment of the model as an artefact (Q3) is relatively weak – I believe that is perhaps more an indictment of the questioning than the artefact itself. So, the generalisability of the maturity model greatly depends on context. Doesn't make the artefact unverified or unverifiable. Similarly, the ability of people to understand it, doesn't verify it either. Nor does it invalidate it." This respondent attributed his/her low rating to the wording of the statements rather than the artefact's design. The ambiguity of these two statements resulted in too much room for interpretation from the respondents' side, resulting in the high variation of ratings for the statements. This further resulted in consensus not being reached on the verification of these two DRs. The wording might have also created unrealistic expectations regarding the SLIR.

However, the unrealistic expectations do not only lie in the wording, but also in the DRs themselves. Upon reflecting on these two DRs, analysing the respondents' feedback and reviewing Hoshin Kanri, it emerged that these DRs contradict the Lean deployment process as suggested by the Hoshin Kanri strategy deployment process (Liker, 2004). This process is visually presented in Figure 36. This deployment process is concerned with translating the top level strategy into level-specific objectives (Liker, 2004). The staff at different levels have their own measurable goals, aligned with management's strategy (Bicheno & Holweg, 2016). This way, each level contributes towards the main goal.

Therefore, instead of designing the SLIR to be used by all the relevant levels and all relevant disciplines, the "target group" design principles of Pöppelbuß and Röglinger (2011) should have informed the differentiation between various target groups and how the SLIR relates to these target groups. Since the rest of the DRs, apart from DRs 5 and 6, are verified indicates, the SLIR is still deemed verified. The fault lies not in the design of the SLIR, but rather the formulation of these two DRs. The way forward to address this issue and incorporate Hoshin Kanri's deployment process into future design is further discussed in the study's conclusions and recommendations.

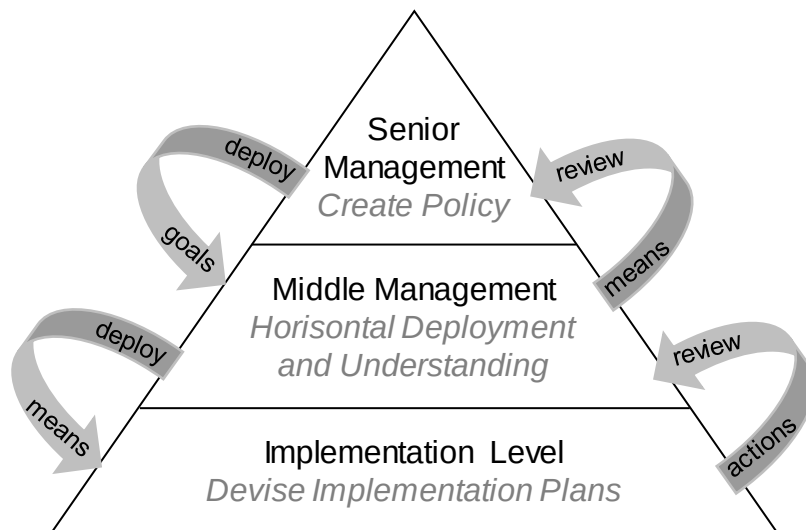


Figure 36: *Hoshin Kanri strategy for deployment reproduced from (Bicheno & Holweg, 2016)*

6.4 Validation

This section reports on the validation of this study. Firstly, the research problem addressed in this study is validated. Secondly, the research method followed in the course of this study is validated. Finally, the SLIR developed to address the identified research problem is validated. These three validation processes constitute the subsections in rest of this section.

6.4.1 Validation of research problem

The research problem of this study was defined as follows:

The problem is that Lean implementations in hospital environments are not sustained.

Although this problem was proven to be relevant during the discussions in Chapter 1 based on the available literature, it was further validated by incorporating statements into the survey that was sent to respondents with experience in implementing Lean in hospitals. Three statements were developed to validate the research problem. The first two statements were derived from the background discussions in Chapter 1. The third statement was derived from this study's research problem. These three statements, together with how respondents rated them can be found in Table 35.

Table 35: Research problem validation – survey results

Respondents	Survey statements with their received rating		
	Lean implementation in healthcare environments has increased over the past two decades	Lean has the capability to increase a hospital's quality of service and performance	Although initial lean implementations might be successful it is not sustained in the long run
R1	4	5	4
R2	5	5	4
R3	5	5	1
R4	5	5	3
R5	5	5	4
R6	4	5	4
R7	1	1	2
R8	4	4	5
R9	5	5	5
R10	4	4	4
R11	5	5	5
R12	4	5	4
R13	5	5	2
R14	5	4	4
Average score	4.36	4.5	3.64

Table 35 shows that two of the three statements received an average rating above 3.75. Respondent 7 rated the first two statements with a “strongly disagree rating”. Based on basic statistic calculations (see Annexure E), respondent 7’s ratings for the first two statements are outliers. Despite these outliers, there is still consensus on the validity of the first two statements.

The third statement in Table 35 did not initially obtain a rating higher than 3.75. Respondent 3, 7 and 13 rated it either a 1 or a 2. Respondent 3 and 13 did not provide additional comments on this rating. Respondent 7’s comment on his/her rating for the third statement was as follows:

“Again, just talking from my subjective perspective – I think Leratong is doing a superb job of it, and it is sustained, so I could not agree that in all cases this is so. Statistically, yes, many don’t sustain”.

The respondent perhaps based his/her rating on the minority of implementation cases instead of considering what the situation is in most implementation attempts. The rating was justified based on the last part of the respondent's comment, namely that the respondent did agree with the statement. However, since an objective rating cannot be allocated to replace respondent 7's initial rating, the third statement's average rating was recalculated without taking respondent 7's rating into account. The updated average rating for statement three can be seen in Table 36.

Table 36: Updated research problem validation - survey results

Respondents	Survey statements with their received rating		
	Lean implementation in healthcare environments has increased over the past two decades	Lean has the capability to increase a hospital's quality of service and performance	Although initial lean implementations might be successful it is not sustained in the long run
R1	4	5	4
R2	5	5	4
R3	5	5	1
R4	5	5	3
R5	5	5	4
R6	4	5	4
R7	1	1	-
R8	4	4	5
R9	5	5	5
R10	4	4	4
R11	5	5	5
R12	4	5	4
R13	5	5	2
R14	5	4	4
Average score	4.36	4.5	3.77

Since the updated average rating of the three statements are above 3.75, there was consensus that this study addresses a valid research problem.

6.4.2 Validation of research methodology

As discussed in the Chapter 3, this study was conducted within the DSR paradigm. DSR is a science concerned with performing rigorous research with the aim of developing artefacts to address problems (Hevner *et al.*, 2004). An important part of validating

research output is ensuring that the method that was followed to develop the output is scientifically sound (Coetzee, 2019; Van Dyk, 2013). Subsequently, the aim of this section is to validate the research method followed to develop the SLIR. Hevner *et al.* (2004) provide researchers with seven DSR guidelines to ensure that rigorous research has been conducted, resulting in a sound artefact. Confirming adherence to these guidelines during the development of the SLIR results in validating the research methodology.

The SLIR was developed by following a maturity model development procedure proposed by Becker *et al.* (2009). As discussed in Chapter 3, Becker *et al.* (2009) developed this procedure model based on the seven DSR guidelines. They achieved this by deriving eight DRs from the seven DSR guidelines and using these eight requirements to develop the procedure model (Table 4). They further indicated where these requirements feature in the procedure model. This procedure model can be found in Chapter 3, Figure 15.

Therefore, confirming adherence to the eight maturity model development requirements indicated by Becker *et al.* (2009) also confirms adherence to the seven DSR guidelines. As such, the research methodology is verified. The following table presents the proof of adherence to the eight procedure model DRs, by means of a retrospective view:

Table 37: Research methodology retrospective view validation

Procedure model development requirements Becker et al. (2009)	Corresponding DSR guideline(s) Hevner <i>et al.</i> (2004)	Confirmation	Corresponding chapter
R1: Comparison with existing maturity models	G1: Design as an Artefact G4: Research Contributions	During the literature study the currently body of maturity model literature was reviewed to ensure the SLIR (artefact) will contribute to the current body of literature.	·Chapter 2
R2: Iterative procedure	G6: Design as a search process	5 development iterations were conducted. Each iteration resulted in the development of a maturity model component. A bottom-up approach was followed to develop each maturity model component respectively.	·Chapter 5
R3: Evaluation	G6: Design as a search process	The SLIR was evaluated, by the researcher, for design requirement adherence after every iteration. The SLIR was further evaluated by means of a survey completed by 11 participants with lean in healthcare experience.	·Chapter 5 ·Chapter 6
R4: Multi-methodological procedure	G3: Evaluation G5: Research Rigour	Various techniques were used in the respective development iterations. This included: literature analysis, creativity techniques and applied thematic analysis.	·Chapter 5
R5: Identification of problem relevance	G2: Problem relevance	Problem relevance was established by means of literature and also by means of the survey.	·Chapter 1 ·Chapter 6
R6: Problem definition	G2: Problem relevance	The problem was identified and defined based on literature. The problem was validated by means of the survey.	·Chapter 1 ·Chapter 6
R7: Targeted presentation of results	G7: Communication of research	This study was communicated in various ways. For academic readers a detailed dissertation document is available. The survey participants received a 5-minute video to communicate the information they needed prior to completing the survey.	·Chapter 6 ·Dissertation document
R8: Scientific documentation	G7: Communication of research	The dissertation document reports on the scientific research conducted throughout the study.	·Dissertation document

6.4.3 Validation of developed SLIR

The solution developed to address the research problem identified in this study was the SLIR. Two statements with regard to the SLIR's validity were developed and included in the evaluation survey. The two statements with their allocated ratings from the respondents can be seen in Table 38.

Table 38: SLIR validation – survey results

Respondents	Survey statements with their received rating	
	The SLIR contributes towards the sustainability of lean implementations in a hospital environment	The 7 dimensions of the SLIR represents critical areas where maturity need to be achieved in order for lean implementations to be sustained
R1	4	4
R2	4	4
R3	5	4
R4	4	5
R5	4	4
R6	4	4
R7	3	3
R8	4	4
R9	5	5
R10	3	4
R11	4	4
R12	3	4
R13	4	4
R14	4	4
Average score	3.93	4.07

Both statements received an average rating above 3.75, indicating consensus on the validity of the SLIR. Accordingly, the respondents all agree that the SLIR addresses the problem of Lean implementations not being sustained in hospital environments.

6.5 Chapter conclusion

By means of an evaluation survey and a retrospective view of the study, the SLIR has been verified and validated. There is consensus among respondents with experience in

implementing Lean in hospitals that the SLIR is a valid solution to a relevant research problem. Subsequently the SLIR offers an implementation roadmap that contributes to ensuring fidelity and sustainability during the implementation of Lean in a hospital environment. By confirming adherence to the seven DSR guidelines, the research methodology was validated. Finally, although two DRs were not verified, the SLIR was verified based on a combination of a retrospective view and results from the evaluation survey. The following chapter reports on the study's conclusions and recommendations, including addressing the unverified DRs.

CHAPTER 7

CONCLUSION

This chapter presents the study's conclusion and recommendations.

CHAPTER 7: CONCLUSION

This chapter offers concluding remarks and recommendations for future work. It starts with a brief overview of the research, after which the contribution of this study is discussed. This is followed by a consideration of the limitations and recommendations for future work. The chapter closes with concluding remarks.

7.1 Research overview

Although Lean was not traditionally implemented in service sectors such as the healthcare sector, Lean has the potential to increase a hospital's performance and patient satisfaction. However, in most of these implementations the Lean implementation is not sustained in the long run. This study aimed to address this problem. Research has been conducted on the implementation of Lean in healthcare and on Lean implementation maturity models. However, there is no prescriptive maturity model that addresses sustainable Lean implementation by incorporating Lean success factors and an implementation science framework.

The factors influencing the success of Lean implementations in hospitals were identified by conducting an SLR. By systematically synthesising the relevant qualitative data, 32 success factors were identified and incorporated into the SLIR. These factors were grouped under eight themes and these themes were in turn incorporated into the SLIR. An implementation science framework selection method suitable to the context of this study was developed and applied. This led to the QIF being selected as the most appropriate framework to be incorporated into the SLIR. In order to guide the development of the SLIR. Eight DRs were derived from three inputs, namely Lean success factors, the QIF and maturity model development literature.

By following an iterative maturity model development approach together with a bottom-up design approach, each design level of the SLIR maturity model was developed. This resulted in the SLIR which was complemented by additional descriptions of the included activities. The SLIR was primarily evaluated by means of a survey sent to participations with experience in implementing Lean in hospitals. A retrospective view in terms of adherence to certain DRs and the DSR guidelines was part of the final evaluation. The SLIR was verified and respondents confirmed that the SLIR would contribute to the sustainable implementation of Lean in hospitals. Since the aim of the study was to develop a Lean implementation roadmap to guide sustainable Lean implementation, it can be concluded that the aim of this study was reached. Table 46 in Annexure G

provides a breakdown of the research objectives and where in the research they were met.

7.2 Contribution

The contribution of this study is twofold. Firstly, it contributes to the current body of literature on Lean implementation in healthcare. Secondly, it equips hospitals that aim to implement Lean.

Based on the DSR knowledge contribution framework developed by Gregor and Hevner (2013), this research and the artefact that resulted from it lies in the exaptation quadrant (Figure 18). Seeing as Lean originated in the automotive industry in the early 1900s (Ajmera & Jain, 2019), the solution (Lean) maturity is high. However, considering the low sustainability rate of Lean implementation in hospitals and the fact that research on this application only increased from the 1990s (Graban, 2016) onwards, the application domain has a low maturity.

7.2.1 Contribution to literature

Considering the low maturity of the application domain, this study contributes to literature on Lean implementation in healthcare. The following literature contributions stem from the completed study:

- Factors influencing the success of Lean implementation in a hospital environment
- A conceptual implementation science framework selection method
- The SLIR

7.2.2 Contribution to hospitals

The SLIR was developed as a roadmap to guide healthcare providers in hospital environments as they implement Lean in their hospitals with sustainability as the end goal. By using the SLIR together with the additional activity descriptions and initial assistance from in-house or external expertise, the healthcare providers can use the SLIR to guide their implementation journey.

7.3 Limitations and future research

7.3.1 Limitations

Although extensive research was conducted to develop the SLIR, the research did not have a strong empirical element. Nilsen (2015) recommends that implementation

research should not be conducted without being connected to the application domain. Although the evaluation of the SLIR was conducted by including respondents with not only academic experience, but also experience in implementing Lean in real-world hospital environments, further empirical research should be conducted in future research. Empirical research will assist in truly evaluating the SLIR's contribution to sustainable Lean implementations and will provide a platform for feedback to improve the SLIR. On average the survey respondents with the most years of experience gave a lower rating for the SLIR. By including these respondents in empirical research, their experience and expertise can inform the improvement of the SLIR.

The second limitation to the study was the low response rate of the evaluation survey. A response rate of 52% was attained. Although the yielded response rate is low it is still deemed sufficient due to the respondents, who completed the survey, sufficiently representing years of experience and the three respective application domains (Bryman & Bell, 2014) as was presented in Table 31 and Table 32. However, by attaining a response rate of between 60% and 65%, as is suggested by literature, the validity of the SLIR can be further confirmed. Future research can aim for such a response rate by either providing more time to complete the survey or by changing the way of administering the survey.

7.3.2 Future research

The potential future research that can be conducted stems from two sources. The first is the survey respondents' additional feedback (comments) and the second is the survey respondent's feedback concerning DRs 5 and 6 (Chapter 6). Finally, possible research that fell outside the scope of this study is also described.

The survey respondents' additional feedback was categorised into two future research aims. The first aim is concerned with the improvement of the SLIR's content. Three minor changes to the content can be made in future research based on the following three comments:

- Respondent 1: "The 4 levels clearly follow an implementation path, but do not show how the hospital's maturity increases." Therefore, maturity must be better defined and indicated on the SLIR.
- Respondent 10: "...perhaps it is important to note that the steps must not necessarily be sequential." Therefore, the application of the SLIR must be better

communicated, together with the order in which the various capability activates must be performed.

- Respondent 10: “I think for a maturity model the phrases should be expressed in some more discrete (or measurable way) in the past tense... a maturity model must be phrased in terms of attained maturity levels, rather than in terms of actions required to achieve maturity.” Therefore, instead of only focusing on the execution of the capability activities the SLIR must clearly indicate what is seen as mature within each capability dimension and maturity level. This will assist healthcare providers in knowing what they must aim to achieve within each capability dimension.

The second aim is concerned with the improvement of the SLIR before it can be implemented/used by healthcare providers. Respondent 13 indicated that the SLIR should be simplified before it can be used by healthcare providers. This second aim touches on the improvements that should be made based on the verification results of DRs 5 and 6. These two requirements relate to the SLIR being used by staff from all (relevant) levels and all (relevant) disciplines. For the sake of the remaining discussion, these two DRs are viewed as one requirement concerning the operationalisation of the SLIR. As discussed in Chapter 6, the Lean deployment process, Figure 36, was not incorporated into the development of the SLIR. This deployment process is concerned with translating top management’s goals to measurable goals for each level within the organisation (Bicheno & Holweg, 2016). Therefore, although the SLIR can be used by top management in conjunction with initial external or in-house expertise, it should be translated into measurable goals for each level, resulting in additional level-specified SLIR goals.

Liker (2004) suggests that the deployment process incorporates the plan-do-check-act (PDSA) approach. This approach is iterative and aims to solve problems. Aij and Lohman (2016) similarly suggest that employees’ problem-solving skills be improved as part of Lean deployment. Thus, in future research the SLIR must be operationalised and translated into measurable goals for each level within the hospital’s staff structure. This will address respondent 11’s concern that additional attention should be given to the operationalisation of the SLIR by incorporating existing tools into the SLIR. The SLIR can also be informed by existing, dimension-specific maturity models, such as the culture changing maturity model identified in the literature review (Guimarães & Carvalho, 2015).

Possible research, that fell outside the scope of this study, that can contribute to future Lean implementation in healthcare research is grouped under three themes. Firstly, determining the Lean implementation processes that healthcare providers have followed in previous research. Secondly, determining which factors ensures the sustainable implementation of Lean in sectors other than the healthcare environment. Thirdly determining how continuous improvement methodologies, apart from Lean, has been sustainably implemented in the healthcare environment.

7.4 Concluding remarks

The implementation of Lean in a hospital environment should be properly planned with sustainability as the end goal. If improvements in performance and patient satisfaction brought about by the implementation of Lean are not sustained and normalised as part of the everyday routine, the implementation was not successful. The SLIR contributes towards an implementation guide that healthcare providers can use to plan their Lean implementation process and to help them maintain fidelity throughout the execution of this process towards a sustainable Lean implementation.

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ANNEXURE A: ADDITIONAL DSR INFORMATION

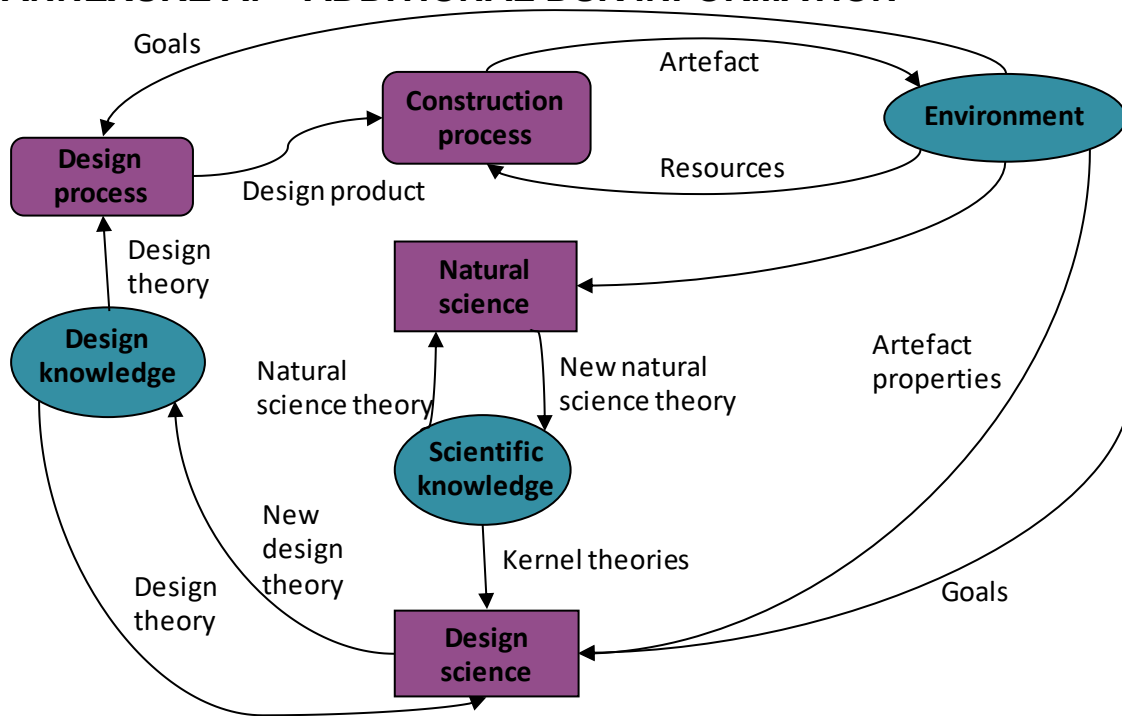


Figure 37: Representation of relationship between natural science, design science and design theory compiled from Walls et al. (2004)

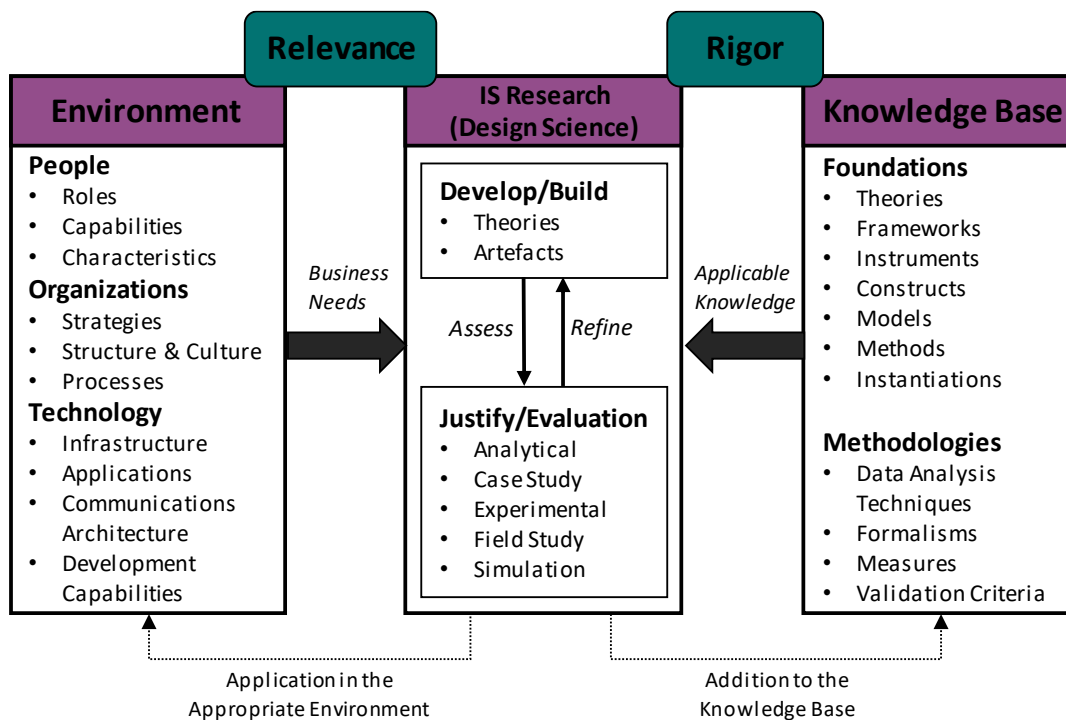


Figure 38: Information Systems Research Framework compiled from Hevner et al. (2004)

ANNEXURE B: ADDITIONAL SLR INFORMATION

Table 39: Detailed summary of factors influencing success of Lean implementation within hospital environment

Factors influencing successful lean implementation	Source(s)
Planning	
Clarify strategic goals, organisational vision, organisational targets and employee expectations	Jain & Ajmera (2018), Noori (2015b), Grove et al. (2010), Mazur et al. (2011), Ajmera & Jain (2018), Sobek (2011), Aij et al. (2013), Régis et al. (2018), Noori (2015a), Patri & Suresh (2018), Lorden et al. (2018), D'Andreamatteo
Define value in terms of all stakeholders and processes	Jain & Ajmera (2018), Grove et al. (2010), Mazur et al. (2011), Ajmera & Jain (2018), Poksinska (2010), Régis et al. (2018)
Plan and manage implementation timeline	Jain & Ajmera (2018), Ajmera & Jain (2018), Patri & Suresh (2018), Sobek (2011)
Carefully select and brief implementation team while encouraging their involvement in implementation process	Noori (2015b), Mazur et al. (2011), Régis et al. (2018), Noori (2015a), Holden (2011)
Implementation process in terms of stakeholders and project selection	Noori (2015b), Mazur et al. (2011), Noori (2015a), Lorden et al. (2018), D'Andreamatteo et al. (2015), Harrison et al. (2016), Sobek (2011), Régis et al. (2018), Ulhassan et al. (2013)
Plan intervention and its application in the specific organisation (including patients, materials and information flows)	Ulhassan et al. (2013), Régis et al. (2018), Holden (2011), Noori (2015b), Noori (2015a)
Incorporate "lessons learned" into planning process	D'Andreamatteo et al. (2015), Holden (2011)
Engagement	
Patient engagement in implementation process (capture patient experience)	Jain & Ajmera (2018), Ajmera & Jain (2018), Holden (2011)
Employee engagement in decision making and initiative progress update	Jain & Ajmera (2018), Mazur et al. (2011), Ajmera & Jain (2018), Sobek (2011), Patri & Suresh (2018), Harrison et al. (2016), Holden (2011), Lorden et al. (2018)
Early physician engagement	Sobek (2011), Holden (2011), Ulhassan et al. (2013)
Management engagement in implementation process	Lorden et al. (2018), Noori (2015b), Sobek (2011), D'Andreamatteo et al. (2015), Lorden et al. (2018), Majjala et al. (2018), Harrison et al. (2016)
Management	
Management commitment to implementing, managing and sustaining the initiative	Jain & Ajmera (2018), Noori (2015b), Grove et al. (2010), Mazur et al. (2011), Ajmera & Jain (2018), Poksinska (2010), Ulhassan et al. (2013), Aij et al. (2013), Noori (2015a), Patri & Suresh (2018), Lorden et al. (2018), D'Andreamatteo et al. (2015), Holden (2011)
Evaluate and communicate implementation progress and employee performance (give incentives)	Jain & Ajmera (2018), Noori (2015b), de Souza & Pidd (2011), Ajmera & Jain (2018), Sobek (2011), Noori (2015a), D'Andreamatteo et al. (2015), Harrison et al. (2016), Majjala et al. (2018), Mazur et al. (2011)
Ensure organisational momentum (no often changes in strategy)	de Souza & Pidd (2011), Aij et al. (2013)
Ensure leadership style and strategies contribute to encouraging a culture of change and a realisation that continuous improvement is necessary	Steed (2012), Majjala et al. (2018), Aij et al. (2013), Sobek (2011)
Environment	
Hierarchy of healthcare staff and management roles must not hinder teamwork	de Souza & Pidd (2011), Sobek (2011), Poksinska (2010), Ulhassan et al. (2013), Noori (2015a), Lorden et al. (2018), Noori (2015b)
Although patient care is top priority, data must be collected for lean to work	de Souza & Pidd (2011)
High process variability must be managed in terms of how it affects lean implementation	Grove et al. (2010), D'Andreamatteo et al. (2015)
Difficulty in defining healthcare waste must be managed	D'Andreamatteo et al. (2015), Grove et al. (2010)
Training	
Provide employees with the necessary knowledge and skills to implement lean and apply lean principles	Jain & Ajmera (2018), Noori (2015b), Grove et al. (2010), Mazur et al. (2011), Ajmera & Jain (2018), Sobek (2011), Poksinska (2010), Aij et al. (2013), Noori (2015a), Patri & Suresh (2018), D'Andreamatteo et al. (2015), Harrison et al. (2016)
Ensure employees understand the overall philosophy and need for continuous improvement	Jain & Ajmera (2018), Grove et al. (2010), Ajmera & Jain (2018), D'Andreamatteo et al. (2015)
The implementation team/facilitators need to receive additional training	Mazur et al. (2011), Noori (2015a), Noori (2015b), Sobek (2011), Harrison et al. (2016), Holden (2011)
Resources	
Financial resource must be available	Jain & Ajmera (2018), Ajmera & Jain (2018), Sobek (2011), Holden (2011)
Resources to support implementation process	Sobek (2011), Harrison et al. (2016), Holden (2011), Aij et al. (2013)
Expert consultants (in-house or external)	Sobek (2011), Régis et al. (2018), D'Andreamatteo et al. (2015), Harrison et al. (2016), Holden (2011)

Factors influencing successful lean implementation	Source(s)
Communication	
General communication and mediums used	Noori (2015b), Sobek (2011), Noori (2015a), Lorden et al. (2018), Harrison et al. (2016)
Communication between different departments (breakdown silos) and (multidisciplinary)	Jain & Ajmera (2018), de Souza & Pidd (2011), Grove et al. (2010), Ajmera & Jain (2018), Sobek (2011), Poksinska (2010), Aij et al. (2013)
Both goals and achievements needs to be communicated (vertical and horizontal)	Jain & Ajmera (2018), Ajmera & Jain (2018), Aij et al. (2013)
Terminology	de Souza & Pidd (2011)
Culture	
Create a supportive and encouraging organisational culture	Jain & Ajmera (2018), Noori (2015b), Ajmera & Jain (2018), Noori (2015a), Patri & Suresh (2018), D'Andreamatteo et al. (2015), Sobek (2011), Holden (2011)
Manage employee resistance and their misconceptions of lean	Jain & Ajmera (2018), de Souza & Pidd (2011), Ajmera & Jain (2018), Ulhassan et al. (2013), Aij et al. (2013), Patri & Suresh (2018), Lorden et al. (2018), D'Andreamatteo et al. (2015), Harrison et al. (2016), Holden (2011)
Cultivate culture of continuous improvement as part of everyday practice	de Souza & Pidd (2011), Sobek (2011), Ulhassan et al. (2013), Régis et al. (2018), Poksinska (2010), Harrison et al. (2016), Holden (2011), Noori (2015b), Noori (2015a)

Table 40: Borderline excluded studies

Borderline exclusion article title
AHP framework to assist lean deployment in Abu Dhabi public healthcare delivery system
Managing paradoxical tensions during the implementation of lean capabilities for improvement
A tool to assess continuous improvement culture: Adapting servqual scale to measure employee satisfaction, and identify factors of success
Implementing operations strategy through Lean processes within health care: The example of NHS in the UK
Implementing a Lean Management System in Primary Care: Facilitators and Barriers from the Front Lines
Measuring and managing radiologist workload: Application of lean and constraint theories and production planning principles to planning radiology services in a major tertiary hospital
The role of the physical layout in the implementation of lean management initiatives
Improvement in prescription renewal handling by application of the lean process
Application of lean methodology prescription of nutrition supplements as medication by dieticians
Applying Lean Methods to Improve Quality and Safety in Surgical Sterile Instrument Processing.
Applying the Principles of Lean Production to Gastrointestinal Biopsy Handling: From the Factory Floor to the Anatomic Pathology Laboratory.
A Case Review: Integrating Lewin's Theory with Lean's System Approach for Change.
A waste walk through clinical pharmacy: how do the 'seven wastes' of Lean techniques apply to the practice of clinical pharmacists.
Adoption of Lean Principles in a High-Volume Molecular Diagnostic Microbiology Laboratory
Safety improvements from health lean management implementation: Evidences from three cases
Application of lean methodology for improved quality and efficiency in operating room instrument availability
Applying the principles of lean production to gastrointestinal biopsy handling: From the factory floor to the anatomic pathology laboratory
Applying lean methods to improve quality and safety in surgical sterile instrument processing
Combining Lean and Applied Research methods to improve rigor and efficiency in acute care outcomes research: A case study
Streamlining The Interventional Breast Imaging Workflow by Lean Methodology Implementation
The application of lean management in the management of the psychiatric care system in the regional model of psychiatric care in Denmark (the region of Zealand)
Lean management in hospital pharmacy: Integration in clinical trial quality assurance [Lean management en pharmacie hospitalière: intégration dans la démarche qualité des essais cliniques]
Application of lean management for improving productivity of housekeeping staff in health care industry: A case study
A case review: Integrating lewin's theory with lean's system approach for change
Integrating lean management to breast cancer center: Case study in Turkey
A waste walk through clinical pharmacy: How do the 'seven wastes' of Lean techniques apply to the practice of clinical pharmacists
Adoption of lean principles in a high-volume molecular diagnostic microbiology laboratory
Lean thinking applied to a chemotherapy centralized preparation unit
Applying Lean Principles to Reduce Wait Times in a VA Emergency Department
Integrating Behavioral Health in Primary Care Using Lean Workflow Analysis: A Case Study
Barnes-Jewish Hospital applies lean methodology to acute stroke care, maximizing resources and slashing door-to-needle times.
An exploration of the leadership attributes and methods associated with successful lean system deployments in acute care hospitals

Table 41: Leadership characteristics associated with successful Lean implementation compiled from Steed (2012)

Personal characteristics	Behaviours and actions	Knowledge
Skilled communicator	Leads by example and acting as a role model	Understands the change process
Able to motivate others	Holds self and others accountable	Understands process improvement
Driven	Consistent	Understands Lean
Ambitious	Leads from behind through other people	Data savvy
Passionate for excellence	Actively visible through participation	Experienced and credible
Change leader and manager	Can lead change and sustain change	Technical expert
Honest	Empowers and engages	Strong performance track record
Motivated and motivating	Pace-setter	Abreast of evidence-based best practices
Inspired and inspiring	Team-oriented	Learns by seeing and doing
Agile	Inclusive and collaborative	Quick learner
Confident	Problem solver	Committed to lifelong learning and continuous development
Strong work ethic	Skilled facilitator	Learns from others
Humble	Coach and mentor	Role model and coach
Good listener	Encourages shared decision making	
Approachable	Walks-the-walk and talks-the-talk	
Resilient	Proactive and adaptive	
High performer	Goal and action oriented	

Table 42: Leadership attributes associated with successful Lean implementation compiled from Maijala *et al.* (2018)

Activities	Style	Purpose	Focus
Problem-solving techniques and skills	Role of leaders as mentors, coaches or facilitators	Clear communication of vision and targets for improvements	Continuous learning
Measuring performance	Emotional intelligence	Understanding who is the customers and what does value mean to them	attention to sensitivity of professional values and culture of health care
Communication including visible techniques	Multi-professional collective perspective and teamwork		

Table 43 : 21-item ENTREQ statement reproduced from Tong et al. (2012)

No	Item	Guide and description
1	Aim	State the research question the synthesis addresses.
2	Synthesis methodology	Identify the synthesis methodology or theoretical framework which underpins the synthesis, and describe the rationale for choice of methodology (e.g. meta-ethnography, thematic synthesis, critical interpretive synthesis, grounded theory synthesis, realist synthesis, meta-aggregation, meta-study, framework synthesis).
3	Approach to searching	Indicate whether the search was pre-planned (comprehensive search strategies to seek all available studies) or iterative (to seek all available concepts until theoretical saturation is achieved).
4	Inclusion criteria	Specify the inclusion/exclusion criteria (e.g. in terms of population, language, year limits, type of publication, study type).
5	Data sources	Describe the information sources used (e.g. electronic databases (MEDLINE, EMBASE, CINAHL, PsycINFO, Econlit), grey literature databases (digital thesis, policy reports), relevant organisational websites, experts, information specialists, generic web searches (Google Scholar) hand searching, reference lists) and when the searches conducted; provide the rationale for using the data sources.
6	Electronic Search strategy	Describe the literature search (e.g. provide electronic search strategies with population terms, clinical or health topic terms, experiential or social phenomena related terms, filters for qualitative research, and search limits).
7	Study screening methods	Describe the process of study screening and sifting (e.g. title, abstract and full text review, number of independent reviewers who screened studies).
8	Study characteristics	Present the characteristics of the included studies (e.g. year of publication, country, population, number of participants, data collection, methodology, analysis, research questions).
9	Study selection results	Identify the number of studies screened and provide reasons for study exclusion (e.g. for comprehensive searching, provide numbers of studies screened and reasons for exclusion indicated in a figure/flow chart; for iterative searching describe reasons for study exclusion and inclusion based on modifications to the research question and/or contribution to theory development).
10	Rationale for appraisal	Describe the rationale and approach used to appraise the included studies or selected findings (e.g. assessment of conduct (validity and robustness), assessment of reporting (transparency), assessment of content and utility of the findings).
11	Appraisal items	State the tools, frameworks and criteria used to appraise the studies or selected findings (e.g. Existing tools: CASP, QARI, COREQ, Mays and Pope [25]; reviewer developed tools; describe the domains assessed: research team, study design, data analysis and interpretations, reporting).
12	Appraisal process	Indicate whether the appraisal was conducted independently by more than one reviewer and if consensus was required.
13	Appraisal results	Present results of the quality assessment and indicate which articles, if any, were weighted/excluded based on the assessment and give the rationale.
14	Data extraction	Indicate which sections of the primary studies were analysed and how were the data extracted from the primary studies? (e.g. all text under the headings "results /conclusions" were extracted electronically and entered into a computer software).
15	Software	State the computer software used, if any.
16	Number of reviewers	Identify who was involved in coding and analysis.
17	Coding	Describe the process for coding of data (e.g. line by line coding to search for concepts).
18	Study comparison	Describe how were comparisons made within and across studies (e.g. subsequent studies were coded into pre-existing concepts, and new concepts were created when deemed necessary).
19	Derivation of themes	Explain whether the process of deriving the themes or constructs was inductive or deductive.
20	Quotations	Provide quotations from the primary studies to illustrate themes/constructs, and identify whether the quotations were participant quotations of the author's interpretation.
21	Synthesis output	Present rich, compelling and useful results that go beyond a summary of the primary studies (e.g. new interpretation, models of evidence, conceptual models, analytical framework, development of a new theory or construct).

ANNEXURE C: COMPARING THE QUALITY IMPLEMENTATION FRAMEWORK WITH LEAN SUCCESS FACTOR

Table 44: Quality implementation framework with corresponding Lean success factors

Phase one (a): Initial considerations regarding the host setting	Corresponding lean success factor
Assessment strategies	Communication: General communication
1. Conducting a needs and resources assessment:	
Why are we doing this?	
What problems or conditions will the innovation address (i.e., the need for the innovation)?	Engagement: Patient engagement
What part(s) of the organization and who in the organization will benefit from improvement efforts?	
2. Conducting a fit assessment:	
Does the innovation fit the setting?	
How well does the innovation match the:	
Identified needs of the organization/community?	
Organization's mission, priorities, values, and strategy for growth?	Planning: Define strategy, define value
Cultural preferences of groups/consumers who participate in activities/services provided by the organization/community?	
3. Conducting a capacity/readiness assessment:	
Are we ready for this?	Resources: Financial resources
To what degree does the organization/community have the will and the means (i.e., adequate resources, skills and motivation) to implement the innovation?	Culture: Readiness and resistance
Is the organization/community ready for change?	
Decisions about adaptation	Planning: Contextualisation
4. Possibility for adaptation	
Should the planned innovation be modified in any way to fit the host setting and target group?	
What feedback can the host staff offer regarding how the proposed innovation needs to be changed to make it successful in a new setting and for its intended audience?	
How will changes to the innovation be documented and monitored during implementation?	
Phase one (b): Initial considerations regarding the host setting	
Capacity Building Strategies (may be optional depending on the results of previous elements)	
5. Obtaining explicit buy-in from critical stakeholders and fostering a supportive community/organizational climate:	Engagement: Management engagement, Physician engagement
Do we have genuine and explicit buy-in for this innovation from:	
Leadership with decision-making power in the organization/community?	Management: Management commitment
From front-line staff who will deliver the innovation?	Engagement: Employee engagement
The local community (if applicable)?	
Have we effectively dealt with important concerns, questions, or resistance to this innovation? What possible barriers to implementation need to be lessened or removed?	
Can we identify and recruit an innovation champion(s)?	
Are there one or more individuals who can inspire and lead others to implement the innovation and its associated practices?	
How can the organization/community assist the champion in the effort to foster and maintain buy-in for change?	
Note. Fostering a supportive climate is also important after implementation begins and can be maintained or enhanced through such strategies as organizational policies favoring the innovation and providing incentives for use and disincentives for non-use of the innovation	
6. Building general/organizational capacity:	
What infrastructure, skills, and motivation of the organization/community need enhancement in order to ensure the innovation will be implemented with quality?	Resource: Expertise
Of note is that this type of capacity does not directly assist with the implementation of the innovation, but instead enables the organization to function better in a number of its activities (e.g., improved communication within the organization and/or with other agencies; enhanced partnerships and linkages with other agencies and/or community stakeholders).	

Phase one (c): Initial considerations regarding the host setting	
7. Staff recruitment/maintenance:	
Who will implement the innovation?	
Initially, those recruited do not necessarily need to have knowledge or expertise related to use of the innovation; however, they will ultimately need to build their capacity to use the innovation through training and on-going support	Training: Facilitator training
Who will support the practitioners who implement the innovation?	Culture: Supportive culture
These individuals need expertise related to (a) the innovation, (b) its use, (c) implementation science, and (d) process evaluation so they can support the implementation effort effectively	
Might roles of some existing staff need realignment to ensure that adequate person-power is put towards implementation?	Environment: Staff structure
8. Effective pre-innovation staff training	Training: Employee training
Can we provide sufficient training to teach the why, what, when, where, and how regarding the intended innovation?	Environment: Define waste
How can we ensure that the training covers the theory, philosophy, values of the innovation, and the skill-based competencies needed for practitioners to achieve self-efficacy, proficiency, and correct application of the innovation?	Training: Lean philosophy Environment: Process variability
Phase two: Creating a structure for implementation	
Structural features for implementation	
9. Creating implementation teams:	Planning: Implementation team
Who will have organizational responsibility for implementation?	
Can we develop a support team of qualified staff to work with front-line workers who are delivering the innovation?	
Can we specify the roles, processes, and responsibilities of these team members?	
10. Developing an implementation plan:	Planning: Implementation process
Can we create a clear plan that includes specific tasks and timelines to enhance accountability during implementation?	Planning: Implementation timeline
What challenges to effective implementation can we foresee that we can address proactively?	
Phase three: Ongoing structure once implementation begins	
Ongoing implementation support strategies	
11. Technical assistance/coaching/supervision:	Management: Organisational momentum Resources: Supporting resources
Can we provide the necessary technical assistance to help the organization/community and practitioners deal with the inevitable practical problems that will develop once the innovation begins?	
These problems might involve a need for further training and practice in administering more challenging parts of the innovation, resolving administrative or scheduling conflicts that arise, acquiring more support or resources, or making some required changes in the application of the innovation	
12. Process evaluation	
Do we have a plan to evaluate the relative strengths and limitations in the innovation's implementation as it unfolds over time?	Culture: Normalisation of initiative
Data are needed on how well different aspects of the innovation are being conducted as well as the performance of different individuals implementing the innovation	Environment: Data collection
13. Supportive feedback mechanism	Management: Follow-up
Is there an effective process through which key findings from process data related to implementation are communicated, discussed, and acted upon?	Communication: Interdepartmental cooperation Management: Leadership style
How will process data on implementation be shared with all those involved in the innovation (e.g., stakeholders, administrators, implementation support staff, and front-line practitioners)?	Communication: Progress communication Communication: Terminology
This feedback should be offered in the spirit of providing opportunities for further personal learning and skill development and organizational growth that leads to quality improvement in implementation	
Phase four: Improving future applications	
14. Learning from experience	Planning: Learn from mistakes
What lessons have been learned about implementing this innovation that we can share with others who have an interest in its use?	
Researchers and innovation developers can learn how to improve future implementation efforts if they critically reflect on their experiences and create genuine collaborative relationships with those in the host setting	
Collaborative relationships appreciate the perspectives and insights of those in the host setting and create open avenues for constructive feedback from practitioners on such potentially important matters as: (a) the use, modification, or application of the innovation; and (b) factors that may have affected the quality of its implementation	

ANNEXURE D: MODEL EVALUATION SURVEY

11/2/2019

Evaluation of the Sustainable Lean Implementation Roadmap (SLIR)

Evaluation of the Sustainable Lean Implementation Roadmap (SLIR)

Thank you for taking the time to complete this survey.

This survey forms part of the evaluation phase of the dissertation with the title - Developing a maturity model to facilitate the sustainability of Lean implementations in hospitals. (Ethics clearance no: NWU 00283-19-A1).

The maturity model, titled the Sustainable Lean Implementation Roadmap, will be referred to as the SLIR throughout the rest of the survey.

Please ensure that you watch the 5-minute background video, as described in the email, prior to completing the survey. You can follow the following link to watch the video: ???

Please note the following relevant, to this survey's sections:

*Validation is the process of determining if a tool is fit for its purpose (Nordin, 2012).

**Verification is the process of determining whether an artefact satisfies its design requirements (Coetzee, 2019).

*Required

1. This section aims to validate* the relevance of the problem addressed in this study

The problem addressed in this study is as follows: lean implementations in hospitals are not sustained.

1. Please indicate whether you agree with the following statements concerning the problem addressed in this study: *

Mark only one oval per row.

	Strongly disagree	Disagree	Undecided	Agree	Strongly Agree
Lean implementation in healthcare environments has increased over the past two decades	☐	☐	☐	☐	☐
Lean has the capability to increase a hospital's quality of service and performance	☐	☐	☐	☐	☐
Although initial lean implementations might be successful it is not sustained in the long run	☐	☐	☐	☐	☐

2. This section aims to validate* whether the SLIR addresses the research problem identified in this study

Please refer to the SLIR as described in the 5-minute introductory video or the attached pdf version of the SLIR.

Evaluation of the Sustainable Lean Implementation Roadmap (SLIR)

Thank you for taking the time to complete this survey.

This survey forms part of the evaluation phase of the dissertation with the title - Developing a maturity model to facilitate the sustainability of Lean implementations in hospitals. (Ethics clearance no: NWU 00283-19-A1).

The maturity model, titled the Sustainable Lean Implementation Roadmap, will be referred to as the SLIR throughout the rest of the survey.

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1. This section aims to validate* the relevance of the problem addressed in this study

The problem addressed in this study is as follows: lean implementations in hospitals are not sustained.

1. Please indicate whether you agree with the following statements concerning the problem addressed in this study: *

Mark only one oval per row.

	Strongly disagree	Disagree	Undecided	Agree	Strongly Agree
Lean implementation in healthcare environments has increased over the past two decades	☐	☐	☐	☐	☐
Lean has the capability to increase a hospital's quality of service and performance	☐	☐	☐	☐	☐
Although initial lean implementations might be successful it is not sustained in the long run	☐	☐	☐	☐	☐

2. This section aims to validate* whether the SLIR addresses the research problem identified in this study

Please refer to the SLIR as described in the 5-minute introductory video or the attached pdf version of the SLIR.

2. Please indicate whether you agree with the following statements concerning the SLIR: *

Mark only one oval per row.

	Strongly disagree	Disagree	Undecided	Agree	Strongly Agree
The SLIR contributes towards the sustainability of lean implementations in a hospital environment	☐	☐	☐	☐	☐
The 7 dimensions of the SLIR represents critical areas where maturity needs to be achieved in order for lean implementations to be sustained	☐	☐	☐	☐	☐

3. This section aims to verify whether the developed maturity model adheres to specified design requirements**

The relevant design requirements are listed below.

3. Please indicate whether you agree that the SLIR adheres to the respective design requirements: *

Mark only one oval per row.

	Strongly disagree	Disagree	Undecided	Agree	Strongly Agree
The model is applicable to any hospital environment with the necessary contextualisation	☐	☐	☐	☐	☐
The model facilitates sustainable lean implementation	☐	☐	☐	☐	☐
Staff members from all (relevant) levels will be able to interpret and apply the model	☐	☐	☐	☐	☐
Staff members from various (relevant) disciplines will be able to interpret and apply the model	☐	☐	☐	☐	☐
Maturity and the steps to achieve maturity within maturity levels is clearly defined	☐	☐	☐	☐	☐
Maturity levels form a logical maturation path towards sustainable lean implementation	☐	☐	☐	☐	☐

Closure

Thank you for taking the time to complete this survey. It is highly appreciated.

If you have any comments you would like to share with the researcher, please do so in the space provided below.

Please note that the participant details, requested below, will be dealt with confidentially as explained in the email.

4. Name and surname (record-keeping purposes): *

5. How many years of experience on lean implementation in a healthcare environment do you have? *

Mark only one oval.

☐ 0-2 years

☐ 2-5 years

☐ 5-10 years

☐ +10 years

6. Please indicate in which area(s) lies your experience within lean in healthcare implementation: *

Tick all that apply.

☐ Academic

☐ Private healthcare

☐ Public healthcare

7. Comments:

ANNEXURE E: STATISTICAL CALCULATIONS OF SURVEY RESULTS

Table 45: Ordered datasets used to calculate inner boundaries of datasets

Survey statements with their received	
Dataset 1	Dataset 2
Lean implementation in healthcare environments has increased over the past two decades	Lean has the capability to increase a hospital's quality of service and performance
1	1
4	4
4	4
4	5
4	5
4	5
5	5
5	5
5	5
5	5
5	5
5	5
5	4
5	5

Dataset 1

Lower quartile (Q1) = 4

Median = 5

Higher quartile (Q3) = 5

Interquartile range (IQR) = $Q3 - Q1$

$$= 5 - 4$$

$$= 1$$

Lower inner boundry = $Q1 - (IQR * 1.5)$

$$= 4 - (1 * 1.5)$$

$$= 2.5$$

Upper inner boundry = $Q3 + (IQR * 1.5)$

$$= 5 + (1 * 1.5)$$

$$= 6.5$$

Dataset 2

Lower quartile (Q1) = 4

Median = 5

Higher quartile (Q3) = 5

Interquartile range (IQR) = $Q3 - Q1$

$$= 5 - 4$$

$$= 1$$

Lower inner boundry = $Q1 - (IQR * 1.5)$

$$= 4 - (1 * 1.5)$$

$$= 2.5$$

Upper inner boundry = $Q3 + (IQR * 1.5)$

$$= 5 + (1 * 1.5)$$

$$= 6.5$$

ANNEXURE F: SLIR WITH INDICATED SOURCE OF INPUT

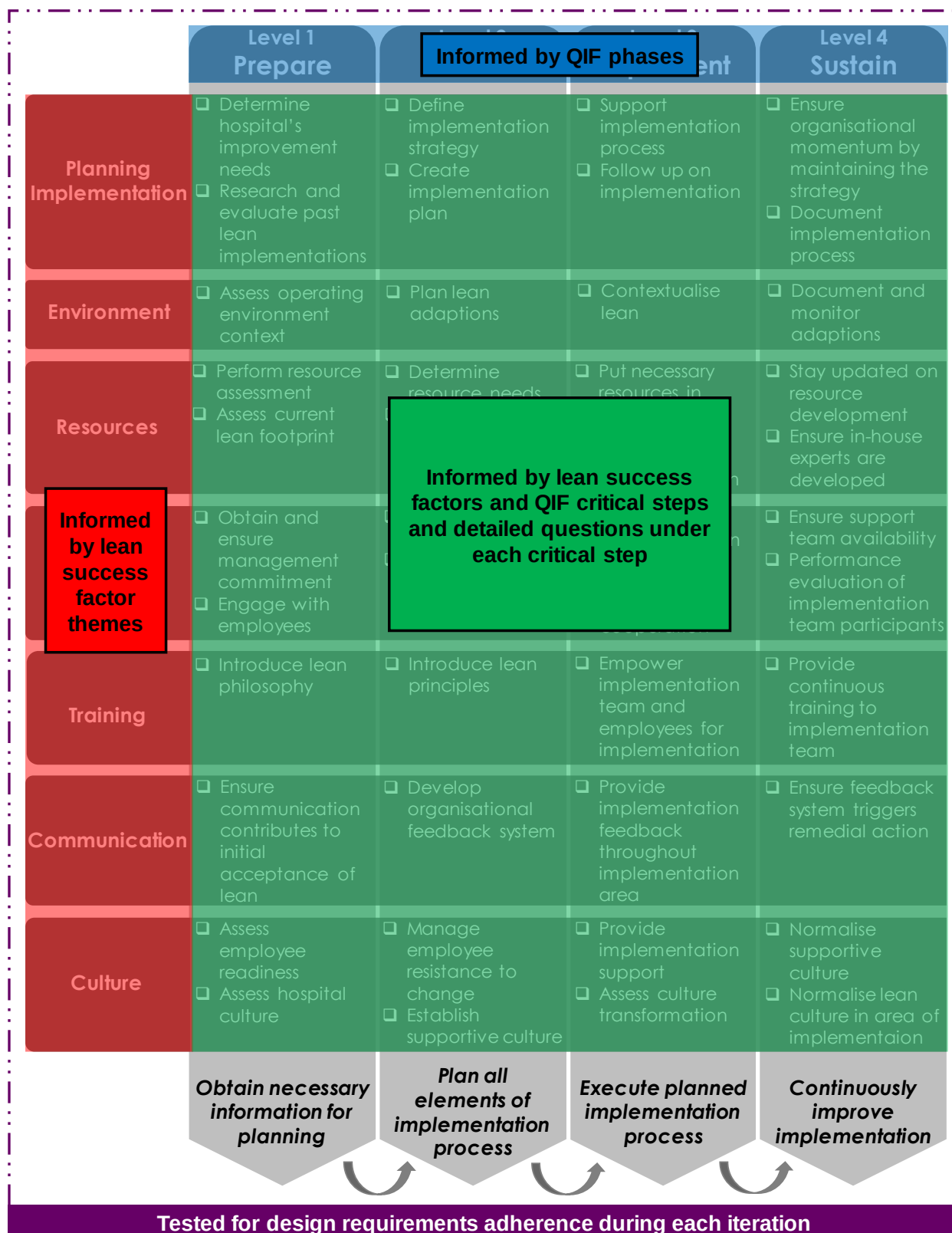


Figure 39: SLIR with indicated sources of input

ANNEXURE G: RESEARCH OBJECTIVES FULFILMENT

Table 46: Breakdown of research objectives and their fulfilment

Research objectives	Confirmation	Corresponding chapter(s)
To explore sustainable Lean implementation in hospital environments as a relevant research problem	Research problem's relevance was explored in chapter 1 based on various literature resources and validated in chapter 6 by means of the survey	·Chapter 1 ·Chapter 6
To investigate maturity models and determine whether a maturity model that address the aim of this study exists in the current body of knowledge	Maturity models was investigated as part of the study's literature review. As part of the literature review it was determined that not only is there no maturity model in the current body of knowledge that addresses the aim of this study but also that little literature on Lean healthcare maturity models exist.	·Chapter 2
To define and develop the input required for the development of the SLIR	In chapter 4 the model input is defined as: Lean healthcare implementation success factors, a relevant implementation science framework and the SLIR's design requirements. These three inputs are respectively developed in chapter 4 by means of a SLR, a self-developed framework selection process and maturity model design requirements literature.	·Chapter 4
To develop the SLIR	The study's research methodology is based on a procedure model developed to guide the development of a maturity model. Chapter 3 reports on this research methodology and chapter 5 reports on the development of the SLIR by following an iterative maturity model development approach together with a bottom-up design approach and using the model inputs. Defined in chapter 4, to inform the development of the SLIR.	·Chapter 5
To verify that the SLIR adheres to all its design requirements	The SLIR's adherence to it's DRs was evaluated by means of a retrospective view and an evaluation survey.	·Chapter 6
To validate the SLIR	Validation was done by means of an evaluation survey. Validation was broken down into three components: the research problem, the research methodology and finally whether the SLIR addresses the research problem. All three these components were validated by the survey's respondents.	·Chapter 6