

THE DEVELOPMENT OF A LEAN MATURITY MODEL IN THE CONTEXT OF NURSE PROBLEM-SOLVING

Aantal woorden/ Word count: 33592

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Promotor/ Supervisor: Prof. dr. Paul Gemmel

Masterproef voorgedragen tot het bekomen van de graad van:
Master's Dissertation submitted to obtain the degree of:

Master of Science in Business Engineering

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Foreword

I chose to write a master dissertation about lean management applicable in hospitals because first of all the term lean management is not unknown for me. In courses like 'Productiebeleid', 'Service Management', 'Advanced Production Management' and 'Supply Chain Management', the term lean management was discussed. Learning about lean management in theory was one thing, but I wanted to learn how it could be applied in practice. Secondly, my interest in the healthcare sector comes from the fact that I already did a lot of group assignments about the healthcare sector and because my mother is a head nurse of a department in the hospital of Aalst. She gave me inspiration and practical insights about my research topic.

I would like to thank some special persons since without them it wouldn't be possible to complete successfully this master dissertation. I would like to thank first of all my promotor *prof. dr. Paul Gemmel* for the time he spend with me in developing the research topic, thinking about the implementation and practical feasibility, reading the text, providing recommendations, improvements and useful insights, and getting me into contact with lean experts. Prof. dr. Paul Gemmel is a very friendly person who is always willing to help and I have a high regard for his thorough knowledge on the healthcare environment. Secondly, I would like to thank the lean experts who were willing to make time free for the in-depth interviews. Despite their buzzy schedule, *Raf Coppens, Kris Vierendeels, Pascal Vanmeenen, Hans Crampe, Alain Antierens and Sylvain Landry* were willing to get their mind into the lean maturity model in the context of nurse problem-solving. I obtained a lot of valuable feedback and this certainly served as an input for improving my research. Moreover, I learned more about the Flemish hospitals and how lean management is perceived from their point of view, in contrast to the academic standpoint. I would also like to thank *Simon Van Beveren* for his interesting and profound master dissertation. I liked to work further on his work. Furthermore, I would like to thank both of my parents, *Hilde* and *Frédéric*, who were willing to control the text and to give constructive advices. Moreover, they were a great support during the time I worked on my master dissertation. I would also like to thank my parents that they gave me the opportunity to go to the university and that they gave me the freedom to choose what I wanted to learn. Moreover, I would like to thank my brother *Alexander* and sister *Charlotte* in the times that I struggled with the master dissertation because they were always there to sheer me up.

To all of these person, thank you. And to all the readers, lots of reading pleasure.

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List Of Used Abbreviations

PW Productive Ward

SEI Software Engineering Institute

CMM Capability Maturity Model

CMMI Capability Maturity Model Integration

People CMM People Capability Maturity Model

LESAT Lean Enterprise self-assessment tool

LAI Lean Aerospace Initiative

HALMAT The Highways Agency Lean Maturity Assessment Toolkit

IRISS Interdisciplinaire de Recherche et d’Intervention dans les Services de Santé

MSSS Le ministère de la Santé et des services sociaux du Québec

i.e. id est / that is / in other words

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1 INTRODUCTION

In this master dissertation a lean maturity model is developed that is able to assess the degree of lean implementation in a department of a hospital in the context of nurse problem-solving behavior. More specifically, the degree of lean implementation is assessed in a department of a hospital, where the lean assessment is focused on the way nurses solve problems. The real aim of the model is thus not to measure lean thoroughly, but do a quick scan of the lean maturity in a department of a hospital, where the quick scan involves investigating the way in which nurses solve problems. The model is based on theory, models found in literature and on the knowledge of lean experts.

A lean maturity model is a self-assessment tool that assesses lean management in an organization. The outcome of the model is a lean maturity level that represents the degree in which an organization adopts lean management into its business. Lean management is a technique originated from manufacturing and is now adopted in different types of organizations. The technique aims to continuously improving business' processes to increase customer value.

This master dissertation is built on the master dissertation of Simon Van Beveren (2015). Van Beveren's work is called 'The Impact of Lean on the Problem-Solving Behavior of Nurses'. He investigated if the lean philosophy has an impact on the behavior of nurses to solve problems. (Van Beveren, 2015) More specifically, the research question of Van Beveren (2015) dealt with the fact that "in a successful Lean environment, hence in an environment in which the maturity of Lean implementation projects reaches high levels, second-order problem-solving behaviors displayed by nurses who face organizational problems will be more frequently observed than second-order problem-solving behaviors performed by nurses employed in environments in which Lean has lower levels of maturity." (Van Beveren, 2015, p. 34)

To prove the research question in practice, Van Beveren (2015) surveyed nurses from different hospitals using a scenario-based assessment tool. Two hospitals in Belgium were chosen, namely the University Hospital of Ghent and the University Hospital of Antwerp. In each hospital two departments were selected with a varying degree of lean maturity. A first department with a high level of lean maturity and a second department with a low level of lean maturity. In Ghent, the selection procedure was based on the experience of lean in the departments. One department was widely known for its lean implementation, while the other department had no experience with lean. However in Antwerp, this measurement technique could not be made. In this hospital, a Productive Ward (PW) program was implemented throughout the whole hospital. This program was based on the lean philosophy. So they had their own lean maturity scale. Therefore, based on the degree of PW implementation (or the degree of lean implementation), a

department with high level of lean maturity and a department with low level of lean maturity could be selected. In the two departments of each hospital, nurses were surveyed according to a scenario-based tool in order to prove whether the degree of lean maturity had an impact on the problem-solving behavior of nurses. (Van Beveren, 2015)

Unfortunately, the research question could not be confirmed in both hospitals. In the hospital of Antwerp the proposition was valid, in opposition to the hospital of Ghent. Van Beveren (2015) investigated why the proposition could not hold in both hospitals and came up with several explanations. First of all, both hospitals had a different approach in implementing lean. In Antwerp, the hospital implemented lean in an holistic approach, based on the Productive Ward Program. The program was implemented in every department so that all employees were involved in the lean approach. Moreover, the lean implementation was supported by the hierarchical structure of the hospital. In Ghent, such a holistic approach did not exist. Only a couple of departments worked according to the lean culture. This was due to the fact that lean was not developed throughout the whole hospital. Lean practices were implemented in some departments as stand-alone projects. Top management did not supported the lean implementations, only some middle managers. Secondly, the hospital of Ghent saw lean as a bundle of lean practices and lean tool that had to be implemented. Antwerp on the other hand, saw lean as a real management philosophy, a different way of working. Thirdly, the scenario-based survey executed in both hospitals performed not as it should be. This surely had effects on the results. (Van Beveren, 2015)

Van Beveren (2015) eventually made a couple of recommendations for further investigation. The most important one was that a new method should be used to determine the lean maturity in the departments. More specifically, a standardized scale which measures lean maturity should be developed. With this standard method researchers can rely on objective data instead of just the perception of the hospitals in evaluating lean maturity in departments. Moreover, comparisons between hospitals can be made in terms of lean maturity when using the standardized scale. Van Beveren (2015) also stated that the maturity model based on the Productive Ward program could be a first step in developing this standardized scale.

This recommendation is of big interest. It is clear that hospitals nowadays don't have a standard method to measure the degree in which they implemented lean management into their organizations, like the University Hospital of Ghent. That is why this master dissertation focuses on the development of a standardized tool which measures lean maturity in departments of hospitals. The tool will not measure lean in all its facets, but will only measure lean in the function of nurse problem-solving behavior since the effect of lean on the problem-solving behavior of nurses is studied.

2 RESEARCH METHOD

The research method, represented by the model development framework, consists of several consecutive phases. Each phase has to be followed in the development of the lean maturity model in the context of nurse problem-solving. The method is based on the work of Maasouman & Demirli (2015).

In the *literature review stage*, more information is studied about the research topic. On the one hand, the review is concerned about lean maturity models. In this review, more information is searched on basic lean concepts, principles, tools and objectives, but also on the elements that are part of a lean maturity model namely lean maturity levels and lean maturity dimensions. Moreover, general lean maturity models are described that serve as an illustration. On the other hand, the review is concerned about problem-solving. The definition of problem-solving and different models related to problem-solving are described. The findings out of the first and second part of the literature review serve as a base for the development of the lean maturity model in the context of nurse problem-solving behavior.

In the *design stage*, lean maturity levels, dimensions and assessment items are designed. These are the interplay between the theory found in the literature review and the practical knowledge of lean experts. These lean experts have the task to validate the lean maturity levels, dimensions and assessment items of the designed model. The validated levels, dimensions and assessment items form together the lean maturity model in the context of nurse problem-solving.

The former stages are all performed in this master dissertation. The stages which are further described are not performed in this master dissertation, but need to be executed in order to completely develop the model.

In the *measurement stage*, the lean maturity model in the context of nurse problem-solving is tested. Respondents from departments with a varying degree of lean maturity should complete the model.

In the *analysis stage*, the data is analyzed to determine the overall lean maturity level for a department. This level is based on the lean maturity of the different dimensions' components.

In the *verification stage*, the research results are discussed and verified. It is believed that in departments with a high degree of lean maturity, nurses perform more frequently second-order problem-solving behavior than the second-order problem-solving behavior performed by nurses from a department with a low degree of lean maturity. (Van Beveren, 2015) If this statement is true, the model is validated completely and can be used in further research.

3 RESEARCH BACKGROUND

3.1 Introduction

Today, organizations continuously try to improve their business to gain a competitive advantage in order to outcompete rivals. Cutting costs, improving quality, improving efficiency and so on are part of the daily business. Maturity models are developed to support organizations in this aspiration. These models are intended to evaluate the maturity of a selected domain in an organization based on a set of criteria. They also have an informative approach for increasing the capability of the specific area. (De Bruin, Rosemann, Freeze, & Kulkarni, 2005)

The first maturity models were introduced by the Software Engineering Institute. The SEI is an American research and development center, which task is to optimize the developing, acquiring, and maintaining of software-reliant systems. (Rouse, 2007) The SEI invented six maturity models. The most well-known model is the Capability Maturity Model (CMM). (De Bruin et al., 2005) This model helps organizations to develop and improve their software development processes. (Rouse, 2007) "The CMM is a framework representing a path of improvements recommended for software organizations that want to increase their software process capability." (Wendler, 2012, p.318) Paulk et al. (1993) stated that the CMM provides the most common and widely adopted structure amongst maturity models. (Nesensohn, Bryde, Ochieng, & Fearon, 2014) In the beginning, the model was developed for military purposes, as an evaluation method for software subcontractors. Recently, the CMM and 2 other maturity models merged together to 1 model named the Capability Maturity Model Integration (CMMI). At least, the other 2 models are called the People Capability Maturity Model and the Software Acquisition Capability Maturity Model. (De Bruin et al., 2005) Besides the Software Engineering Institute, there are many other maturity model developers. These developers do not only focus on software-related domains. Diverse topics that are also covered in maturity models include project management, quality management, business process management, strategic, information technology, learning, human resources, testing, analytics, enterprise architecture, energy infrastructure, sustainability, supply chain, social media, marketing, continuous delivery, support, and security assurance. ("Maturity model", n.d.)

Unfortunately, quantity does not entail quality. There exist a lot of disapproval about published maturity models. Pöppelbuß & Röglinger (2011) declare that there exist criticism on the process of maturity model design and on the maturity models as design products. The former implies that the design process of maturity models is insufficiently documented. The models are just a non-reflective adoption of the CMM model. In some maturity models, little information is given about how the models are effectively developed. (Mettler & Rohner, 2009) Many maturity

models are built on former models without a critical view on the appropriateness of the assumptions of these models. (Kohlegger, Maier, & Thalmann, 2009) Authors such as Becker et al. (2009) claim that the major weakness of maturity models is that these models oversimplify reality. The models lack commonly accepted methods (Domingues, Sampaio, & Arezes, 2016) and empirical foundation. The latter implies that there is no general understanding of the maturity model's form and function. (Pöppelbuß & Röglinger, 2011)

3.2 Maturity models

A maturity model represents the evolution of an organization of people, technology, products and processes. (Nesensohn et al., 2014) The model is described as a collection of steps that include different stages of a process development. The maturity model stages are sequential and represent a hierarchical development. Additionally, they should be closely connected to the organizational structure and activities. (Wendler, 2012)

According to the Oxford English Dictionary, maturity can be defined as “the state of being complete, perfect or ready”. “Maturity thus implies an evolutionary progress in the demonstration of a specific ability or in the accomplishment of a target from an initial to a desired or normally occurring end stage.” (Mettler & Rohner, 2009, p. 2)

Maturity can be defined from another point of view. A process which has the power to develop itself from initialization to the ideal state is called mature. Thus, maturity is measured for so called capabilities. (Wendler, 2012) According to the Oxford English Dictionary, a capability is defined as “A capacity, the power or ability in general, whether physical or mental” (Wendler, 2012, p. 1318) to perform certain goals.

According to Mettler & Rohner (2009) maturity consist of three dimensions. The process maturity, the object maturity and the people capability. The first one is the degree in which a process is defined, managed, measured, controlled and effective. The second, object maturity, is the degree in which an object or tool that support the process reaches a level of sophistication. And last, the people capability reflects the degree of employee commitment, knowledge creation and enhanced expertise.

Wendler (2012) stated that a process that reaches the end maturity stage can be perceived from two points of view. First, the life cycle perspective and second from a potential performance perspective. The former one defines the levels of maturity based on an organizations life cycle. The organization evolves over time while passing all stages of growth due to improvement and learning effects. Eventually, the final stage can be reached which is called maturity. Then, the corresponding management technique is really sustained into the

organization. The potential performance perspective has also a final stage, which is the perfect or best, but the previous stages are not based on a life cycle. Rather, the levels focus on the potential improvements which occur by moving further. Every level represents an intrinsic effectiveness and natural value. The organization itself has to decide which level of maturity is the best for their current situation, and if they are ready to proceed to the next stage. Most of the models today are following the potential performance perspective.

While reviewing several maturity models, one observation is that all maturity models got the same composition. They all describe a number of maturity levels that represent the stages of maturity. A description of these levels is given where the characteristic performance of the levels is specified. The basic components of a maturity model according to Fraser (2002) are first of all the number of maturity levels, a descriptor for each level, a generic description for each level, next the number of dimensions, the number of elements or activities for each dimension and a description of each element or activity for each dimension. (Mettler & Rohner, 2009) As an illustration, the People Capability Maturity Model is used to demonstrate the basic components of a maturity model according to Fraser (2002). The People Capability Maturity Model is developed by the SEI. The People CMM is used as a “roadmap for implementing workforce practices that continuously improve the capability of an organization’s workforce.” (Curtis, Hefley, & Miller, 2001, p.3) It helps organizations in determining their current workforce maturity and improving their processes for managing and developing their workforce. (“People Capability Maturity Model”, 2016) This model consists of 5 levels ranging from low maturity to high maturity. Each level has a number, descriptor and description. 22 dimensions are integrated which represent the different process areas and each dimension has a number of elements or activities and a corresponding description. (Curtis et al., 2001)

Number of levels	Level 1	Level 2	Level 3	Level 4	Level 5
Descriptor	Initial	Managed	Competency management	Capability management	Change management
Description	Workforce practices applied inconsistently	Managers take responsibility for managing and developing their people	Develop workforce competencies and workgroups, and align with business strategy and objectives	Empower and integrate workforce competencies and manage performance quantitatively	Continuously improve and align personal, workgroup, and organizational capability

Table 1: Illustration of Fraser’s theory on the People CMM, by Curtis et al. (2001)

The levels in a maturity model can be defined by a top-down or a bottom-up approach. In the first method, definitions of the stages are written and next the assessment items are developed to fit these definitions. The opposite occurs in the second method. The assessment items are described first and next the stages which capture the essence are defined. (Mettler & Rohner, 2009)

Since maturity models are representing stage-of-growth models, stage models, or stage theories, the basic purpose entails a description of the maturity stages. Maturity models in practice on the other hand, are used to define the organization's current and desirable capability (Pöppelbuß & Röglinger, 2011) or to implement an improvement strategy into the enterprise. The objective is to identify and remove deficient capabilities. (Nesensohn et al., 2014)

Pöppelbuß & Röglinger (2011) described 3 application-specific purposes of maturity models. The first purpose is descriptive. Maturity models are used for as-is assessments where the entity's capabilities are assessed according to specified criteria. The second purpose is prescriptive. It identifies the entity's desirable maturity level and gives recommendations for improvement. The last purpose is to compare the maturity levels of similar organizations.

3.3 Lean maturity models

A lean maturity model is a maturity model applied into the area of lean management. A lean maturity model has the intention to determine the position of a company in terms of implementing a lean culture in its organization. It is actually a guiding tool that helps to assess the current business situation against the basic lean principles as well as continuously following the degree of implementation over a period of time. ("Lean maturity matrix tutorial", n.d.) Thus, in literature, lean maturity models are frequently called lean assessment tools.

Over the last years, companies implemented improvement techniques such as lean at a high extent. Hence, there was an explosion in the development of lean assessment tools in order to keep track of this lean evolution. (Maasouman & Demirli, 2015) The most comprehensive model of lean transition found in literature is called the lean enterprise self-assessment tool (LESAT). It is a lean maturity model that is developed by the Lean Aerospace Initiative (LAI) at the Massachusetts Institute of Technology. It mainly focusses on internal and external relations in the organization and on strategic lean implementation. (Maasouman & Demirli, 2015) The LESAT model is a tool for organizations to self-assess lean maturity and its readiness to change. It is a simple, easy to use tool that is completed by enterprise leadership. It focusses on the lean characteristics and is aligned with the business performance planning. Goals are determined upfront are compared with the results of the lean assessment. (Nightingale, 2005) The tool also provides feedback for improvement. (Urban, 2015)

3.4 Lean maturity models in hospitals

Hospitals have to deliver healthcare services to more people with higher quality and security and with fewer employees and economical resources. (Curatolo, Lamouri, Huet, & Rieutord, 2014) In today's world, hospitals face a growing pressure in terms of service quality, patients safety, efficiency, costs, waiting times, staff morale, and many more. (Grabau, 2011) These pressures come from both outside and inside stakeholders like the environment, government, stockholders, employees and patients. If hospitals keep on operating in the same way, pressure from these elements above will keep on increasing. This results in longer waiting times, reduction in quality through an increase in errors, higher costs, decrease in employee motivation and satisfaction and a decrease in customer satisfaction. (Robinson, Radnor, Burgess, & Worthington, 2012)

Since every hospital continuously want to improve their performance, a series of tools, methodologies and models are implemented into the business. The lean management approach is a technique that is very effective at achieving productivity improvements in a relatively short time. (Urban, 2015) With lean management, processes will streamline, employee satisfaction will increase, finances of the hospital will boost, and patient care will improve. (Berczuk, 2008) That is why nowadays more and more hospitals implemented lean management into their business.

Therefore, maturity models can be used by hospitals to review the performance of lean management into their business. Maturity models are able to measure the degree of lean implementation, give feedback regarding the weak points in the healthcare system, suggest improvement techniques, and support for continuous improvement. Moreover, they can be used to compare different hospitals. (Pöppelbuß & Röglinger, 2011)

Although many maturity models are developed for the healthcare sector, few lean maturity models exist that assess lean management in hospitals. A lot of projects are set up or are running at this time, but no profound publication is online yet. Since a lot of hospitals are implementing lean management into their business, a tool is needed that measures the maturity of lean instead of relying on subjective assumptions. That is why in this master dissertation, a lean maturity model is developed that will measure the degree of lean implementation in departments of hospitals. This model is a quick scan of lean maturity i.e. it doesn't assess lean management in all its aspects but only in the context of nurse problem-solving behavior.

4 LITERATURE REVIEW: LEAN MATURITY MODELS

4.1 Maturity levels

Existing lean maturity models all have the same design principle by representing lean maturity as a number of hierarchical stages. The first stage signifies low lean maturity while the last stage represents the highest level of lean maturity. The lean maturity levels are all distinct and well-defined. Furthermore, each level builds on the requirements of lower levels and there is a logical development through the stages. (De Bruin et al., 2005)

Lean maturity levels are represented by the hierarchical progression of lean management in an organization. According to “Lean maturity matrix tutorial” (n.d.), Jorgensen, Matthiesen, Nielsen & Johansen (2007) and Raje (n.d.), the progression of lean management in a company is categorized into 5 levels.

Level	Description
Sporadic optimization	<ul style="list-style-type: none"> - The company does not adopt lean management into its business. - Optimization project are executed but are occasional, random, not planned and not supported by a strategy or philosophy. - The optimization project are led by experts, no involvement of employees.
Basic lean understanding and implementation	<ul style="list-style-type: none"> - Lean management is recognized. - Employees are encouraged to contribute and start believing in lean. - Start of education and training for lean awareness for both experts and personnel. - Tools and techniques are made accessible in isolated units. - The management has set-up improvement programs based on the philosophy of lean management. - The program’s methodology is not clearly defined and deployment is inconsistent. - Lean programs are executed in isolated teams.
Strategic lean interventions	<ul style="list-style-type: none"> - Lean management is a part of the company’s strategy. - Projects and activities translate the strategy into lean execution. They all have one common goal. However, they are still implemented according to an established plan. - The lean philosophy as well as theoretical and practical lean tools and methods are spread into every level of the company through education and training programs. - First performance improvements are achieved with the lean projects.
Proactive lean culture	<ul style="list-style-type: none"> - Lean projects occur continuously from all areas of the company since practical lean tools and method are highly understandable.

	<ul style="list-style-type: none"> - All units throughout the company now strive for quality, cost and delivery performance measures and local targets. - The lean philosophy is more like a habit than a task. - The lean improvement project are only executed inside the boundaries of the company rather than extended outside. - An information infrastructure is used that supports information exchange across the company.
Culture transformation	<ul style="list-style-type: none"> - The top maturity level. - All leaders support and encourage the lean philosophy to achieve quality, cost and delivery targets. - Education and training of the employees is linked with the strategy and the budget determined from business performance improvement needs. - The majorities of improvement projects are derived from analysis of the gap between current and desired performance. - Improvement projects are no longer executed inside but also outside the boundaries.

Table 2: Lean maturity levels, by "Lean maturity matrix tutorial" (n.d.); Jorgensen et al. (2007); Raje (n.d.)

Many existing maturity models use one-dimensional linear stages as a representation of maturity. The model's result is an 'average' maturity stage for the entity under investigation. The multi-dimensional approach on the other hand is used in complex related domains, like lean management, where maturity is much more differentiated. The model consists of different dimensions, where each dimension is subdivided into several components. This enables separate maturity assessment for each dimension, component and a maturity assessment for the entity as a whole. As a results, the maturity model determines a maturity level for the entity under investigation, a maturity level for the different dimensions and a maturity level for the components. The results of this multi-dimensional approach enable organizations to target easily strong and weak areas of their business. (De Bruin et al., 2005) This multi-dimensional approach is represented in the figure below.

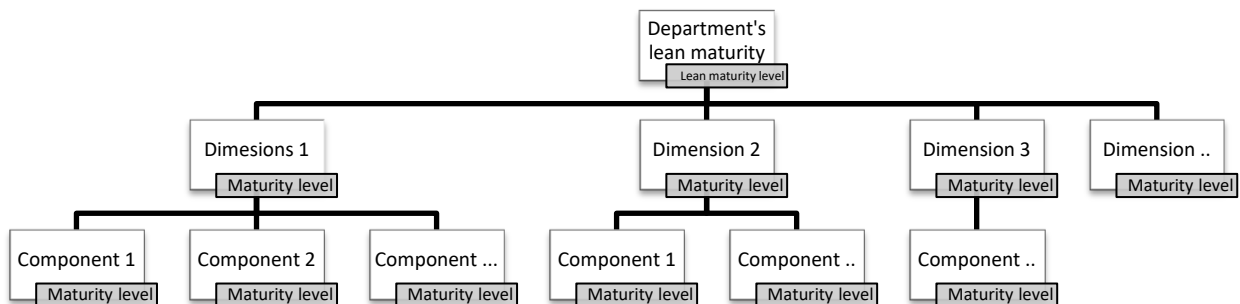


Figure 1: The multi-dimensional approach

Since a separate maturity assessment for each dimension and component is required, the definition of maturity will be different for each dimension and each component. Therefore they each will have different maturity levels. However, the levels for the dimensions and the components all signify the progression of a specific entity, or the capability to move further. That is why the levels of a maturity model are represented by capability maturity levels.

As Kohlegger et al. (2009, p. 59) stated: “A maturity model conceptually represents phases of increasing quantitative or qualitative capability changes of a maturing element in order to assess its advances with respect to defined focus areas.” According to Curtis et al. (2001, p. 17), “a maturity level represents a new level of organizational capability created by the transformation of one or more domains of an organization’s processes.” Therefore, an organization goes to the next level if they have created new practices or transformed existing practices that provides capabilities and results that the organization didn’t had at the former level. However, the transformation method of the practices is different at each level and necessitates capabilities at the former levels. (Curtis et al., 2001)

The term capability signifies the ability and capacity that enables an organization to achieve a business goal in a specific area. The term ability refers to the level of available competence. Capacity on the other hand refers to the availability of resources needed to employ the ability. (Bërzisa et al, 2015)

Originally, capability maturity levels were designed by Humphrey who developed the process maturity framework. He stated that a continuous process improvement evolves through 5 stages. The organization goes through several transformations, where each transformation entails a more sophisticated and mature level of best practices. (Curtis et al., 2001) The capability levels are shortly described as follows:

Level	Description
Initial	The implemented processes are chaotic and disorganized, mainly because the processes are not defined and documented. Therefore, the processes could not be executed repeatedly and individual group efforts are mostly present.
Managed	This is the foundation level since this level enables that processes are executed repeatedly. Processes are established, defined and documented through basic management practices. This allows that successes can be recurring.
Defined	Best practices are identified through documentation and are integrated into standard or common processes.
Predictable	The organization is able to control and manage its own processes through data collection and analysis.
Optimizing	The processes are being constantly optimized based on their quantitative knowledge.

Table 3: Capability levels, by Rouse (2007)

Although the levels were developed for software development, they have been used for general business processes worldwide. The LESAT model (Lean Enterprise Self-Assessment Model) is one example that adopted the 5 capability stages as levels of maturity for the assessment of lean management into an organization. The LESAT model consists of 54 practices, where each practice is assessed on a unique capability maturity scale from 1 to 5. (Nightingale, 2005)

The characteristics of the 5 process capability maturity levels are listed below.

Nr	Description
1	Some awareness of this practice, sporadic improvement activities may be underway in a few areas.
2	General awareness, informal approach deployed in a few areas with varying degrees of effectiveness and sustainment.
3	A systematic approach / methodology deployed in varying stages across most areas, facilitated with metrics, good sustainment.
4	On-going refinement and continuous improvement across the enterprise, improvement gains are sustained.
5	Exceptional, well-defined, innovative approach is fully deployed across the extended enterprise (across internal and external value streams), recognized as best practice.

Table 4: Process capability maturity levels, by Nightingale (2005)

To summarize, a lean maturity model is composed out of different dimensions and components. The main goal of the model is to determine the ultimate lean maturity level in an organization. This lean maturity level is represented by the progression of lean management and is calculated based on the lean maturity levels of the dimensions and the components.

Since for each component a separate maturity assessment is required, the definition of maturity will be different for each component. Therefore they each will have different maturity levels. However, the levels all signify the progression of a specific entity, or the capability to move further. Thus, there is a maturity definition for every capability maturity level in every component.

4.2 Maturity dimensions

A lean maturity model consists of lean maturity dimensions, where each dimension is composed out of different elements or activities. (Mettler & Rohner, 2009) The dimensions represent the content of the model or *what* need to be measured in the lean maturity assessment. (De Bruin et al., 2005)

The dimensions of the model have to be mutually exclusive and collectively exhaustive. (De Bruin et al., 2005) The term mutually exclusive means that all the information should be grouped into dimensions where there is no overlap between the dimensions. Collectively

exhaustive on the other hand means that all the dimensions added together covers all the possible options. (Cheng, 2016) In a mature domain, the identification of maturity dimensions is done based on an extensive literature review. This great stream of knowledge reduces the concerns whether the dimensions are mutually exclusive and collectively exhaustive. (De Bruin et al., 2005) Since lean management is a mature domain, the dimensions of the model are identified through literature review.

Constructing the lean maturity dimensions imply that the enablers of lean should be determined. More specifically, the areas in which lean has an impact on should be defined. In that way, assessing lean management means reviewing all the business areas where lean management is embedded. It is believed that the lean maturity dimensions are constructed based on the implementation process of lean management into an organization. Since in this master dissertation a lean maturity model in the context of nurse problem-solving for departments of hospitals is developed, the implementation process of lean into hospitals is discussed.

4.2.1 Lean management

First of all, the concept of lean management has to be understood thoroughly. Most of the time people consider lean management only as a cost and waste reduction technique. However, the opposite is true. Lean management is more than only waste and cost reduction. (Radnor, Holweg, & Waring, 2012) Lean is defined as “a management practice based on the philosophy of continuously improving processes by either increasing customer value or reducing non-value adding activities (muda), process variation (mura), and poor work conditions (muri).” (Radnor et al., 2012, p. 365)

In lean management, there is one central element namely value. “Value is defined as the capability to deliver exactly the (customized) product or service a customer wants with minimal time between the moment the customer asks for that product or service and the actual delivery at an appropriate price.” (Joosten, Bongers, & Janssen, 2009, p. 342) Lean aims at increasing the customer value to improve the business processes.

The main important aspect of the lean philosophy is removing all the waste streams in the processes. Ohno (1988) made a detailed definition of the different manufacturing wastes. He stated that the elements of wastes are located in 7 domains: transportation, inventory, motion, waiting, overproduction, over-or inappropriate processing and defects. These types of waste are translated later into different types of service wastes. (Robinson et al., 2012)

Womack & Jones (2003) defined lean through 5 operational principles of lean thinking: “provide the value customers actually desire, identify the value stream and eliminate waste, line up the remaining steps to create continuous flow, pull production based on customers consumption,

and start over in a pursuit of perfection". (Joosten et al., 2009, p. 342) These principles relate the concept of value, waste reduction, and continuous improvement into an ever-iterative process. (Robinson et al., 2012)

The second element of lean management is mura, or process variation. Processes are subjected to variation that comes from the variation in the demand. The customer demand is uncertain and unstable. Variable processes imply that the process flows are not smooth and less efficient. Thus, process variation has to be reduced. (Robinson et al., 2012)

Muri, or poor working conditions is the last element that lean management aims to reduce. Organizations need to go for good working conditions in order to prevent injuries and stress on the employees. (Robinson et al., 2012) A good working climate will increase employee productivity and satisfaction.

4.2.2 Implementation process of lean

Besides the knowledge of lean management, an investigation has to be done on how lean is implemented into hospitals. The implementation process of lean management into a hospital is investigated by Zidel (2009), who made a model for lean implementation. (Zidel, 2009)

According to Zidel (2009), a hospital that adopts lean management into its business has to follow an implementation route if it wants that the transformation happens successfully. The model consists of 2 paths. The first path is the culture creating path and the second path is called the system creating path. However, both paths have the same starting point namely the hospital's strategic plan. The strategy of the hospital needs to provide direction regarding establishing a lean culture and improving the care delivery system. Thus, the strategic goals of the hospital cascades down into the different units of the organization. The first path aims at creating a lean culture where continuous improvement, empowerment, recognizing problems, training, and taking action is the standard. On the other hand the second path aims at creating a system which is based on the lean management principles. The system is focused on flow through the value streams, eliminating waste, and smoothing the processes. These 2 paths are interdependent which means that results on one path affect the performance on the other path. Moreover, these 2 paths are necessary to conduct a successful lean transformation.

This point of view leads to the conceptual framework of lean thinking in hospitals by Joosten et al. (2009). Lean thinking in healthcare is subdivided into an operational aspect and a sociotechnical aspect. The former approach aims at using technical tools like 5S and visual stream mapping to create value. These lean tools focus on removing non-valuable elements in the processes. Hospitals can reduce inventory and waiting times and improve productivity and quality using these lean tools. The latter, namely the sociotechnical aspect of lean thinking

studies the relationship between social and technical elements of lean since lean implementations have an impact on the hospital's staff's job task. More specifically, some jobs become more simple and repetitive through standardization, or require more thinking, planning and responsibility. Moreover, the managerial task is also shifted. Managers need to create a culture where there is better collaboration between the employees in order to increase the level of performance. Joosten et al. (2009) claimed that these 2 aspect added together return synergies for the hospital. The term cumulative capabilities is then used. Higher performance is achieved when a hospital focusses both on the sociotechnical aspect of lean thinking and the operational aspect. Higher quality, speed and flexibility on the one hand and better working condition and organizational climate on the other hand.

In this research it is believed that the system creating path in the Zidel model (2009) and the operational aspect of Joosten et al. (2009) are based on the operational principles of Womack & Jones (2003). That is why most lean maturity models found in literature are based on the 5 operational principles of lean management by Womack & Jones (2003). These 5 principles of lean thinking are thus partly representing the enablers of lean management. The other enablers of lean management are represented by the culture creating path in the Zidel model (2009) and the sociotechnical aspect of Joosten et al. (2009).

4.3 Model examples

As an illustration, 3 models are described in the section below to understand the theory behind a lean maturity model. The first model, the Lean Maturity Self-assessment Tool, is constructed for the healthcare sector. It is thus a very good representation for this master dissertation. The second model, the Highways Agency Lean Maturity Assessment Toolkit (HALMAT), is a model not applied into the healthcare sector, but is a very good example to understand the design principles of a lean maturity model. The last model, the PW model, is a lean maturity model used by the University Hospital of Antwerp and recommended by Van Beveren (2015).

4.3.1 Lean Maturity Self-assessment Tool

The Lean Maturity Self-assessment Tool is developed by the HEC Montréal Health Cluster and the IRISS Chair (Interdisciplinaire de Recherche et d'Intervention dans les Services de Santé) and is part of the research study issued by the MSSS (le Ministère de la santé et des services sociaux du Québec). The purpose of the model is that healthcare organizations can self-assess their lean maturity level. In that way, the deployment of lean in these organizations can be monitored and thus can be used as a reflection process for the organization. (Jobin et al., 2015a)

The model is constructed based on a literature review on lean maturity and on a field research with 3 showcase centers and 6 lean institutions, which are part of the MSSS project. (Jobin et al., 2015a) More specifically, the MSSS made commitment to study the approach of lean, more specifically in healthcare. The ministerial project was split-up into two phases each with a different focus. In the first phase, that ranged from 2011 until 2014, the MSSS made an investment of 12 million to select three healthcare institutions where lean projects were realized. In the second phase, from 2013 until 2015, MSSS made again an investment of 12 million to examine 16 institutions. There, they investigated the cultural change of the sustained lean institutions. Of course, the MSSS needed a system that evaluated the performance. The measurement system needed to investigate whether the institutions from phase 1 were capable to work with the lean processes, whether the lean processes led to good results and whether investors were able to get their money back. Thus, an extensive field research was done in collaboration with several Quebec healthcare organizations to develop this measurement system. To summarize, the goal of the project was firstly to develop a monitoring tool for healthcare institutions and the MSSS in the evolution of their organizational performance and their lean practices. Secondly, to develop a lean assessment tool for the institutions and thereby to measure the maturity of lean. Thirdly, to be able to transfer the lean success factors to other organizations. (Jobin et al., 2014)

The model is composed out of 10 dimensions, where each dimension consists of different components. Each component is evaluated using an assessment question, which is measured on a scale from 1 until 5. To calculate the level of maturity for the organization, an average is taken from the maturity levels of the different assessment questions. No weighting is taken into account, thus each dimension has the same level of importance. When the maturity model is completed, the distribution scores for each dimension is illustrated on a web chart, which is a graphical representation of the end scores. The organization obtains thus a level of lean maturity on a 5-point scale. A higher level of lean maturity corresponds to a more mature lean healthcare organization. The self-assessment tool consists of 3 lines of transformation. The 3 themes are called coherence, capability and engagement. Coherence is related to the alignment of the strategic vision at the top of the organization and the translation of this vision into the different areas of the organization. Capability refers to the degree in which the organization controls lean tools, lean techniques and lean practices. Engagement evaluates how deep the lean culture is embedded in the organization. (Jobin et al., 2015a)

The maturity model with the corresponding dimensions and components is summarized in the table. The real maturity model (in French) is illustrated in the figure below. For more interest, the complete model with the lean maturity levels for each of the dimension's components can be obtained by the HEC Montréal Health Cluster or the IRISS Chair.

Theme: Coherence	
Patient / user value	<ul style="list-style-type: none"> Listening to patient / user family Patient involvement in projects and continuous improvement initiatives Impact on patient experience Tangible improvement in organizational results Integration of risk and quality management for patients
Performance management	<ul style="list-style-type: none"> Measurement culture Presence and use of scorecards / dashboards Monitoring sharing and steering of plans Accountability reporting and organizational learning upon completion of plans Accountability and empowerment Benchmarking
Strategy and governance	<ul style="list-style-type: none"> Focusing the organizational issues and strategic objectives Shared planning and cascade of objectives to units Bottom up communication Organizational vision consistent, clear and shared Project portfolio management Alignment of objectives of lean projects and continuous improvement initiatives with organizational objectives Approach to prioritization and selection of lean projects and continuous improvement initiatives Concentration of lean deployment in model units Internal human resources dedicated to supporting lean Use of margins generated by lean projects
Continuous improvement and sustainability	<ul style="list-style-type: none"> Application of lean practices and principles in all projects and continuous improvement initiatives Standardization of work (organization of work, procedures and protocols) Audits and controls Optimal use of lean in improvement of clinical practices Daily continuous improvement Right to experiment and take risk Sharing and learning of knowledge acquired in projects/continuous improvement initiatives Maintaining knowledge
Theme: Capability	
Processes (tools and techniques)	<ul style="list-style-type: none"> Process documentation Flow management Error and irregularity Identifying and eliminating waste Use of lean approach Search for root causes of problems Visual management
Project and change management	<ul style="list-style-type: none"> Meeting initial objectives Project scope Project management tools Team makeup Team dynamics Change management in lean projects Implementation of solutions Experimentation in projects or continuous improvement initiatives Closing activities

Cross-functional management	<ul style="list-style-type: none"> Cross-functional vision Client orientation shared by process actors Process owners Empowerment within processes Interdisciplinary within processes Collaboration within process teams Clarity of roles and coordination between process actors Management based on measurement and analysis of results within processes Process accountability
Theme: engagement	
Stakeholders	<ul style="list-style-type: none"> Impact on organizational climate Engagement of management team (director general and team) Engagement of unions Engagement of physicians and/or clinical professionals Engagement of middle managers Engagement of employees Communication of progression of the lean approach Sharing of achievements and knowledge transfer Mobilization of external partners
Leadership	<ul style="list-style-type: none"> Lean management skills development Creation of an operational vision aligned with strategic objectives Coaching and development Support to continuous improvement Recognition, celebration and sharing of success internally Management team's presence, frequency and diligence on Gemba Middle managers' presence, frequency and diligence of Gemba
Support to projects and for transformation	<ul style="list-style-type: none"> Presence of consultants Cultural change management strategy Talent management practices (attraction and staffing, performance assessment and profile management) Provision of lean-related training Organizational development practices Capacities of existing information systems IT team support for data use Material and financial support from departments

Table 5: The Lean Maturity Self-assessment Tool, by Jobin et al. (2015b)

MATURITÉ LEAN

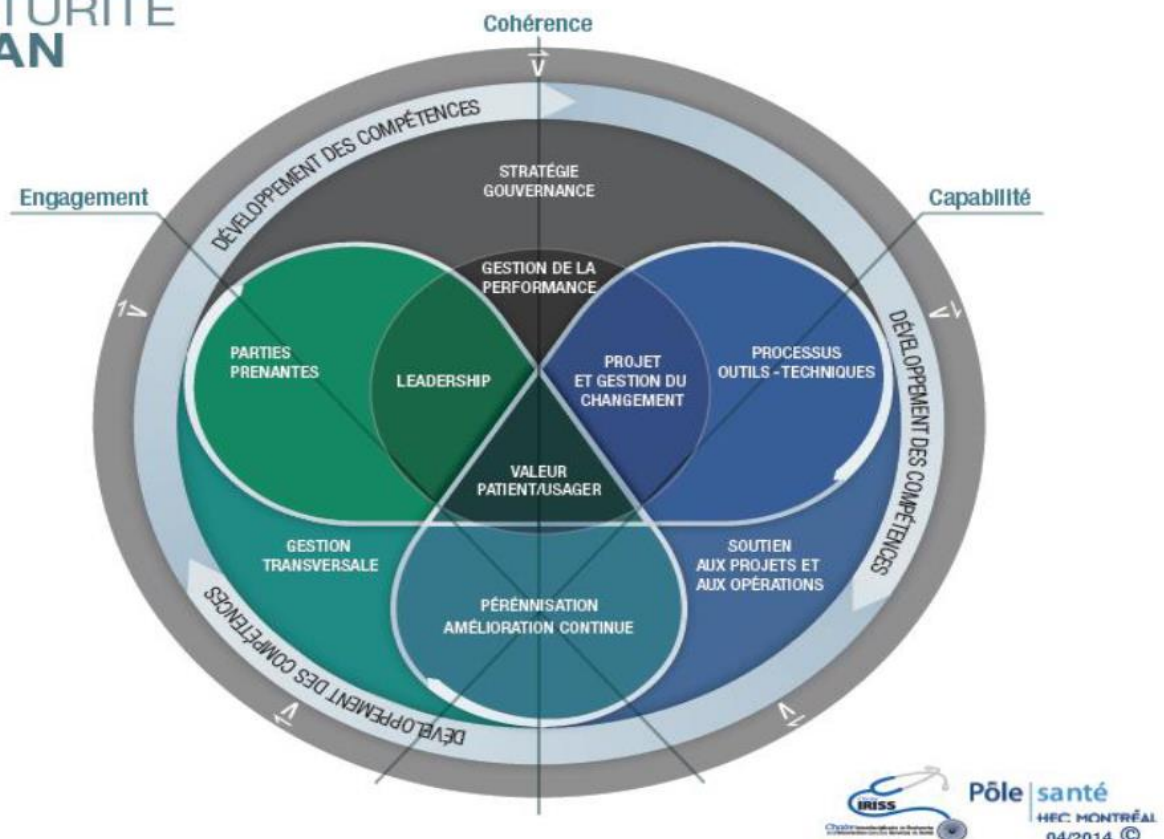


Figure 2: The Lean Maturity Self-assessment Tool, by Jobin et al. (2014)

As depicted on the figure, the patients value is the central element of the model and all other dimensions are situated around it. The themes engagement, coherence and capability intersect along the 10 dimensions. On the outer side of the figure, skills development is located which covers the 10 dimensions. “It allows users of the tool to consolidate the organization’s situation, and support changes and professional tracks, for a variety of processes required to attain the lean vision and objectives.” (Jobin et al., 2015a, p. 14) The 10 dimensions, together with skills development are the drivers of continuously transforming the organization. (Jobin et al., 2015a)

The advantage of this model is that it covers all aspects of a business environment. Like Maasouman & Demirli (2015) stated: such models provides a general direction and a company-wide roadmap. This is a good element because lean transforms the whole business where it is implemented eventually. Lean is a continuous improvement system in all layers of the organization. So every manager, employee, patient, union, etc. is integrated into the model. But this is a negative point too. The model is so large that a lot of time must be spend on the assessment of every component for every dimensions in order to assign a level of maturity. A big assessment is thus time-consuming and probably involves a lot of people. On top of that, when people don’t want to participate, biased results will be the consequence.

4.3.2 The Highways Agency Lean Maturity Assessment Toolkit (HALMAT)

The Highways Agency Lean Maturity Assessment Toolkit (HALMAT) is a lean assessment tool that “helps organizations in the Highways Agency’s supply chain to determine the extent in which they have transformed themselves to adopt lean principles in line with the Agency.” (Highways Agency, 2012, p. 4) The tool thus enables every organization in the Highways Agency’s supply chain to assess itself on the degree of lean implementation. In that way, those organizations can easily identify the areas where actions need to be taken and the areas where lean performance is outstanding. The organization can use an improvement template to help improve the areas where low lean maturity is marked. (Highways Agency, 2012) “It is the aim of the Highways Agency to encourage their supply chain to adopt Lean principles to help foster a culture of continuous improvement for mutual advantage.” (Highways Agency, 2012, p. 8) The Highway Agency, which is now called Highways England operates, maintains and improves England motorways and major roads and is owned by the government. (“Highways England”, n.d.)

The HALMAT assessment toolkit consist of 10 different dimensions. Each dimension is composed out of different lean adoption questions who are validated by indicative evidence. These questions actually represent the components of a dimension. Organizations that fill in the tool need to position the lean adoption questions on a lean maturity scale from 0 to 4. Moreover, each dimension has a weighting which represent the importance. In the HALMAT model dimensions 1 until 4 have got 15% importance whereas dimensions 5 until 10 have got each 6.67% importance. (Highways Agency, 2012) The dimensions of the HALMAT model with the lean adoption questions are summarized below.

Dimensions	Lean adoption questions
Strategic use of lean	<ul style="list-style-type: none"> - Is the delivery of business improvement through lean performance management principles integrated as part of the formal strategic plans of the business? - Does your organization demonstrate a long term commitment to adopting the deployment of an effective lean performance improvement approach? - Does your organization employ a formal process for determining customer value?
Financial, information, and procurement systems	<ul style="list-style-type: none"> - To what extent are lean improvements supported by the company’s financial measurement system and linked to the business’ overall financial performance?

	<ul style="list-style-type: none"> - Are the information systems compatible with stakeholder communications and analysis needs? - Does the purchasing policy encourage developing a supply chain of the correct size and demographic to be effectively managed and participate in cooperative relationships to enhance value?
Lean leadership	<ul style="list-style-type: none"> - Do all senior leaders and management within the organization enthusiastically embrace the concept of lean and support a transformation to a lean culture?
People development	<ul style="list-style-type: none"> - Has the personnel department taken appropriate steps to ensure that suitable lean skills are available within the organization? - Are resources and support made available to employees to contribute to lean improvement?
Lean structure and behavior	<ul style="list-style-type: none"> - Has the organization, its policies and processes been revised to promote, encourage and support lean behavior? - Is prudent 'initiative taking' encouraged at all organizational levels to create value-adding innovation?
Collaborative working	<ul style="list-style-type: none"> - Are the Planning / Design / Construction teams integrated, working to an understood process, operating concurrently to reduce project / cycle critical path lead time and encourage flow?
Delivery of value	<ul style="list-style-type: none"> - Is the performance of the organization's key value streams evaluated and is improvement of this performance actively managed?
Standard work	<ul style="list-style-type: none"> - Have processes, tools and systems been standardized across all sites and departments where appropriate?
Process flow	<ul style="list-style-type: none"> - Are processes planned and designed along value streams, aligning demand to customer pull with flow and minimum waste in all aspects of delivery, design, construction, and maintenance?
Process control and quality assurance	<ul style="list-style-type: none"> - Is process variation continually reviewed and reduced in all processes throughout the organization? (using tools such as Six Sigma) - Is the root cause of defects analyzed and are processes updated with lessons learned? - Is mistake proofing (where possible) incorporated in processes and considered in initial design? - Do you ensure that the equipment you rely upon to deliver customer value is in a condition to contribute to quality and provide a high level of availability with maintenance schedules and capacity evaluated?

Table 6: The HALMAT model, by Highways Agency (2012)

This model is chosen to be part of the literature review on lean maturity models since it is a good illustration for understanding the design principles of lean maturity models in general. The HALMAT model follows the basic principles of a maturity model. The model consists of different dimensions and each dimension has different components. Each component is assessed on a

capability scale from 1 to 5. The dimensions have got different weights and their maturity level is computed as an average of their components. The overall maturity level is calculated taking the maturity level of the dimensions and the weights into account. Thus, reading and understanding the HALMAT model results in the understanding of the basic principles of a maturity model i.e. the model really follows the theory found in literature. Moreover, the HALMAT model is a very clear, simple and easy to use tool. The dimensions of the model are logical and the components of the dimensions serve as a good description for the dimensions. The levels of the components are well explained. This serves as a good insight for the development of the lean maturity model in the context of nurse problem-solving. Additionally, the total number of questions that have to be completed by the respondents are 19. A limited number of questions results in a non-time consuming survey and probably this encourages the respondents to participate more. In this master dissertation, a lean maturity model is developed that assesses lean in the context of nurse problem-solving in a very simple and quick way. Therefore, the HALMAT model can serve as a guideline in the development of the lean maturity model. Furthermore, some dimensions in the HALMAT model are directly related to the operational lean principles of Womack & Jones (2003). This is an indication that lean management is studied well while constructing the HALMAT model and that it based on the literature. Additionally, the HALMAT model can be easily transferred to other areas than the construction industry, since the dimensions and the components are rather general.

4.3.3 The Productive Ward model

Simon Van Beveren (2015) wrote in his master dissertation several recommendations for further investigation. One of the recommendations was that a standardized scale for lean maturity could be set up based on the measure implemented by the University Hospital of Antwerp, the Productive Ward Program. (Van Beveren, 2015)

The Productive Ward (PW) Program, developed by the NHS Institute for Innovation and Improvement, is based on the lean philosophy. This program aims at improving quality of the healthcare services by the co-operation of all nurses, doctors and staff. On the one hand, more time is spent on patients care by the nurses. On the other hand, the ward is continuously improved on the level of efficiency and safety. ("NHS Institute for Innovation and Improvement", n.d.) Positive outcomes of the PW are: improved patient care times, ward improvements, staff engagement, improved team working, leadership development, empowerment and positive change management. (White, 2015)

Van Bogaert et al. (2014) demonstrated that in order to measure the level of lean maturity in a department, one should measure the degree of PW implementation. A high degree of PW implementation corresponds to a high degree of lean implementation. The degree of PW

implementation is measured according to the nurses point of view. Nurses are asked to evaluate the degree of PW implementation, based on a five-item measure. Namely “the involvement of the nurses working in the PW environment, the development of the required skills to work with various methodologies of the program, the knowledge of the PW methodologies, the intention to work further with PW methodologies, and finally the support of the hospital board towards the program.” (Van Beveren, 2015, p. 41) Departments with high scores on this five-item scale, are assigned to have a high lean maturity. (Van Beveren, 2015)

In other words, measuring the PW Program can be seen as a lean maturity model. The degree of lean maturity is based on the degree of PW implementation. The number of lean maturity levels are 4 ranging from strongly disagree to strongly agree. (Van Bogaert et al., 2014) The dimensions of the lean maturity model are represented by the 5 assessment items. A negative point to this model is that these 5 assessment items are very broad. A more narrower and detailed description of each assessment item is needed to completely understand what each assessment item aims to measure. Moreover, the PW model can only be used in hospitals that work according to the PW philosophy. Not all hospitals work according to this technique, so it is not possible to generalize the PW model. However, like Van Beveren (2015) already stated, this lean maturity model is a very good starting point for the development of the lean maturity model in the context of nurse problem-solving.

5 LITERATURE REVIEW: PROBLEM-SOLVING

5.1 Theory

As already mentioned in the introduction, the research question of Van Beveren (2015) dealt with the fact that “in a successful Lean environment, hence in an environment in which the maturity of Lean implementation projects reaches high levels, second-order problem-solving behaviors displayed by nurses who face organizational problems will be more frequently observed than second-order problem-solving behaviors performed by nurses employed in environments in which Lean has lower levels of maturity.” (Van Beveren, 2015, p. 34) Van Beveren (2015) thus studied whether lean management has an impact on the problem-solving behavior of nurses. Van Beveren (2015) made an extensive literature review on problem-solving hence the major findings are assembled.

Nurses are confronted day in day out with problems ranging from medical to organizational problems. The first type of problems deal with clinical decision-making or the process of evaluating and treating a patient’s medical problem. The decision-making process is largely based on inductive reasoning i.e. subjective experience problem-solving. The latter type of

problems that nurses are confronted with are organizational problems. These type of problems cope with missing or incorrect information, supplies, equipment, waiting for a human or equipment, or simultaneous demands on the workers time. These problems are solved in a deductive way i.e. rational problem-solving based on theory and principles created by the hospitals management. It its thus the responsibility of the management to create the correct methods and principles to guide nurses to solve and prevent problems. (Van Beveren, 2015) In this master dissertation, only an investigation will be done in the way nurses solve organizational problems and not medical problems, since the former problem-solving behavior is highly subjective.

Nurses can respond in 2 different behaviors to organizational problems. On the one hand, nurses solve problems according to some kind of routine created by the hospital management. No deviations from the routine are allowed. On the other hand, nurses solve problems by questioning the current way of working in order to find the root causes of the problems. The first approach is thus a quick way of solving a problem. Nurses who face problems, solve them as fast as possible. No underlying cause is searched. This method is called first-order problem-solving. In the opposite approach, which is called second-order problem-solving, nurses look for the underlying or root cause of the problem, since these root causes created the problems. (Van Beveren, 2015) Both behaviors are a reactive approach. A problem occurs and a solution to the problem is implemented. However, in the first-order problem-solving behavior problems reappear again, in contrast to the second-order problem-solving behavior where problems are removed. Van Beveren (2015) mentioned that nurses are able to solve problems according to the 2 approaches together. So they can use both when solving a problem. Typically, first-order problem-solving is executed first to cope with a problem in a fast manner, and afterwards the problem is investigated thoroughly to find the root cause. This is done because nurses have limited time dealing with a problem immediately.

Since lean management is partly about removing waste, departments who work according to the lean philosophy try to eliminate the first-order problem-solving behavior. This behavior spends a lot of time on tasks and rework, which can be considered as pure waste. Rather, nurses should work according to second-order problem-solving behavior since the effect are very positive: nurses have the opportunity to enhance organizational learning by communicating to the persons responsible for a problem. (Van Beveren, 2015)

Typical actions of second-order problem-solving behavior are summarized as follows: "Communicating to the person or department responsible for the problem, bringing the problem to the attention of the manager or the head nurse, sharing ideas about the cause of the situation

and how to prevent recurrence with someone in a position to implement changes, implement changes and finally verify that changes have the desired effect". (Van Beveren, 2015, p. 6)

5.2 The Model of Nurse Second-order Problem-solving

In the master dissertation of Simon Van Beveren (2015), the Model of Nurse Second-order Problem-solving of Tucker & Edmondson (2002) is mainly used to describe the variables that lie at the foundation of second-order problem-solving behavior. The model is pictured below.

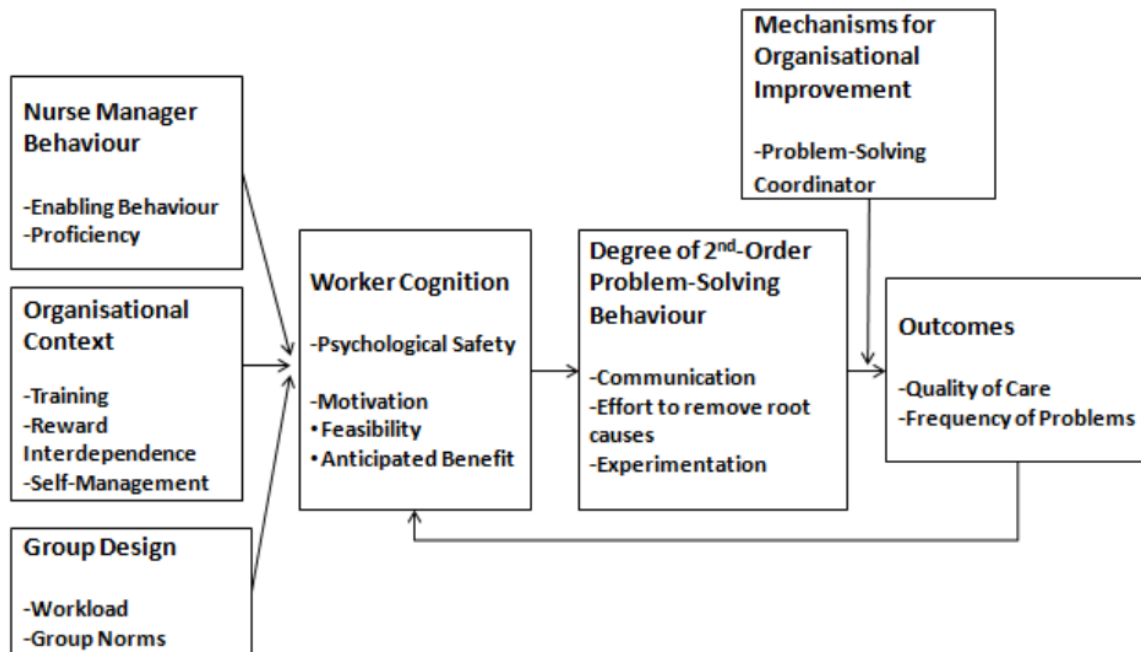


Figure 3: The Model of Nurse Second-order Problem-solving, by Tucker & Edmondson (2002)

On the left hand side of the figure, three managerial levers can be found, namely the nurse manager behavior, the organizational context and the group design. These 3 levers represent the supportive conditions for second-order problem-solving behavior. (Tucker & Edmondson, 2002)

The first managerial lever, nurse manager behavior, is a crucial enabler since second-order problem-solving behavior cannot happen without managerial support. Nurses have to be supported and encouraged to behave in a manner that exceeds first-order problem-solving behavior. Moreover, managers need to assist and coach nurses when problems arise. This is called enabling behavior. On the other hand, managers need to be present on the work floor, have the time to solve problems and strive for continuous improvement. This is called proficiency. (Tucker & Edmondson, 2002)

The management team is not solely responsible for stimulating nurses to adopt second-order problem-solving behavior, but the organizational culture as well. The culture of the hospital has

to change from a first-order to a second-order working environment. That is why the second enabler is called organizational context. This enabler involves training, reward interdependence and self-management. First of all, second-order problem-solving training is important to increase nurse awareness and problem-solving competences and it thus helps in creating a culture of continuous improvement. Secondly, reward systems have to be adjusted to an environment where group tasks are dominating individual efforts such that a cooperative behavior is stimulated. This is called reward interdependence. The last dimension of organizational context is self-management. This motivates nurses to make decisions on their own which leads to a higher nurse satisfaction and productivity improvements. Although the culture of nurse empowerment causes a creation of nurse responsibilities, managerial support still remains necessary. Otherwise nurses are left on their own and this has negative effects on the chances that nurses investigate the root causes of the problems. (Tucker & Edmondson, 2002)

The third supportive condition is group design and consists of 2 dimensions. The first dimension is workload. This represents the amount of work a nurse has to perform in a certain timespan. The workload in hospitals is very high since there is a shortage in nurse supply and therefore nurses have to work very hard. The nursing units are focused on individual efficiency. Consequently, nurses don't have the time to investigate the root causes of the problems. To move to a culture of second-order problem-solving behavior, more time has to be made available for the nurses. The second dimension of group design is group norms, which copes with the behavioral aspect in a group. Improvement and communication efforts can differ between groups members and other groups. Meetings on a regular basis can improve the behavioral norms in a group such that communication runs smoother. (Tucker & Edmondson, 2002)

The three supportive conditions influence the degree of second-order behavior through worker cognition. A higher level of the three levers lead to more psychological safety and motivation of the nurses. Psychological safety means that nurses have the perception that the work conditions are interpersonally and psychologically safe. This is very important because second-order problem-solving behavior leads to an environment where human errors and shortcomings are exposed. This thus may not affect the feelings of the nurses or the nurse reputation because otherwise this will result in a situation where first-order problem-solving dominates and no attempts will be made to perform second-order problem-solving behavior. Secondly, the motivation to contribute to a higher degree of second-order problem-solving. On the one hand, nurses must believe that the benefits of second-order problem-solving are larger than their personal costs. On the other hand, nurses must be certain that the resources and processes needed to perform second-order problem-solving are present. These involve mechanisms to communicate, the time free and a support person. (Tucker & Edmondson, 2002)

To summarize, the degree of second-order problem-solving behavior is enlarged by the 3 managerial levers through the intermediate enabler worker cognition. (Tucker & Edmondson, 2002)

The 3 main dimensions of second-order problem-solving behavior are communication, the effort to remove root causes and experimentation. A more detailed list of actions is already listed above. (Tucker & Edmondson, 2002)

Eventually, the outcomes of a high degree of second-order behavior consist of a higher quality of care and a reduction of the frequency of problems, since the root causes of the problems are investigated and removed. A higher quality of care is the result of an increase in the number of cared patients since problems are removed and thus delays in the treatment process are reduced. Moreover, less patients are bothered with problems and are satisfied more. The outcomes of second-order problem-solving behavior influence the worker cognition since positive outcomes increases the motivation of the nurses. (Tucker & Edmondson, 2002)

However, to completely remove the root cause of the problems a problem-solving coordinator is needed to make real improvements. "A problem-solving coordinator is a person in a formal role at the work group level who is given the slack time and responsibility for communicating about problems across organizational boundaries, investigating for root causes, and implementing countermeasures." (Tucker & Edmondson, 2002, p. 104) When change is really desired in a work group, this person should influence the activities. (Tucker & Edmondson, 2002)

To conclude, the Model of Nurse Second-order Problem-solving of Tucker & Edmondson (2002) describes the main action of second-order problem-solving behavior, what the outcomes of this type of behavior are and what inputs or enablers are needed to come to this type of behavior. Moreover, Van Beveren (2015) claims that the literature found on second-order problem-solving is mainly based on the model of Tucker & Edmondson (2002). As a consequence, this model is of great interest for this master dissertation and thus can definitely be used in the development of the lean maturity model in hospitals in the context of problem-solving behavior.

5.3 The 4P model

In literature, problem-solving is described as the highest level that can be reached in a lean management organization. Problem-solving in this context means root cause analysis. This assumption is described in the broadly discussed model of Liker: the 4P model. The 4P model of Liker is a summarization of the 14 management principles of Toyota. The Toyota Motor Corporation is the creator of the lean management system. The 4P model is represented by a pyramid where philosophy, process, people, partners and problem-solving characterize the

layers of the pyramid. The first layer of the 4P model is philosophy which represents the purpose of the company and why it exists. The second layer is about operational excellence by eliminating waste based on what a company believes. People are the drivers of the company and culture is about how to teach people to work together to a common goal. The top layer is problem-solving which indicates the way people focus their efforts to continuously improve. (Liker, Hoseus, & CQPO, 2008)

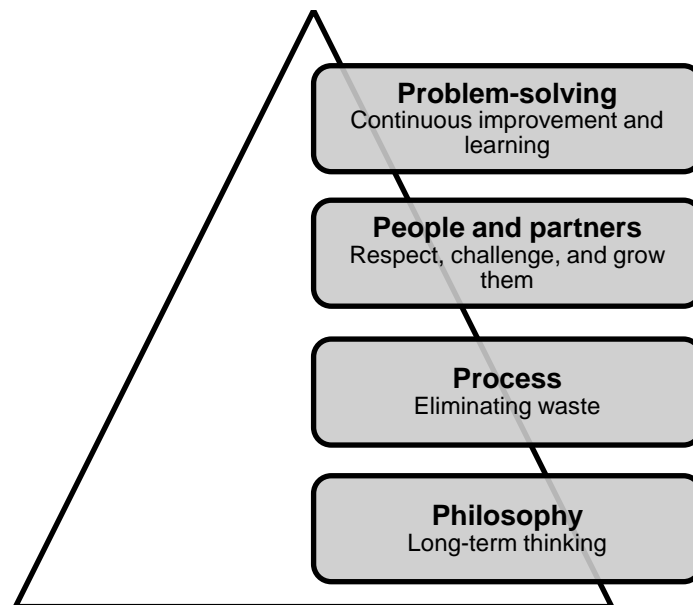


Figure 4: The 4P model

In this master dissertation, a lean maturity model is developed to measure the degree of lean maturity in the context of nurse problem-solving behavior in hospitals. According to the 4P model, philosophy, process and people are the underlying dimensions to reach problem-solving. Rigorous problem-solving will never happen if the other 3 dimensions are not present in an organization. Thus to know the enablers of problem-solving, the underlying 3 dimensions have to be studied.

An organization that works according to the Toyota way, or the lean way, puts the long-term philosophy at the foundation of its business. Management decisions are always based on the long-term philosophy, even if it is against the short-term financial goals. All the people in the organization work towards a common goal in order to bring the organization to a next level. The philosophy does not focus only on the generation of value for the company, but also for the customer, society and economy. Every employee in the company looks to its own capabilities and try to improve them to provide added value. (Liker, 2004)

Based on the philosophy, the organization selects the right processes that produce the right results. Bringing problems to the surface is done by creating a continuous process flow. Work

processes are redesigned by remove idle time, improve the link between people and processes and improve the flow of material and information. Avoiding overproduction is done by using pull systems. The customer demand is incorporated throughout the whole supply chain in order to be more responsive. Eliminating the overburden of people and equipment and the unevenness in the production schedule is done by levelling out the workloads of all the manufacturing and service processes. Getting the quality right for the first time is done by stopping or slowing down the processes rather than fixing problems on the short-term. Building a culture of continuous improvement and employee empowerment is done by standardizing tasks. Best practices are standardized to obtain a regular output of the processes. Improvements are constantly made by the people to increase learning. All problems are detected by using visual tools such that nothing is hidden and finally only reliable and thoroughly tested technology is used that support the people and processes in the right way. To conclude, the organization implements these principles to the processes to remove waste i.e. to obtain the right results. (Liker, 2004)

Not only the right processes but also the development of people and partners results in added value to the organization. That is why the company has leaders that embrace the philosophy, thoroughly understand the work and are eager to teach it to others. They act thus as a role model. Besides good leaders, exceptional people and teams are developed that work and act according to the philosophy. Training, cross-functional teams, empowerment and a strong culture contribute to the development of brilliant individuals. Moreover, the organization's network of partners and suppliers are respected and helped to show that the organization value them. (Liker, 2004)

Lastly, the organization motivates people to continuously solve problems since this drives organizational learning. People go and see themselves the sources of the problems to thoroughly understand the situation i.e. people base their decisions on own looked-up data instead of relying on other people's point of view or theory. Moreover, people consider all possible alternatives where communication between team members is crucial, since in that way consensus is reached. This is a very time-consuming process but enlarge the search for solutions. When the right solution is selected, it is implemented rapidly. Once stable processes are established, reflection happens and people implement continuous improvement tools. (Liker, 2004)

The description of the different layers of the 4P model shows that the model is invented for helping an organization to implement lean management into its business. First, top down techniques are necessary to implement the lean approach into an organization and later bottom up techniques take over i.e. the employees themselves believe in the lean philosophy and take

over rather than the management team who made the lean environment available. (R. Coppens, personal communication, March 9, 2017)

For developing a lean maturity model that assesses lean management in all its aspect, this 4P model is the ideal starting point. However, this master dissertation develops a lean maturity model only in the context of problem-solving, thus this model is too broad. Although insights of the model can be used. The fourth layer, problem-solving, can be used to construct the dimensions of the lean maturity model. "Go and see for yourself to thoroughly understand the situation, make decisions slowly by consensus, thoroughly considering all options, implement decisions rapidly, relentless reflection and continuous improvement" (Liker, 2004, p. 4) all are enablers of rigorous problem-solving.

A characteristic of the 4P model is that the layers are hierarchical and that each layer represent a step in the development of a true learning organization. An organization that wants to change first starts with the development of a strong company culture that is based on a long-term philosophy. Next, processes are adapted and optimized, which is a translation of the company strategy into the operations. The result of this is a company which processes are embracing the long-term philosophy, but the people in the organization are left out. As a consequence, the organization should invest in the people to develop them. They will be valuable if they are supported by the right leaders and if they can perform in a strong company culture. A culture where all the people believe in the same values and norms that are based on a long-term philosophy. A true learning organization can be achieved when people strive for continuous improvement by solving the root causes of the problems. The learning point of the model is as follows: rigorous problem-solving, people, partners and processes all result in added-value for a company only if a long-term philosophy is the foundation of the organization. In other words: a true learning organization implements a philosophy and changes its processes and people according to it. The highest level where people strive for continuous improvement is the result of the interplay of the philosophy, people and processes. Thus, problem-solving is based on philosophy, processes, people and partners. It is built on it. (Kumar, 2013); ("The Toyota Way - J. Liker (samenvatting)", n.d.) Applying this theory on the development of the lean maturity model in the context of nurse problem-solving means that this model is going to asses only the top layer of the pyramid. A department with a high level of lean maturity suggests that the top level of the pyramid is reached and that the underlying layers are covered.

6 LITERATURE REVIEW: CONCLUSION

Van Beveren (2015) claimed in his research study that there is a need for a general method or tool that assesses the degree of lean implementation in departments of hospitals. More specifically, a standardized scale which measures lean maturity should be developed. With this standard method hospitals can now rely on objective data in evaluating the lean maturity in their departments, since currently hospitals just rely on their intuition or subjective point of view.

That is why in this master dissertation a lean maturity model is developed that assesses the degree of lean implementation in department of hospitals, but only in the context of nurse problem-solving. The aim of the model is to investigate the relationship between lean maturity and the problem-solving behavior of nurses. Departments where a high lean maturity is observed, nurses perform more frequently second-order problem-solving behavior than the second-order problem-solving behavior performed by nurses in departments where a low level of lean maturity is observed. (Van Beveren, 2015) This model is a quick scan of assessing lean management because only the problem-solving behavior of nurses in departments of hospitals is investigated, rather than a complete lean management assessment.

The first part of this master dissertation involved an extensive literature review on lean maturity models and problem-solving behavior. The outcome of the literature review is represented below.

The lean maturity model in the context of nurse problem-solving assesses a department of a hospital regarding the degree of lean implementation in the function of nurse problem-solving. The lean maturity model consists of different levels. Each level is represented by capability levels, or the ability to move further. A higher maturity level corresponds to higher departmental capabilities. The content of the model is composed out of dimensions. Each dimension is composed out of components related to nurse problem-solving behavior. The ultimate goal of the model is that the corresponding department of a hospital obtains a lean maturity level. This lean maturity level is the degree of lean implementation in their department. The lean maturity level of the department is the outcome of the aggregated lean maturity levels of the different dimensions. The lean maturity levels of the dimensions are obtained by taking the components for each dimension into account. Each component is assessed based on assessment questions, ranging from a low to a high capability level.

A summary of the capability maturity levels is listed below. These levels are the basis for the components' lean maturity levels. Each component has a different maturity definition, thus different maturity levels. However, they all represent the capability to move further.

Capability Maturity Levels	Level 1	Level 2	Level 3	Level 4	Level 5
	Initial	Managed	Defined	Predictable	Optimizing

Table 7: Capability maturity levels, by Rouse (2007)

A summary of the lean maturity levels is listed in the table below. The assessed hospital's department will obtain one of these levels.

Maturity	Level 1	Level 2	Level 3	Level 4	Level 5
Lean Maturity	Sporadic optimization	Basic lean understanding and implementation	Strategic lean interventions	Proactive lean culture	Culture transformation

Table 8: Lean maturity levels, by Jorgensen et al. (2007)

By reviewing the literature on lean maturity models, it is believed that the following models will serve as an input for the lean maturity model in the context of nurse problem-solving: the Lean Maturity Self-assessment Tool and the PW model. The dimensions and the corresponding assessment questions from the first model and the 5 assessment questions from the second model can serve as an inspiration and a guideline for the development of the lean maturity model in the context of nurse problem-solving.

Moreover, by reviewing the literature on nurse problem-solving behavior, it came clear that most of the literature is based on the Model of Second-order Problem-solving. The model describes a set of second-order problem-solving enablers, a set of second-order problem-solving actions, and a set of second-order problem-solving outcomes. It is believed that the set of enablers, actions and outcomes of second-order problem-solving behavior will serve as an input for the dimensions of the lean maturity model in the context of nurse problem-solving.

7 EMPIRICAL RESEARCH

7.1 Goal of the empirical research

The goal of this master dissertation is to develop a lean maturity model in the context of nurse problem-solving. In the empirical research the lean maturity model in the context of nurse problem-solving is designed based on the knowledge obtained in the literature review and through in-depth interviews with lean experts. The designed model will then be validated by lean experts.

7.2 Scope of the research

Defining the scope of the lean maturity model in the context of nurse problem-solving is a very crucial step since it influences model development. For model application and use it is important to know the outer boundaries of the model. The most significant decision in this step involves the focus of the model. It compromises the maturity model's target group and application domain. (De Bruin et al., 2005) More specifically, when designing a lean maturity model, basic decisions have to be taken on the method of application, the application domain, the entity under investigation, the audience and the respondents. (De Bruin et al., 2005); (Pöppelbuß & Röglinger, 2011)

First of all, a general design principle for the lean maturity model is listed. A decision is made in the purpose for which the model will be applied. As previously described, a maturity assessment is either descriptive, prescriptive or comparative. A descriptive model assesses only the here-and-now situation of a business. Whereas a prescriptive model provides the business performance and an indication for maturity improvement. Finally a model which enables to benchmark across industries or regions is called a comparative model. (De Bruin et al., 2005) In this master dissertation, a model is developed that is purely descriptive. It should only be capable to assess the as-is situation of the department of a hospital. However, the original purpose of the lean maturity model is comparability. Departments within and across hospitals should be compared in order to select high and low lean maturity departments.

The developed maturity model in this master dissertation is a maturity model that focus on lean management in the domain of healthcare organizations. This model assess the maturity of lean in hospitals within the context of nurse problem-solving behavior. More specifically, the lean maturity model is used to measure the degree of lean implementation according to the problem-solving behavior of nurses in departments of hospitals. To conclude, the lean maturity model assess lean on the level of departments, and not on the whole hospital and the assessment

involves lean in the context of nurse problem-solving and not the complete aspect of lean management.

Most lean assessment tools are based on surveys that investigate the companies' business practices. (Ray, Zuo, Michael, & Wiedenbeck, 2006) In this research, the method of application of the model is a self-assessment tool. This means that the respondents should be able to self-assess the current departmental lean situation by using a kind of questionnaire. The questionnaire consists of assessment questions with the corresponding levels of maturity. The answers to the assessment questions are thus fixed. Moreover, the tool must be very simple to use and must have a limited number of assessment items in order that the completion time is short. However, it should be able to appropriately reflect the complex reality and provide sufficient information to the audience.

The audience, to whom results are reported, are the hospital's management team, but also external parties who audit hospitals on their way of working. The respondents of the lean maturity model are nurses of a department who have an affiliation with lean. These can be nurses, head nurses, lean coaches, etc.

A summary of the scope of the research study is illustrated as follows:

Criterion	Characteristic
Purpose	Descriptive
Method of application	Self-assessment tool
Application domain	Departments of hospitals
Entity under investigation	Lean management in the context of nurse problem-solving behavior
Audience	Internal: management team External: auditors
Respondents	Nurses affiliated with lean

Table 9: Scope of the research

7.3 Research methodology

The main goal of this master dissertation is not to self-design the lean maturity model in the context of nurse problem-solving but rather to develop a model which is based on models found in literature and which is based on the knowledge of lean experts. Hence, it is believed that the Model of Nurse Second-Order Problem-Solving, the Lean Maturity Self-assessment Tool, and the PW model are the starting points of the lean maturity model. These works will be the input of the lean maturity model and will be discussed by lean experts. When the lean maturity model is constructed based on these insights, it will be validated by lean experts. To summarize, the

experts should give their critical opinion about the three input models and on the other hand the lean experts should validate the proposed lean maturity model. This validation process entails investigating whether the assessment items are truly mutually exclusive and collectively exhaustive, and what the definitions of high and low maturity levels are for each assessment item.

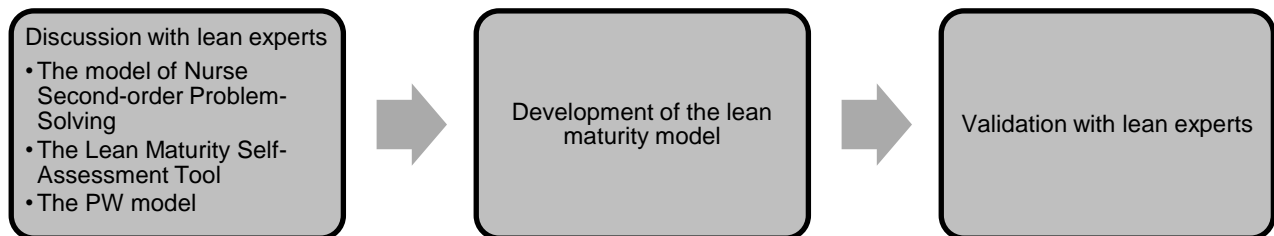


Figure 5: Research methodology

7.3.1 Validation

7.3.1.1 Theory

A good lean maturity model requires for reliability and validity. (De Bruin et al., 2005) Reliability is a necessary condition for validity, thus without reliability there is no validity. However, reliability is no sufficient condition for validity. (De Pelsmacker & Van Kenhove, 2014) Reliability means that the measurement of a model is consistent (Eva., 2011), accurate and repeatable (De Bruin et al., 2005). If the lean maturity model assesses for lean maturity in a certain department then the lean maturity level should be the same for the first and second test (Eva., 2011) independent of who is using the model. Other researchers must thus be able to get the same results. (Shuttleworth, 2008) Otherwise stated, reliability is the degree in which the model result is free from random errors. (De Pelsmacker & Van Kenhove, 2014) Measuring reliability can be done in 2 different ways. The first one is a test and retest: assess the lean maturity model in a department twice and compare the results. If the lean maturity level is the same, then the model is reliable. The second way is internal consistency and is done by questioning. Two different set of surveys have to be developed that measure the same topic. These 2 surveys are completed by different groups. Even if the different people answered these 2 questionnaires, but still came with the same result, then the measurement tool is reliable. (Eva., 2011)

Validity on the other hand has to do more with how strong the outcomes of a certain hypothesis are. Validity gives an answer to the question: is this research question right or not? (Eva., 2011) Applicable to this master dissertation, the initial research question was that in departments with high levels of lean maturity, nurses adopt more frequently second-order problem-solving behavior than the second-order problem-solving behavior performed by nurses who work in departments where a low level of lean maturity is observed. (Van Beveren, 2015) If it is not

valid, it means that the maturity model is biased. There are systematical errors in the model. (De Pelsmacker & Van Kenhove, 2014) Validity consists out of different types: internal validity and external validity. (De Pelsmacker & Van Kenhove, 2014) External validity is about generalization and whether results from a small sample can be extended to a population. This is the most difficult one to achieve. (Campbell & Stanley, 1966) Is it possible to generalize the lean maturity model to any hospital? Internal validity deals with how well the lean maturity model measures what it is aimed to measure. Internal validity comprises different aspects: face validity, content validity, construct validity, convergent validity and discriminant validity. (De Pelsmacker & Van Kenhove, 2014) First of all, "face validity is assessed by whether good translations of the constructs have been achieved." (De Bruin et al., 2005, p.8) This entails reviewing the model at first sight by non-experts. It is mainly done by pretesting. This first type of internal validity is the weakest form of validity but is always the first step in evaluating the validity of a model. (De Pelsmacker & Van Kenhove, 2014) Content validity on the other hand measures "how completely the domain has been represented." (De Bruin et al., 2005, p.8) This evaluation is done with experts to analyze the maturity model on its content correctness. (De Pelsmacker & Van Kenhove, 2014) Next, construct validity is about the relationship between constructs. If it is stated that lean maturity and second-order problem-solving are highly correlated, then the relationship between these 2 should be found in the model that assesses the degree of lean. If this is not the case, then there is a problem with the construct validity of this model. (De Pelsmacker & Van Kenhove, 2014) Otherwise stated, construct validity represents if the researcher's experimental design closely follows the principle of cause and effect. If there is another variable, a confounding variable, that alternatively causes the results, then the construct validity is low. (Shuttleworth, 2009) The last 2 types of internal validity are convergent validity and discriminant validity. The first type of validity is present when 2 or more different models that measure the same concept are highly correlated. If there are 2 different models that assess both the lean maturity level of a department, and the results of the 2 models are highly correlated, then there is convergent validity. The last type of validity is present when 2 or more constructs (measured with 1 or more models) are correlated low and are thus enough different from each other. (De Pelsmacker & Van Kenhove, 2014)

Besides a model's validity and reliability, some operational concepts are required as well in order to speak of a good maturity model. First of all, the efficiency of the maturity model. The maturity model consists of different dimensions. If more dimensions are added to the model, the reliability of the model increases. But the consequence is that the model becomes too large and this results in an increased effort by the respondents. Thus the maturity model becomes less efficient. Secondly, the maturity model should be convenient. This means that the model should be easy to use and that the difficulty level is not too high. It should be adapted to the

competences of the respondents. Thirdly, the maturity model should be interpretable. This entails that the result of the model should be easily understood by the respondents and by the audience to whom results are reported. (De Pelsmacker & Van Kenhove, 2014)

Since in this master dissertation the maturity model in hospitals in the context of nurse problem-solving behavior is only developed and not tested or implemented, it will not be possible to evaluate the model's reliability and different types of validity. It is not possible to evaluate the reliability of the model since the maturity model is not tested and certainly not re-tested to measure if the model is consistent and accurate. Moreover, construct validity, convergent and discriminant validity can't be evaluated either since these types of validity also require to test the model. As a result, only the face validity, content validity and external validity will be evaluated. Moreover, the operational requirements of the model can be evaluated too. During the development of the model, the concepts of efficiency, convenience and interpretability can be taken into account. The question is now how to make sure that the lean maturity model is valid and meets the operational requirements.

7.3.1.2 Validation technique

The chosen technique to validate the lean maturity model in the context of nurse problem-solving is in-depth interviewing with lean experts. "In-depth interviewing is a qualitative research technique that involves conducting intensive individual interviews with a small number of respondents to explore their perspectives on a particular idea, program, or situation." (Boyce, & Neale, 2006, p. 3) In-depth interviews are ideal in situations where the respondents' points of view is needed to be distinguished from group responses or where participants are not comfortable to talk openly in a group e.g. in focus groups. Moreover, in-depth interviews deliver much more detailed information about a certain topic than for example a questionnaire. This can even be fostered by creating a relaxed environment. Unfortunately, every interview technique has its pitfalls. Working with in-depth interviews can be very time consuming since interviewing respondents, transcribing and analyzing the results takes a lot of time. Moreover, results might be biased since the respondents want to show off that a certain program is working or that they have a lot of knowledge about a topic. Another drawback of in-depth interviews is that it is difficult to generalize the results, since large samples and random sampling methods are not used. (Boyce, & Neale, 2006) This drawback can be circumvented by increasing the number of respondents and making the respondents more differentiated. By interviewing just enough differentiated experts, different visions about a topic are collected and in that way generalization of ideas can be made.

7.3.1.3 Contacted lean experts

Since in-depth interviewing is selected to be the best technique to validate the lean maturity model, lean experts have to be contacted to participate in order to obtain critical opinions about the lean maturity model.

A lean maturity model is composed out of components with each a different maturity definition. The levels of maturity range from low to high. To obtain the right description for each component's maturity level, lean experts from different hospitals are contacted. Ideally, lean experts from hospitals with a varying level of organizational lean maturity are interviewed to obtain different points of view in order to construct the low to high lean maturity levels.

In the master dissertation of Van Beveren (2015), the University hospital of Ghent and the University hospital of Antwerp were contacted. In both hospital, 2 departments were chosen with a varying degree in lean maturity. In each department the research question was tested to investigate whether the research question hold. This was positive in the Antwerp but not in Ghent. (Van Beveren, 2015) For this master dissertation, it would be interesting if other hospitals would be incorporated.

That is why lean experts from the OLV Hospital of Aalst, from the BZIO Hospital in Oostende, and from the Maria Middelaes Hospital in Ghent are contacted. Moreover, a lean expert from the HEC Montréal business school is contacted. The following lean experts have been contacted from the hospital of Aalst: *Raf Coppens* who is a staff member of the department of Processes and Quality, *Kris Vierendeels* who is a 'zorgzone' manager of the technical care services, and *Pascal Vanmeenen* who is also a 'zorgzone' manager. From the Maria Middelaes hospital in Ghent, *Hans Crampe* is contacted since he is active in lean literature and is the nursing and paramedical director of the hospital. Moreover, *Alain Antierens* is contacted. He is the director of patient care of the hospital in Oostende and the developer of a lean maturity model for PhD research in Ghent. The last person who is contacted is prof. dr. *Sylvain Landry* of the HEC Montréal who is the co-developer of the Lean Maturity Self-assessment Tool.

7.4 Input models discussion

7.4.1 Model of Nurse Second-order Problem-solving

The Model of Second-order Problem-solving which describes the action, outcomes and enablers of second-order problem-solving behavior is thoroughly described in the literature review. It is believed that it serves as an input for the development of the lean maturity model in the context of nurse problem-solving. However, it should be validated by lean experts. This

model is highly theoretical and it is necessary to have a practical point of view on the topic of nurse problem-solving.

R. Coppens, K. Vierendeels & P. Vanmeenen gave their critical opinion about the model of nurse second-order problem-solving. They largely share the same point of view as Tucker & Edmondson, however they made some recommendations and points of discussion. Especially for the dimensions nurse manager behavior and organizational context.

Nurse manager behavior is the first enabler of the model. It represents the coaching and stimulation of nurses to do second-order problem-solving, the opportunities nurses get to do second-order problem-solving and the presence of the nurse manager on the work floor. (R. Coppens, personal communication, March 9, 2017) For this enabler, it is important to know what the definition of a nurse manager is. (K. Vierendeels & P. Vanmeenen, personal communication, March 21, 2017) If it is assumed that a nurse manager is the head nurse of a department, then the model lacks of a major information source. The higher level managers should be integrated into the model as well. If the higher management is not standing behind the idea of second-order problem-solving then there is nothing going to happen. No time is given to work on projects, no training will be done, etc. Thus it is important that the hospital's vision embraces second-order problem-solving. Successfully implementing second-order problem-solving in a hospital is only possible when the hospital's board is mature. A top-down approach is the starting point where the management team believes in the philosophy. Later, bottom-up techniques where nurses themselves believe in lean can take over. Thus, it would be better if an extra component is added to the model namely the alignment of the department's vision with the organizational vision. (R. Coppens, personal communication, March 9, 2017)

The second enabler, organizational context, firstly involves training. In some hospitals nurses get training, but in some not. This is dependent on the stage in which the hospital is situated regarding lean management. The lower in the hierarchy training is given, the higher the chances that the lean maturity of an organization is higher. In low lean maturity organizations on the contrary, training is only given in higher hierarchy levels. When nurses thus don't get training, mostly the head nurse or a problem-solving coordinator obtains training. Hence, it is better to differentiate training between nurses and head nurses. Therefore, a new component to the nurse manager behavior dimension is added that assesses if head nurses get training. (R. Coppens, personal communication, March 9, 2017)

Another component of the enabler organizational context is self-management. Tucker & Edmondson describe self-management in their model as the amount of independence, initiative and freedom in daily work activities. (Tucker & Edmondson, 2002) Translated to this context, the component implies the extent in which nurses have independence, initiative and freedom to

perform second-order problem-solving projects. Through the interview with the lean experts, it became clear that they were not in favor of this component. Healthcare organizations will give nurses never the freedom to work on second-order problem-solving projects themselves. Instead, nurses are free to propose projects within the objectives of the organization. The ideal situation would be that nurses collaborate and give ideas within the project but not that nurses take initiative on their own. (R. Coppens, personal communication, March 27, 2017) It is therefore very important that the projects are done in a structured way rather than in a chaotic approach. Nurses can't make decisions on their own behalf without collaboration with the head nurse. (R. Coppens, personal communication, March 9, 2017) Moreover, Tucker & Edmondson (2002) stated that a high degree of self-management not always results in positive outcomes since nurses need enough support and coaching in second-order problem-solving projects. On the contrary, the chances of root cause analysis are decreased when nurses are too empowered. (Tucker & Edmondson, 2002) That is why this component is no further an input element for the developed model anymore.

When talking about processes that are made available to nurse to perform problem-solving, it became clear that an improvement board, scoreboard, or dashboard, is used to communicate the results of the second-order problem-solving projects to the nurses and that this is a way to stimulate and involve them. It is the task of the head nurse to share the project results via the board. A condition is that the head nurse first assembles and analyzes the project results. That is why a new component should be added to the nurse manager behavior dimension: analyzing and sharing project results to nurses. (R. Coppens, personal communication, March 9, 2017)

To conclude, the model is a very theoretical model with a lot of valuable elements. All the dimensions are theoretically correct, but translating the dimension into assessment items will be a hard task. Each department of a hospital is structured differently and has nurses with a varying competence level. In order that every respondent can complete the model, it is required that the model is not based on a specific 'type' of hospital i.e. not adapted to a specific department's structure. (K. Vierendeels & P. Vanmeenen, personal communication, March 21, 2017)

7.4.1.1 Illustration

As an illustration, the Model of Nurse Second-order Problem-solving is applied to the hospital of Aalst in order to have a practical point of view.

In the hospital of Aalst, the top management introduced the concept of lean since a couple of years. The real aim for the future is that lean management projects become organization-wide and that there will be a lot of tools and motivational drivers available to nurses. As from now, the

engagement in lean projects is fluctuating a lot since more effort is done when accreditors were reviewing the hospital. But the main goal for the future is that lean grows more and more in the hospital. (R. Coppens, personal communication, March 9, 2017); (K. Vierendeels & P. Vanmeenen, personal communication, March 21, 2017)

The hospital, under the direction of the quality department, established a quality house, which is a hospital-wide quality initiative to stimulate everyone to pursue quality and quality projects. Care for the patient, care for a safe caring environment and safe care are the 3 pillars of the quality house. It even has links with the Productive Ward model adopted in the hospital of Antwerp. It is a representation tool for the employees of the hospital how future quality work will look like. The link with the departmental level is that the departmental projects should be situated in one of the 3 pillars. (R. Coppens, personal communication, March 9, 2017); (K. Vierendeels & P. Vanmeenen, personal communication, March 21, 2017)

In each department, it is the head nurse who obtains 3 or 4 times a year a theoretical training in lean management, followed by practical case studies and exercises. The training is a structured way to cope with quality on the work floor. In each department, there is also a reference person who is assigned to be responsible for the improvement projects. Head nurses and reference nurses most of the time get training in lean management together. Nurses themselves don't get training i.e. the topic of lean is nearly unknown for them. Rather, the head nurse and reference nurse themselves communicate the knowledge of lean to the nurses. Through the improvement projects, the hospital is trying to make the processes lean by initiating lean tools: 5S, visualization techniques, A3 method, etc. Through an improvement board, projects results are illustrated in order that every nurse can see what is going on in the department and that every nurse can give his point of view. Hence, not only the persons responsible for improvement projects are related to improvement projects but an open culture is created. However, it is important that the improvement projects happen in a structured way and not in a chaotic way. Nurses can be involved into the projects, but need to be in close communication with the head nurse. Though, the impact of the nurses is limited to sharing ideas. Nurses don't really solve problems or look to the root causes of the problems. This is the task of the head nurse. To motivate people, meetings are organized once in a while where people come together and share their ideas. A reward system is not in place to motivate them. Moreover, nurses don't get extra time available to work on improvement projects, so the involvement remains low. Reference nurses get a couple of hours available to spend on improvement projects, but this happens almost never in practice. The hospital's board knows that workloads should be adapted, but in practice it still remains hard. Care for the patients remains the number one priority. The efforts to execute and to involve into improvement projects varies a lot from department to department. Some nurses really try to implement the lean knowledge in practice but others aren't. This is

because they don't really see the benefit of the lean methodology and are thus not motivated enough, because they have other priorities, or because there isn't enough time to do improvement project and give it up too quickly. Departments that try to implement the lean knowledge in practices, are department where nurses see that the projects result in more efficient and effective work are thus more involved and engaged. (R. Coppens, personal communication, March 9, 2017); (K. Vierendeels & P. Vanmeenen, personal communication, March 21, 2017)

To conclude, the hospital of Aalst takes its first efforts in introducing lean management into the different departments of the hospital. There are still a lot of weak points in the system but implementation of lean management into the whole organization takes time. Everybody in the organization should give lean management a chance and real efforts should be taken to implement it for the long-term. A more structured framework at the organizational level is needed that gives direction and support to the departments. There are departments that are doing a good job in lean management, departments that started with lean but gave it up, and there are department that just don't implement lean. (R. Coppens, personal communication, March 9, 2017); (K. Vierendeels & P. Vanmeenen, personal communication, March 21, 2017)

The link between the description of Aalst and lean maturity is that it is hard to assign an overall lean maturity level to the hospital of Aalst since there is a large variance between the different departments of the hospital. The lean maturity level varies a lot from department to department and between the different persons in one department. The latter implies that it is even hard to assign a correct lean maturity level to a department. In the development of the lean maturity model in the context of nurse problem-solving it is thus important to take this last remark of variation within the department into account since the model assesses the lean maturity in only one specific department.

7.4.2 The Lean maturity Self-assessment Tool

This lean maturity model is thoroughly described in the literature review. Again, this model assesses lean management in healthcare institutions based on 10 organization-wide dimensions. Each dimension consists of different components, where every components is evaluated using an assessment question, which is measured on a scale from 1 until 5. (Jobin et al., 2014) The Lean Maturity Self-assessment Tool is developed for assessing lean management in all its aspects. It is thus necessary to perform a reduction process where only assessment questions that are affiliated with nurse problem-solving remain. Prof. dr. Sylvain Landry of the HEC Montréal, who is part of the development team of the Lean Maturity Self-assessment Tool, evaluated the assessment questions and selected the questions that are related to the problem-solving behavior of nurses.

Dimension	Assessment question
Patient / user value	To what extent is the patient's voice listened to and integrated in the organization? (1.1)
Performance management	To what extent has the organization developed scorecards/ dashboards, and how much are they used for steering and monitoring management? (2.2)
Strategy and governance	How effective is participative bottom up communication from employees to their supervisors? (3.3)
	To what extent are Lean project objectives and continuous improvement initiatives aligned with organizational objectives? (3.6)
Continuous improvement and sustainability	To what extent is standardized work part of the organizational culture? (4.2)
	To what extent are audits and controls part of the management practices of the organization? (4.3)
	To what extent does Lean contribute to improving clinical practices? (4.4)
	To what extent is daily continuous improvement part of the organizational culture? (4.5)
	To what extent does the organization promote the right to experiment and allow its members to take risks? (4.6)
Processes (tools and techniques)	To what extent does the organization document its processes? (5.1)
	To what extent is visual management used in the organization? (5.7)
Project and change management	How effectively have solutions been implemented in Lean projects? (6.7)
	To what extent do team members take steps to test solutions envisioned? (6.8)
Cross-functional management	To what extent is management based on measurement and analysis of results deployed within processes? (7.8)
	To what extent are different process contributors accountable for results obtained? (7.9)
Stakeholders	To what extent does lean contribute to improving the organizational climate? (8.1)
	To what extent is the management team involved in deployment of the lean approach? (8.2)
	To what extent does the organization communicate the progression of the Lean approach? (8.7)
Leadership	To what extent do managers create an operational vision aligned with strategic objectives? (9.2)
	To what extent do managers coach and develop their employees? (9.3)
	How present is the management team on Gemba in terms of: frequency, diligence, pertinence and form? (9.6 & 9.7)

Table 10: Screened assessment questions of the Lean Maturity Self-assessment Tool, by Jobin et al. (2015b); S. Landry (personal communication, March 10, 2017)

As it can be seen on the table, a lot of questions are organization-wide, so they should be adapted to a departmental point of view since the lean maturity model in this master dissertation only assesses departments of hospitals.

In the 'support for projects and for transformation' dimension, no items were selected that had a relation with assessing lean management in a department of a hospital in the context of problem-solving behavior of nurses. (S. Landry, personal communication, March 10, 2017)

Screening the questions with K. Vierendeels & P. Vanmeenen, it immediately raised the concern how these assessment items could be translated into a common language, since each hospital has its own habits, structure and terminology. Questions that K. Vierendeels & P. Vanmeenen found interesting were assessment items about communication, dashboards, the hospital's strategy, standardization, audits and results. (K. Vierendeels & P. Vanmeenen, personal communication, March 21, 2017)

7.4.3 The PW model

Simon Van Beveren wrote in his master dissertation several recommendations for further investigation. One of the recommendations was that a standardized scale for lean maturity could be set up based on the measure implemented by the University hospital of Antwerp, the Productive Ward Program. (Van Beveren, 2015)

Since the model is already described in the literature review, only a short summary of the 5 assessment items is listed below:

The involvement of the nurses working in the PW environment
The development of the required skills to work with various methodologies of the program
The knowledge of the PW methodologies
The intention to work further with PW methodologies
The support of the hospital board towards the program

Table 11: PW assessment items, by Van Beveren (2015, p. 41), from Van Bogaert et al. (2014)

The PW model is a very good starting point for the development of the lean maturity model in the context of nurse problem-solving. The PW program is based on the lean philosophy and thus entails a lot of lean characteristics. However, the assessment items of the PW model have to be discussed with lean experts. The real aim of the assessment items of the lean maturity model is that they reflect lean in the context of nurse problem-solving behavior. On the contrary, the PW model contains assessment items that reflect the PW methodology. Hence, it required that the PW model is discussed with lean experts to know to what extent the PW model can serve an input for the lean maturity model in the context of nurse problem-solving. Secondly, the

lean maturity model that is developed in this master dissertation should be a model applicable to any hospital. The PW model can only be used in hospitals which work according to the Productive Ward program. To generalize the PW model, several problems could arise since not all hospital are organized like a PW environment. Thus, the PW model assessment items should be investigated whether they are applicable to other hospitals.

K. Vierendeels & P. Vanmeenen point of view is that the assessment items of the PW model are too general and unspecified. Respondents will probably not understand the questions. The PW model is a good assessment tool for a department that is embedded with lean management. Every employee in the department knows the concept and acts like it. Answering to these 5 assessment items is thus a very easy task. But for departments where this is not the case, employees are not able to answer these questions since they will not understand the items. A possible solution to this problem would be to add to each of the 5 questions more practical questions. The dimensions of the PW model are thus good, but need to be more specified by using practical examples. In that way, every department of a hospital can use the lean maturity model and not only department that are based on the PW methodology. (K. Vierendeels & P. Vanmeenen, personal communication, March 21, 2017) Thus, in the lean maturity model design, it will be taken into account that the PW model assessment items are a good starting point, but that these items need to be specified further using more practical assessment items in order that every respondent can answer the questions.

7.5 Model design

In this section, the lean maturity model in the context of nurse problem-solving is developed based on the 3 input models explained in the section before. The result of this section is a model that can be proposed to lean experts. In the development of the model, it is important that the concepts of efficiency, convenience and interpretability are taken into account. (De Pelsmacker & Van Kenhove, 2014) The first requirement of the model is that it should be efficient. The number of dimensions and the corresponding assessment question should not be too large since the model should assess lean management in the context of nurse problem-solving with minimal waste of time and effort. Secondly, the lean maturity model should be convenient which means that the respondents understand the goal of the model, the assessment questions and the different possible answers to the questions. The model should thus be adapted to the competences of the respondents in order that the difficulty level is not too high. Finally, the interpretability of the model is the hardest requirement to assure since the model isn't tested and thus no real results of the model can't be extracted. It can't be tested that the results of the model are easy to interpret. However, the lean maturity model's result is a level of lean maturity. The respondent can easily interpret this result by investigating the

different lean maturity levels for each assessment item. Hence, since a lean maturity model is simply structured, it is not difficult to interpret the model.

7.5.1 Development of the dimensions

The Model of Second-order Problem-solving, developed by Tucker & Edmonson (2002), is the starting point in the development process. In this model the actions, outcomes and enablers of nurse problem-solving are discussed. To measure the degree in which nurses in a department adopt second-order problem-solving behavior, all the dimensions of the Model of Second-order Problem-solving should be questioned (table 12). That is why it is assumed that each dimension and the corresponding components in the Model of Second-order Problem-solving will be a dimension in the lean maturity model in the context of nurse problem-solving. However, the names of the dimensions and components are adapted to a more operational and understandable context. Additionally, components are added to some dimensions, based on the input model discussion with the lean experts. These are illustrated in italic in table 13. For the first dimension, leadership, there are 3 components added namely *head nurse training, keeping track of results, and sharing results*. In the second dimension, organizational context, a new component *organizational alignment* is added and one component is removed namely self-management. For the third dimension, nurse cognition, group norms is divided into *group collaboration and cross-departmental team collaboration*. The next dimension, actions, consists now of 7 components where the first 2 represent communication, the component *implementing solutions and continuous improvement* are added, and the component *problem-solving coordinator* is moved to this dimension.

The question is now how these dimensions should be assessed.

Dimensions	Components
Nurse manager behavior	Enabling behavior
	Proficiency
Organizational context	Training
	Reward interdependence
	Self-management
Group design	Workload
	Group Norms
Worker cognition	Psychologically safety
	Motivation <ul style="list-style-type: none"> - Feasibility - Anticipated benefit

Degree of second-order problem-solving behavior	Communication
	Effort to remove root causes
	Experimentation
Mechanisms for organizational improvement	Problem-solving coordinator
Outcomes	Quality of care
	Frequency of problems

Table 12: Dimensions and components of the Model of Second-order Problem-solving, by Tucker & Edmonson (2002)

Dimensions	Components
Leadership	Coaching
	Presence on the work floor
	<i>Head nurse training</i>
	<i>Keeping track of results</i>
	<i>Sharing results</i>
Organizational context	<i>Organizational alignment</i>
	Nurse training
	Reward system
Group design	Time
	<i>Team collaboration</i>
	<i>Cross-departmental team collaboration</i>
Nurse cognition	Psychologically safety
	Motivation <ul style="list-style-type: none"> - Available processes - Anticipated benefit
Actions	<i>Communicating to the responsible</i>
	<i>Communicating to the head nurse</i>
	Root cause analysis
	Testing solutions
	<i>Implementing solutions</i>
	<i>Continuous improvement</i>
	<i>Problem-solving coordinator</i>
Outcomes	Quality of care
	Frequency of problems

Table 13: Dimensions and components of the lean maturity model in the context of nurse problem-solving

7.5.2 Development of the assessment questions

To assess the dimensions and the corresponding components, information is assembled from the PW model and the Lean Maturity Self-assessment Tool.

The PW model consists of 5 questions that measure the degree in which the PW program is implemented.

The knowledge of the lean methodologies
The development of the required skills to work with various methodologies of the program
The involvement of the nurses working in the lean environment
The intention to work further with lean methodologies
The support of the hospital board towards the program

Table 14: PW model assessment items, by Van Beveren (2015, p. 41), from Van Bogaert et al. (2014)

The Lean Maturity Self-assessment Tool is a complete lean maturity model and consists of 10 dimensions where each component corresponds to an assessment question. Based on the initial screening done by S. Landry, the assessment questions that are important to incorporate into the lean maturity model in the context of nurse problem-solving i.e. the assessment questions that are affiliated with the problem-solving theory, are selected from the Lean Maturity Self-assessment Tool. The list of the selected assessment items from the Lean Maturity Self-assessment Tool, is pictured below.

Dimension	Assessment question
Patient / user value	Impact on the patient experience (1.3)
Performance management	Presence of scorecards / dashboards (2.2)
Strategy and governance	Bottom up communication (3.3), organizational vision consistent, clear and shared (3.4), alignment of objectives of lean projects and continuous improvement initiatives with organizational objectives. (3.6)
Continuous improvement and sustainability	Standardization of work (4.2), audits and controls (4.3), clinical practices (4.4), daily continuous improvement (4.5), right to experiment and to take risk (4.6), sharing and learning of knowledge acquired in projects / continuous improvement initiatives (4.7), maintaining knowledge (4.8)
Process documentation	Process documentation (5.1), search for root causes of problems (5.6), visual management (5.7)
Project change management	Implementation of solutions (6.7), experimentation in projects or continuous improvement initiatives (6.8)
Cross functional management	Collaboration within process teams (7.6), management based on measurement and analysis of results within processes (7.8), process accountability (7.9)
Stakeholders	Impact on organizational climate (8.1), engagement of the management team (8.2), engagement of middle management (8.5), engagement of employees (8.6), communication of progression of the lean approach (8.7)
Leadership	Lean management skills development (9.1), creation of an operational vision aligned with strategic objectives (9.2), coaching and development (9.3), recognition, celebration and sharing of success internally (9.5), management team / middle managers presence, frequency and diligence on the Gemba (9.6 & 9.7)
Support for projects and for transformation	Provision of lean-related training (10.4)

Table 15: Selected assessment questions of the Lean Maturity Self-assessment Tool per dimension, based on Jobin et al. (2015b)

Based on this table, an idea about the assessment questions to incorporate into the lean maturity model in the context of nurse problem-solving is obtained. The next step is to sort the selected assessment questions over the dimensions belonging to the lean maturity model in the context of nurse problem-solving.

Dimension	Assessment questions
Leadership	Lean management skills development (9.1), creation of an operational vision aligned with strategic objectives (9.2), coaching and development (9.3), management team / middle managers presence, frequency and diligence on the Gemba (9.6 & 9.7), engagement of the management team (8.2), engagement of middle management (8.5), communication of progression of the lean approach (8.7), management based on measurement and analysis of results within processes (7.8), sharing and learning of knowledge acquired in projects / continuous improvement initiatives (4.7), organizational vision consistent, clear and shared (3.4), alignment of objectives of lean projects and continuous improvement initiatives with organizational objectives. (3.6), presence of scorecards / dashboards (2.2), audits and controls (4.3)
Organizational context	Provision of lean-related training (10.4), maintaining knowledge (4.8), recognition, celebration and sharing of success internally (9.5)
Group design	Collaboration within process teams (7.6)
Nurse cognition	Impact on organizational climate (8.1), engagement of employees (8.6), process documentation (5.1), standardization of work (4.2), visual management (5.7)
Actions	Search for root causes of problems (5.6), implementation of solutions (6.7), experimentation in projects or continuous improvement initiatives (6.8), daily continuous improvement (4.5), right to experiment and to take risk (4.6), bottom up communication (3.3)
Outcomes	Impact on the patient experience (1.3), clinical practices (4.4), process accountability (7.9)

Table 16: Assessment items of the Lean Maturity Self-assessment Tool sorted over the dimension of the lean maturity model in the context of nurse problem-solving, based on Jobin et al. (2015b)

This table reflects thus the Lean Maturity Self-assessment items sorted over the dimensions of the lean maturity model in the context of nurse problem-solving. The ultimate goal however is that unique assessment items are constructed for the components of the lean maturity model in the context of nurse problem-solving. The next step is thus to integrate all the information together in order to construct the real assessment items for the lean maturity model in the context of nurse problem-solving. For each dimension's component, an assessment question is created based on the assessment questions of the Lean Maturity Self-assessment Tool (1), the components of the Model of Second-order Problem-solving (2), and the PW assessment questions (3) associated with the particular component. All the components are listed per dimension in the tables below.

Leadership
(1): Coaching and development (9.3)
(2): Enabling behavior
(3): The support of the hospital board towards the program
Q1,1: To what extent does the head nurse provide direction and support to nurses when they encounter problems?
(1): Management team/middle managers presence, frequency and diligence on the Gemba (9.6 & 9.7)
(2): Proficiency
Q1,2: How present is the head nurse on the work floor?
(1): Communication of progression of the lean approach (8.7), lean management skills development (9.1)
Q1,3: To what extent does the head nurse develop second-order problem-solving skills through training?
(1): Presence of scorecards / dashboards (2.2), audits and controls (4.3), sharing and learning of knowledge acquired in projects / continuous improvement initiatives (4.7), management based on measurement and analysis of results within processes (7.8)
Q1,4: To what extent does the head nurse keep track of the second-order problem-solving project results?
Q1,5: To what extent does the head nurse share second-order problem-solving project results with the nurses?

Table 17: Development of the assessment questions for the dimension: Leadership

Organizational context
(1): Organizational vision consistent, clear and shared (3.4), alignment of objectives of lean projects and continuous improvement initiatives with organizational objectives (3.6), engagement of the management team (8.2), engagement of middle management (8.5), creation of an operational vision aligned with strategic objectives (9.2)
Q2,1: To what extent are departmental second-order problem-solving projects aligned with organizational objectives?
(1): Maintaining knowledge (4.8), provision of lean-related training (10.4)
(2): Training
(3): The knowledge of the lean methodologies
Q2,2: To what extent is the nurse knowledge of second-order problem-solving developed through training?
(1): Recognition, celebration and sharing of success internally (9.5)
(2): Reward interdependence
Q2,3: To what extent are second-order problem-solving project results recognized and praised across the department?

Table 18: Development of the assessment questions for the dimension: Organizational context

Group Design
(2): Workload
Q3,1: To what extent do the nurses have time to deal with second-order problem-solving projects besides their normal work package?
(1): Collaboration within process teams (7.6), process accountability (7.9)
(2): Group Norms
Q3,2: To what extent does the departmental team collaborate in second-order problem-solving projects?
Q3,3: To what extent do the cross - departmental teams collaborate in departmental second-order problem-solving projects?

Table 19: Development of the assessment questions for the dimension: Group Design

Nurse cognition
(2): Psychological safety
Q4,1: How does the nurse environment behave when problems are reported?
(1): Standardization of work (4.2), process documentation (5.1), visual management (5.7)
(2): Feasibility
(3): The development of the required skills to work with various methodologies of the program
Q4,2: To what extent are processes available and used by nurses that are needed to overcome a certain problem?
(1): Impact on organizational climate (8.1), engagement of employees (8.6)
(2): Anticipated benefit
(3): The involvement of the nurses working in the lean environment
Q4,3: To what extent are the second- order problem-solving projects improving the nurse climate through satisfaction and engagement?

Table 20: Development of the assessment questions for the dimension: Nurse Cognition

Actions
(1): Bottom up communication (3.3)
(2): Communication
Q5,1: To what extent do nurses communicate to a person or department responsible for problems?
Q5,2: To what extent do nurses bring problems to the attention of the head nurse?
(1): Search for root causes of problems (5.6)
(2): Effort to remove root causes
Q5,3: To what extent do nurses share ideas about the cause of the problem and how to prevent recurrence with someone in a position to implement changes?
(1): Right to experiment and to take risk (4.6), experimentation in projects or continuous improvement initiatives (6.8)
(2): Experimentation
Q5,4: To what extent do nurses obtain the right to test the solutions envisioned with someone in the position to implement changes?
(1): Implementation of solutions (6.7)
Q5,5: To what extent are solutions for problems implemented?
(1): Daily continuous improvement (4.5)
(3): The intention to work further with lean methodologies
Q5,6: To what extent is daily continuous second-order problem-solving improvement part of the departmental culture?
(2): Problem-solving coordinator
Q6,7: To what extent is a person available in the team, other than the head nurse, that provides direction, support, assistance and coaching to nurses in second-order problem-solving projects?

Table 21: Development of the assessment questions for the dimension: Actions

Outcomes
(1): Impact on the patient experience (1.3), clinical practices (4.4)
Q6,1: To what extent has the second-order problem-solving approach got a positive effect on the quality of care?
(2): Frequency of problems
Q6,2: To what extent has the second-order problem-solving approach got a positive effect on the nurse working experience?

Table 22: Development of the assessment questions for the dimension: Outcomes

7.5.3 Development of the lean maturity levels

Each assessment question, belonging to a dimension's component, has a different maturity definition and thus different maturity levels, ranging from low to high. In general, a maturity model has 5 maturity levels, where each level is based on the capability to move further. That is why the levels are called capability levels. As described in the literature review, the following capability levels were defined: initial, managed, defined, predictable and optimizing (Rouse, 2007). Moreover, in the literature review were 5 levels described that illustrated the progression of lean management through an organization (sporadic optimization, basic lean understanding and implementation, strategic lean interventions, proactive lean culture and culture transformation (Jorgensen et al., 2007)). For this master dissertation, it is sufficient to reflect the difference between high and low maturity, since it is the goal of the maturity model to select easily high and low lean maturity departments. However, only assuming 2 levels would be too extreme. That is why a third level is introduced which represents a medium maturity level of lean. The goal is now to describe the 3 maturity levels to have a clear understanding what each maturity level represents.

A high level of lean maturity corresponds with a high degree of second-order problem-solving behavior. This means that nurses adopt second-order problem-solving behavior when they are confronted with problems. Nurses solve problems by looking at the root causes of the problems and implement a solution in such a way that the problems do not reoccur again. Moreover, every nurse in the team works together in performing second-order problem-solving. Group efforts are thus dominating individuals efforts. In general, it indicates that in a department where nurses adopt second-order problem-solving behavior, the hospital of the department successfully changed its people, partners relations, processes and philosophy to lean management. The 4 layers of the 4P model of Liker are thus present in a high mature organization.

A low lean maturity level corresponds with a low degree of second-order problem-solving behavior. This represents that nurses adopt first-order problem-solving behavior when they are encountered with problems. Nurses solve problems on the short term without looking to the root causes of the problems. The result is that problems reoccur again. In general it means that the underlying layers of the 4P model of Liker to reach second-order problem-solving are not met. The philosophy, processes, people and/or partners are not adapted to lean management.

A medium level of lean maturity corresponds to nurses that take an effort to perform root-cause analysis but this does not result in the highest lean maturity level. This is due to the fact that not all nurses believe in the same goals and individual efforts dominate group efforts. There are only some dedicated nurses in the department that perform second-order problem-solving

behavior. In general a medium degree of second-order problem-solving means that an organization did not reach the top level of the 4P model of Liker and that there are insufficiencies in the underlying layers of the 4P model. By investigating the maturity levels per component, an estimation can be done where the medium level of maturity comes from.

Based on those 3 maturity levels, a different maturity definition can be constructed for each assessment item. These are described in the following section.

7.6 Expert validation

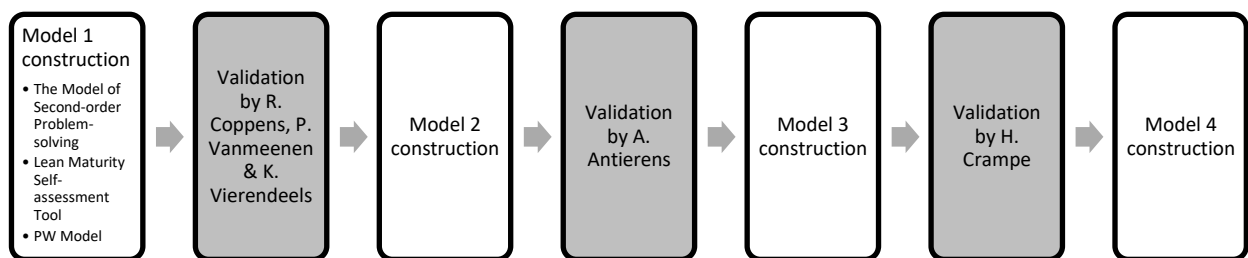


Figure 6: Validation process

The output of the model design is the input for the expert validation process. As illustrated on the figure above, the expert validation process consists of 3 validations and 4 model constructions, where each model construction is a refinement of the model in the previous step with the critical opinion of the expert(s) validating the model. In this section of the master dissertation, the final model is illustrated (table 23) and thoroughly explained per component using the insights of the lean experts.

The goal of the expert validation is to assure that the lean maturity model is externally and internally valid. The lean maturity model should be able to assess lean management in the context of nurse problem-solving in a department of any hospital. This means that the model is not related to a specific kind of hospital, but should be applicable to any kind of healthcare organization. As a result, the assessment questions should be very general in order that everyone can understand the questions and answers. Typical hospital's vocabulary isn't used and the model isn't based on a specific kind of hospital's structure. Secondly, the dimensions of the model need to cover the complete assessed domain. This entails that lean management in the context of nurse problem-solving behavior is assessed in all its components in order that the topic is completely represented. The levels of the maturity model need to represent the complete lean maturity progression of each component. Finally, the assessment questions and levels should be concrete, non-subjective, not socially desirable or acceptable.

Assessment questions	Low maturity of lean	Medium maturity of lean	High maturity of lean
Leadership			
Q1,1: To what extent does the head nurse provide direction and support to nurses when they encounter problems?	The head nurse only provides direction to nurses when they encounter problems. No support is given.	The head nurse provides direction to nurses when they encounter problems. Besides direction, the head nurse also gives nurses support in dealing with problems.	The head nurse provides mainly support to nurses when they encounter problems. The provided direction is limited.
Q1,2: How present is the head nurse on the work floor?	The head nurse is present on the work floor but information from the field is gathered through traditional and hierarchical communication channels. The head nurse is thus not involved into the daily work and is not really available and accessible to nurses.	The head nurse knows the importance of being present on the work floor: observe the work, interact with the nurses, be involved, accessible and available. But in practice, the walk arounds on the work floor do not fulfill its real purpose and the head nurse is still detached from the nurses.	The head nurse is present on the work floor and goes to see for her/himself how work is executed. There is a high interaction with the nurses. The head nurse is thus available, involved and accessible.
Q1,3: To what extent does the head nurse develop second-order problem-solving skills through training?	The head nurse doesn't have second-order problem-solving training or had training randomly once. The head nurse doesn't have any knowledge about the concept and is thus not able to teach it to others.	The head nurse got second-order problem-solving training. Since the head nurse doesn't really embrace the concept, teaching it to others and implementing it is still difficult.	The head nurse got second-order problem-solving training and knowledge is updated frequently. The head nurse stands behind the concept, teaches it to others and deploys it into the department.

Q1,4: To what extent does the head nurse keep track of the second-order problem-solving project results?	The head nurse doesn't keep track of the problem-solving project results.	The head nurse analyses the second-order problem-solving project results only when auditors control the department. The head nurse thus only keeps track of the results when it is necessary / imposed.	The head nurse analyses the second-order problem-solving project results to have up-to-date information about the performance of the projects and to investigate whether the solutions to problems have the desired effect.
Q1,5: To what extent does the head nurse share second-order problem-solving project results with the nurses?	The head nurse doesn't share any problem-solving results.	The head nurse shares second-order problem-solving project results through an improvement or scoreboard.	The head nurse shares second-order problem-solving projects results through a scoreboard and discusses the results with the nurses.
Organizational context			
Q2,1: To what extent are departmental second-order problem-solving projects aligned with organizational objectives?	There is no alignment between departmental problem-solving projects and organizational objectives. At the departmental level, projects are performed out of the blue and/or at the organizational level, there is no framework that structures the objectives of the organization.	The departmental second-order problem-solving projects are in line with the departmental goals. At the departmental level, and not at the organizational level, the objectives are structured. The organization however approves the projects. There is thus minimal alignment between departmental second-order problem-solving projects and organizational objectives	Departmental second-order problem-solving projects are directly aligned with the organizational objectives. Every departmental project can be assigned to one of the organizational improvement goals. The organizational objectives are structured at the higher level. The hospital and department have thus the same objectives.

Q2,2: To what extent is the nurse knowledge of second-order problem-solving developed through training?	Nurses don't have training in second-order problem-solving techniques and no other medium exists where knowledge of second-order problem-solving can be developed.	Nurses don't have training in second-order problem-solving techniques. The only knowledge of second-order problem-solving is established through communication with the person(s) responsible for second-order problem-solving projects.	Nurses have training in second-order problem-solving techniques themselves.
Q2,3: To what extent are second-order problem-solving project results recognized and praised across the department?	No one is praised and recognized when problems are solved. A reward system is not in place.	The reward system only praises and recognizes the person(s) responsible for second-order problem-solving projects regarding the effort and time which is put into the second-order problem-solving projects and regarding the results obtained.	The reward system is focused on group rewarding. The complete departmental team is recognized and praised regarding the effort and time which is put into the second-order problem-solving projects and regarding the results obtained.
Group Design			
Q3,1: To what extent do the nurses have time to deal with second-order problem-solving projects besides their normal work package?	Nurses don't have time to deal with second-order problem-solving projects besides their normal work package because the workload is too high and / or the hospital has other priorities.	The work schedule of nurses is adapted to work on second-order problem-solving projects besides their normal work package. But in practice this is not always achievable since the workload of the nurses is high.	The work schedule is adapted. Nurses have time available to work on second-order problem-solving activities besides their normal work package. This is achievable in practice.

Q3,2: To what extent does the departmental team collaborate in second-order problem-solving projects?	There is no collaboration between the nurses of the department regarding problem-solving projects since only the head nurse is accountable for solving problems.	Group collaboration is performed only between the person(s) responsible for second-order problem-solving projects. They are setting up communication meetings and later communicate the information to the other nurses.	Extensive collaboration is performed across the departmental team since all parties are involved into the second-order problem-solving projects. Communication meetings are setup to work together and share ideas.
Q3,3: To what extent do cross - departmental teams collaborate in departmental second-order problem-solving projects?	Other departmental teams are not collaborating with the department's problem-solving projects. Departmental projects are not part of a large whole.	Other departmental teams are occasionally involved into the departmental projects. There is no further alignment or collaboration.	The departmental team is part of a larger whole. Other departmental teams are involved, tuned and collaborating with the departmental second-order problem-solving projects.
Nurse Cognition			
Q4,1: How does the nurse environment behave when problems are reported?	Nurses are blamed when a problem arises since problems are related to human shortcomings and errors. Nurses thus don't feel psychologically safe. As a result, problems are reported only anonymously.	There is a semi-open culture. Problems are reported but nurses still don't feel that they are psychologically safe since they fear for being sanctioned. As a result, a large number of nurses report problems anonymously.	There is an open culture created and nobody is blamed when a problem is communicated, rather it is stimulated. Nurses feel psychologically safe. All nurses report problems freely and no anonymity is observed.
Q4,2: To what extent are processes available and used by nurses that are needed to overcome a certain problem?	Second-order problem-solving tools aren't available to the nurses and thus aren't used to overcome a certain problem.	Second-order problem-solving tools are available to nurses but they don't make really use of them even when they are recommended.	Second-order problem-solving tools and techniques are available to nurses and make use of these when needed.

<p>Q4,3: To what extent are the second- order problem-solving projects improving the nurse climate through satisfaction and engagement?</p>	<p>Nurse satisfaction and engagement is low regarding second-order problem-solving projects because nurses don't see the benefit of it. The second-order problem-solving projects thus have a negative impact on the nurse climate.</p>	<p>Nurses do see the benefit of second-order problem-solving projects but this does not truly lead to a positive nurse climate. The second-order problem-solving projects thus don't have an impact on nurse satisfaction and engagement.</p>	<p>Second-order problem-solving projects have a positive influence on the nurse climate since nurses are motivated by the positive results and really see the benefit of it. Nurse satisfaction and engagement is thus high.</p>
<p>Actions</p>			
<p>Q5,1: To what extent do nurses communicate to a person or department responsible for problems?</p>	<p>There is no communication to the person or department responsible for problems since nurses do not see the benefit of reporting the problem to the responsible.</p>	<p>There is communication to the person or department responsible for problems but this is only executed by the person(s) responsible for the second-order problem-solving projects.</p>	<p>Every one of the nursing team communicates to the person or department responsible for problems.</p>
<p>Q5,2: To what extent do nurses bring problems to the attention of the head nurse?</p>	<p>Nurses don't communicate problems with the head nurse. They solve problems in a quick, quiet way. As a result, problems reappear again.</p>	<p>Nurses are communicating problems to the head nurse. Afterwards, they are no longer involved in solving them. Instead, only the person(s) responsible for the second-order problem-solving projects try to solve the problems.</p>	<p>Nurses are communicating problems to the head nurse. Afterwards, teams are formed to solve them.</p>

<p>Q5,3: To what extent do nurses share ideas about the cause of a problem and how to prevent recurrence with someone in a position to implement changes?</p>	<p>Nurses don't share ideas about the cause of a problem and how to prevent recurrence since they feel that root cause analysis is too time-consuming and / or there is no person in a position to implement changes.</p>	<p>Nurses share ideas about the cause of a problem and how to prevent recurrence. They are directed and supported by someone in a position to implement changes. However, their impact is moderate since not all possible solutions for a problem are investigated thoroughly.</p>	<p>Nurses are actively involved into the process of root cause analysis and share their ideas with the person that is in the position to implement changes. This person mainly supports the nurses in this task. All the possible solutions for a problem are investigated slowly by consensus.</p>
<p>Q5,4: To what extent do nurses obtain the right to test the solutions envisioned with someone in a position to implement changes?</p>	<p>Solutions for problems are never tested. Nurses don't have the right to test the solutions and / or there is no range of possible solutions to test.</p>	<p>Nurses together with the person that is in the position to implement changes test the solutions envisioned.</p>	<p>Nurses themselves have the right to test the solutions envisioned. Nurses keep thorough communication with the person in a position to implement changes.</p>
<p>Q5,5: To what extent are solutions for problems implemented?</p>	<p>Solutions for problems are implemented instantaneously without investigating the range of possible solutions.</p>	<p>Solutions for problems are implemented too quickly since a good but not optimal solution for a problem is implemented.</p>	<p>Solutions for problems are implemented rapidly since the best solution for a problem is selected.</p>
<p>Q5,6: To what extent is daily continuous second-order problem-solving improvement part of the departmental culture?</p>	<p>There is little of no continuous second-order problem-solving improvement on a daily basis in the department.</p>	<p>There is daily continuous second-order problem-solving improvement but only during follow-up and control phases of lean projects. Not all nurses of the department participate in continuous improvement.</p>	<p>There is daily continuous second-order problem-solving improvement throughout the whole department. It is the norm. It is encouraged and supported by the higher levels. All nurses participate in continuous improvement.</p>

<p>Q5,7: To what extent is a person available in the team, other than the head nurse, that provides support, direction, assistance and coaching to nurses in second-order problem-solving projects?</p>	<p>There is no extra person available that is responsible for second-order problem-solving projects in the team. The head nurse is responsible for solving problems.</p>	<p>There is an extra person, other than the head nurse, assigned in the team that is responsible for second-order problem-solving projects. This person mainly trusts on the head nurse in providing direction, assistance and coaching to nurses to deal with problems since this is not the main task of the assigned person.</p>	<p>There is an extra person, other than the head nurse, assigned in the team that is responsible for second-order problem-solving projects and provides support, assistance and coaching to nurses to deal with problems. This is the main task of the assigned person. This person is an independent individual, but communicates thoroughly with the head nurse.</p>
Outcomes			
<p>Q6,1: To what extent has the second-order problem-solving approach an effect on the quality of care?</p>	<p>Nurses have the impression that the second-order problem-solving projects have a negative effect on the patients experience and thus the quality of care since they observed that patients are confronted with even more problems.</p>	<p>Nurses feel that the quality of care and thus the patients experience didn't change since they observed that similar problems reoccur again. The second-order problem-solving approach has thus no impact on the quality of care.</p>	<p>Nurses are convinced that the quality of care is improved since they observed that patients are experiencing less inconvenience because problems are solved and thus do not reoccur again. The second-order problem-solving approach has a positive impact on the quality of care.</p>
<p>Q6,2: To what extent has the second-order problem-solving approach an effect on the nurse working experience?</p>	<p>Nurses feel that the second-order problem-solving projects result in even more problems. It has thus a negative impact on the nurse working experience.</p>	<p>The second-order problem-solving projects have no impact on the nurse working experience in the department since nurses observed that similar problems reoccur again.</p>	<p>The second-order problem-solving projects have a positive effect on the nurse working experience in the department since problems are solved and do not reappear again.</p>

Table 23: Final lean maturity model in the context of nurse problem-solving

Leadership

The first dimension of the lean maturity model in the context of nurse problem-solving is *leadership*. This dimension represents everything related to a department's management. Managing a department is mainly the task of the head nurse.

According to Meijboom, Gemmel, Ahaus, & Ruel (2017, p.2), "lean leaders convince their team of the importance of the program and involve everyone from an early stage, are present on the work floor, visualize, provide insights and use information sessions, pay attention on an individual level, monitor progress and take action when necessary, facilitate by providing resources, seek support from higher management, use the core team as a driving force, encourage nurses to take the lead, develop the team to becoming self-steering, use communication skills, act as a coach, act as a role model and support lean principles". It is believed that these dimensions of lean leadership are reflected in the components of the lean maturity model's dimension: *leadership*.

Coaching

The first component of the dimension *leadership* is *coaching*. To what extent does the head nurse provide direction and support to nurses when they encounter problems?

The low lean maturity level represents that a head nurse gives only direction when nurses are encountered with problems. The head nurse says what nurses have to do when they encounter problems, and nurses follow these directions. There is no support given since nurses aren't authorized to solve the problems on their own. Nurses thus not own the problem. Solving problems here means solving problems on the short-term. Thus, no second-order problem-solving behavior is executed.

A medium level of lean maturity characterizes that nurses obtain a level of support but are still directed when nurses are encountered with problems. This implies that nurses are involved into solving a problem, but still need a level of direction since they do not really feel they own the problem.

The high lean maturity level signifies that a head nurse gives mainly support when nurses are encountered with problems. This means that nurses themselves are highly involved into solving a problem. They have a feeling of ownership and are supported by the head nurse. The head nurse gives only a little degree of direction anymore and pays more attention at the individual nurse level in order to learn nurses to become self-steering in the function of problem-solving.

The levels of the component *coaching* are related to the theory about empowerment. In the beginning phase, nurses are directed by a head nurse and have no affinity with the problem. In the most mature phase, nurses are only supported by a head nurse and completely own the problem. Nurses are learned to become self-steering in performing second-order problem-solving behavior i.e. they are empowered. (A. Antierens, personal communication, April, 10, 2017)

The component *coaching* is personal related. In a department, there are nurses with very different competences. Some nurses with lower competences need to have more coaching than nurses with higher competences. Moreover, some head nurses are more trained / educated than other head nurses, and their type of coaching can vary a lot. The nurses who have lower competences thus need more direction than support. The persons who have higher competences need more support than direction. To conclude, dependent on the education level of the nurses and head nurse, different levels of coaching are possible. (K. Vierendeels & P. Vanmeenen, personal communication, March 27, 2017)

Additionally, not only the variance in competence level, but also the nurse experience and nurse maturity plays a role. Nurses that are more experienced and mature have more skills to be involved in second-order problem-solving projects than nurses that are less experienced and mature. They need a lot more direction, which can be very hard for the head nurses in return. (R. Coppens, personal communication, March 9, 2017)

Presence on the work floor

This component assesses how present the head nurse is on the work floor. The question is about how a head nurse behaves on the work floor and what the interactions between the head nurse and the nurses are. Not only being present is important, but also interacting with the nurses. (K. Vierendeels & P. Vanmeenen, personal communication, March 27, 2017)

A low lean maturity level signifies that a head nurse is present on the work floor, but interaction with nurses is limited. The head nurse is thus not involved into the daily work and is not available and accessible to nurses. Information from the field is only gathered through traditional and hierarchical communication channels.

A medium lean maturity level means that the head nurse is present on the work floor and knows what the importance of being present means: interacting with nurses, observing the work, being involved, accessible and available. However, this not always happens in practice. The head nurse is still detached from the nurses and the real goal of walk arounds is not fulfilled.

A high level of lean maturity imposes that the head nurse is present on the work floor and interacts with the nurses, observes the work, is involved, accessible and available. The head nurse wants to know her/himself how work is executed.

In some cases, head nurses are frequently on the work floor and coach, communicate and divide the work. They are the central element of the department and are involved into the work processes. This type of head nurse behavior implies a rather low lean maturity level since the head nurse is too controlling, organizing and steering. Rather, a head nurse that takes a step back and let the team become self-steering and independent implies a higher level of lean maturity: organizing a department in such a way that the head nurse becomes partly superfluous and is only needed to support and assist instead of constantly being part of the team. (K. Vierendeels & P. Vanmeenen, personal communication, March 27, 2017)

Moreover, this component is based on the 12th principle of Liker: “Go and see for yourself to thoroughly understand the situation.” (Liker, 2004, p. 4) Leaders should be present on the work floor to go and see things for themselves so they have a thorough understanding of the situation and what is going on in the department. (Liker, 2004) Is a head nurse involved, available and accessible to nurses when being present on the work floor? This component thus measures to what extent the head nurse is really involved with the work and the nurses. (A. Antierens, personal communication, April, 10, 2017)

Head nurse training

The third component *head nurse training* measures to what extent the head nurse develops second-order problem-solving skills through training.

A low lean maturity level indicates that the head nurse doesn't have second-order problem-solving training or had it randomly once. The head nurse doesn't have any knowledge of second-order problem-solving and is thus not able to teach it to others.

A medium level of lean maturity implies that the head nurse gets training in second-order problem-solving. The head nurse has the knowledge, but does not really embraces it in order to successfully teach it to others and implement it into the department.

A high level of lean maturity represents that the head nurse gets training in second-order problem-solving, embrace the concept, teach it to others and implement it into the department.

Performing second-order problem-solving projects first requires training. Training involves both theoretical and practical sessions. (R. Coppens, personal communication, March 27, 2017) For this component, the frequency of the training is not essential, since the amount of training is

related to how fast a head nurse absorb the knowledge. (A. Antierens, personal communication, April, 10, 2017)

Important is that head nurses have training, but even more important is that they do something with this knowledge. Do head nurses see the benefit of the lean methodology? Are they eager to learn it to others? Are they willing to implement it into the department? Etc. (K. Vierendeels & P. Vanmeenen, personal communication, March 27, 2017) This component is related to the 9th principle of Liker: "Grow leaders who thoroughly understand the work, live the philosophy, and teach it to others." (Liker, 2004, p. 3)

Keeping track of results

This component assesses to what extent the head nurse keeps track of the second-order problem-solving project results i.e. whether projects results are followed-up.

A low lean maturity level indicates that a head nurse doesn't keep track of project results and thus doesn't take time to analyze the results.

A medium lean maturity level implies that a head nurse analyses the second-order problem-solving project results only when auditors control the department. The head nurse thus only keeps track of the results when it is necessary / imposed.

A high lean maturity level signifies that the head nurse analyses the second-order problem-solving project results to have up-to-date information about the performance of the projects and to investigate whether the solutions to problems have the desired effect.

The head nurse's task is to analyze the obtained information about the second-order problem-solving projects. The project results are measured by external parties and accumulated by the head nurse. (A. Antierens, personal communication, April, 10, 2017) Checking results is part of the PDCA cycle. The difference between the high and medium level of lean maturity is that in the former case the head nurse keeps track of results on their own initiative and that in the latter case the head nurse keeps track of results only when they are controlled i.e. when it is necessary. (R. Coppens, personal communication, March 9, 2017)

Sharing results

This component of the dimension *leadership* assesses whether a head nurse shares the results with the nurses in the department. It is thus not only necessary that a head nurse keeps track of the results, but also that results are shared across the department in order that everyone is up-to date about the second-order problem-solving projects.

A low level of lean maturity means that the head nurse doesn't share any problem-solving results.

In a medium level of lean maturity, the head nurse shares second-order problem-solving project results through an improvement board or scoreboard.

A high level of lean maturity means that the head nurse shares second-order problem-solving projects results through a scoreboard and discusses the results with the nurses.

Sharing second-order problem-solving projects results is mainly done by using scoreboards. These boards are a representation of the department's problems and are focused on the possible solutions. Moreover, the results of the problem-solving projects are pictured. This is something different than an improvement board. These type of boards represent all the department's problems and is more a frustration board. It is thus better to use scoreboards instead of improvement boards. (H. Crampe, personal communication, April, 18, 2017)

Besides sharing results, it is important that the results are discussed with all nurses. Not only looking to the board, but really discussing why some results are good or bad is necessary. Action should be taken when results are not as expected. (A. Antierens, personal communication, April, 10, 2017) This also is related to the PDCA cycle.

Organizational context

The second dimension of the lean maturity model is *organizational context*. This dimension reflects how the healthcare organization is organized and is adapted to the lean approach. Does the organization offers training, and is the organization's vision and the reward system adapted to the lean approach?

Organizational alignment

The first component of the dimension *organizational context* is *organizational alignment* and assesses to what extent the departmental second-order problem-solving projects are aligned with the organizational objectives. It indirectly assesses the healthcare organization's philosophy and whether projects are part of a larger whole.

A low level of lean maturity implies that there is no alignment between departmental problem-solving projects and organizational objectives. At the departmental level, projects are set up out of the blue and at the organizational level, there is no framework that structures the objectives / goals of the organization.

A medium level of lean maturity indicates that the department performs projects that fit within the departmental goals, since objectives are structured at the departmental level using a framework. Thus, at the organizational level there doesn't exist a framework where objectives are structured. However, the department has the approval of the management team to perform these projects. The medium level represent thus minimal alignment between departmental second-order problem-solving projects and organizational objectives.

A high level of lean maturity signifies that the department performs second-order problem-solving projects that are in line with the organizational objectives. Each project falls into a category of the organizational framework, where goals are structured. The healthcare organization and the department have thus the same objectives.

It is assumed that a healthcare organization structures its mission, goals and objectives using a framework. When a department wants to set up a second-order problem-solving project, they need to have the approval of the management team i.e. checking whether the project is in line with the organizational objectives. (R. Coppens, personal communication, March 27, 2017) When the management team comes to the conclusion that some goals or objectives are not met, it stimulates the departments to work on problem-solving projects related to these objectives. (A. Antierens, personal communication, April, 10, 2017) The organizational framework is thus a way in which the management team stimulates the departments and gives the departments opportunities to work on quality projects. (R. Coppens, personal communication, March 27, 2017) If respondents can't give an answer to this component, it means that there is no framework present that structures the goals and objectives and no alignment with the departments is possible. Projects are thus implemented randomly. (K. Vierendeels & P. Vanmeenen, personal communication, March 27, 2017)

The scoreboard in the departments usually represents the organizational framework where goals are structured. The employees in the department can see which goal pillars are available and which projects belong to which goal pillar. (H. Crampe, personal communication, April, 18, 2017)

In a high lean mature healthcare organization, the goals and objectives should be in line with the lean objectives. It is not compulsory that the term lean management is used, but rather that the objectives reflect quality, safety, patient's focus etc. These goals are the pillars of the structured framework. Each organization has in general the same goals and objectives, but the focus and vision is different. They all want qualitative patient's care, but the means to reach this goal is different. (A. Antierens, personal communication, April, 10, 2017)

Nurse training

The second component of the *organizational context* dimension is *nurse training*. This component assesses whether nurses have developed knowledge of second-order problem-solving through training.

A low level of lean maturity represents that nurses don't have training and have no other medium accessible to obtain some knowledge about second-order problem-solving training.

A medium level of lean maturity characterizes that nurses don't have training in second-order problem-solving techniques but are taught by the person(s) responsible for problem-solving projects. These person(s) have a knowledge of this topic and are eager to learn it to others.

A high level of lean maturity indicates that nurses have training in second-order problem-solving projects themselves.

The extent in which nurses obtain knowledge about second-order problem-solving is dependent on how a healthcare organization is structured. When only head nurses get training, the nurses obtain knowledge through head nurses. When both the head nurse and a problem-solving coordinator obtain training, the cascade of the knowledge happens through them. When the healthcare organization makes it possible that nurses obtain training themselves, nurses have access to this knowledge directly. (K. Vierendeels & P. Vanmeenen, personal communication, March 27, 2017)

Reward system

The next component for the second dimension is *reward system* and is assessed by whether second-order problem-solving project results are recognized and praised across the department.

In the lowest maturity level, no one is praised and recognized for the results obtained since a reward system is not in place.

The medium level of lean maturity implies that only the person(s) responsible for second-order problem-solving projects are praised and recognized for the results obtained and the effort and time put into the project. The reward system is thus mainly based on individual performances.

The highest level of lean maturity represents that the whole team is recognized and praised regarding the time and effort which is put into the projects and the results obtained. The reward system is thus focused on group rewarding.

According to the lean culture, the whole group is rewarded when something is done. This is what the highest lean maturity level implies. According to the in-depth interviews with the lean experts, it became clear that the answers of the respondents to this component will result in a low or medium level of lean maturity, since in practice the reward systems are not organized effectively. It is difficult to choose the right reward, difficult to evaluate when someone deserves a reward (R. Coppens, personal communication, March 9, 2017), and sometimes the nurses have the wrong perception about the rewards i.e. the rewards and the team assignments are not effectively linked. (A. Antierens, personal communication, April, 10, 2017) Possible rewards can range from non-monetary rewards to monetary rewards in the form of money or materialistic items. (R. Coppens, personal communication, March 9, 2017)

Group design

The third dimension of the lean maturity model in the context of nurse problem-solving is *group design*. This dimension assesses a department whether the nurse workload is adapted to the lean approach and whether nurses collaborate within and across teams.

Time

The first component assesses whether nurses have the time to deal with second-order problem-solving projects besides their normal work package.

A low lean maturity level indicates that nurses don't have the time to deal with second-order problem-solving projects because the workload is too high and / or because the department has other priorities. The work schedule is thus not adapted to deal with second-order problem-solving projects.

A medium level of lean maturity implies that the work schedule of nurses is adapted to work on second-order problem-solving projects but in practice this is not always achievable since the workload of the nurses is high. Nurses don't have time enough to deal with second-order problem-solving projects.

A high level of lean maturity indicates that the work schedule of nurses is adapted. Nurses have the time available to work on second-order problem-solving activities besides their normal work package and this is achievable in practice.

This component is fair and justified and should definitely be integrated into the lean maturity model. When nurses don't have the time to investigate the root causes of the problems, they are pushed to do first-order problem-solving behavior. (R. Coppens, personal communication, March 9, 2017)

Through the interviews with the lean experts, it became clear that the response on this component would tend to the low or medium lean maturity level since in practice healthcare organizations have not enough personnel and the workload is very high. Patient's care always prioritizes. As a result, time to work on quality projects decreases. Even when time is made free to work on projects, it is very hard to retain on it since patient's care is more important. (R. Coppens, personal communication, March 9, 2017)

Team collaboration

This component assesses whether nurses collaborate with the departmental team in second-order problem-solving projects. Do nurses actually communicate and collaborate enough with the other team members to perform second-order problem-solving projects or are nurses more stand-alone operators?

A low lean maturity level indicates that there is no collaboration between the nurses of the department regarding problem-solving projects since only the head nurse is accountable for solving problems.

A medium lean maturity level represents that group collaboration is performed only between the person(s) responsible for second-order problem-solving projects. They are setting up communication meetings and later communicate the information to the other nurses.

A high level of lean maturity means that extensive collaboration is performed across the departmental team since all parties are involved into the second-order problem-solving projects. Communication meetings are setup to work together and share ideas.

One of the most important characteristics of lean management is group collaboration. To foster group thinking, communication meetings are set up to share ideas and work together on projects. These meetings are a good motivator to work on second-order problem-solving projects since nurses have the perception that they are not standing alone. In such a way, all nurses can work together to solve problems. (R. Coppens, personal communication, March 9, 2017) Important to note is that in order to obtain a high mature level of team collaboration, communication meetings are not sufficient. The support of the head nurse to communicate and collaborate with the team members is necessary as well.

Cross-departmental team collaboration

Not only the collaboration within but also across departmental teams is important. That is why this component assesses to what extent cross-departmental teams collaborate in departmental second-order problem-solving projects.

A low lean maturity level implies that the departmental team does not collaborate with other cross-departmental teams. The departmental projects are thus not part of a larger whole. They are only focused at the departmental level.

A medium lean maturity level indicates that other departmental teams are occasionally involved into departmental second-order problem-solving projects. There is no further alignment or collaboration.

A high lean maturity level signifies that the departmental team is part of a larger whole. Other departmental teams are involved, tuned and collaborating with the departmental second-order problem-solving projects.

A department of a healthcare organization does not work on its own. It is related to other departments and thus it is rational that the nurses from one department work together with nurses from other departments in the context of problem-solving. The component assesses thus whether the departmental team is part of a larger whole. It is possible that one department performs a second-order problem-solving project and that this results in negative outcomes for another department if they do not collaborate together. (A. Antierens, personal communication, April, 10, 2017) However in practice, collaborating between departments does not always happen since each department has its own structure and way of working.

Nurse cognition

The next dimension of the maturity model is *nurse cognition*. This dimension entails 2 components *psychological safety* and motivation. The last components is divided into *available processes* and *anticipated benefit*.

Psychological safety

This component is assessed by how the nurse environment behaves when problems are reported.

A low lean maturity level implies that nurses are blamed when a problem arises since problems are related to human shortcomings and errors. Nurses thus don't feel psychologically safe. As a result, problems are reported only anonymously.

A medium level of lean maturity indicates that there is a semi-open culture. Problems are reported but nurses still don't feel that they are psychologically safe since they fear for being sanctioned. As a result, a large number of nurses report problems anonymously.

A high level of lean maturity means that there is an open culture created and nobody is blamed when a problem is communicated, rather it is stimulated. Nurses feel psychologically safe. All nurses report problems freely and no anonymity is observed.

In an open culture it is easier to work on second-order problem-solving projects than in a closed culture. (R. Coppens, personal communication, March 27, 2017) An open culture is characterized by nurses that communicate problems freely and openly with the other people. This is of major importance since a characteristic of second-order problem-solving is exposing problems. Problems are often related to human shortcomings and errors. That is why nurses sometimes don't dare to expose problems since they fear for being sanctioned. Nurses need to feel psychologically safe in order to communicate about problems openly. This component is related to the anonymous and non-anonymous reporting of problems. Problems are reported anonymously when nurses don't dare to communicate openly and nurses will report non-anonymously when they feel psychologically safe. (A. Antierens, personal communication, April, 10, 2017) Often the fear of being sanctioned is caused by the fear of the head nurse. Nurses are afraid to fail in the eyes of their team leader. That is why a open communication and mutual trust in a department is very important.

Available processes

The second and third component assess the motivation of the nurses. This component is going about whether processes are available and used by nurses that are needed to overcome a certain problem. These processes can range from an A3 procedure, PDCA (plan, do, check and act), DMAIC (define, measure, analyze, improve and control), root cause analysis, clinical paths, fishbone diagrams, value stream maps, etc.

A low level of lean maturity implies that second-order problem-solving tools aren't available to the nurses. The tools are thus not used by nurses to overcome a certain problem.

A medium level of lean maturity represents that second-order problem-solving tools are available to nurses but they don't make really use of them even when they are recommended.

A high level of lean maturity characterizes that second-order problem-solving tools and techniques are available to nurses and make use of these when needed.

Important is that nurses have access to second-order problem-solving tools, but more important is that they use it at the right time and in the right manner. The frequency of usage is not important since it is seen in practice that nurses use tools at a high extent and solve problems in a more advanced and complicated way than the problem actually is. (A. Antierens, personal communication, April, 10, 2017) Having access to the second-order problem-solving tools

means that they have the faith that the tools are available to overcome a certain problem. This is thus a type of motivator. (Tucker & Edmondson, 2002) Since the lean maturity tool in the context of nurse problem-solving needs to be generalized i.e. used by all healthcare organizations, it is assumed that no examples of second-order problem-solving tools are given. Organizations use different types of tools, so some respondents will know the type of tool and other don't. All respondents of the lean maturity model should be able to understand and respond to the question. (H. Crampe, personal communication, April, 18, 2017)

Anticipated benefit

The second component that represents motivation of the nurses assesses whether second-order problem-solving projects improve the nurse climate through satisfaction and engagement.

A low level of lean maturity implies that nurse satisfaction and engagement is low regarding second-order problem-solving projects because nurses don't see the benefit of it. The second-order problem-solving projects thus have a negative impact on the nurse climate.

A medium level of lean maturity signifies that nurses do see the benefit of second-order problem-solving projects but this does not lead to a positive nurse climate. The second-order problem-solving projects thus don't have an impact on nurse satisfaction and engagement.

A high level of lean maturity characterizes when second-order problem-solving projects have a positive influence on the nurse climate since nurses are motivated by the positive results and really see the benefit of it. Nurse satisfaction and engagement is thus high.

Nurses are motivated if they see the benefits of the second-order problem-solving projects. This means that positive outcomes of the projects influence the nurse cognition. Motivated nurses that see the benefits of the projects will be more involved and will be more satisfied. In some cases, positive project results don't lead to an increase in nurse engagement, although the satisfaction is high. This means that nurses do see the benefits of the projects, but don't have time enough to work on second-order problem-solving projects. (A. Antierens, personal communication, April, 10, 2017)

Actions

This dimension involves all the actions that are related to second-order problem-solving behavior. "Communication to the person or department responsible for the problem, bringing the problem to the attention of the head nurse, sharing ideas about the cause of the situation and how to prevent recurrence with someone in a position to implement changes, and implement changes." (Van Beveren, 2015, p. 6) Moreover, the component *continuous improvement* is part

of this dimension since actions of second-order problem-solving need to happen continuously. The last component of the dimension *actions* is a *problem-solving coordinator*. This component is important since successful second-order problem-solving is only possible when a problem-solving coordinator is present that supports, assists and coaches nurses in second-order problem-solving projects.

Communication to the responsible

The first component is communication to the person or department responsible for problems.

A low level of lean maturity signifies that there is no communication to the person or department responsible for problems since nurses do not see the benefit of reporting problems to the responsible person or department.

A medium level of lean maturity characterizes that there is communication to the person or department responsible for problems but this is only done by the person(s) responsible for the second-order problem-solving projects.

A high level of lean maturity indicates that every one of the nursing team communicates to the person or department responsible for problems.

Communicating a problem first requires that the team sees the problems. This is related to the statement of Ohno (1988): "Learn to see". If teams do not see the problems, nothing can be improved since in their point of view everything runs smoothly. In literature, there are 4 types of teams. Teams that are performing good and know (these teams know their processes and know when something runs bad or good), teams that are performing good but don't know (these type of teams see problems everywhere), teams that are performing bad and know (these teams see the problems but don't do anything about it), and teams that are performing bad and don't know (these teams do not see problems). All 4 teams are possible to be present in an organization. The type of teams largely depend on the coaching style of the head nurse. A head nurse in the last type of team doesn't performs well. (A. Antierens, personal communication, April, 10, 2017)

Communication to the head nurse

Not only communication with the person or department responsible for problems is important, but bringing problems to the attention of the head nurse is also important.

A low level of lean maturity implies that nurses don't communicate problems with the head nurse. They solve problems in a quick, quiet way. As a result, problems reappear again.

A medium level of lean maturity means that nurses are communicating problems to the head nurse. Afterwards, they are no longer involved in solving them. Instead, only the person(s) responsible for the second-order problem-solving projects try to solve the problems.

A high level of lean maturity indicates that nurses communicate problems to the head nurse. Afterwards, teams are formed to solve them.

Not only the communication is important, but also what happens after problems are communicated to the head nurse. Are problems transferred to the head nurse or does the communicator stay involved with the problems? The first case does not imply second-order problem-solving, in contrast to the latter case. Problems rise from the group and the group itself remains related to the problem. (K. Vierendeels & P. Vanmeenen, personal communication, March 27, 2017)

Stand-up meetings is a mean to communicate a problem to the head nurse. These semi-formal meetings are setup each day with every team member. In that meeting, nurses can share the positive and negative points experienced during the day. The goal of this meeting is that everyone is up-to-date about the processes going on in the department. The head nurse task is to assemble the information and make projects based on the negative experiences, i.e. problems, observed in the organization. Thus in this meeting no problems are solved, rather problems are reflected. (A. Antierens, personal communication, April, 10, 2017)

This component is related to incidents reporting. It is compulsory that each healthcare organization performs an incident registration across the organization. If an incident, or nearly incidents happens, an employee needs to register and needs to report this. This can happen anonymously. Afterwards, these incidents need to be investigated through for example a risk analysis. The healthcare organization can give feedback to the employees that reported problems, can set up a proactive plan, can set up improvement projects based on high risk problem, etc. (H. Crampe, personal communication, April, 18, 2017)

Root cause analysis

The main important component is this lean maturity tool is *root cause analysis*. This is assessed by whether nurses share ideas about the cause of a problem and how to prevent recurrence with someone in a position to implement changes. This component is the most fair and direct one.

A low level of lean maturity implies that nurses don't share ideas about the cause of a problem and how to prevent recurrence since they feel that root cause analysis is too time-consuming and / or there is no person in a position to implement any changes.

A medium level of lean maturity signifies that nurses share ideas about the cause of a problem and how to prevent recurrence. They are directed and supported by someone in a position to implement changes. However, their impact is moderate since not all possible solutions for a problem are investigated thoroughly.

A high level of lean maturity indicates that nurses are actively involved into the process of root cause analysis and share their ideas with the person that is in the position to implement changes. All the possible solutions for a problem are investigated slowly by consensus.

In low lean mature organizations, no root cause analysis is done. Solving the problem is executed by the head nurse but is not based on second-order problem-solving. Nurses are only involved through improvement boards where the information is transferred. (R. Coppens, personal communication, March 9, 2017)

Testing solutions

When ideas are shared about the cause of a problem and how to prevent recurrence, the possible solutions can be tested in the department. Not testing the possible solutions to a problem is not rational, since no one knows what the outcome of a solution will be. (R. Coppens, personal communication, March 27, 2017)

A low level of lean maturity represents that solutions for problems are never tested. There is no range of possible solutions to test since no root cause analysis is done. Moreover, nurses don't have the right to test the solutions.

A medium level of lean maturity means that nurses together with the person who is in the position to implement changes, test the solutions envisioned.

A high level of lean maturity implies that nurses themselves have the right to test the solutions envisioned. Nurses keep thorough communication with the person in a position to implement changes.

Implementing solutions

After the testing round, the best solution for a problem is selected. *Implement solutions* is a component of the dimension *actions* that assesses to what extent solutions for problems are implemented.

A low level of lean maturity characterizes that solutions for problems are implemented instantaneously without investigating the range of possible solutions.

A medium level of lean maturity implies that a good but not optimal solution for a problem is implemented. Thus, the implementation process happened too quickly. There is no complete root cause analysis executed in order to find the best solution.

A high level of lean maturity signifies that when the best solution for a problem is selected, it is implemented rapidly. In this case, root cause analysis is executed thoroughly in order to find the best solution. When the best solution is determined, it is implemented rapidly.

This component thus investigates if something happens with the made solutions i.e. if solutions are actually implemented. (R. Coppens, personal communication, March 27, 2017) This component is related to the 13th principle of Liker: “Make decisions slowly by consensus, thoroughly considering all options and implement decisions rapidly.” (Liker, 2004, p. 4) First of all, enough time should be spend to find all possible solutions to a problem. When the right solution to a problem is found, it should be implemented rapidly. The component’s levels are thus constructed based on the time to consider all options and the implementation speed. (A. Antierens, personal communication, April, 10, 2017)

The medium level of lean maturity implies that a team has took the time to look for possible solutions for a problem but goes too fast to the implementation stage. As a result, not all solutions for a problem are investigated and thus root cause analysis is not performed completely. Although very rare, it can also happen that a team investigates all the possible solutions for a problem but implements the best solution too slowly. For example, the implementation process takes too long since at the higher level the decision making process is difficult. This is the case when a solution for a problem is very expensive. (A. Antierens, personal communication, April, 10, 2017) If a solution to a problem is more expensive than the problem actually is, then it commonly happens that this solution is not implemented, even when it is a better solution than the state before. (K. Vierendeels & P. Vanmeenen, personal communication, March 21, 2017)

Continuous improvement

Actions of second-order problem-solving need to happen continuously on a daily basis. That is why the component *continuous improvement* assesses to what extent daily continuous second-order problem-solving improvement is part of the departmental culture.

A low level of lean maturity implies that there is little or no continuous problem-solving improvement on a daily basis in the department.

A medium level of lean maturity implies that there is daily continuous second-order problem-solving improvement but only during follow-up and control phases of lean projects. Not all nurses of the department participate in continuous improvement.

A high level of lean maturity is when there is daily continuous second-order problem-solving improvement throughout the whole department. It is the norm. It is encouraged and supported by the higher levels. All nurses participate in continuous improvement.

This component is related to the 14th principle of Liker: “Become a learning organization through relentless reflection and continuous improvement.” (Liker, 2004, p. 4)

The highest and lowest lean maturity level actually represents the difference between continuous improvement and continuous change. In the first case, a team will implement a solutions and will keep track of the performance in order to investigate what can happen better. In the second case, a team will implement a solution to a problem, but the solution will not hold since the problem reappears again. This team constantly stays into the same cycle. (A. Antierens, personal communication, April, 10, 2017)

Continuous improvement is very difficult to achieve in practice. It is a long-term progression where everybody should be involved in improving the processes. A new culture should be created that is based on a complete adaption of the underlying principles and where everybody believes into the culture.

Problem-solving coordinator

The last component, a problem-solving coordinator is a person that is part of the team that has the task to give direction, support, assistance and coaching to nurses in second-order problem-solving projects. This person has thus a functional, operational task and is still at the nurse level.

A low lean maturity level means that there is no extra person available that is assigned to this operational task. Only the head nurse is responsible for solving a problem.

A medium lean maturity level indicates that there is a person assigned in the team to be a problem-solving coordinator but this person mainly trusts on the head nurse in providing direction, assistance and coaching in second-order problem-solving projects since this is not the main task of the assigned person.

A high lean maturity level implies that there is a person available in the department, other than the head nurse, that is responsible for supporting, assisting and coaching nurses in second-

order problem-solving projects. This is the main task of the assigned person. This person is an independent individual, but communicates thoroughly with the head nurse.

The real aim of the problem-solving coordinator is to bring nurses together to coach and assists them in second-order problem-solving projects. Second-order problem-solving behavior entails that nurses are involved and motivated in second-order problem-solving projects rather than only a couple of individuals. However, in order that the results of the projects are truly successful, the nurses need to be assisted and supported by someone that helps them. It is seen that when nurses are too independent, second-order problem-solving projects don't lead to very successful results since there is a lack of coaching and stimulation. Therefore, a problem-solving coordinator is needed who gives direction, support, assistance and coaching to nurses in second-order problem-solving projects. (Tucker & Edmondson, 2002) This component is of course also related to the competences of the problem-solving coordinator. (K. Vierendeels & P. Vanmeenen, personal communication, March 27, 2017) A problem-solving coordinator together with the head nurse has more impact in performing second-order problem-solving projects. (R. Coppens, personal communication, March 9, 2017) Moreover, there is a clear difference between a person which is positioned on the nurse level in a department who helps, assists, supports and directs nurses in second-order problem-solving projects, and a person which is positioned on the management level who helps, assists, supports and directs nurses in second-order problem-solving projects across different departments. (A. Antierens, personal communication, April, 10, 2017) It is assumed that the component represents a person on the nurse level, since the lean maturity model only assesses lean within the boundaries of one department of a healthcare organization. A person at the nurse level has higher chances to be involved into the daily processes than a person positioned at the management level. A person that is positioned at a higher level than the nurse level is hierarchical higher and has thus more authority to direct nurses. However, a person that is positioned at the nurse level has less authority to direct nurses since the person is not positioned hierarchically higher. (A. Antierens, personal communication, April, 10, 2017)

Outcomes

The last dimension of the lean maturity model in the context of nurse problem-solving is *outcomes*. It is rational to incorporate this dimension into the model since project results are the objectives why projects are done. (R. Coppens, personal communication, March 9, 2017) This dimension reflects if the second-order problem-solving projects results have an effect on both the quality of care and on the daily processes of the department. It is believed that the effect can be negative, positive or no effect. (K. Vierendeels & P. Vanmeenen, personal communication, March 27, 2017)

Quality of care

The first component is quality of care and it assesses to what extent the second-order problem-solving approach has an effect on the quality of care.

A low level of lean maturity indicates that the second-order problem-solving approach got a negative effect on the quality of care. The quality of care is decreased since patients are experiencing more problems.

A medium level of lean maturity represents that nurses feel that the quality of care and thus the patients experience didn't change since they observed that similar problems reoccur again. The second-order problem-solving approach has thus no impact on the quality of care.

A high level of lean maturity implies that the second-order problem-solving approach got a positive effect on the quality of care. The quality of care is improved since nurses observed that patients are experiencing less inconvenience during their stay because problems are solved and do not reoccur again.

Since patients normally do not revisit the same department again, the effect on the patient experience from their point of view can't be a measure to assess the quality of care. That is why the point of view of the nurses is chosen to assess the change in the patient experience and thus the quality of care. Do nurses see a positive, negative or no change in the patient experience? Moreover, this components also measures indirectly the extent in which the nurses believe into the second-order problem-solving approach. (A. Antierens, personal communication, April, 10, 2017)

Although this dimension measures the effect of the patient experience through the eye of the nurses, it is still very important to listen to the patient's voice. Lean management puts the customer central to the organization and constantly tries to improve processes in order to increase the value to the customer. Hence, nurses should listen to the patients' wishes and involve them in order that patient are empowered.

In literature, it is stated that in some healthcare organizations the lean approach has a negative effect on the quality of care since the organization is too focused on meeting organizational objectives that have an positive effect on the daily processes. It thus become less agile and can't respond to the wishes of the patients anymore. (A. Antierens, personal communication, April, 10, 2017)

Frequency of problems

On the other hand, the outcomes of second-order problem-solving projects are related to the daily processes of the department. Have the second-order problem-solving projects effect on the nurse working experience?

A low lean maturity level means that nurses feel that the second-order problem-solving projects result in even more problems. It has thus a negative impact: the working experience in the department is less efficient, effective and/or morally acceptable.

A medium level of lean maturity represents that the second-order problem-solving projects have no impact on the nurse working experience in the department since nurses observed that similar problems reoccur again. As a result, the effectiveness, efficiency and/or moral perception of the work remains the same.

A high lean maturity level characterize that the second-order problem-solving projects have a positive effect on the nurse working experience in the department since problems are removed and do not reappear again. Nurses feel that they can execute their work in a more efficient, effective and/or morally acceptable way.

This component should measure the change in the frequency of the problems. However, assessing by incorporating the amount of problems is not a good approach, since some departments can work on a small number of big problems and other departments can work on a large number of small problems. Moreover, continuous improvement means that new problems are constantly identified i.e. the number of problems increases. A reduction in the number of problems thus doesn't imply a high lean maturity level. (R. Coppens, personal communication, March 27, 2017) What is surely important is whether similar problems reappear again or not. When problems reappear again this means that the right solution for the problem is not implemented i.e. the complete root causes of the problem is not investigated. On the other hand, when problems don't reappear again, the root causes of the problem is investigated completely and the best solution for the problem was implemented. Nurses in an environment that solved the problem can thus operate in a more efficient, effective and/or moral acceptable way. (A. Antierens, personal communication, April, 10, 2017) For example: there is a time gain, a more structured way of working, etc.

8 MODEL DISCUSSION

8.1 Conclusion

The outcome of this master dissertation is a lean maturity model in the context of nurse problem-solving. The final model is described in table 23. It is based on literature review, face, content and external validity of lean experts. The model is an approach to assess the degree of lean implementation in the context of nurse problem-solving behavior in a department of a hospital. The model thus don't assesses lean management in all its aspects but only does a quick scan of assessing lean in the context of nurse problem-solving. This is because an investigation is done about the effect of lean on the problem-solving behavior of nurses. The model is also not intended to assess lean organization-wide but only focusses on a single department of a hospital. With this model, departments obtain a knowledge about their current lean maturity level. This level can then be used to compare different departments within and across hospitals.

Through the interviews with the lean experts it became clear that in practice hospitals don't know their current lean maturity level or estimate the lean maturity level completely wrong. Some organizations are for example more lean than they actually realize. These type of organizations have a healthy organizational way of working without the intention of using lean approaches. The management team did not introduced the concept of lean and the employees don't recognize the lean concepts. On the other hand, there are organizations that think that they are lean but only implemented randomly basic lean tools. There is thus a need for a standardized measure that assesses departments of hospitals in order to have a knowledge of their current lean maturity level without relying on their intuition or subjective point of view. The lean maturity model in the context of nurse problem-solving is thus a good solution to this problem.

Important to discuss is how the final lean maturity model in the context of nurse problem-solving is related to the literature review. Through reviewing literature, it became clear that three models could serve as an input for the development of the model: the Model of Nurse Second-order Problem-solving, the Lean Maturity Self-assessment tool and the PW model. The first model describes all the enablers that were needed to assess nurse problem-solving behavior. In the empirical review, the elements were renamed to a more operation point of view and were criticized with lean experts. The outcome was that some elements were added and some removed. However, the final lean maturity model in the context of nurse problem-solving is still mainly based on the Model of Nurse Second-order Problem-solving. The second model, the Lean Maturity Self-assessment tool, represents a complete lean assessment in a hospital. From

this model, the assessment questions were selected that had an affiliation with nurse problem-solving behavior. Based on these assessment questions, unique assessment questions were constructed for the lean maturity model in the context of nurse problem-solving. Since these questions are unique and adapted several times, it thus not truly reflect its origin anymore (the assessment questions of the Lean Maturity Self-assessment tool). On the contrary, the assessment items of the lean maturity model in the context of nurse problem-solving though reflect the 5 assessment items of the PW model.

8.2 Limitations and recommendations for further investigation

The lean maturity model in the context of nurse problem-solving is a grid with dimensions, components and 3 different maturity levels per component. It is still a theoretical approach to assess the lean maturity in a department of a hospital. It is not a questionnaire that is designed since this is more pragmatic and operational in contrast to the grid, which is theoretical. In a survey with open questions, for example real life cases, the respondents can reflect their own point of view in the answers to the questions. More valuable information could be obtained using a survey with open questions. With a survey, the lean maturity in a department can thus be assessed in a more operational way which this is not possible with a grid.

In this master dissertation a lean maturity model is developed that assesses lean in the context of nurse problem-solving. It is assumed that second-order problem-solving behavior is the highest level that a lean organization can reach. In literature however, there are authors that contradict this statement and argue that rigorous problem-solving is not the highest level in a lean organization. Shigeo Shingo for example developed the idea of mistake proofing, poka-yoke, or preventing errors and defects. He stated that an organization is situated at the highest level when no errors or problems are occurring anymore. This type of environment eliminates thus the process of quality control inspections, since it is assumed that every process or product has zero problems. All processes and products are thus value-adding. This idea is based on the intelligence of the workers. Most of the workers' time is dedicated to creative and value-adding activities. (Shimbun, 1987) To conclude, in poka-yoke organizations, second-order problem-solving does not exist since problems do not exist in these organizations. There is a proactive approach that eliminates the chances that problems occur, in contrast to the reactive problem-solving approach. Poka-yoke organizations thus don't see the benefit of using the lean maturity model in the context of nurse problem-solving behavior. However, only a limited amount of poka-yoke healthcare organizations exist and thus the majority of hospitals use rigorous problem-solving techniques to continuously improve their business. It is thus assumed that the lean maturity model in the context of nurse problem-solving is practically useful.

There exist a way to assess the lean maturity of a healthcare organization besides hospitals' intuition or subjective point of view. A possible ways to assess the lean maturity is by using culture indexes. For example, the organizational culture is determined by investigating the patient's safety culture index (i.e. 'patientveiligheidscultuurmeting'). It is mandatory that all healthcare organizations measure the patient's safety culture according to a tool that consists of 12 dimensions: managers expectations and actions that improve patient safety, the way in which the organization learns and continuously improves, teamwork within the departments, communication openness, feedback and communication about safety, non-sanctioned reaction on mistakes, blaming culture, the management support for patient safety, teamwork across the departments, transfer and transmission, the global perception about safety, and the frequency of incidents reporting. (Hellings & Schrooten, 2008) The result of this investigation is that a healthcare organization obtains a patient's safety culture score that is higher, lower or the same as the patient's safety culture benchmark. There is a correlation between the patient's safety culture index and lean maturity. Healthcare organizations that have a high / low score on the patient's safety culture index tend to have a high / low level on lean maturity. To conclude, it is important to remark that a culture index can be used, that has a correlation with lean maturity, in order to select easily high and low lean mature hospital. A department of a high lean mature hospital and a department of a low lean mature hospital can then be used to investigate the effect of the lean approach on the problem-solving behavior of nurses. This approach can thus be used as a substitute for the lean maturity model in the context of nurse problem-solving, where departments obtain a level of lean maturity. Departments with high and low lean maturity levels can then be examined to investigate the effect of lean on the problem-solving behavior of nurses.

In this master dissertation, the lean maturity model in the context of nurse problem-solving is only validated based on face, content and external validity. It is required that the maturity model is tested to validate the model's reliability and construct, convergent and discriminant validity. Testing the model entails selecting 2 departments with a varying degree of lean maturity. One department with a high level of lean maturity and one department with a low level of lean maturity. If the department with a high respectively low level of lean maturity has a high respectively low lean maturity level score, then the research question of Van Beveren (2015) is confirmed. In departments with a high level of lean maturity, nurses adopt more frequently second-order problem-solving behavior than the second-order problem-solving behavior from nurses in departments with a low level of lean maturity. Thus, when the research question is valid, the lean maturity model in the context of nurse problem-solving should be a substitute for the scenario-based assessment tool of Van Beveren (2015). Both models should deliver the same results. Departments with a high level of lean maturity, according to the lean maturity

model in the context of nurse problem-solving, should also be departments where a high level of second-order problem-solving is observed, according to the scenario-based tool of Van Beveren (2015).

The initial goal of this master dissertation was to develop a lean maturity model in the context of nurse problem-solving where nurses are surveyed i.e. nurses are the respondents of the model. Since the respondents of the lean maturity model are employees that are affiliated with lean management, it is required that further researchers translate the current model to the point of view of nurses, the nurse level. The terminology of the questions should change drastically in order that every nurse in every hospital can understand it. As a suggestion, lean in the context of nurse problem-solving can be assessed indirectly such that nurses are not directly confronted with the assessed domain. It is thus needed that the lean maturity model is adapted to an operational level. Nurses need to have operational assessment items in order that they completely understand the assessed concept. Moreover, a more valuable point of view regarding the degree of lean management will be obtained by questioning nurses. Tucker & Edmondson (2002) stated that nurses themselves add value directly in contrast to leaders who are supporting nurses and setting up the required framework for the ideal value creation.

The lean maturity model developed in this master dissertation is specifically designed for assessing nurse problem-solving behavior. However, the actors in a department of a hospital consist of more than only nurses. Also administrative personnel, doctors, logistic employees, and other staff members are related to a department. That is why the model could be expanded from only nurses to all the actors involved in a department of a hospital. As a suggestion, the term head nurse could be changed by teamleader, since a head nurse leads a lot more other people than only nurses. The term nurse could also be changed by employee. In that way, not only nurses but every employee related to the department are integrated into the model. It is actually unrealistic that only nurse departments are assessed on their lean implementation, and the supporting departments like logistic departments are excluded. Lean management is after all a group effort where all the people should work together to make something happen. However, when all actors of a department are integrated into the model, a difficulty arises in how the results will be interpreted. More specifically, all the employees of the department have a different competence level. If only a small team of employees are highly affiliated with lean and the rest of the employees are not, then the first group will be outliers and will influence the results at a high extent. All the results can't be added together since the outcomes will vary a lot. A possible way to deal with this problem is that different questionnaires are constructed for the different types of employees in the department. Results are compared over the different questionnaires. The correlation between the results of the different actors are measured i.e. it is investigated whether lean management is experienced the same way between the different

groups. If the last case is true, then this would be an extra assessment that lean management is not truly embedded into the organization.

Another possible extension of the lean maturity model in the context of nurse problem-solving could be that the model is linked to a lean maturity tool that measures lean management in all its aspects. Suppose that a department is assessed using the lean maturity model in the context of nurse problem-solving and the result is that the department has a high level of lean maturity i.e. nurses in the department perform second-order problem-solving behavior. This suggests that the department implemented successfully lean management into its business. There is thus no need to assess the department further using a complete lean maturity tool since the lean maturity model in the context of nurses-problem solving indirectly confirmed that the philosophy, processes, people and partners are adapted to lean management. Now suppose that another department is assessed using the lean maturity model in the context of nurse problem-solving and that the result is that the department got a low level of lean maturity i.e. nurses in the department do not perform second-order problem-solving behavior. This suggests that the department does not successfully implemented lean management into its business. A lean maturity tool that assesses lean management in all its facets can now be used to investigate where the department fails in implementing lean management into its business.

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