

**Master Thesis**

## **Care 4 Supply**

The development of a serious game to improve the hospital's internal supply chain

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## Summary

The chain of activities to provide medical professionals with the right products at the right place and at the right time is a complex but critical part of any hospital. Improving this internal supply chain can yield benefits in terms of finance, job satisfaction and patient safety, but many hospitals are struggling to accomplish such improvements. Existing literature indicates that the engagement of stakeholders is an especially difficult challenge in the hospital setting, but no study has yet addressed the question how this can be accomplished. Literature on serious gaming indicates that the use of a game could be a way to realize such engagement. Therefore, this thesis sets out to research to which extent a serious game can accomplish the engagement of stakeholders in a hospital's internal supply chain in order to improve its performance. This research is performed in the Dr. Horacio E. Oduber Hospitaal (HOH) in Aruba.

### Method and design

The Design Science Research Methodology of Peffers et al. (2007) is used to structure the study. First, a literature review is used to translate the problem of stakeholder engagement to the following three main objectives for the serious game:

1. Involve stakeholders in the entire internal supply chain
2. Increase stakeholders' supply chain knowledge
3. Enhance stakeholder relationship alignment

In addition, serious gaming literature is reviewed to determine that a serious game could be most effective in approaching these objectives by providing a meaningful in-game context, immediate feedback, (inter)active engagement and by engaging players in the right flow.

Then, the internal supply chain situation in the HOH is analyzed to determine the most relevant contextual aspects for the game. These insights from practice and the developed literature frameworks, provide the basis for an iterative design process. In this process, choices are made to create a board game that has nurses and management positions as initial target audiences, and game mechanics are designed that address the defined objectives as effectively as possible.

The resulting serious game, *Care 4 Supply*, is a board game in which six players fulfill the roles of nursing, department management, and central warehouse management. Each role has its own in-game goals, but players must work together to create a successful internal supply chain. The game is tested in four sessions in the HOH with a post-play questionnaire and evaluation. The reception of the game is very positive and the results indicate that playing *Care 4 Supply* can accomplish each of the defined objectives.

### Conclusions

The test results are analyzed by means of the developed literature frameworks and by using the developed insights in the HOH to understand how the internal supply chain itself can be affected. With this analysis, it becomes clear that a serious game can indeed accomplish the engagement of stakeholders in a hospital's internal supply chain in order to improve its performance. The following conclusions are drawn concerning the extent to which *Care 4 Supply* can do this by accomplishing the three defined objectives:

First, playing *Care 4 Supply* can involve stakeholders in the entire internal supply chain. While stakeholders have the tendency to only think from their own perspective, the game mimics the entire

internal supply chain and encourages players to interact with it through its goals and events. The players indeed recognized the in-game situation and had a lot of fun being involved in it. This involvement with the entire internal supply chain can improve the performance of the real-life supply chain, because stakeholders acquire insight in how they can adapt their own behavior to benefit the situation as a whole and because the game can in this way be used to introduce and support improvement initiatives.

Second, playing Care 4 Supply can increase stakeholders' supply chain knowledge. It engages them in interactive processes where they receive direct feedback and uncover relevant supply chain dynamics by themselves as they try to accomplish the highest in-game performance scores. Players indeed indicated the game had increased their knowledge and provided a variety of learned lessons. This increased level of knowledge can improve the performance of the hospital's internal supply chain because it makes it possible for stakeholders to ground their actions and because shared knowledge stimulates a culture of best practice.

Third, playing Care 4 Supply can enhance stakeholder relationship alignment. Stakeholders by nature encounter conflicts in a hospital situation and in the game they experience the perspectives of the other stakeholder and gain insight in the different kinds of interests involved. The game made them in this way experience the importance of communication and increased their understanding of the relevant interdependencies. This better stakeholder alignment can improve the performance of the internal supply chain because a shared perspective can lead to increased job satisfaction and to more effective discussions and relationships.

### **Contributions and recommendations**

The performed design science research contributes to literature because it shows how a game can contribute to the accomplishment of stakeholder engagement in the internal supply chain and in what way this can improve its performance. This thesis is thereby the first study to address the challenge of stakeholder engagement in the hospital supply chain setting. In addition, the findings indicate that the value of individual knowledge and insight of stakeholders might be more important than is assumed in current literature.

The thesis also contributes to serious game literature, by showing the value of using serious gaming for healthcare support functions and for addressing stakeholder issues. In addition, the findings indicate that the aspect of 'fun' deserves more attention as an effective game attribute, as it can be a crucial aspect of a serious game to be able to involve its players.

This thesis also contributes to the HOH's practice, by providing an analysis of its internal supply chain processes, on which basis propositions are formulated to improve its performance. In consultation with the management, a plan is developed to use Care 4 Supply as an important element on this road towards improvement. In addition, Care 4 Supply could also be used and adapted for other practices.

The thesis concludes by formulating suggestions for future research. The first one is to further examine how hospitals can improve their internal supply chain, especially concerning the question how hospitals can realize a system in which products are delivered as close to the point of care as possible. The second suggestion is to perform follow-up research on the promising relation between serious gaming and stakeholder engagement.

## Samenvatting

De keten van activiteiten die medisch personeel van de juiste producten voorziet op de juiste plaats en op het juiste moment is een complex maar essentieel onderdeel van ieder ziekenhuis. Het verbeteren van deze 'interne bevoorradingsketen' kan zowel financiële voordelen opleveren als bijdragen aan verhoging van werktevredenheid en patiëntveiligheid. Veel ziekenhuizen ervaren het echter als problematisch deze verbeteringen te realiseren. Bestaande literatuur geeft aan dat met name het betrekken van stakeholders een lastige uitdaging is, maar geen enkele studie heeft zich nog beziggehouden met de vraag hoe de gewenste betrokkenheid kan worden gerealiseerd. Literatuur over 'serious gaming' maakt duidelijk dat een spel een middel zou kunnen zijn om dit te bereiken. Daarom onderzoekt deze thesis in hoeverre een serious game stakeholders kan betrekken in de interne bevoorradingsketen van een ziekenhuis en daarmee kan bijdragen aan verbetering van de prestaties daarvan. Dit onderzoek wordt uitgevoerd in het Dr. Horacio E. Oduber Hospitaal (HOH) in Aruba.

### Methodie en ontwerp

De Design Science Research Methodology van Peffers et al. (2007) is gebruikt om het onderzoek te structureren. Eerst is een literatuurstudie uitgevoerd, waarmee het probleem van stakeholders betrokkenheid kan worden vertaald naar de volgende drie hoofddoelstellingen voor de serious game:

1. Betrek stakeholders bij de gehele interne bevoorradingsketen
2. Vergroot de kennis van stakeholders over de bevoorradingsketen
3. Verbeter de afstemming tussen stakeholders

Daarnaast is aan de hand van serious game literatuur vastgesteld dat een serious game deze aspecten het meest effectief kan benaderen middels een herkenbare in-game context, het geven van directe feedback en door het bieden van een (inter)actieve benadering en de juiste 'flow'.

Vervolgens is de interne bevoorradingsketen in het HOH geanalyseerd om de meest relevante contextuele aspecten van het spel te bepalen. Deze praktijkinzichten en de ontwikkelde theoretische kaders bieden de basis voor een iteratief ontwerpproces waarin gekozen wordt voor een bordspel dat zich in eerste instantie op verpleegkundigen en managementposities richt, en waarvan de gamemechanieken de gedefinieerde doelstellingen zo effectief mogelijk benaderen.

De uiteindelijk ontworpen serious game, *Care 4 Supply*, is een bordspel waarin zes spelers de rollen vervullen van verpleegkundige, afdelingsmanagement en centraal magazijnmanagement. Deze rollen hebben elk hun eigen in-game doelen, maar de spelers moeten samenwerken om een succesvolle bevoorradingsketen neer te zetten. Het spel is getest in vier sessies in het HOH met een vragenlijst en evaluatie. Het spel is zeer positief ontvangen en de testresultaten maken duidelijk dat met het spelen van *Care 4 Supply* elk van de gedefinieerde doelstellingen kan worden bereikt.

### Conclusies

De testresultaten zijn geanalyseerd vanuit de ontwikkelde literatuurkaders en met behulp van de inzichten in het HOH is vastgesteld hoe de interne bevoorradingsketen kan worden beïnvloed. Deze analyse maakt duidelijk dat een serious game inderdaad in staat is de stakeholders te betrekken in de interne bevoorradingsketen van een ziekenhuis om diens prestaties te verbeteren. De volgende conclusies kunnen worden getrokken over de manier waarop *Care 4 Supply* dit kan doen door het bereiken van elk van de drie vastgestelde doelstellingen:

Ten eerste, kan het spelen van Care 4 Supply stakeholders betrekken bij de gehele interne bevoorradingsketen. Stakeholders hebben de neiging alleen vanuit hun eigen perspectief te denken, en daarom simuleert het spel de gehele interne bevoorradingsketen en moedigt het spelers met behulp van in-game doelen en gebeurtenissen aan om veel te communiceren. De spelers herkenden de in-game situaties inderdaad en hadden veel plezier in het spel. Deze betrokkenheid kan de prestaties van de echte bevoorradingsketen verbeteren, omdat stakeholders inzicht verwerven in hoe ze hun gedrag kunnen aanpassen ten bate van de gehele situatie en omdat het spel zo kan worden gebruikt om verbeterinitiatieven te introduceren en te ondersteunen.

Ten tweede, kan het spelen van Care 4 Supply de kennis van stakeholders over de bevoorradingsketen vergroten. Het spel betreft stakeholder in een interactief proces waarin ze aan de hand van directe feedback zelf de relevante kennis kunnen ontwikkelen om de hoogste in-game prestaties te kunnen realiseren. Spelers geven inderdaad aan dat het spelen van het spel hun kennis vergroot heeft en dat ze verschillende lessen hebben geleerd. Dit verhoogde kennisniveau kan de prestaties van de interne bevoorradingsketen verbeteren, omdat stakeholders hiermee beredeneerde beslissingen kunnen nemen en omdat gedeelde kennis een stimulerende cultuur bevordert.

Ten derde, kan het spelen van Care 4 Supply de afstemming tussen stakeholders verbeteren. Van nature hebben stakeholders conflicterende belangen en in het spel kunnen zij de perspectieven van anderen ervaren en meer inzicht krijgen in de verschillende belangen die een rol spelen. Op deze manier ervaren spelers hoe belangrijk communicatie is en krijgen ze inzicht in wederzijdse afhankelijkheden. Met een verbeterde afstemming, kunnen de prestaties van de bevoorradingsketen verbeterd worden, omdat een gedeeld perspectief kan leiden tot een hogere werktevredenheid en tot effectievere discussies en relaties.

### **Bijdragen en aanbevelingen**

Het uitgevoerde ontwerponderzoek draagt bij aan literatuur omdat het laat zien dat een serious game de betrokkenheid van stakeholders kan verwezenlijken en op welke manier dit de prestaties van de interne bevoorradingsketen verbetert. Deze thesis is daarmee de eerste studie die de uitdaging van het betrekken van stakeholders in de bevoorradingsketen in het ziekenhuis verder heeft onderzocht. Daarnaast wijzen de bevindingen erop dat het belang van individuele kennis en inzicht van stakeholders in de praktijk groter zou kunnen zijn dan in de huidige theorie wordt aangenomen.

Deze thesis draagt ook bij aan serious game literatuur, omdat het de waarde aantoont van het toepassen van serious gaming voor ondersteunende functies in de zorg en voor het aanpakken van stakeholderproblematiek. Daarnaast wijzen de bevindingen erop dat het aspect 'plezier' meer aandacht verdient als een effectieve eigenschap van serious gaming, omdat dit een essentieel aspect lijkt om spelers te kunnen betrekken.

Naast de bijdrage aan theorie, draagt deze thesis ook bij aan de praktijk van het HOH door de analyse van diens interne logistieke keten, op basis waarvan voorstellen worden gedaan om de prestaties te verbeteren. In overleg met het management zijn er plannen gemaakt om het spelen van Care 4 Supply hierin een rol te geven. Daarnaast kan Care 4 Supply ook worden toegepast in andere praktijksituaties.

De thesis sluit af met het formuleren van suggesties voor toekomstig onderzoek. De eerste suggestie is om verder te onderzoeken hoe ziekenhuizen hun interne logistieke keten kunnen verbeteren, in het bijzonder het systeem om producten zo dicht mogelijk bij het punt van zorg te brengen. De tweede

suggestie is om vervolgonderzoek uit te voeren naar de veelbelovende relatie tussen serious gaming en het betrekken van stakeholders.

## Foreword

This document is the final product of my career as a master student. It is with a bit of melancholia that I finish this great period stretching two master studies. I am very happy that this final project has been anything but a routine and provided many new exciting challenges: I was part of the practice in the Dr. Horacio E. Oduber Hospitaal, which was a great experience for many more reasons than only that it coincided with a stay on the tropical island of Aruba; I designed an actual game, a process which was much more complex, but also much more fun, than I ever imagined; and I used my findings in the hospital practice to write an academic thesis which I am truly proud of and which I really hope will lead to further research on this promising subject. I could not have completed either of these challenges if it were not for the help of the following great people:

First of all, my great thanks go to my supervisors at the University of Twente: Ton Spil, who was so kind to step in as first supervisor and made me more aware of the scientific value in my own research, and Ingrid Vliegen who helped me to set up my project in a great way and who I am very grateful to that she found the time to help me finish it, even when new challenges were already demanding her attention. Furthermore, I would like to thank Rafal Hryniewicz of T-Xchange for his help in the start-up periods of game design.

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Third, there are many persons who I am grateful for on a more personal level: my mother, my brother and my sister who show so much love and support and so beautifully each find their own exciting path; my friends who provide valuable moments for reflection and distraction; and finally Ashley, who I love being with every single day, whether that day is in tropical Aruba or in not-so-tropical Enschede.

Wouter Versluijs,

Enschede, November 2016

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## Chapter 1: Introduction

A hospital's internal supply chain is the chain of activities that sustain the flow of medical and non-medical products, such as needles, gloves and bandages. This chain is critical to keep a hospital functioning day-to-day. Improving it entails financial savings, increased job satisfaction and better patient safety (Landry and Philippe 2004). However, there has been very little accumulated knowledge concerning the question *how* improvements can be realized. A call for action is made:

“The hospital, due to the particularities of its internal supply chain, consequently merits greater attention, and solutions are needed that address its unique situation.” (Landry and Beaulieu 2013, 469)

Authors and practitioners indicate that stakeholder engagement can be a critical enabler, but no academic study has yet further investigated this topic. Theory on gaming indicates that using a ‘serious game’ could provide an unprecedented way to approach this problem concerning the engagement of stakeholders in the hospital's internal supply chain:

“[G]ames [...] can demonstrably motivate users to engage with them with unparalleled intensity and duration” (Deterding, et al. 2011, 2) and “allow us to develop and test strategies, test alternatives and their impact upon our goals in a much tighter, responsive time frame than the real world” (Qualters, et al. 2006, 3).

This thesis researches whether a serious game can be developed that engages stakeholders in order to accomplish internal supply chain improvement. This first chapter presents the introduction of this thesis. Section 1.1 provides a further background of the central research topic. Section 1.2 presents the used methodology for the structural accomplishment of the research objective. Section 1.3 concludes with the main research question and an outline of the thesis.

### 1.1 Problem background

Many authors in academic literature have recognized that engaging stakeholders, especially medical professionals, is one of the unique challenges in the improvement of the hospital's internal supply chain. Authors argue that the large number of different stakeholders impedes the implementation of industrial supply chain practices (De Vries and Huijsman 2011), that hospital stakeholders often lack the incentive to engage in new ways of working (Cheng and Whittemore 2008), that often only a minority is interested in reducing costs and improving efficiency (De Vries 2011), and that politics often overrule data-driven insights (Iannone, et al. 2013). Moreover, almost everyone in a hospital is involved in its supply chain, but very few realize how they can in this way affect the hospital's performance (Landry and Beaulieu 2013).

This thesis wants to contribute to overcoming this discrepancy between the often-recognized need to engage stakeholders and the lack of theory that further investigates this aspect, by researching the possibility of a *serious game* to accomplish a higher level of engagement. A serious game seems promising to approach the subject because “[d]eveloping the big picture requires mechanisms for visualizing and identifying the critical elements or dimensions of the complex problem and relating them to the situation as a whole [...] Framing the confusion is the first step to doing something about it. Games [...] provide such a mechanism” (Wenzler and Chartier 2000, 379).

Serious games have been used in a myriad of industries and situations, but their use in the area of the hospital’s internal supply chain has never been researched. Moreover, no initiatives concerning the engagement of stakeholders and the potential benefits have been investigated at all. This thesis thereby contributes to both theory concerning the improvement of the internal supply chain, and theory concerning the use of serious gaming. The research is performed in the Dr. Horacio E. Oduber Hospitaal (HOH) in Aruba.

## 1.2 Research objective and methodology

The objective of this thesis is to *develop a serious game to accomplish the engagement of stakeholders in order to improve the hospital’s internal supply chain*. To achieve this objective, the ‘Design Science Research Methodology’ of Peffers et al. (2007) is used. This methodology was developed to provide researchers with a commonly accepted framework for successfully carrying out design science research. Design science research attempts to “create things that serve human purposes” (p.4), in contrast to natural and social sciences, whose main aim it is to develop an understanding of reality. Peffers et al. provide a solid methodology for design science research, because they build on prior literature – both design research and research about design research – and are able to distill a six-step structured framework, presented in Figure 1.

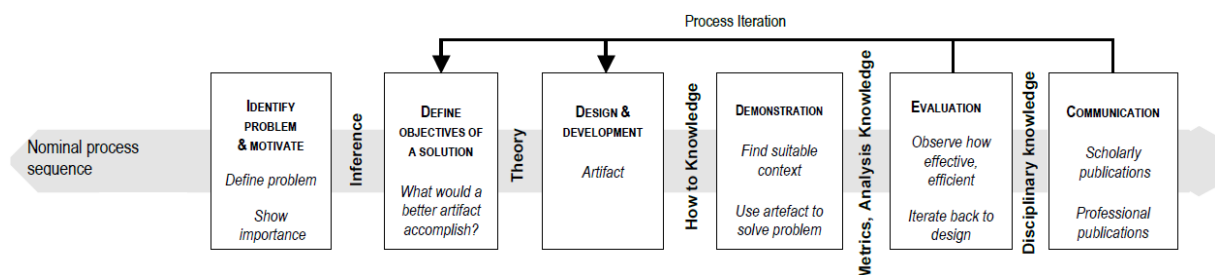


Figure 1 Six-step Design Science Research Methodology. Reprinted from Peffers et al. (2007)

The DSRM methodology of Peffers et al. is used to structure this thesis research, with one critical adaption following a suggestion by Wieringa (2010): the phase that Peffers et al. originally called ‘evaluation’ is replaced by ‘validation’. This is more appropriate because this thesis researches the effects of using a serious game *before* it has been implemented in practice and “validation questions ask for what *will* happen and evaluation questions ask for what *has* happened” (p.493, emphasis added).

## 1.3 Research question and thesis outline

Improving the hospital’s internal supply chain is a unique challenge, of which stakeholder engagement is a component that has not been addressed before. This thesis addresses this issue and aims to contribute to theory and practice by developing an answer to the main research question:

*“To which extent can a serious game accomplish the engagement of stakeholders in a hospital’s internal supply chain in order to improve its performance?”*

The proposed Design Science Research Methodology is used to structure the development of an answer to this question. Figure 2 presents the thesis structure.

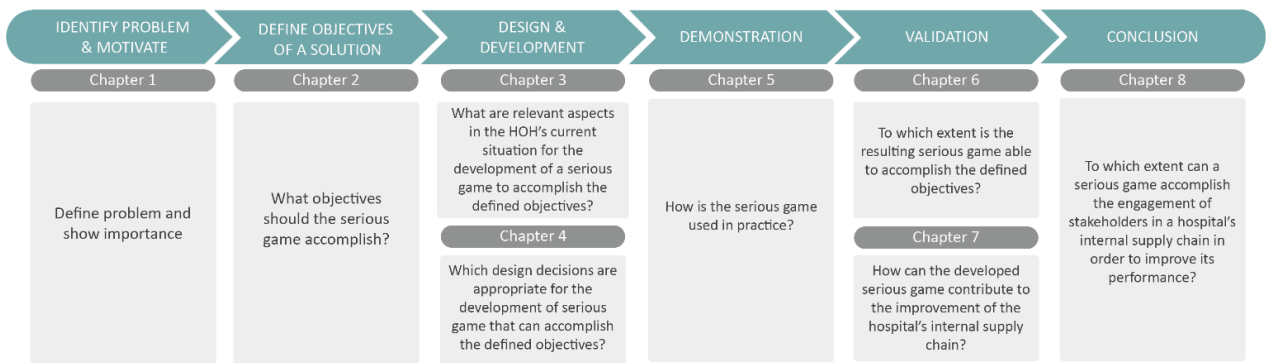
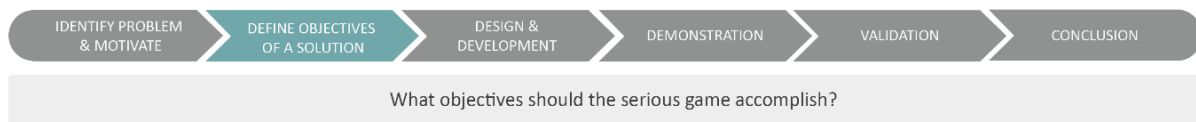


Figure 2 Thesis outline, based on Design Science Research Methodology of Peffers et al. (2007)

First, Chapter 2 theory reviews theory to determine the relevant objectives for the serious game considering the main research question. Then, Chapter 3 investigates the context of research, the internal supply chain of the Dr. Horacio E. Oduber Hospitaal, to be able to design a suitable game. With this information, Chapter 4 develops a serious game that addresses the objectives as well as possible. Chapter 5 demonstrates the use of the serious game. Chapter 6 tests this design and Chapter 7 analyzes the results by means of the developed relevant insights from literature and practice. Chapter 8 concludes the thesis with the main conclusions, an evaluation of its contribution to research and practice and formulates suggestions for future researchers.

## Chapter 2 Definition of objectives: Literature review

Following the proposed methodology, this chapter defines the objectives for a solution to the introduced problem. Knowledge of the state of problems is required, for which Section 2.1 discusses the set-up of the performed literature review. Section 2.2 then presents the structural review of the topic of improvement of the hospital internal supply chain. To understand how a serious game could address the relevant objectives, Section 2.3 presents an overview concerning serious gaming effectiveness and Section 2.4 concerning existing serious games. Section 2.5 concludes the chapter with the objectives for the serious game that is designed in this thesis.



### 2.1 A structured literature review

This thesis has two main topics: the hospital's internal supply chain and serious gaming. For each of these topics, a structured literature review was performed. The methodology of Wolfswinkel et al. (2013) was used to iteratively define, search, select and analyze the search terms and resulting articles. For each of the topics, the relevant articles were analyzed and corresponding insights between the authors were categorized. In this way, the next sections can present a structured review of the success factors for a hospital's internal supply chain, the characteristics of successful serious games and relevant existing games. More details of the complete literature study can be found in Appendix I.

### 2.2 The success factors in a hospital's internal supply chain

Table 1 summarizes the academic insights on the success factors for a successful internal supply chain. These success factors relate to different aspects of the organization; the information system, the appointed leaders, the hospital's transportation system. An elaborate presentation of the authors' insights of all success factors can be found in Appendix II. For the artefact we are developing, three success factors are especially relevant because these relate to the engagement of stakeholders and are discussed below.

Table 1 Results of literature review: success factors per author

	Landy and Philippe (2004)	Landy and Beaulieu (2013)	Iannone (2013)	Kumar et al. (2008)	De Vries (2011)	Kowalski (2009)	McKone-Sweet et al. (2005)	Chen and Paulraj (2004)	Fredendall et al. (2009)	Huijsman (2011)	De Vries and Huijsman (2011)	Whitemore (2008)	Cheng and Whitemore (2008)
All stakeholders are involved in improving the entire internal supply chain	x					x	x	x		x		x	x
Products are delivered as close to the point of care as possible	x	x	x	x	x								x
There is top management support and clear supply chain leadership		x			x	x	x			x			x
There is an organizational culture of shared knowledge, best practice and continuous improvement							x	x	x	x			

Stakeholder relationships are well-aligned			x		x		x		x		
A data-driven system is used for measuring and control over the internal supply chain	x				x	x	x				
There is an overall set of goals					x	x		x			
All stakeholders have an appropriate level of supply chain knowledge	x						x				x

**Success factor: All stakeholders are involved in improving the entire internal supply chain**

In a well-functioning hospital, improving and sustaining the internal supply chain is not just a project of the hospital’s logistics management, but of all stakeholders involved. Kowalski (2009) argues that the participants that should be involved include the supply chain staff as well as representatives from the departments that the supply chain serves, such as nurses and clerks. McKone-Sweet et al. (2005) argue something similar and add that the perspective of all the stakeholders involved should include the entire chain.

Landry and Philippe (2004) stress the importance of especially involving nursing personnel in the supply chain and that the involved stakeholders should be encouraged to not only consider the care-side of the operations, but also look through the ‘supply support services lens’. According to McKone-Sweet et al. (2005) a focus should then also be to take away the fear of change and prevent stakeholders from only operating in their own best interest. Chen and Paulraj (2004) add that stakeholders should be encouraged to work across the silos that often characterize organizational structures.

**Success factor: All stakeholders have an appropriate level of supply chain knowledge**

Cheng and Whittlemore (2008) describe how a lack of knowledge of basic inventory techniques can cause stock out conditions, because employees keep ordering more than needed. McKone-Sweet et al. (2005) conclude that a main “barrier to implementation is the lack of skills and knowledge about supply chain management practices, both at the operational and executive levels” (p.10). From expert interviews they conclude that hospitals that have both general higher levels of supply chain training and for their executives can create higher levels of supply chain performance. Landry and Philippe (2004) also indicate that a good understanding of the processes and activities in place is a requisite to successfully select, adapt and implement leading practices.’

**Success factor: Stakeholder relationships are well-aligned**

Many authors describe how stakeholder relations can entail many different problematic aspects in the hospital’s internal supply chain. As De Vries (2011) discusses, the problems can already start with unaligned project expectations. McKone-Sweet et al. (2005) add that “misaligned incentives lead to poor work performance” (p.9). De Vries’ (2011) research of practice concludes that with so many interests involved, managing the inventory levels in a hospital setting often becomes more politically based than data-driven. Iannone et al. (2013) discuss a similar observation, that these politics form a major obstacle towards improving these inefficient aspects of inventory management. McKone-Sweet et al. (2005) generalize that the corporate and organizational culture in a hospital often impedes rather than facilitates change, which then forms a major barrier for improvement.

As these three success factors form the main aspects concerning stakeholders and the improvement of the internal supply chain, they form the basis for the objectives for the serious game:

1. Involve stakeholders in the entire internal supply chain
2. Increase stakeholders' supply chain knowledge
3. Enhance stakeholder relationship alignment

### 2.3 The effective attributes of serious gaming

For a valuable design science research study, not only an understanding of the problem topic is required, but also “how the artifact is expected to support solutions to problems not hitherto addressed” (Peffer, et al. 2007, 12). As this thesis focuses on serious gaming, a literature study is performed on this topic and its effectiveness.

Table 2 presents an overview of the results of the literature review concerning how serious games can effectively contribute to (what most authors summarize as) ‘motivational and cognitive processes’. These aspects could later be used to understand how a game could be designed to fulfill the formulated objectives.

*Table 2 Results of literature review: effective serious gaming attributes per authors*

	Van Eck (2004)	Connolly et al. (2012)	Wouters et al. (2013)	Greitzer et al. (2007)	Breuer and Bente (2010)	Boyle et al. (2011)
SG can provide a meaningful context	x	x	x	x	x	x
SG can provide a way for (inter)active engagement with the content		x	x	x		x
SG can provide immediate feedback	x	x	x			x
SG can engage the player in the right ‘flow’	x			x	x	

The review indicates four ways in which serious games can be effective:

#### **Serious games can provide a meaningful context**

All authors indicate that one of the main effective attributes of serious gaming is the provision of a meaningful context for learning. As van Eck (2006) says: “Lions do not learn to hunt through direct instruction but through modeling and play” (p.4). This aspect which is also called ‘situated cognition’, facilitates learning and recall of information, also because performing them in the game involves the same processes that are required for performance in the real world (Wouters, et al. 2013). This characteristic also has motivational effects, because players experience their actions to be effective in a simulated game world, which can bring a sense of control that is pleasurable and motivates further interaction (Breuer and Bente 2010).

#### **Serious games can provide immediate feedback**

A serious game can provide players with direct feedback, which gives them the opportunity to correct their own actions and knowledge and thereby reinforces the learning processes (Wouters, et al. 2013). This motivates players to enter a valuable continuous cycle of hypothesis formulation, testing and revision (van Eck 2006).

### **Serious games can provide a way for (inter)active engagement with the content**

Educational psychology emphasizes that active cognitive processing is required for effective and sustainable learning (Wouters, et al. 2013). Greitzer et al. (2007) explain that the manipulation objects in a game encourages active processing of material that help build lasting memories and deepen understanding.

### **Serious games can engage the player in the right ‘flow’**

Many authors point to the importance of ‘flow’, “the optimal balance between challenges and skills that has been identified as a central prerequisite for enjoyment. Games that are engaging hover around the borders of a player's competencies” (Breuer and Bente 2010, 12). Greitzer et al. (2007) call this the engaging ‘narrow zone’ between too easy and too difficult. Van Eck (2006) states that the extent to which games are able to challenge the player without exceeding his or her capacity determine whether they are engaging.

## **2.4 Review of related existing serious games**

Serious games have been developed for many different purposes. This thesis researches the use of a serious game in a supply environment in the hospital. This section therefore investigates currently existing supply chain games and to which extent these relate to the research question. A review of these relevant existing games is provided in Table 3.

*Table 3 Results of literature review: characteristics of related existing serious games*

<b>Authors</b>	<b>Year</b>	<b>Name of serious game</b>	<b>Objective</b>	<b>Target audience</b>	<b>Domain</b>
D. Battini, M. Faccio, A. Persona and F. Sgarbossa	2010	Logistic Game™	Teaching	Students	Production plant
H. Duin, M. Oliveira and A. Saffarpour	2007	PRIME	In-game analysis	Practitioners	Manufacturing company
R.C. Basole, D.A. Bodner and W. Rouse	2013	Health Advisor	Teaching	Practitioners	Healthcare
S. Foster and J. Hopkins	2011	The supply chain game	Teaching	Students	Manufacturing company
J. Forrester	1960s (-now)	The Beer Game	Teaching	Students and Practitioners	Manufacturing chain
F. Costantino, G. Di Gravio, A. Shaban and M. Tronci	2012	Simulation Game	Teaching	Students	Production plant
M. O'Connor	2014	Friday Night at the ER	Teaching <sup>1</sup>	Students and Practitioners	Hospital
S. Meijer, G.J. Hofstede, S.W.F. Omta and G. Beers	2008	The Trust and Tracing game	In-game analysis	Students	Manufacturing chain
D. Qualters, J. Isaacs, T. Cullinane, A. McDonals and J. Laird	2006	Shortfall	Teaching	Students	Manufacturing chain
S. Meijer, G. Zuniga-Arias and S. Sterrenburg	2005	The Mango Chain Game	In-game analysis	Practitioners	Export chain

<sup>1</sup> Friday Night at the ER's main purpose is to increase the players' knowledge and insight, not necessarily focused on the supply chain, but on dependencies between different stakeholders in general.



This review shows that two groups of serious games concerning the supply chain can be identified:

- Serious games that have been created to *teach* the principles of supply chain behavior. Most of these games have students as main target audience.
- Serious games that concern the supply chain, where researchers are not per se interested in teaching but in *researching* the players' behavior or outcomes. Two of the three games have stakeholders in practice as main audience.

The review shows that serious games have been successful concerning the teaching and investigation of the topic of supply chain management. Addressing the internal supply chain, and hospital logistics at all, has however never been done before. Of the reviewed games, only the games of Basole et al. (2013) and O'Connor (2014) relate to the domain of health care, but these are both not concerned with aspects related to the internal supply chain. Friday Night at the ER is the most interesting game in relation to our research question and therefore the developers were contacted and the CEO was interviewed, discussed in Section 4.1.

Supply chain literature showed that the hospital's supply chain faces unique challenges and serious gaming literature showed that recognizable context and interaction are important aspects for serious gaming's effective qualities. Thus, although supply chain knowledge from other industries is relevant for internal supply chain management in the hospital, it is worthwhile to develop a game focused on the hospital's internal supply chain and its stakeholder challenges.

## 2.5 Conclusion

In this chapter, literature showed that a serious game could contribute to three main success factors of the hospital's internal supply chain if it can:

1. Involve stakeholders in the entire internal supply chain
2. Increase stakeholders' supply chain knowledge
3. Enhance stakeholder relationship alignment

The game could accomplish these objectives by contributing to cognitive and motivational processes by providing a meaningful context, immediate feedback, a way for (inter)active engagement and by providing an engaging flow.

The two reviewed topics, concerning the hospital's internal supply chain and the effectiveness of serious gaming, can be brought together in the next stage: 'design and development'. To design a game suited to established objectives, first we have to understand which elements are relevant in the internal supply chain and what the relevant problematic aspects are.

## Chapter 3 Design and development: Context analysis

The objectives and required details of practice have been established. In the following two chapters, the stage of ‘design and development’ is presented; “determining the artifact’s desired functionality [...] and then creating the actual artifact” (Peppers, et al. 2007, 13).

This chapter acquires an understanding of the objectives in Chapter 2 in the practical context. Section 3.1 first introduces the hospital and the method of data collection. Section 3.2 presents the hospital’s internal supply chain situation and Section 3.3 discusses which dynamics are relevant, which stakeholders are of interest and what are the main problematic aspects. In Section 3.4. we then can conclude upon the most relevant contextual aspects for the serious game.



### 3.1 General demographics and method for further data collection

The HOH is the only hospital on the Caribbean island Aruba and offers all major specialisms, to more than 10,000 patients per year. It has a capacity of 288 beds divided over five floors, with the central warehouse, emergency department and outpatient clinics on the ground floor and two nursing department on each of the second, third and fourth floors. In 2014 the management of the HOH formulated the mission to become one of best hospitals of the Caribbean region, including the other islands. This goal is formulated in a multi-year plan ‘Hunto Miho’; ‘better together’. Improving their internal supply chain is part of this plan and provides an excellent opportunity for this thesis research.

Concerning scope, this context analysis focuses on the chain of activities that supply the *nursing* departments with products. This is because the hospital managers indicate this currently has the most inefficiencies and generates the most stakeholder frustrations; aspects that are not only most relevant for the HOH but also most interesting in relation to our research question. The supply chain to other departments such as the operating rooms and the emergency department is thus out of scope.

To get an understanding of the HOH’s situation from each of the stakeholder’s perspectives, every stakeholder was at least interviewed elaborately once. In addition, an arrangement was made to participate two days with the activities of the central warehouse employees and two days with the nurses. Appendix III shows the details on the data gathering process.

Quantitative data was acquired from two main sources. First, ordering information in the VILA-system was analyzed. Although the complete accuracy of this data could not be guaranteed, conflicting alterations are filtered out as good as possible. Second, the actual situations at the department and the department warehouse were investigated by hand-counting, to get a direct indication of the inventory situations.

### 3.2 Overview of the HOH’s internal supply chain

To be able to provide care to their patients, **nurses** at the care department require products. At the medical departments, these are stored in the department warehouse. The nurses place the products from the department warehouse also in other locations such as the medicine room, bandage carts or patient rooms cabinets. To refill the department warehouse, the **department secretary** orders products once or twice per week. At those ordering moments, she checks the inventory levels in the

department warehouse. If she thinks these are too low, she orders the products. Most of the products in the departments warehouses have a label with a set minimum and maximum level of inventory, but these are often not used. If products run out in the department inventory before the moment of ordering they can place an emergency order. These have to be approved by the **care manager** who is responsible for the care department's general functioning.

The department orders are sent to the central warehouse. There, the **central warehouse employees** pick the right products and if the products are available deliver them the same or the next day. If an emergency order comes in, they directly pick the products. The products in the central warehouse are replenished weekly by external suppliers. The **central warehouse team leader** places the external orders, at American or Dutch suppliers or intermediaries on the island. The **central warehouse management** is responsible for the central warehouse's functioning and the external procurement.

Aside from those directly involved with these operations, also **clustermanagers** and **financial managers** are involved as part of their responsibilities.

### 3.3 Stakeholder analysis and problem exploration

In the processes of the internal supply chain, different persons have different roles, creating a much larger constellation of powers and interests than only the employees who directly handle the products. Figure 3 shows the stakeholders in a simplified organogram of the organization. The grey blocks are outside of the scope. The relevant stakeholders are thus the nurses, medical department secretaries, care managers, clustermanagers, central warehouse employees, central warehouse team leader, central warehouse management and financial management.

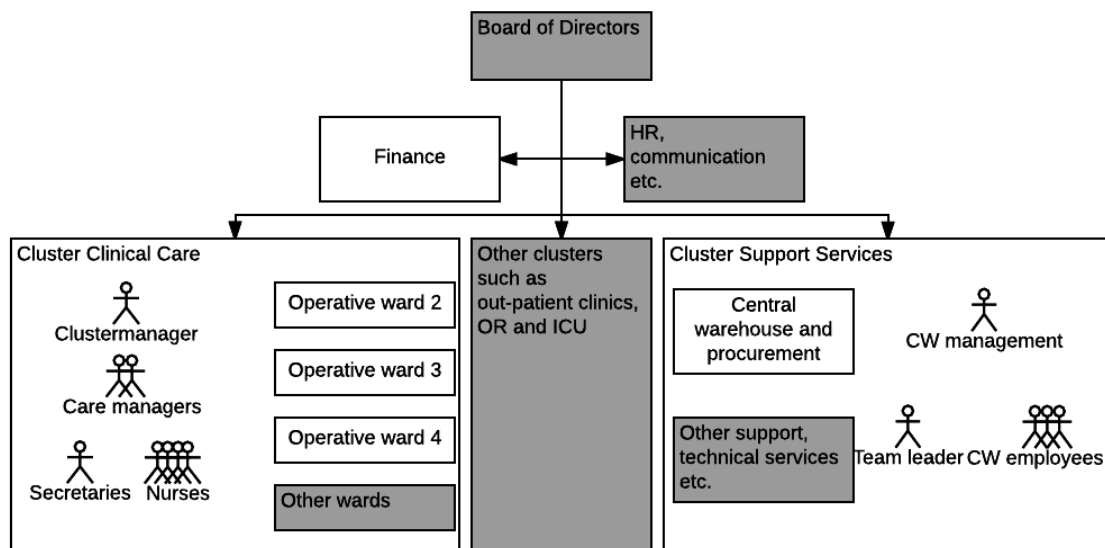


Figure 3 Simplified organogram of HOH with the relevant stakeholders depicted

#### Problem analysis

In the interviews with the stakeholders, it became clear that each of them has different ideas why the current situation in the HOH's internal supply chain is not fully successful. Table 4 summarizes the different problematic aspects they encounter and identifies which aspects are only encountered by specific stakeholders and which are shared by many. An elaborate analysis of the findings per stakeholder, of which this table is the summary, can be found in Appendix IV.

This problem exploration provides us with the insight that the unreliability of the central warehouse, the methods of ordering of the secretaries and the hoarding culture and the medical departments are most often seen as problematic aspects. Furthermore, it is striking that every aspect of the internal supply chain is considered problematic and that the problems the stakeholders encounter generally stay within those stakeholder groups.

Table 4 Overview of problems expressed by stakeholders in HOH

Reason why internal supply chain is currently not fully successful	Refers to	Expressed by							
		Nurses	Secretaries	Care managers	Clustermanagement	CW employees	Team leader CW	Logistic management	Finance
The central warehouse does not reliably supply the ordered products	Central warehouse		x	x					x
Secretaries order on basis of their own insight instead on system values	Secretaries			x		x	x		
There is a hoarding culture at the medical departments	Medical departments					x	x		x
Unofficial inventories are not replenished correctly by all nurses	Medical departments - nurses	x							
Products are not always available in the department warehouse	Secretary and care manager	x							
The central warehouse does not take back products and does not communicate about this	Central warehouse		x						
The nurses spread products over the department	Nurses		x						
Nurses hoard products and create systems on basis of own insights	Nurses			x					
The central warehouse is not always available for (emergency) service on the moments needed	Central warehouse			x					
There is little structural communication between the support side of the central warehouse and the care side of the hospital's departments	Communication within supply chain				x				
There is little insight and overview over the current situation	Information system				x				
The services of the central warehouse are not trusted by the medical departments	Medical departments and central warehouse				x				
There is no feedback about the orders between the central warehouse and the departments	Communication between stakeholders					x			
Many emergency orders are placed, often for non-critical items	Medical departments					x			
There is a general lack of appreciation and understanding of the function of the central warehouse	Medical departments					x			
The current VILA system requires much effort to function as desired	Information system						x		
Departments orders do not fit the actually required amounts and fluctuate a lot over time	Medical departments								x
Insight into, overview of and control over the department situations is hard on the management level	Workload								x
Effective procurement of products in time is hard because of the island location of Aruba	Location of Aruba								x

The many different perspectives create a complex problem situation. To further scrutinize this situation, a problem tree is drawn in Figure 4 to understand how the problems relate to each other. The different colored blocks present the aspects of the current situations that the different stakeholders distinguish. The resulting picture confirms the complexity of the situation. It also shows that there seem to be no central problems, but that the situation as a whole is problematic and should be improved.

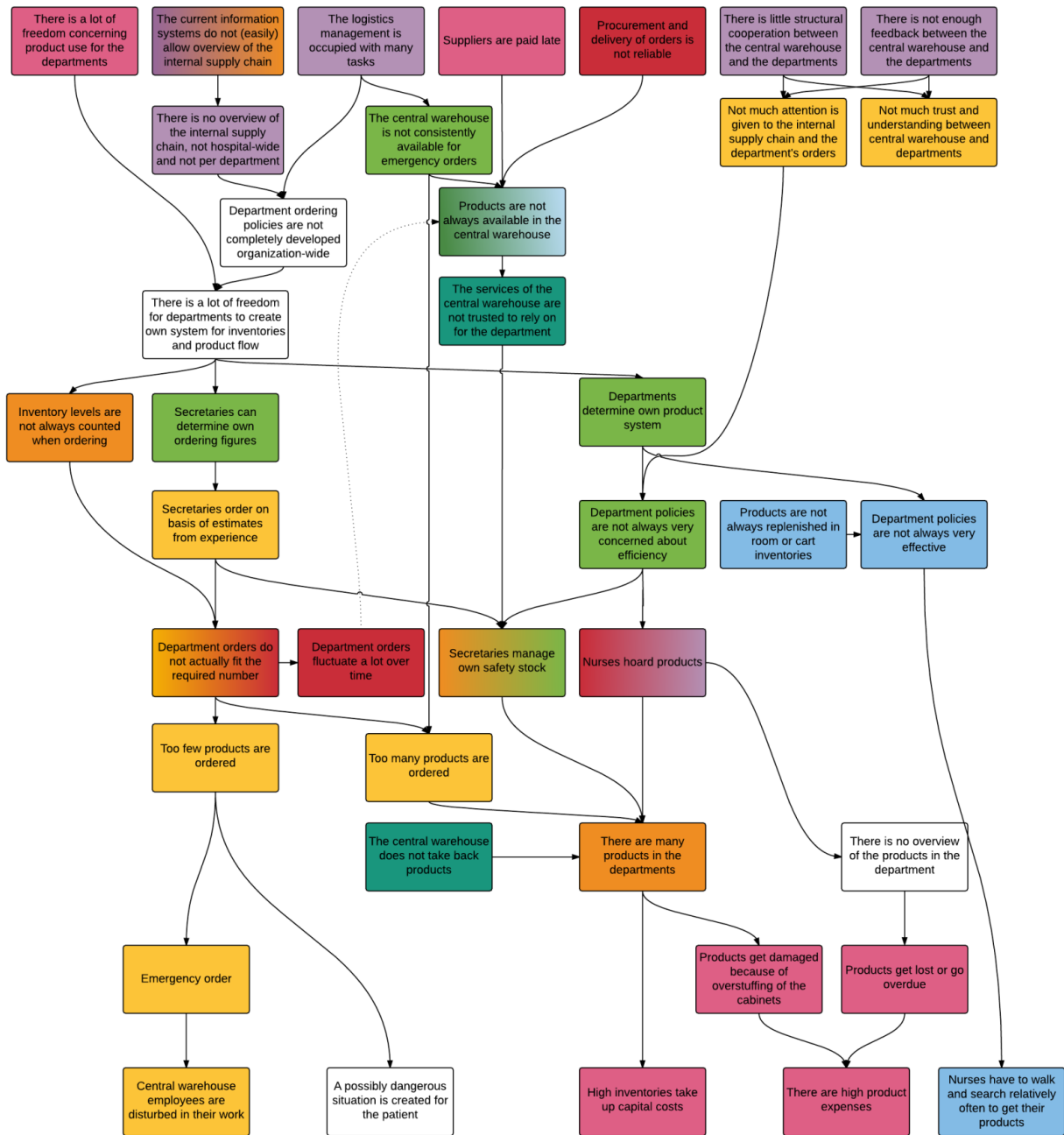
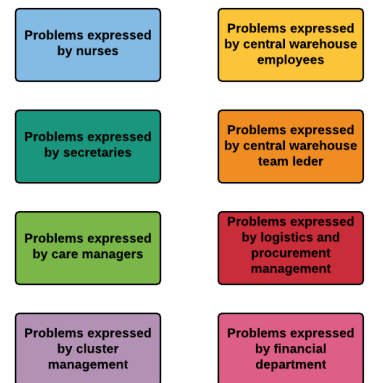


Figure 4 Problem tree of internal supply chain situation HOH

Legend



### Power-interest stakeholder analysis

There are different groups of stakeholders. The power-interest analysis (Johnson, Scholes and Whittington 1998) in Figure 5 shows to which extent these stakeholders can affect the internal supply chain situation and their interest in this situation. The accompanying analysis can be found in Appendix V. The analysis makes clear that the different management stakeholders have both a high level of interest and power and are thus important to drive change. The secretaries, nurses and finance department each have a high power concerning the improvement of the internal supply chain, but are currently not engaged and are quite reserved towards change.

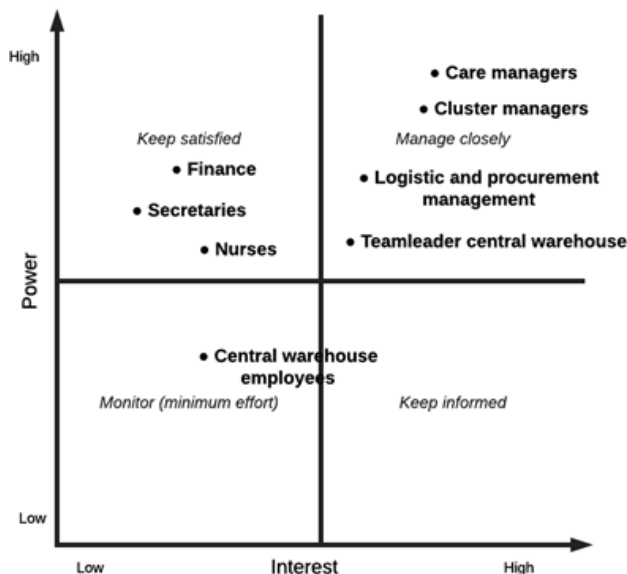


Figure 5 Power-interest matrix HOH

### Data analysis

The quantitative analysis shows that the three most often mentioned problems are reflected in the available data: the different locations for inventory at the nursing wards contain up to twenty times the required products per week, the central warehouse cannot fulfill orders in six percent of all situation and the orders for most products do not comply to the set minima and maxima but are ordered in much higher quantities. An extensive quantitative analysis of the situation can be found in Appendix VI.

### 3.4 Conclusion

An analysis of the internal supply chain situation in the HOH was performed to understand the relevant aspects for the development of the serious game. In this way is found that:

- The HOH's internal supply chain consists of the central warehouse side which procures the products externally and transports them on order to the medical departments where they are used.
- The most important dynamics in the HOH concern the interaction between the central warehouse and the medical departments and the way the products are used there. Each of these aspects influence each other and create a complexity that currently lead to frustrations for all involved.
- Every stakeholder in the internal supply chain affects its performance. There is a difference in the level to which the stakeholders experience an interest in doing so. The managing stakeholders in the HOH have both a high influence and a high interest in the performance of the internal supply

chain. The other stakeholders also influence the situation, but are currently not always interested in the situation and how their performance influences this situation and the other stakeholders.

- The aspects in the HOH's internal supply chain situation that are experienced as most problematic are:
  - The unreliability of the central warehouse
  - The product ordering of the medical departments by the secretaries
  - The hoarding culture at the medical departments

The now performed context analysis forms the input for the development of a serious game to improve the HOH's internal supply chain. That process of game design is presented in the next chapter.

## Chapter 4 Design and development: Design decisions

This chapter presents the second step in the ‘design and development’ stage: the creation of the actual artefact. This development requires “knowledge that can be brought to bear in a solution” (Peppers, et al. 2007, 13). Section 4.1 therefore discusses the additional sources of input for this stadium of game design. Section 4.2 then discusses the target audience and Section 4.3 the most appropriate technology for the game. Section 4.4 presents the development of the game mechanics on the basis of the literature frameworks developed in Chapter 2. Section 4.5 concludes with the most important decisions made in this chapter.



### 4.1 Additional sources of input for the design and development stage

The literature review and the context review form the starting points for game development, but the creation of a game is not a straightforward process. To make a game that is effective as possible - in other words: to transitional the theoretical insights to a successful game - the following additional sources of insight and information were used:

- Three experienced logistics managers were interviewed in three different Dutch hospitals which had recently improved their internal supply chain. Appendix VII presents an overview of their insights. These confirm the insight from literature that the internal supply chain as a whole is especially an important level of thinking. Furthermore the managers indicate that the use of ‘common sense’ and ‘rule of thumb’ is often much more valuable in practice than complex algorithms and heuristics, useful for the teaching objective of the serious game. Finally their experience confirmed the importance of ‘demonstration’ of effects to stakeholders in order to convey the advantages of certain ways of working.
- ‘The Art of Game Design: A book of lenses’ (Schell, 2015) provided guidelines for game design. This book is one of the most well-known in the field of (serious) game development and recommended by multiple serious game designers that were interviewed. It provides ‘lenses’ which can be used to structure and evaluate the game design process.
- Existing serious games and their design processes were reviewed and several researchers experienced with serious gaming were consulted. Also the CEO of the related serious game ‘Friday night at the ER’ was interviewed, leading to interesting insights about issues such as game progression, the use of in-game data and the value of encouraging in-game communication.

With these sources, an iterative design process was set up. Consults with serious games experts indicated that due to time constraints, it was best to first determine the audience and technology of the game as scope boundaries. With these boundaries, the iterative process of game mechanic design could be started which brings together all relevant information and insight from supply chain theory, serious gaming theory and the HOH’s internal supply chain practice.

### 4.2 Target audience

To be able to create the most effective serious game possible within the timespan available the target audience has to be established. The engagement of medical stakeholders in the internal supply chain is stressed in literature to be especially important. As Landry and Philippe (2004) write:



“Because the raison d’être of hospitals is to provide care, people have historically looked at healthcare problems and challenges through a clinical lens, striving to optimize the utilization of clinical resources and equipment from within clearly-defined specialties. We propose to look at some of these same issues through the support services lens” (p.25).

The nurses thus make for an interesting and relevant initial target audience, and the managers in the HOH practice confirm that engaging the nurses with the internal supply chain situation would be a very worthwhile feat to accomplish and thereby an interesting aspect to start with.

The most relevant management positions – the care managers, central warehouse managers and cluster manager - are the second main target audience because of their pivotal positions, as also found the power-interest analysis in Chapter 3 showed. Their decisions can influence the internal supply chain more than any others, which makes it especially important that they have a shared understanding of the entire chain and their own influence.

Other stakeholders such as the department secretaries and central warehouse employees also seem interesting to involve in the project. However, they are not an initial target group; future hospital plans will already address their performance, while the nurses and managers will continue to perform a key role in the HOH’s internal supply chains situation.

#### 4.3 The technology of the game

There are three main commonly used alternatives for the ‘hardware’ of the serious game: a video game, a board game, and a hybrid including elements of both a board and a video game. After extensive consultation with people in the field of serious gaming, and thoroughly comparing the alternatives by means of ‘Harris’ profiles (Roozenburg and Eekels 1998) (see Appendix VIII), it was chosen to create a board game with digital simulation component. This choice was based on the following reasons:

- An important goal is to create an environment for discussion in which also difficulties in stakeholder relationships can be overcome. A table-top board game is expected to best suit this need, as video games do not allow convenient real-life communication in most setups.
- A lack of experience of medical employees with video games could be a barrier to using that type of games. In addition, a board game also allows for relatively easy set-up and can be used in settings without the need for additional technology, such as in nurses’ meeting rooms.
- A board game allows for making quick prototypes and testing loops, because simple material can conveniently be used. Even during a test session, the game could be adapted and further tested. A video game is much less flexible.
- A drawback of using a board game, is that it is relatively hard to determine what the different metrics in the game should be or whether the mechanics will consistently work as planned. To overcome this limitation, a simulation model is developed to be used together with the board game. This model is developed in Excel VBA and is used to fine-tune the starting values, the in-game goals and the various details such as product costs and required nursing steps.

#### 4.4 The serious game mechanics

Having established that the serious game is a board game aimed at the nurses and management positions, many iterations were performed and test sessions varied from extensive sessions with the game to test specific possibilities, to sessions where nurses, doctor interns and graduation researchers

played the game to help create a realistic situation. The many iterations that comprised the development process can be found in more detail in the testing logbook in Appendix IX.

These iterations led to the formulation of design decisions for each of the seven categories of game mechanics presented in a framework by Schell (2015). The specific processes of game design and coming together of different sources of theoretical and practical information is presented in Appendix X.

Knowledge on internal supply chain improvement and serious game development come together in the process of game development. Table 5 therefore presents the design decisions in light of the formulated objectives concerning internal supply chain improvement and the effective attributes of serious gaming (as reviewed in Chapter 2). In this way, during the process it was evaluated whether the “research contribution is embedded in the design” (Peffer, et al. 2007, 13).

*Table 5 Design mechanics to use effective attributes of serious gaming for the accomplishment of the defined objectives*

<i>Serious game theory</i>	<b>Provide a meaningful context</b>	<b>Provide (inter)active engagement with the content</b>	<b>Provide immediate feedback</b>	<b>Engage the player in the right ‘flow’<sup>2</sup></b> (clear goals, no distraction and continuous challenge)
<i>Supply chain objectives</i>				
<b>Involve stakeholders the entire internal supply chain</b>	<ul style="list-style-type: none"> <li>The game set-up is a (simplified) version of the entire HOH’s internal supply chain</li> </ul>	<ul style="list-style-type: none"> <li>The players fulfill a role and make decisions as stakeholders in the simulated supply chain</li> <li>There are unexpected situations for each of the positions which realistically affect the whole chain</li> </ul>	<ul style="list-style-type: none"> <li>The decisions of all players affect the shared goal of the performance of the chain as a whole</li> </ul>	<ul style="list-style-type: none"> <li>There are different ‘levels’ to which objectives in the game can be accomplished</li> <li>Players have four minutes to make decisions in in-game days</li> <li>Two players together fulfill one in-game role</li> <li>The simulation model is only used behind the scenes, not during game sessions themselves</li> <li>All stakeholders in the HOH are reduced to three main in-game roles</li> <li>All types of products in the HOH are reduced to four main in-game products</li> </ul>
<b>Increase stakeholders’ supply chain knowledge</b>	<ul style="list-style-type: none"> <li>Relevant supply chain knowledge is situated in real HOH context</li> </ul>	<ul style="list-style-type: none"> <li>Supply chain knowledge is not provided but should be explored by the players themselves</li> </ul>	<ul style="list-style-type: none"> <li>In-game goals are fine-tuned with the simulation model, so the highest score can only be accomplished with best use of supply chain knowledge</li> </ul>	
<b>Enhance stakeholder relationship alignment</b>	<ul style="list-style-type: none"> <li>In-game stakeholder have realistic and conflicting incentives and interests</li> </ul>	<ul style="list-style-type: none"> <li>Players directly interact with each other and in-game events further encourage realistic interaction</li> <li>Players rotate in-game roles so they can experience each perspective</li> </ul>	<ul style="list-style-type: none"> <li>Stakeholders act simultaneously, creating situation in which they directly communicate with each other</li> <li>In-game weekends provide moments for reflection on how the players’ decisions have affected each other</li> </ul>	

<sup>2</sup> Different concepts of flow can be used, although most resemble each other. Here we use Schell’s concept, where the key components that are necessary are: clear goals, no distractions and continuous challenge.

## 4.5 Conclusion

This chapter concludes the design and development phase of the research. The developed reviews of theory and practice and additional sources of insight were used to design a board game with simulation fine-tuning, with as target audience the nurses and management in the organization. Iterations of playtests and evaluations led to the development of game mechanics that use the attributes of serious gaming as effective as possible. As the design and development phase has been completed, the next chapter demonstrates the use of the game in practice.

## Chapter 5 Demonstration: Care 4 Supply

With the previous chapter, the design and development stage of the serious game is completed. This chapter presents the 'demonstration stage' of the developed artifact. Section 5.1 presents the game's structure. Section 5.2 presents an example of one in-game day to give the reader an understanding of possible in-game situations. All required material to play the game, including a manual for the 'game master', can be found in Appendix XI.



### 5.1 Care 4 Supply: game set-up and structure

The developed serious game is called 'Care 4 Supply'. The mechanics were already addressed in Chapter 4; the game can be played by up to six players, whose goal is to together sustain the internal supply chain of a simplified version of the HOH. The three roles concerning nursing, department management and central warehouse management are based on the real stakeholder positions and it is encouraged to fulfill each role with two persons, to stimulate discussion and thinking out loud during the game. Each of the three roles has its own activities, its own agenda and its own goals. However, each of the roles affects the other roles, and players have to work together to create a well-functioning hospital.

The performance of the players is evaluated in the weekend. Each of the players can achieve 1, 2 or 3 *Performance Points*, which are added to the score of all players together on the shared performance point meter. The in-game events and emergency orders can lead to additional Performance Point wins or losses. The goal is to get at least 15 Performance Points in the three in-game weeks. After each of the weekend evaluations, the players rotate roles.

A full game session requires an average time of around one and a half hours, including preparations, instruction and post-play evaluation. If needed, the session can be shortened by playing two weeks, or by simplifying the nursing role. The pictures in Figure 6 show an example of a Care 4 Supply game session. Below the actions, decisions and goals per role are presented.



Figure 6 Pictures of Care 4 Supply play sessions in the HOH

### **In-game role 1: Nurses**

#### *Actions*

As in real life, every day there are patients in the nurse ward that require treatment. There are six beds available on the department. It is up to the nurses to get the products that the patients require to their beds and use these to care for them. Different methods are available, based on the real situation: a cart, a room cabinet, or the products can be transported by hand. Each of these means requires a different number of 'nursing steps'. After a specified number of nursing steps, an unexpected event will happen, which can influence the situation. This can for instance be the entrance of a new patient, an earlier dismissal or an unexpected bleeding (see the 'unexpected situations' card in the Appendix XI). Each day, the number of nursing actions the nurses require is tracked.

#### *Choices*

The nurses in the game have the same choices as nurses make in the real hospital situation, but the game makes these choices and their consequences more explicit. These choices concern whether and where products are stored in the department and how many. If more products are stored, this can for instance be convenient if they are needed for an unexpected patient complication. However, it can also lead to the products going overdue, getting damaged, and to other consequences that become clear throughout the game.

#### *Goals for evaluation*

The nurses have as goal to treat all the patients in time. They keep track of the nursing steps and these form the basis of their evaluation.

### **In-game role 2: Department management**

#### *Actions*

The department management has specified moments in the week on which it can place orders at the central warehouse to replenish their levels in the department warehouse. On the days on which they do not have to order, the players draw a card with an event (see Department management event cards in Appendix XI). An event can concern the management of their department warehouse, but could also require them to cooperate with the nurses or the central warehouse. These events can change the game dynamics and emphasize specific elements or dependencies. The department management can also place emergency orders at the central warehouse when their nurses run out of products and keeps track of the number of products that have to be thrown away in the department.

#### *Choices*

The department management has to determine their ordering figures at the ordering moments. They also must decide how to respond to the different events happening at their positions. Furthermore, they should communicate with the other roles as they form the link between the central warehouse and the nursing.

#### *Goals for evaluation*

The department warehouse is evaluated based on how many products the department required and how many products had to be thrown away (for instance due to going over-due).

### **In-game role 3: Central warehouse management**

#### *Actions*

The central warehouse has to fulfill the orders of the departments. The orders placed by the

'department management' role arrive two times per week. On two other days, orders come in from a 'department 2', by means of the picking of a random card. This mechanic simulates the different, and sometimes conflicting, wishes the central warehouse has to fulfill. Furthermore, as in reality, the central warehouse has to place external orders. These are delivered three days later, by the game master acting as external supplier.

#### *Choices*

The central warehouse management has to determine their ordering figures for the external suppliers. Because they receive up to 4 orders per week from the department, this is often a complicated decision and the effects of the nurses and department management actions (as in real-life) become clear throughout the game. The management can also place external emergency orders and needs to work together with the department management under certain events.

#### *Goals for evaluation*

The central warehouse management has as goal to fulfill the departments' orders and to do this as efficiently as possible; they order the products externally and thus are the eventual 'spenders' of the money that is used for the products. The expenses are based on the number of products they ordered, the number of orders they placed and the total inventory stored at the end of the period.

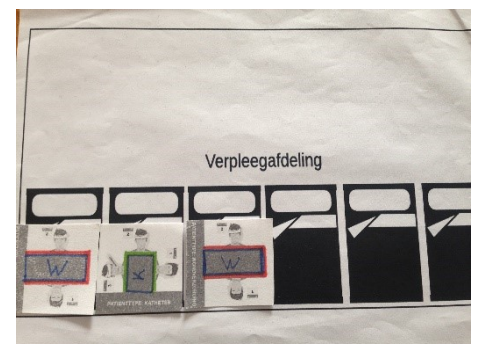
### 5.2 Demonstration of one in-game day in Care 4 Supply

To show the dynamics in Care 4 Supply, an example of an in-game day is presented. Figure 7 shows an overview of the table set-up, as Day 11 commences. This in-game example of a day is based on the observations of a real situation in one of the test sessions.



Figure 7 Pictures showing in-game events

At the beginning of this day, the ward has three patients; each of them requires products for daily treatment, two of them a wound treatment and one needs a catheter.



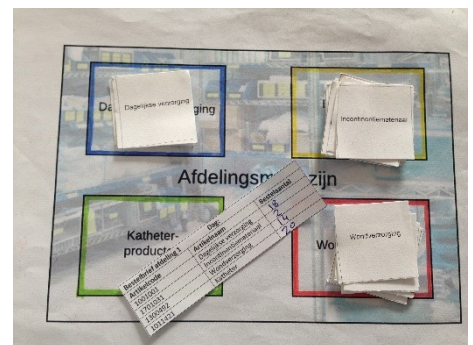
To save on their nursing steps, the players who have the nursing role have been using the room cabinet to store their products in the previous days. In this way, they do not have to walk up and down between the department warehouse and the patient room. Unfortunately, they did not expect to need a catheter, so they still have to get this out of the department warehouse. They decide to directly replenish the room cabinet, which costs 5 nursing steps. In this way they hope to prevent that they have to walk the next day again.



After they have cared for the patients, the nursing team has used a total of eight nursing steps which means they have to throw the dice to see which event will happen. The patient with the catheter can leave a day earlier. "Pfew, that could have been worse, but why did we store all those catheters again...?"



Meanwhile, the players with the role of department management have to place an order today. They want to replenish their inventories to the original level of twenty. Their warehouse is almost empty, so the department management orders quite a lot of products.



The central warehouse management overhears the department management determining their ordering figures and react: "Should you really order that much? We have to fulfill an order of Department 2 and are really running out of products, while our external supplies come in after the weekend." The department management responds that they really require the products for the coming days, as they do not know how many products the nurses will require the coming days.



The players in the central warehouse become a little agitated: “Of course you can know how many products will be required, you can overview the patient room!” The department warehouse inspects what is going on and realize why they ran out of products: “Wait! It is actually the nurses to blame, they have hoarded all these products!”. The department management decides to order less products, so the central warehouse department does not need to place a costly external emergency order.



In the example scenario, the nurses are ‘blamed’ for the struggles in the internal supply chain. Often this results in the nurses working much more efficiently in the next week. However, now the central warehouse might get in a situation in which they overcompensate for ordering too much. As each of the players can make mistakes in the game, a lot is learned by feedback the players provide each other and the way their decisions all influence the performance points the group ends up with.

There are many more examples of ways in which the in-game situations become very challenging quickly, such as the unexpected events and the simple fact that all players influence each other. To really experience all aspects of the game, the reader would have to play the game him- or herself. In Appendix XI, all material for the game can be found. This includes the cards with the actions per day per role and the different explanations of the events that can happen.



## Chapter 6 Validation: Test results

The final version of Care 4 Supply has been presented. The following two chapters concern the validation phase of the developed artefact; an investigation of its effects “before it has been transferred to practice” (Wieringa 2010, 493). This chapter shows how the game is tested and what the initial results are and Chapter 7 then analyzes these results to complete the validation.

Section 6.1 discusses the testing set-up. Section 6.2 presents the results of these sessions and Section 6.3 discusses the findings concerning the most effective set-up. Section 6.4 provides the initial conclusions concerning the findings.



### 6.1 Testing set-up

The final design<sup>3</sup> of Care 4 Supply was tested in four sessions:

1. A session of one and a half hours with managers involved in the project: two care managers of the operative nursing wards, the logistics manager and the assistant logistics manager, the information manager and one elder nurse.
2. A test session of one and a half hours with five nurses and one department secretary.
3. A test session of one and a half hours with five nurses and one medical student.
4. A test session of one and a half hours with three nurses and three medical students.

The first session was not evaluated with the post-play questionnaire, but was concluded with an evaluative discussion and was used as a moment for input. Sessions 2, 3 and 4 were evaluated with a post-play questionnaire and a post-play evaluation. The objectives formulated in Chapter 2 formed an important guideline in establishing the questionnaire. A copy of the questionnaire can be found in Appendix XII.

### 6.2 Test results

This section presents the results of the test sessions. The first session is mostly discussed in qualitative terms concerning the experience of the players, while the other sessions are also addressed in quantitative terms by using the questionnaire results.

#### **Management play session and discussion**

The managers’ reception of the game was very positive and they were enthusiastic to further play the game with their employees. This play session also presented the impulse to formulate future plans of using the plan in the HOH’s practice, as will also be discussed in Section 8.3.

Many of the managers’ decisions in the game were motivated by their insights in the real situation and the in-game mechanics allows them to show each other how they work. The care managers for instance got the chance to show the other managers how their department stores products and how the nurses can affect how much is ordered. Interesting discussions took place during the play session,

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<sup>3</sup> Only a few details were further fine-tuned with the feedback from the final sessions

concerning for instance the use of the room cabinet, as they used the in-game cabinet to discuss the effects of using it in the real hospital situation.

It was also interesting to see that the players clearly became more conscious in their ignorance concerning the roles of the others in the internal real supply chain, a process also discussed by Quarters et al. (2006) as one of the positive effects in serious gaming. This became for instance apparent when the logistics managers took on the role as nurses in the game. As the care managers told them how the mechanics in-game also took place in the real situation, it became clear that these two ‘sides’ of the hospital do not often directly encounter each other tasks. This led the logistics manager to ask: “Could we take an internship with you?” and the general agreement that it would benefit the situation if these sides would sometimes come in contact with each other’s daily occupation and decisions, as also the game contributes to.

In general, the discussion during the game and evaluation afterwards indicated that the game allowed managers to oversee the whole internal supply chain and get in touch with the roles of the other stakeholders, which opened their eyes to the decisions, actions and influence belonging to those roles. Furthermore, the game became a means for discussion of the hospital situation. The use of the room cabinet to store products for instance was discussed by showing its effects in-game.

#### **Nurse test session post-play questionnaire results**

The sessions with the nurses were experienced as very successful. All nurses not only had a lot of fun, but also indicated they learned a lot throughout these play sessions, in a way they had never experienced before. They recognized the situation in the nursing role from their day-to-day operations (“An unexpected bleeding, that always happens during [nurse’s name] shift!”), while being impressed by the chain and complexity of actions leading to getting the products to them, which they normally do not encounter (“When you do not order enough as a department, it sucks. You have to place an emergency order, which really has an impact. We should really prevent this from happening by telling the secretary if we need certain material, so we can prevent that.” “Being the central warehouse, wow that is a tough job!”).

To be able to acquire data to test the design these sessions were evaluated by means of the post-play questionnaire. Table 6 presents the responses from the nurses and department secretary to the closed questionnaire questions. Also four medical students participated in these sessions, because a few nurses had to leave for an unexpected high workload on their department. The student responses can be found in Appendix XIII.

*Table 6 Questionnaire results closed questions (n=14)*

	1. Strongly disagree	2. Disagree	3. Neither agree or	4. Agree	5. Strongly agree	Average score
1. I enjoyed playing the serious game	-	7%	7%	64%	21%	4.0/5
2. The game has increased my knowledge of the hospital's product supply chain (= the flow of products from the hospital's central warehouse to the nursing departments)	-	-	21%	57%	21%	4.0/5

3. The game has increased my understanding of how the central warehouse and care departments in the hospital influence each other	-	-	7%	71%	21%	4.1/5
4. Playing the game has made me think of ways in which the current situation in the hospital could be improved	-	-	-	71%	29%	4.3/5
5. I think that what was relevant in the game is also relevant in the real hospital situation	-	-	-	71%	29%	4.3/5
6. I think that playing the game was a useful experience	-	-	7%	57%	36%	4.3/5
7. I would recommend my colleagues to play the game	-	-	-	71%	29%	4.3/5

Table 6 presents the results of the seven Likert-scale questions on the questionnaire. Question 8 and 9 are open questions. Question 8 requested the participants to provide examples of things they had learned in the game. Question 9 asked the participants to provide recommendations in order to improve the current situation in the hospital. The answers that were provided by more than one participant are provided in Table 7. The other answers to the open questions can be found in Appendix XIV. As can be seen, for question 9 only a few answers were provided by multiple nurses. The other answers varied from the systematic checking of due-dates to the tracking of the number of products per department to setting up efficiency competitions between the departments.

Table 7 Questionnaire results open questions

Question 8. Things that were learned from the game (times answered)	Question 9. Recommendations to improve the current situation in the hospital (times answered)
That you have to be careful with how and how much products you use (4x)	Create general working guidelines concerning the products in the hospital (3x)
To become aware of the costs involved (4x)	Provide employees with information about the costs of the products and internal supply chain (2x)
To work methodically, with planning and reflection (3x)	The central warehouse should use data from material use as input for procurement (2x)
What the ordering process looks like (3x)	
What a shame it is to waste products when they are not used correctly (2x)	
What the whole chain looks like in the HOH/the logistical steps involved (2x)	
What a large number of products is involved in keeping the hospital running (2x)	

Finally, the questionnaire also provided room for feedback or additional comments. Two comments of the first session said that the instructions could have been better, which was therefore improved for the other two sessions. Other comments mostly concerned how much fun they had; one nurse for instance said that she wanted “more of these kinds of games, we are not used to this and would like to see more of this kind of projects”. The test results are analyzed in the next chapter.

### 6.3 Guidelines for effective play sessions

The test sessions and evaluation with the managers, other employees and students who played the game gives insight into four guidelines to use Care 4 Supply most effectively:

1. Care 4 Supply should be played as much as possible with players with similar levels of education and language. The fourth session was played by three Aruban nurses and three Dutch medicine students. While everyone enjoyed the game and was very positive in their response, it was clear that the students had the tendency to 'be dominant' over the nurses playing, thereby limiting the engagement of the nurses.
2. Mixing the employees of different departments is recommended. The first three sessions each mixed employees from different (care) departments. These were the most valuable sessions, because the players got a chance to discuss different approaches used at these departments.
3. Care 4 Supply can be played multiple times by the same players. Since almost everyone indicated they had a fun and valuable experience, they could for instance play it a few months later again, to test different strategies and ways of playing. An idea a nurse posed and which might make replaying the game even more engaging is to incorporate a 'high score board' at the hospital, showing which teams got the most performance points in a Care 4 Supply session.
4. The first time Care 4 Supply is played, it is recommended to play it in a full session of 90 minutes, so each player gets to understand each of the positions and dynamics. Later sessions could however be much shorter, for instance to focus on specific dynamics or elements.

### 6.4 Conclusion

The serious game designed for the internal supply chain situation of the HOH was put to the test. With a general positive reception and an average score of at least 4 out of 5 on each question in the post-play questionnaire, the initial findings concerning Care 4 Supply are positive. The next chapter places these findings in perspective of the formulated objectives and creates and scrutinizes them by means of the previously developed insights from literature and practice.

## Chapter 7 Validation: Analysis of results

This chapter relates the findings of Chapter 6 to the defined objectives and analyzes these results. Theory on the hospital's internal supply chain (reviewed in Chapter 2) is then used to reflect on the contribution to the relevant success factor. Theory on serious gaming (reviewed in Chapter 2) is used to understand how Care 4 Supply could (not) accomplish the objectives. Knowledge and insight of the HOH's situation (developed in Chapter 3) is used to understand the effects on the internal supply chain of the accomplishment of the formulated objectives. In this way the validation phase can be completed and "knowledge can accumulate by trying to understand how the interaction between an artifact and a problem domain in particular cases produces effects" (Wieringa 2010, 494).

Section 7.1 to 7.3 each analyzes the findings for each of the objectives. Section 7.4 analyzes the results in light of the other success factors presented in Chapter 2. Section 7.5 uses this knowledge to analyze the generalizability of the results and Section 7.6 presents the conclusions of this chapter.



### 7.1 Objective 1: Involve stakeholders in the entire hospital's internal supply chain

#### Observations concerning the accomplishment of this objective

- Care 4 Supply mimics the entire internal supply chain of the HOH. Managers indeed recognized all important elements and each of the nurses agreed with "I think that what was relevant in the game is also relevant in the real hospital situation".
- Players rotate roles, encounter events that relate to the different roles in the chain and 'performance points' show the effects of individual stakeholders on the situation as a whole. That players got involved in these aspects became for instance clear as the nurses who were initially very reserved towards spending one and a half hours for some 'game' of some 'central warehouse intern', got more and more excited during the game, even wanting to continue playing when the initial time was up to accomplish the objectives.
- The care managers who later talked with the nurses who had played the game (without the researcher present), all indicated the nurses had been very enthusiastic about the game and its contents. While these care managers had previously undertaken efforts to improve their product use in their department, they had never expected that this level of engagement was possible. The questionnaire results also indicate that almost all players had fun and found playing the game a useful experience. All of the players would recommend their colleagues to play the game.

With these observations, we conclude that Care 4 Supply succeeded in accomplishing the objective to involve stakeholders in the entire hospital's internal supply chain.

#### Reflection in light of theoretical framework

The objective was motivated by the success factor "All stakeholders are involved in improving the entire internal supply chain", one of the most often-mentioned factors in the reviewed literature. De Vries (2011) for instance illustrated the need for this involvement with an anecdote:

"[A]ssessing the proposals for adjusting the inventory system, each stakeholder involved in the project reviewed the pros and contras of the proposal by discussing the potential consequences of the proposal for the health care process. In doing so, each stakeholder

applied a patient-oriented perspective [...]. Without doubt, this severely hampered discussions about replenishment levels, the amount of safety stock and the procedures to be applied in case of rush orders.” (p.67)

This example illustrates the value of Care 4 Supply: it allows players to experience other and broader perspectives. This encourages insight that overcomes position boundaries. This strongly relates to what Landry and Philippe (2004) called the (highly needed) “support services lens” (p.25) and Chen and Paulraj (2004) as ‘working across silos’ (p.143).

The observations indicate that key to the accomplishment of the objective is that players could interact with an environment they recognize, but do not completely know. Many players were for instance surprised by the complex role of the central warehouse and how their own actions influence its performance. Crucial furthermore seems the aspect of fun. While *flow* keeps the players tight to the game, it was the shared *fun* that enabled them to keep playing. This was for instance stimulated by the players recognizing specific aspects, but also how the board game set-up allowed them to joke with each other and directly discuss what was happening in the game.

### **Effects for the improvement of the hospital’s internal supply chain**

As the required involvement for a successful internal supply chain can be accomplished, which effects can we expect on the internal supply chain in practice? While authors indicate the need for engagement, none of them address the eventual effects. The fact that we have performed this research in a real hospital’s internal supply chain, now allows us to evaluate this question to get an indication of what the effects could be of accomplishing this objective:

First, we can see that the involved stakeholders can improve their own ways of working with the acquired insights. For the HOH, the hoarding of products and resulting inefficient use of material was a major problem. Initially, many employees took a reserved position concerning improving this aspect; they argued that it was caused by the unreliability of the central warehouse. Care 4 Supply provided a new perspective. After playing, the nurses even constructively proposed ways to work more efficiently on their own initiative. Another example is that Care 4 Supply could show central warehouse employees the consequences of making a mistake in delivery. This could improve the quality of delivery in the HOH, contributing to patient safety.

Second, improvement initiatives can be presented in the game with room for feedback and input. The influence of scanning inventory levels on the role of nurses and department management can for instance be showed using the game. Because a game allows for interaction with the content, the stakeholders can both get familiar with the content and directly express any feedback or concerns they have concerning these initiatives.

## **7.2 Objective 2: Increase stakeholders’ supply chain knowledge**

### **Observations concerning the accomplishment of this objective**

- The majority of the players (78%) indicated that his or her knowledge had increased by playing the serious game. Also the students who played the game each indicated that their knowledge had increased.
- During each of the play sessions, the players improved their in-game performance over time. This gives an indication that they were indeed able to acquire an understanding of the relevant dynamics.

- The nurses indicated many different aspects that they had learned by playing Care 4 Supply, among which were the ordering dynamics, what the work of the central warehouse employees looks like, and what the different dependencies within the internal supply chain are. That they had fun during these learning processes is also interesting to contrast with a course that the HOH had organized two years before: while that course was obligatory for the department supporting personnel, only two secretaries showed up, showing the resistance usually involved in these aspects.

With these observations, we conclude that Care 4 Supply succeeded to some extent in accomplishing this objective. This could be further examined with a more extensive evaluation of the players' knowledge levels over a longer period of time.

### **Reflection in light of theoretical framework**

In a successful internal supply chain, "All stakeholders have an appropriate level of supply chain knowledge". McKone-Sweet et al. (2005) called this "the core of effective SCM[,] the collective knowledge and skills of those involved in developing and implementing supply chain processes" (p.13). Correspondingly, most authors discuss the importance of supply chain knowledge and understanding as something that is especially effective if it is shared. Only in that way, a culture can be supportive and incorporate best practices (Fredendall, et al. 2009, McKone-Sweet, Hamilton and Willis 2005). Our observations in-game and in the HOH context however indicate that not only the shared knowledge is valuable; also the individual knowledge is important. It allows stakeholders to stimulate each other and initiate improvement plans to create momentum for change.

Care 4 Supply can improve supply chain knowledge especially by using situated learning and by providing direct feedback. Because players could only accomplish the highest score by working very effectively, they had to think of suitable strategies themselves. Thus instead of forcing theoretical knowledge upon the players, Care 4 Supply provided a way in which they could discover the necessary knowledge themselves. The aspect of 'flow' seems important for this, as players were engaged throughout the session and kept challenging themselves and each other. The direct feedback of the game on the players' performance and how they interact further stimulated learning.

### **Effects for the improvement of the hospital's internal supply chain**

As with engagement, we can again question what the benefits will be if we can provide the involved stakeholders with more understanding. The authors mostly focus on long-term culture effects, but we can already distinguish effects on a more individual scale reflecting on the HOH situation.

These effects are mostly concerned with stakeholders acquiring an understanding of how their actions influence others and subsequently how they can ground their decisions. Secretaries for instance get insight in how and why they can determine their ordering figures; nurses get an understanding of what the effects are (which often surprised them); the logistics management learned why fluctuations in medical department order are not always preventable. With these understandings, the stakeholders can adapt their own decisions and actions in a way that is much more motivating than getting told what (not) to do.

## **7.3 Objective 3: Enhance stakeholder relationship alignment**

### **Observations concerning the accomplishment of this objective**

- The play sessions indicated that the game was a way to experience the perspective of other stakeholders in a way they had never before. There was much discussion and the game allowed,

as a logistics manager formulated it “to stand in each other’s shoes and see the problems from the other’s perspectives”.

- The link between the central warehouse and the medical department is the most important relationship between stakeholders in the entire supply chain, as was discussed in Chapter 3. Thirteen of the fourteen players agreed with the statement that “The game has increased my understanding of how the central warehouse and care departments in the hospital influence each other”.
- It could be observed how throughout the play sessions, the nurses started to discover the importance of communication. A care manager indicated after a play session: “Nurses are not used to the importance of communication at all, because they mostly care for the patients on their own. I was really happily surprised when they figured out how important communication is in the game and thus also outside of the game”.
- In contrast to the preliminary stakeholder analysis – in which stakeholders especially ‘blamed’ others of making the situation problematic – after playing Care 4 Supply many players suggested improvements for their own ways of working.

With these observations, we conclude that Care 4 Supply can accomplish this objective. Testing the game for additional stakeholder groups could be used to further examine these results.

#### **Reflection in light of theoretical framework**

This objective relates to the success factor: “Stakeholder relationships are well-aligned”. A hospital’s central warehouse and the medical departments are by nature in a kind of conflict with each other, because of their different interests. Care 4 Supply provides a way to overcome the difficulties and find a shared space for discussion and evaluation. McKone-Sweet et al. (2005) observed the following:

“When people worked outside their areas, they asked basic questions that challenged the way things were done. This led to radical changes within the organization and eventually helped to eliminate the barriers between departments.” (p.9)

Care 4 Supply provides the means to create this effect in game form. In this way, also frustrations can be vented in the game environment and discussed together; several problems in the real internal supply chain came to discussion in the test sessions, while these had not been touched upon in the sporadic meetings between the care and supply side of the hospital. In addition, Care 4 Supply can overcome what Fredendall et al. (2009) describe as the often seen “lack of access to anyone who both had the ability to change the system and with whom they were comfortable sharing their knowledge of the problems” (p.329).

Care 4 Supply especially leaned on the aspects of a table-top board game to do this: players were encouraged to directly discuss the in-game events and thereby understand each other’s perspectives. Because the players rotated roles and got direct feedback, they got an understanding of what the different interests are and why difficulties arise in the current situation.

#### **Effects for the improvement of the hospital’s internal supply chain**

Let us consider what the impact in practice can be of accomplishing this objective:

First, Care 4 Supply allows stakeholders to get acquainted with the perspective of others, and to show others their own perspective. This can be a key to job satisfaction, as stakeholders understand the reasons for certain decisions and actions taken by others and because stakeholders can feel that their



interests are 'heard' by others. The central warehouse employees for instance initially indicated they felt underappreciated and were very enthusiastic that the game would encourage others to understand their perspective.

Second, it was clear that many managers in the HOH have very different ideas of what the internal supply chain in the HOH should look like. These stakeholders have both a high power and interest position and Care 4 Supply allows them to together create a perspective, instead of only having their own conflicting perspectives.

Third, Care 4 Supply can motivate stakeholders to alter their ways of working. While many in the HOH initially blamed others for inefficient situations, players understand the role of their own decisions and behavior. As already discussed, the nurses present a great example.

#### 7.4 Other success factors

In Chapter 2 the literature review provided an overview of eight success factors. Above we discussed the contribution of Care 4 Supply to the three most relevant success factors. Here we discuss to which extent playing the serious game could contribute to accomplishing the other factors.

A hospital requires a system to ensure **products are delivered as close to the point of care as possible**. While the design of such a system is a completely different project, Care 4 Supply could be beneficial in its implementation. Care 4 Supply can for instance help to explain what the system set-up is, why it is designed that way and what detrimental effects, such as hoarding, are for the system's performance.

A successful internal supply chain requires **an organizational culture of shared knowledge, best practice and continuous improvement**. Playing Care 4 Supply could contribute to this factor, because players get a shared understanding of the situation from a shared experience in the game.

A well-functioning internal supply chain requires the support of **a data-driven system for measuring and control**. Care 4 Supply could help to make stakeholders understand the importance of such system. Apart from that, designing and implementing the system would be a separate improvement project.

In a successful internal supply chain, **there is top management support and clear supply chain leadership**. As was shown, Care 4 Supply does not have to be played only in complete sessions. The simulation set-up can also be used as a means for discussion. This could assist in getting the different stakeholders together and decide upon a vision for the future and accompanying strategy. Especially involving the management stakeholders in this way provides great promises.

Concerning the final success factor that **there is an overall set of goals**, Care 4 Supply could be an excellent way to flesh out which goals are most important in a hospital's internal supply chain.

In conclusion, the requirements for success could be distinguished in those related to 'hard' or to 'soft' factors:

- Hard factors concern for instance the hospital's information system or logistical set-up. Care 4 Supply can provide a means to discuss these and assist in successful implementation, but not to directly improve the hardware systems themselves; these require further initiatives and investments.

- Soft factors relate to human aspects, such as culture and vision. Care 4 Supply can contribute to accomplishing the success factors that relate to these aspects, because it provides a way to discuss the relevant aspects, involve the relevant stakeholders and share perspectives.

### 7.5 Generalization of the research results and wider application of Care 4 Supply

The context of the HOH was used to test and validate the use of Care 4 Supply to improve the internal supply chain. Here we discuss the question to which extent the findings analyzed above can be generalized to other contexts and industries.

While the logistical layout of the HOH provided the basis of the game, the objectives were translated from general success factors of academic literature. This ensures that the game relates to general concerns in hospital internal supply chain management, not only those related to the HOH, as the relevance of improvement is high: studies in North America found that more than 40% of the hospital's expenses were related to the supply chain (Landry and Beaulieu 2013, Kowalski 2009), care professionals spend on average more than 10% of their time on logistical tasks and by improving the internal supply chain the average hospital could cut around two to eight percent of their total hospital operating costs (McKone-Sweet, Hamilton and Willis 2005).

As the game plays into important themes in the field of hospital supply chain management, the game could also be adapted for a specific situation; even if a hospital for instance uses automatic ordering, this could be incorporated in the game, to use 'situated cognition' as effective as possible. Thus positive effects from playing Care 4 Supply in other hospitals would also be expected if the game was played in other hospitals. This general use of the game would have to be tested in practice. To get an indication of how Care 4 Supply could be used in other environments, we can review the examples of the three visited Dutch hospitals, shortly discussed in Section 4.1:

- The SMK works with a similar set-up as the HOH, with a central warehouse, department warehouses and the role of nurses. The manager of the SMK indicated that cultural and behavioral aspects form their major challenge in improving the internal supply chain. Care 4 Supply could thus quite straightforwardly be implemented to improve these aspects.
- The MST also has a set-up with a central warehouse and departments, but the departments have a system with automatic ordering. The manager indicated that one of their major challenges is to involve nurses in this new system and teach them the benefits. Care 4 Supply could be altered to do this, by showing different scenarios, while maintaining its power to involve and engage the relevant stakeholders.
- The AMC devises a department-specific set-up per department, optimized to their needs. Care 4 Supply could here for instance be used as a medium for communication and discussion, providing the players with an understanding how different set-ups influence the supply chain's performance.

Furthermore, the observations related to the second objective indicate the teaching potential of Care 4 Supply. Indicative for this are also the positive results from the students who tested Care 4 Supply. While these students only work in the HOH for several weeks, they found playing the game a valuable experience and indicated they had learned a lot, as also the questionnaire results in Appendix XIII show.

Concerning the use of the game we could also look beyond the field of healthcare. The subjects of the game – alignment, discussion, complexity of decisions and conflicting and mutual interests – address many fields of practice, not only healthcare. This is for instance shown by the serious game Friday Night at the ER, discussed in Chapter 5. Interesting about this example is that it has used its hospital theme to acquire a market far beyond the hospital market, with even the CIA and Disney using it in their organization with great success. The question is thus whether Care 4 Supply could also be generalized outside of the hospital world. The answer might be a big ‘yes’, as the game approaches the subject of supply chain management in a way that could teach anybody involved, and approaches the subject of process-thinking in an accessible but challenging way. More tests and further perfecting the game would of course be needed to completely back this claim.

## 7.6 Conclusion

This chapter reviewed the findings and concluded that Care 4 Supply can accomplish each of the defined objectives. These findings were examined with the developed literature framework and insights from practice, which also led to valuable insights on current literature. The next chapter places these insights and conclusions per objective in the research perspective and discusses the resulting research contribution of this thesis.

## Chapter 8: Conclusions and recommendations

The previous chapters have developed an answer to each of the sub questions. This chapter concludes the thesis by formulating an answer to the main research question in Section 8.1, discussing the contribution to theory in Section 8.2 and to practice in Section 8.3 and by formulating suggestions for future research in Section 8.4.



### 8.1 Conclusion

This thesis investigated whether a serious game could be developed for the engagement of stakeholders in order to improve the hospital's internal supply chain. This section summarizes the answer to each sub questions and then formulates an answer to the main research question.

*What objectives should the serious game accomplish?*

Chapter 2 reviewed relevant literature to formulate the following objectives for a game that could improve the hospital's internal supply chain:

1. Involve stakeholders in the entire internal supply chain
2. Increase stakeholders' supply chain knowledge
3. Enhance stakeholder relationship alignment

*What are relevant aspects in the HOH's current situation for the development of a serious game that can accomplish the defined objectives?*

Chapter 3 presented an overview of the internal supply chain situation in the HOH and the main problematic aspects, which concern the unreliability of the central warehouse, the inefficient product ordering by the secretaries, and the hoarding culture at the medical departments. These findings form the contextual basis for the game design.

*Which design decisions are appropriate for the development of a serious game that can accomplish the defined objectives?*

Chapter 4 presented the process and decisions in the development of a board game for nurses and management. Many iterations of game design were used to approach the objectives with a game design that can provide a meaningful in-game context, provide immediate feedback, provide (inter)active engagement and provide the right flow.

*How is the serious game used in practice?*

Chapter 5 presented the game that was the result of the design and development phase. Care 4 Supply is a board game where six players fulfill the roles of nursing, department management, and central warehouse management. These roles each have their own in-game goals, but players must work together to create a successful internal supply chain.

*To which extent is the resulting serious game able to accomplish the defined objectives?*

Chapter 6 presented the results of the test sessions of the final version of Care 4 Supply. The reception of the game in four play sessions with nurses and management was very positive and the nurses scored each of the questions based on the objectives on average with at least 4 out of 5. The initial results concerning the accomplishment of the objectives thus were very positive.

*How can the developed serious game contribute to the improvement of the hospital's internal supply chain?*

Chapter 7 analyzed the test results concerning the objectives, the developed literature framework and the context of the HOH. The findings make clear that Care 4 Supply has the ability to accomplish each of the formulated objectives, by which it can contribute to the improvement of the hospital's internal supply chain. Further research by means of comparative and longitudinal testing could further scrutinize how profound these effects are on a longer term.

To conclude, we can answer the main research question:

*To which extent can a serious game accomplish the engagement of stakeholders in a hospital's internal supply chain in order to improve its performance?*

The serious game Care 4 Supply was developed to accomplish stakeholder engagement in the hospital's internal supply chain in order to improve its performance. The observations during the test sessions and evaluation with managers indicate that playing Care 4 Supply indeed can improve the hospital's internal supply chain performance by doing this. This happens in three main ways:

In the game, players get the chance to overview the entire chain and are engaged in an exciting and challenging way. Playing Care 4 Supply can thereby **involve stakeholders in the entire internal supply chain**. This can contribute to improving the internal supply chain situation because stakeholders acquire insight in how they can adapt their own behavior, and because the game can be used to introduce and support improvement initiatives.

In the game, players get the chance to develop an understanding of what appropriate strategies are by interaction with the content themselves, not just by being told what do. Playing Care 4 Supply can thereby **increase stakeholders' supply chain knowledge**. This can contribute to improving the internal supply chain because stakeholders acquire insight in how they can ground their decisions, and because shared knowledge enables a supportive culture for the incorporation of best practices.

In the game, players can interact with each other in a setting that resembles their own and experience other stakeholders' perspectives. Playing Care 4 Supply can thereby **enhance stakeholder relationship alignment**. This contributes to the internal supply chain because being able to share perspectives and having the possibility to share feedback can lead to improved job satisfaction and better alignment of objectives and processes.

In addition, playing Care 4 Supply can contribute to other success factors that relate to 'soft' aspects of the organization, because stakeholders can be involved to discuss initiatives and create a shared perspective.

In conclusion, our findings indicate that a serious game is able to connect to the unique challenges in the hospital's internal supply chain, because it engages stakeholders and can thereby broaden their perspective, improve their knowledge and mitigate difficult relationships. Additional comparative and longitudinal testing could further examine the effects on the longer-term performance of the internal supply chain.

## 8.2 Contribution to theory

With the main research question answered, we can consider the contribution of this research to theory.

### **Contribution to supply chain literature**

As other researchers also noticed (Kowalski 2009, De Vries and Huijsman 2011), many authors have argued why industrial supply chain solutions can often not directly be used in a hospital settings and what the promising gains are of improving a hospital's internal supply chain. However, there is a lack of research for ways of supply chain improvement that fit a hospital's situation. This thesis research responded to this gap by researching the use of a game for stakeholder engagement; an aspect that many authors discuss as comprising a unique challenge in the hospital setting but which had not yet been a focus of a design study. The validation shows how the developed game can contribute to the engagement on internal supply chain improvement by means of the three defined objectives and with that we can also conclude that while there is an extensive field of supply chain management concerned with the optimization of the 'hard factors' of a supply chain, a serious game like Care 4 Supply can play an important role in the management of the 'soft' aspects in the implementation of such optimization initiatives.

In analyzing the test results in light of the literature framework (Chapter 7), we furthermore recognized that while literature on the internal supply chain presents a shared understanding of success factors, there is not always a developed understanding of what the effects of accomplishing these factors are. This thesis could review the situation at the HOH to acquire an understanding of these effects. This also showed the degree of uncertainty concerning the eventual effects of improving the relevant success factors.

An additional contributory insight to supply chain literature relates to the finding that existing literature especially emphasizes the importance of stakeholders' collective and shared knowledge and insight. This cultural aspect indeed seems important on the long term, but our observations indicate that the value of individual knowledge and insight might be underappreciated.

### **Contribution to serious game literature**

As reviewed in Chapter 2, serious gaming is a relatively new and upcoming field. The Design Science Research Methodology allowed us to conclude that the developed serious game could be successfully used to improve knowledge, insight and enthusiasm concerning the internal supply chain. Serious games are already present in many sections of healthcare concerning the medical professional side, but applying it to the supporting functions in the hospital is a new approach. This thesis thereby contributed to the field by showing how serious gaming can be a key to implementing interventions in the complex human constellation that is a healthcare organization.

Furthermore, the observations of the test sessions indicate that the relevance of 'fun' for the effectiveness of serious gaming might be underappreciated. Most serious game literature discusses the aspect of 'flow', which is clearly important to tie players to the game. However, fun might be more crucial to be able to involve players in the first place, by offering them a setting in which they feel convenient and are able to interact with each other naturally.

### 8.3 Contribution to practice

This thesis provided a contribution to practice in two ways: a contribution to the practice in the HOH specifically and a contribution to practice in general. The contributions are here discussed.

#### **Development of an internal supply chain strategy for the HOH**

The review of literature and practice provided indications for valuable success factors and guidelines to improve a hospital's internal supply chain. Not all of these factors had a direct relation to the main research question. However, each of these insights proved valuable to analyze the practice in the HOH. By using these insights to scrutinize the internal supply chain situation in the HOH, propositions were established for internal supply chain improvement, one of which concerns the use and further implementation of Care 4 Supply. These propositions are communicated in more detail with the hospital management. An overview can be found in Appendix XV.

#### **Growing engagement of stakeholders in the HOH's internal supply chain**

Care 4 Supply acquired a lot of positive feedback, from all players and from the others in the organization involved in the project. Presenting the game and findings to top managers led to even more positive momentum towards the end of the project in Aruba. Together with these managers it was decided to formulate a plan for further use of Care 4 Supply. The in-house designer and communication manager in the HOH can help to create the final design and two care managers will use the game to organize planned sessions for the employees in the hospital. The positive approach is expected to in this way keep further developing the momentum for internal supply chain improvement and to, along with additionally proposed initiatives, succeed in accomplishing gains in terms of financial means, job satisfaction and patient safety.

#### **General contribution to practice**

As discussed in Section 7.5, Care 4 Supply can be used in many more hospital contexts than only the HOH to realize stakeholder engagement and contribute to accomplishment of the three defined objectives. Concerning the use of the game we could even look beyond the field of healthcare. The subjects of the game – alignment, discussion, complexity of decisions and conflicting and mutual interests – address many fields of practice, also in business and governance for instance.

### 8.4 Suggestions for future research

As discussed, one of the largest contributions of this research is to contribute to answering the question how a hospital's internal supply chain should be improved. Many hospitals are struggling with this challenging question that has as of yet received relatively little attention. The first suggestion is thus that researchers could expand their research concerning the question *why* a hospital can improve its internal supply chain and *what* a successful situation is, with research into *how* such improvement can be realized. This should concern both the soft and hard factors encountered in the presented analysis of literature and practice. More specifically, research in how a hospital can design and implement an effective system to provide medical and non-medical products as closely to the point of care as possible and what relevant contingency factors are for such system would be a valuable step forward in the internal supply chain context.

Other suggestions relate to the way this thesis showed promising results concerning the use of a serious game for the hospital's internal supply chain. Further research could more precisely capture the potential of a serious game in this situation. Comparing the use of Care 4 Supply with a control group could for instance further contribute to insights in the engagement of stakeholders, and a more

longitudinal research would be valuable to gain insights in the long-term influences and strategies concerning the use of serious gaming. Further testing this in the HOH would be interesting, but testing this type of game in other environments would be especially valuable to further scrutinize the merits of using a serious game for the 'soft aspects' in the area of supply chain management and logistics.

As a finishing note, it is interesting to see that this graduation research started with many stakeholders in the HOH questioning the value of analyzing the internal supply chain. It was considered a 'minor aspect' of the whole care process and each depicted a few stakeholders he or she thought simply had to change a few things in their ways of working. The graduation research finished however not only with the hospital management being happy with the established plans for a way forward, but with those same initially reserved stakeholders enthusiastically running to their managers, telling them how much they had learned. Now it is up to future researchers and practice to realize the many potential benefits in terms of finance, job satisfaction and patient satisfaction. The internal supply chain might not directly heal patients on itself, but its efficiency is essential in creating a sustainable future and to be able to keep providing adequate care for supply and supply for care in a world where healthcare costs are continuously on the rise.



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## Appendix I: Structured literature review

In *Using grounded theory as a method for rigorously reviewing literature*, Wolfswinkel et al. (2013) offer a “systematic and rigorous approach to carrying out a literature review” (p.45). Their approach is rooted in the use of *Grounded Theory*, in order to reach a thorough and theoretically relevant analysis of a topic. They present the *Grounded Theory Literature Review Method*, which consists of five stages and is iterative in nature.

Below the steps as suggested by Wolfswinkel et al. are carried out. Before starting the literature review, a question has to be formulated to indicate the topic and scope of the review. The authors indicate that this question could change during the process of finding and reviewing literature. For the literature study for this review, the questions that has led to the final results of the literature study are:

1. “What are success factors in a hospital’s internal supply chain?”
2. “What are effective attributes of a serious game?”
3. “What are relevant existing serious games for our research topic?”

### 1. Define

The first stage consists of the definition of the criteria for inclusion and/or exclusion of an article in the data set. Also the fields of research, the appropriate sources and finally the specific search terms are determined.

#### *Internal supply chain literature*

For the first question, initial criteria were ‘healthcare OR hospital’, ‘inventory (positions)’, ‘product logistics’ and ‘department\*’. These seemed appropriate to gain a background in different inventory systems used between the central warehouse and the departments. However, it appeared that in literature almost no attention has been given to the determination of inventory positions at hospital departments. As such, most search criteria seemed not appropriate. The results were mostly mathematical derivations of theoretical inventory policies or concerned other industries than the hospital. For these two reasons – that the situation in the HOH appeared to be broader than only inventory management and that the initially derived field of knowledge was not directly relevant – the inclusion and exclusion criteria were adjusted a few times by a backward and forward search in order to find the most appropriate terms.

Concerning the fields of research in which articles are searched, no narrow bounds are needed. The hospital’s internal supply chain is an overlap of general healthcare and hospital performance research and more specific inventory, logistics and material management theory. Two important sub-fields were however excluded: The first concerns sources that focus on other industries than the healthcare industry and have no link to the hospital. The second exclusion concerns literature about the inter-organizational supply chain, between different suppliers and finally the buyer. This is left out because the focus in this thesis is on the internal supply chain.

Furthermore, an initial review of different search terms showed the need to filter the results on basis of the number of citations. Because different search terms present different amounts of sources which correlates to how relevant the results are, this minimum of citations was set higher for the broader search terms. This led to the assurance that at least the most important sources were taken into account, without having thousands of possible results.

### *Serious game literature*

For serious gaming, the terms concern the effectiveness of serious gaming, which quite straightforwardly led to relevant sources. For the second question, more specific terms were used. Since serious gaming is a quite clearly demarcated academic field on itself, no further specification was needed.

These steps led to the inclusion and exclusion criteria are presented in Table 8. The search results were limited to the timespan 2000-2016. Google Scholar was used as the main search engine, with the help of the program 'Publish or Perish 4' to sort on basis of number of citations.

*Table 8 Search specifics in literature research*

<i>Search terms</i>	<i>Exclusion term</i>	<i>Minimum number of citations</i>
<i>Hospital</i> <i>"internal supply chain"</i>		Most specific search terms with many relevant results:  At least 10 citations
<i>Hospital departments</i> <i>"inventory management"</i>	Blood (to exclude bloodbank) Depression (to exclude 'depression inventory')	More than 1000 results, some relevant:  At least 50 citations
<i>Characteristics successful supply chain hospital</i>		More than 100,000 results, in order to not accidentally miss relevant articles, results with more than 100 citations were scanned
<i>Success factors hospital supply OR inventory</i>		
<i>Barriers hospital supply OR inventory</i>		
<i>"Serious game"</i> <i>Effective OR Effectiveness</i>		More than 10,000 results, investigate literature standards:  At least 100 citations
<i>"Serious game"</i> <i>supply hospital</i>		More than 1000 results, of which many had very few citations:  At least 5 citations
<i>"Serious game"</i> <i>"Supply chain"</i>		

## **2. Search**

In the second stage, the search terms and criteria from the first stage are used to search in the database. As Wolfswinkel et al. describe how the researcher is likely to find sources that lead him to review his search terms. This has indeed happened and Table 8 were the resulting search terms of this iterative process.

### 3. Select

The third stage consists of the selection of articles from the search sample. This is done by filtering out doubles, refining the sample based on the title and abstract, refining the sample based on the full texts and reviewing the literature sample by a backward and forward search of citations.

#### *Internal supply chain literature*

All found articles were first scanned on the basis of their titles. Articles with titles that were clearly not relevant were then omitted. These for instance covered other areas such as law or mathematics or focused on the use of specific clinical tools. Many of the articles that were not used in the final analysis only considered the supply chain outside the hospital, between the different suppliers.

Filtering these kinds of results out led to 43 potentially relevant articles remaining. For all of these articles the abstract was read and some were completely read. Also a backward and forward search was performed, which led to a number of articles that were scanned and read in addition to the starting sample and this also led to an extra article in the final sample. This final sample after the steps presented above, consists of 11 articles that proved to be relevant and were used for the literature review. See Table 9 for a list of the relevant articles concerning the questions for the internal supply chain.

*Table 9 Results of structured literature research internal supply chain*

Authors	Year	Article	Citations
K.E. McKone-Sweet, P. Hamilton and S.B. Willis	2005	The ailing healthcare supply chain: a prescription for change	131
S. Landry and R. Philippe	2004	How logistics can service healthcare	48
A. Kumar, L. Ozdama and C.N. Zhang	2008	Supply chain redesign in the healthcare industry of Singapore	76
I.J. Chen and A. Paulraj	2004	Understanding supply chain management: critical research and a theoretical framework	600
L.D. Fredendall, J.B. Craig, PJ Fowler and U. Damali	2009	Barriers to swift, even flow in the internal supply chain of perioperative surgical services department: A case study	36
S. Landry and M. Beaulieu	2013	The challenges of hospital supply chain management, from central stores to nursing units	19
R. Iannone, A. Lambiase, S. Miranda, S. Riemma and D. Sarno	2013	Modelling hospital materials management processes	14
S.H.J. Cheng and G.J. Whittemore	2008	An engineering approach to improving hospital supply chains	13
J.C. Kowalski	2009	Needed: a strategic approach to supply chain management	14
J. de Vries	2011	The shaping of inventory systems in health services: A stakeholder analysis	44



J. de Vries and R. Huijsman	2011	Supply chain management in health services: an overview	74
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### *Serious game literature*

For serious gaming, the search results led to thousands of articles. Therefore, the review focused on those with many citations to create an overview of the industry standards on serious game effectiveness. Examples of relevant games were harder to find. Very few of the articles in the literature study concerned discussions of specific games. An extensive forward and backward literature research made sure that we had all important sources in our review. The games that have been developed by commercial companies but have never been tested or discussed in literature are not part of the review.

*Table 10 Results of structured literature research serious gaming*

<b>Authors</b>	<b>Year</b>	<b>Article</b>	<b>Citations</b>
<b>Serious gaming effectiveness</b>			
R. van Eck	2006	Digital Game Based LEARNING It's Not Just the Digital Natives Who are Restless	1024
T.M. Connolly, Elizabeth A. Boyle, E. MacArthur, T. Hailey and J.M. Boyle	2012	A systematic literature review of empirical evidence on computer games and serious games	777
J.S. Breuer and G. Bente	2010	Why so serious? On the relation of serious games and learning	166
E. Boyle, T.M. Connolly and T. Hailey	2011	The role of psychology in understanding the impact of computer games	148
F.L. Greitzer, O.A. Kuchar and K. Huston	2007	Cognitive Science Implications for Enhancing Training Effectiveness in a Serious Gaming Context	182
P. Wouters, C. van Nimwegen, H. van Oostendorp and E.R. van der Spek	2013	A Meta-Analysis of the Cognitive and Motivational Effects of Serious Games	294
<b>Specific serious games</b>			
D. Qualters, J. Isaacs, T. Cullinane, A. McDonalds and J. Laird	2006	Assessment of Shortfall: A Board Game on Environmental Decisionmaking	<i>unknown</i> <sup>4</sup>
D. Battini, M. Faccio, A. Persona and F. Sgarbossa	2010	Logistic Game™: learning by doing and knowledgesharing	20
H. Duin, M. Oliveira and A. Saffarpour	2007	A Simulation Model for Virtual Manufacturing Environments for Serious Games	6

<sup>4</sup> Article has been found by backward citation review, but metrics cannot be obtained

R.C. Basole, D.A. Bodner and W. Rouse	2013	Healthcare management through organizational simulation	9
S. Foster and J. Hopkins	2011	ERP Simulation Game: Establishing Engagement, Collaboration And Learning	8
F. Costantino, G. Di Gravio, A. Shaban and M. Tronci	2012	A simulation based game approach for teaching operations management topics	7
M. O'Connor	2014	Changing Organizational Culture Through Gaming	<i>Unknown<sup>4</sup></i>
S. Meijer, G.J. Hofstede, S.W.F. Omta and G. Beers	2008	The organization of transactions: Research with the Trust and Tracing game	18
S. Meijer, G. Zuniga-Arias and S. Sterrenburg	2005	Experiences with the mango chain game	5

#### 4. Analyze

For both subjects, the presented sample is analyzed to provide the insights that provide an answer to the question that formed the start of the literature review. In the proposed method, first a random paper is read and its relevant findings and insights are highlighted. In this way all the articles are highlighted and the relevant excerpts are collected. These concepts are used with 'open coding' to capture the concepts that they propose. The insights are used to find a set of excerpts that can be incorporated into a set of concepts and insights. The concepts are abstracted in order to identify a set of categories and 'comparative analysis' is used to refine the concepts. All papers are in this way carefully read, linked and analyzed until 'theoretical saturation' has occurred, when no new concepts or relationships arise. This method was followed in order to find the answers to the starting questions in literature.

#### 5. Present

The final results of the literature study are presented. These results can be found in Chapter 2. As can be seen, as the method suggested it was decided to "prefer the creativity of the data over the creativity of the researches who carries out the review" (p.52). A clear way to present the findings was chosen in order to make it for the reader an understandable as possible how the developed insights came to be.

## Appendix II: Success factors for internal supply chain improvement

Section 2.2 provides an overview of the success factors that are the result of a structured literature review concerning the topic of the hospital's internal supply chain. That section discusses only the three most relevant success factors for the research question are presented. This appendix presents each of the success factors and how it is discussed in literature.

### **Success factor 1: Products are delivered as close to the point of care as possible**

Many authors that describe the successful internal supply chain, discuss how there is a system in place in which products are delivered as close as possible to the point where they will actually be applied. This should prevent nurses from being disturbed from their caring process (Landry and Philippe, 2004). Up to 10% of nurse time can be spent on the product flow and by decreasing this, savings can be gained in terms of both time and frustration (McKone-Sweet, Hamilton and Willis 2005).

Another argument for delivering the products as close to the point as care as possible is to prevent inventories on medical departments from piling up. These places of product storage between the central warehouse and the patient beds can in total represent up to ten times the value of the official inventory. This gives improvements in this region of inventory management a major savings potential (Landry and Beaulieu 2013). Good management close to the point-of-care also allows nurses to acquire their goods as efficiently as possible (Iannone, et al. 2013), without having the need to device their own systems.

Landry and Philippe (2004) argue that in order to make these benefits possible, the centralized body should take a more proactive role than it usually has. By giving logistics a credible and significant supporting role in the organization, it can become not only a source of savings in terms of support services, but also renders clinical professionals themselves more productive (Landry and Beaulieu 2013). Kumar et al. (2008) argue that in the ideal situation, a central warehouse is not even required in the hospital at all, as products can be shipped directly from the suppliers to the appropriate hospital units. This so called 'stockless approach' (De Vries 2011) would mean the hospital makes as little costs on inventory and handling as possible.

### **Success factor 2: There is top management support and clear supply chain leadership**

A requisite for a successful supply chain is the support by the hospital top management. De Vries (2011) found that the level of this support was a major contingency factor for the successfulness of inventory management processes. Also McKone-Sweet et al. (2005) discuss that many people who have been involved in supply chain improvement projects indicate that there has to be supply chain leadership at the executive level, as it is otherwise very difficult for any material or logistics manager to actually drive change in the organization. In practice often a middle manager is responsible for logistics whose authority is too limited to adequately do this (Landry and Beaulieu 2013). Kowalski (2009) indicates that also senior financial executives should be involved for a successful supply chain.

De Vries and Huijsman (2011) and McKone-Sweet et al. (2005) mention that the absence of strong leadership can hinder the success of improvement projects. Fredendall et al. (2009) add that a barrier for improvement in this sense can also be that employees lack access to a leader who both has the ability to change the system and with whom they are comfortable sharing their knowledge of problems. By means of creating project leaders, a clear sense of ownership has to be created and all positions have to be involved, instead of only one or two levels of employees (Cheng and Whittemore 2008).

High-skilled managers at the logistical side of the hospital are a must. McKone-Sweet et al. (2005) argue that those involved in the everyday management of the supply chain operations require proficiency in internal processes as well as a broad understanding of best practices, in and out of the healthcare industry.

**Success factor 3: There is an overall set of goals**

There are many different stakeholders involved in the internal supply chain of a hospital. Successful supply chains have succeeded in integrating all their different interests into a proper set of overall goals regarding the inventory systems (De Vries 2011). In a successful organization, this future vision is not encumbered by current limitations, but creative thinking is encouraged in order to overcome possible barriers (Kowalski 2009). The authors of the articles do not discuss how exactly such strategy should be envisioned, but that for a successful hospital supply chain the ones involved should at least have a clear idea how their supply chain should function and that routines should be revisited, as these often form an important reason for change to come to a standstill (Fredendall, et al. 2009). This vision should then be made part of the whole strategy of the organization (Chen and Paulraj 2004). Kowalski (2009) adds that also external suppliers can be involved in creating the most successful strategic plan for the hospital's total supply chain.

**Success factor 4: There is an organizational culture of shared knowledge, best practice and continuous improvement**

Many authors describe how successful internal supply chains have a fitting organizational culture. Fredendall et al. (2009) use as a definition of culture the "values, beliefs, and ways of thinking that organization members viewed as correct" (p.330) and describe that this is especially an element that can encourage or discourage collaboration by the different stakeholders, essential for a well-functioning internal supply chain.

As elements of a successful culture McKone-Sweet et al. (2005) mention the prevalence of shared knowledge and that best practices are institutionalized. Fredendall et al. (2009) argue for 'relational coordination', in which a web of relationships of shared goals, knowledge and mutual respect is created, instead of a focus on routine which can impede change. Chen and Paulraj (2004) generalize that collaborative integration, essential for a successful internal supply chain, requires elements of trust, mutual respect and information sharing, the joint ownership of decision, and collective responsibility for outcomes.

**Success factor 5: A data-driven system is used for measuring and control**

The final characteristic of a successful internal supply chain is that there is an information system that can be used to analyze data and use this as background to make decisions related to the supply chain. De Vries (2011) describes that numerous decisions on the strategic, tactical and operational levels have to be made and a planning and control system and related information system is extremely important for the performance in making such decisions. For the unit managers and planners especially such system should be in place to support their decision making. Such information system should be able to provide accurate, timely and productive processing of information and thereby allow for maximum visibility of meaningful analytic information to everyone who would need it (Kowalski 2009).

The use of an information system to assist in the consistent measurement and management of performance can be expected to lead to higher level of internal supply chain performance, as McKone-Sweet et al. (2005) suggest. They quote a manager who indicates that in the ideal situation, the supply

chain manager does not have to control anything but uses data and education of those involved to let the supply chain function at its best.

**Success factor 6: All stakeholders are involved in improving the entire internal supply chain**

In a well-functioning hospital, improving and sustaining the internal supply chain is not just a project of the hospital's logistics management, but of all stakeholders involved. Kowalski (2009) argues that the participants that should be involved include the supply chain staff as well as representatives from the departments that the supply chain serves, such as nurses and clerks. McKone-Sweet et al. (2005) argue something similar and add that the perspective of all the stakeholders involved should include the entire chain.

Landry and Philippe (2004) stress the importance of especially involving nursing personnel in the supply chain and that the involved stakeholders should be encouraged to not only consider the care-side of the operations, but also look through the 'supply support services lens'. According to McKone-Sweet et al. (2005) a focus should then also be to take away the fear of change and prevent stakeholders from only operating in their own best interest. Chen and Paulraj (2004) add that stakeholders should be encouraged to work across the silos that often characterize organizational structures.

**Success factor 7: All stakeholders have an appropriate level of supply chain knowledge**

Cheng and Whittemore (2008) describe how a lack of knowledge of basic inventory techniques can cause stock out conditions, because employees keep ordering more than needed. McKone-Sweet et al. (2005) conclude that a main "barrier to implementation is the lack of skills and knowledge about supply chain management practices, both at the operational and executive levels" (p.10). From expert interviews they conclude that hospitals that have both general higher levels of supply chain training and for their executives can create higher levels of supply chain performance. Landry and Philippe (2004) also indicate that a good understanding of the processes and activities in place is a requisite to successfully select, adapt and implement leading practices.'

**Success factor 8: Stakeholder relationships are well-aligned**

Many authors describe how stakeholder relations can entail many different problematic aspects in the hospital's internal supply chain. As De Vries (2011) discusses, the problems can already start with unaligned project expectations. McKone-Sweet et al. (2005) add that "misaligned incentives lead to poor work performance" (p.9). De Vries' (2011) research of practice concludes that with so many interests involved, managing the inventory levels in a hospital setting often becomes more politically based than data-driven. Iannone et al. (2013) discuss a similar observation, that these politics form a major obstacle towards improving these inefficient aspects of inventory management. McKone-Sweet et al. (2005) generalize that the corporate and organizational culture in a hospital often impedes rather than facilitates change, which then forms a major barrier for improvement.

## Appendix III: Data gathering for stakeholder perspectives

Table 11 summarizes what efforts were taken to acquire insights from the different stakeholder perspectives in the HOH.

*Table 11 Sources for HOH stakeholder analysis*

Nurses	<ul style="list-style-type: none"> <li>• Two days of participation in day-to-day nursing practice</li> <li>• Multiple interviews with multiple nurses on each of the three operative nursing wards</li> </ul>
Nursing department secretaries	<ul style="list-style-type: none"> <li>• Multiple conversations with the department secretaries on two operative nursing wards</li> </ul>
Care managers	<ul style="list-style-type: none"> <li>• Multiple interviews and conversations with each of the care managers at the operative nursing wards</li> <li>• Additional interview with the care manager of the emergency department</li> </ul>
Clustermanagement	<ul style="list-style-type: none"> <li>• Interview with clustermanager currently responsible of medical side</li> <li>• Involved in setting up research process</li> </ul>
Central warehouse employees	<ul style="list-style-type: none"> <li>• Two days of participation in day-to-day central warehouse employee practice</li> <li>• Many conversations on day-to-day practice</li> </ul>
Team leader central warehouse	<ul style="list-style-type: none"> <li>• Multiple interviews</li> </ul>
Logistic and procurement management	<ul style="list-style-type: none"> <li>• Multiple interviews with both manager and assistant</li> </ul>
Finance	<ul style="list-style-type: none"> <li>• Interview with manager financial department</li> <li>• Interview with manager administration</li> </ul>
Others	<ul style="list-style-type: none"> <li>• An interview with the financial director</li> <li>• Interview with two procurement employees</li> <li>• Interviews with doctor and nursing interns</li> <li>• Continuous conversation and reflection with information manager throughout project (as supervisor)</li> </ul>

## Appendix IV: Complete stakeholder problem description

This appendix provides more information on the role of the different stakeholder in the current internal supply chain situation in the HOH. It also provides more background concerning the expressed reasons the current situation is not ideal.

### **Nurses**

Nurses are the actual users of the products: they use the products to care for the patients and with that form the final link in the internal supply chain. By nature of their work, patients are a nurse's main focus and the products play only a minor part in the process of care providing. At the same time however these products are critical for being able to give the proper care to the patients. This means that for the nurse their primary interest is that the relevant products are available when they need them, are in good shape, and are as close by as possible.

To prevent spending too much time gathering products, some departments have created a system in which each patient room has its own inventory, which is replenished by the day shift nurses. Also some departments use bandage carts which can be packed with products and driven to the entry of the patient rooms, in order to have the products closer by. These carts are also replenished by the nurses themselves. The nurses however also indicate that although their current system allows products to be closer by, they are not entirely happy with it because the rooms and carts are not always properly replenished, due to busy shifts. They also find that they still have to walk quite a lot even if the carts and rooms are properly replenished, to grab additional products or instruments. The nurses are also annoyed that products are not always readily available in the department warehouse. This can be because the secretary has not ordered the products in time or because the central warehouse has not delivered those products (by mistake or because they were not available there either).

*Main expressed reasons why the current situation is not ideal:*

- A department's product flow system does not always function conveniently, especially if unofficial inventories are not replenished correctly by all nurses
- Products are not always available in the department warehouse

### **Nursing department secretaries**

The secretaries are not involved in the caring for the patients themselves but want to make sure the nurses can do their job as good as possible. As they order products, they feel responsible to provide the nurses with enough products at least until the next order period. Their main concern is thus to have enough products in the department warehouse for the nurses to care for their patients. To do this, they are dependent on the delivery of the central warehouse. They indicate that it is difficult to actually rely on the service of the central warehouse because products are often not available there. When this happens, they have to secretary has to keep ordering the products until these can be delivered again.

The secretaries also want to manage the department's warehouse as good as possible, but feel like there are two more obstructions that prevent them from being able to manage it as good as they would want: First, nurses take away many products before use, by storing them in other inventories such as the rooms and boxes. Because the products are then out of the department's warehouse, the secretary will not see those when checking the inventory levels and order too many new ones. Boxes that are left (almost) empty cause the same type of frustrations. A second large annoyance for the

secretaries is that not only does the central warehouse not deliver properly; they also do not retake products when the department has ordered too much or does not need them anymore. This happens for instance with very special products, such as V.A.C.<sup>5</sup>, which keep laying around while the relevant patient is already discharged, or for example when only a few items are needed but the central warehouse only allows the ordering of a complete box of the product. The secretaries also explain that they generally miss information about the status of their orders and see this as demotivating for their performance in the ordering process.

*Main expressed reasons why the current situation is not ideal:*

- The central warehouse does not reliably supply the ordered products
- The central warehouse does not take back products and does not communicate about this
- The nurses spread products over the department, which makes estimating order levels difficult

### **Care managers (zorgmanagers)**

A care manager in the HOH is responsible for the functioning of a specific department. Care managers form the pivot between hospital management on the one side and the operational level of care on the other side. They explain that they are in practice never held responsible financially. However, they understand that because their function is to focus on a good performance of their department, they should also concern themselves with the required products. What the care managers do with this responsibility differs per department, as some are very controlling and have improving efficiency and effectivity of product use as a main point on their agenda, while other care managers indicate that they feel the nurses have the best insight into the actual practice of caring and thus give them more responsibility.

The care managers think that there is much room for improvement on both the operational side and on the central warehouse side. A care manager for instance expresses that she thinks the whole system is currently not functioning. It is hard to stop the nurses from storing products on many places and “the central warehouse itself gives [the department personnel] the chance to hoard products or create an own inventory. Then you find out and they stop, but soon it is there again. It is a continuous battle”. Keeping the nurses from all hoarding their own small inventory is a major challenge, as most care managers indicate. In addition, the care manager indicates that it is simply not possible to review every order of the secretary and that this situation is made more difficult because the secretaries have no financial accountability, sustaining a culture of over-ordering. Furthermore, the care managers indicate that it is quite absurd that the central warehouse only has specific opening times for emergency orders. This means their emergencies orders cannot always be fulfilled, which leads to extra ordering of products in order to prevent such emergencies.

*Main expressed reasons why the current situation is not ideal:*

- The central warehouse does not deliver products reliably
- Nurses hoard products and create systems on basis of own insights, which leads to high inventories, much waste and lack of overview

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<sup>5</sup> A technique in which a vacuum is used to promote the healing of a wound. This procedure is not often performed in the HOH but requires much more extensive material than traditional treatment, as the care managers indicate.



- Secretaries order on basis of their own insight, which is often too much but can hardly be corrected
- The central warehouse is not always available for (emergency) service on the moments needed

### **Clustermanagement**

The clustermanagement acts directly under the board of directors and supervises the care managers. The clustermanagers have a close relationship with the functioning of the hospital as a whole and thus are to some extent interested in the situations and problems of all the other stakeholders. In the internal supply chain they see the current problematic aspects of the inventory management at the departments but also see the larger picture involving the central warehouse, procurement, finance and the care managers.

The clustermanager that was interviewed (responsible for all medical parts of the hospital on that moment) expressed that all these parties have some role in the current inefficiency and ineffectiveness of the current internal supply chain. Aside from confirming the problems expressed by all the other stakeholders, she also indicated that there is relatively little structural and constructive communication between the central warehouse management and the care managers, which makes it harder for both parties to understand each other interests, practice and insights. Also she indicated that the currently used information system is not ideal since it cannot easily provide overview and insight in the situation. In addition the managing personnel at the central warehouse side are over-occupied, leaving relatively little time to reflect upon the internal supply chain. These elements together result in little insight at the management levels of the HOH into the practical use of products by the departments. Furthermore in general the possibilities for product waste and lack of overview, at both the hospital-level and department-level, cause concern for the clustermanagement and stand in the way of creating a more ideal situation.

*Main expressed reasons why the current situation is not ideal:*

- There is little structural communication between the support side of the central warehouse and the care side of the hospital's departments
- There is little insight and overview over the current situation, in part because the current information systems do not easily allow this
- The services of the central warehouse are not trusted by the departments, in part because of the over-occupancy of the logistics managers

### **Central warehouse employees**

The central warehouse employees make sure the products in the internal supply chain actually flow. They pick the orders and deliver them to the department's warehouses. These employees are daily occupied with the actual products and the department orders determine which products they have to pick. Because by delivering the products they can observe the actual inventory levels in the department warehouses, they have developed a feeling for when too much or too few products are ordered. If they think either of these possibilities is the case, they alter the ordered numbers because they feel this is part of executing their job as good as possible. Thus they express that they can sometimes better determine how many products are needed than the secretaries of the departments themselves and this leaves them frustrated and thinking that the secretaries do not count the product levels at all before ordering. Also the places of products in the cabinets can vary per month and between similar departments, causing difficulties when delivering the products.

These frustrations make them less motivated to perform their job and they express that this frustration is increased because they have the feeling that there is not attention to the logistics side of care in general. The irritation further increases as for instance they are often disturbed for emergency orders, the cabinets are continuously overstuffed and for a course that was organized to increase the understanding of logistics in the hospital only two secretaries showed up. Furthermore they miss any feedback from the departments about their deliveries. Stories about 'secret stashes' of products in the departments make their motivation sometimes drops to a very low.

*Main expressed problematic aspects of the current situation for the stakeholder:*

- Secretaries order inappropriate amounts and there is a hoarding culture
- There is a general lack of attention and appreciation for the product logistics in the hospital
- There is no feedback about the orders between the central warehouse and the departments
- Many emergency orders are placed, often for non-critical items
- There is a general lack of appreciation and understanding of the function of the central warehouse

#### **Team leader central warehouse**

While the other stakeholders consist of groups, varying in size, the team leader is one person. He is occupied with responsibility over the day-to-day operations of the central warehouse. A large part of this task is the management of the 'VILA system' and he functions as a pivot between the logistics management and the actual order pickers. The VILA system is used for internal and external orders. The external ordering system gives ordering recommendations, based on inputted minima and maxima per product and the current inventory level. He uses these to order the products, sometimes altering the recommended figures if these seem not appropriate. The internal system is based on the number of products the departments indicate they generally need. The determined minima and maxima are inputted in the system, but currently often not followed when ordering. It is planned to use these as guiding figures in the near future.

The team leader mostly shares the frustrations of the central warehouse employees and sees the hoarding at the departments as a specifically large problem. He indicates that sometimes these departments have even higher inventory levels than the central warehouse itself, because the secretaries overfill the department's warehouse and in addition there are the many products in the carts, patient rooms and other places he has heard about. This makes it hard to know how to appropriately help these departments with their orders, since the central warehouse's function is to support these departments but the situation at these departments seems to make the work of the warehouse extra difficult. Furthermore he experiences many shortcomings in the current VILA-system and is occupied a lot of time by adjusting the numbers.

*Main expressed reasons why the current situation is not ideal:*

- Many departments hoard products and often order too many products
- Department orders are not based on minima and maxima but on rough estimations
- The current VILA system requires much effort to function as desired

### **Logistic and procurement management**

The logistics and procurement side of the HOH are managed by one central manager and an assistant. These two employees are very busy because they are involved in all the strategic decisions for these hospital aspects but also with many tactical and operational tasks such as meeting with the hospital's suppliers. The current planned scanning project and the move to the new building makes their job even busier. This leaves little room to closely manage the internal supply chain. In general they feel that a lot of inefficiency is going on in the departments concerning product use and flow, but they also indicate that from the central warehouse they do not really have insight in what is the exact situation there. The high inventory and fluctuating orders worry them however and they indicate that this also makes efficient procurement very hard. This comes on top of already many challenges with procurement, because of the location of Aruba as an island.

The logistics management is thus very concerned about the internal supply chain, but it is hard for them to get an overview of specific inefficiencies on the receiving end of the internal supply chain. They indicate however that if a department goes out of stock, this can actually often be caused by the department ordering very different amounts than were anticipated on. This might be because they have a unique patient occupancy, but also because they did not order enough before or order more than needed. It is indicated that also sometimes one department may order so many products that there are too few items in stock to still serve the other departments. This is part of the problem and situations such as external orders that take a long time at the customs further complicate the internal supply chain.

*Main expressed reasons why the current situation is not ideal:*

- Departments orders do not fit the actually required amounts and fluctuate a lot over time
- Insight into, overview of and control over the department situations is hard on the management level
- Effective procurement of products in time is hard because of the island location of Aruba and subsequent dependency and lack of flexibility

### **Finance**

The financial department is a stakeholder in the internal supply chain because it is concerned with all expenses and in the end controls all the bills of the products that are used in the HOH. In practice this stakeholder is currently not directly involved in the internal supply chain. They trust on the insight of the procurement and logistics department concerning their financial responsibility and assume that its management has the knowledge and understanding of practice to manage the internal supply chain in a financially responsible way. With the expenses of the departments the financial department has not been involved at all, although long term plans exist to start making the cluster and care managers more responsible for their departmental expenses.

The finance department thus does not take an active role in the internal supply chain, but because they do see the consequences of the product use and the waste and capital expenses the current situation entails. While the financial manager believes that the situation for the HOH is very difficult because acquiring reliable suppliers is hard, he also believes the current situation could be improved. There has been some improvement by being able to pay the suppliers more quickly (within two to four months instead of six months), but he believes the central warehouse still too often runs out of certain products. As stakeholder Finance is however most interested in less waste at the departments and is

therefore also especially worried about the hoarding culture currently existing there. If products are too long on the shelves or are forgotten on a temporary place, they can go overdue and have to be removed. Also sterile products can be damaged by being overstuffed in the cabinets. In addition, high inventories take up much capital costs in the form of the money invested.

*Main expressed reasons why the current situation is not ideal:*

- Departments hoard products, which leads to waste in the form of products going overdue or getting damaged
- High inventories take up capital costs
- The central warehouse runs out of products often, which in part has to do with the late payment of the suppliers

## Appendix V: Stakeholder power-interest analysis

This appendix presents an analysis of the power and interest of the stakeholders involved in the HOH's internal supply chain. These insights are used to create a power-interest stakeholder matrix (Johnson, Scholes and Whittington 1998) in Chapter 3.

### **Nurses**

#### *Power*

One nurse does generally not directly affect the internal supply chain. The nurses together do however function as a powerful unit in the current situation, as they have, at least in some departments, a lot of autonomy to create a product situation that works for them. With this they determine how products are used and how products are stored in the departments. Thus in practice the nurses can exercise a relatively high power in the current situation, as their systems can greatly affect the flow from the central warehouse to the department.

#### *Interest*

The nurses are primarily interested in caring for their patients. The products only play a secondary role in that process and thus their interest is not directly with improving the internal supply chain itself. Initiatives concerning the supply chain are not directly welcomed because these might affect the care they can provide for their patients and they indicate that their current systems work relatively well. In first instance the nurses thus take quite a defense position. This does however not mean nurses would not be willing to improve a situation if they are more engaged and gain an understanding of what their influences are and how these can benefit the situation.

### **Secretaries**

#### *Power*

Within the internal supply chain, secretaries have quite a lot of power because they are the ones ordering the products from the central warehouse, in which they have a lot of autonomy. This means that the demand which the central warehouse has to fulfill is effectively completely defined by what the secretaries order.

#### *Interest*

The secretaries see the management of their department's warehouse as their responsibility and most secretaries have done so for many years. This makes them not very interested in changes in their own ways of working because these are based on knowledge accumulated over those many years. They then also express that the situation concerning delivery from the central warehouse has to be improved first, before the departments would be able to change their product management.

### **Care managers (zorgmanagers)**

#### *Power*

The care managers have a lot of potential power over their department and this power is exercised to different extents by different managers. As the care managers express they can simply not keep directly controlling all personnel and also check every order, this means they have to give their personnel some distance, some autonomy, while they try to manage them as good as possible from that distance.

### *Interest*

The interest of the care managers in improvement of the internal supply chain is high. As a care manager expresses that she has “tried all kinds of methods to make [product use] less” and that the current state of their department warehouse forms a large frustration.

### **Clustermanagement**

#### *Power*

It is hard to completely pinpoint the power relations in the hospital and to estimate the ‘power’ of the clustermanagement. While the care managers are mostly responsible with the daily operations of their department, the clustermanagement seems more involved in the tactical side and the more structural problems. At least their potential power is large in the sense that they have the ability to involve all the other stakeholders and can create a more overarching perspective of all these sides because of the nature of their role.

### *Interest*

Because the current internal supply chain creates problems and frustrations for all the other stakeholders, the clustermanagement is very interested in improving this situation and creating better situations for everyone.

### **Central warehouse employees**

#### *Power*

The warehouse employees are needed to keep the internal supply chain running at all. Also by adjusting the order numbers they affect the situation. However, further than that they seem to have relatively little power and also express the feeling that their input is never really valued.

### *Interest*

The level of interest in the internal supply chain broader than the main tasks for a central warehouse employee differs per employee. They are generally completely focused on their job and react to initiatives in quite a neutral way.

### **Team leader central warehouse**

#### *Power*

The team leader is mostly occupied by solving day-to-day tasks that come up from the central warehouse and the departments. The central warehouse employees are quite autonomous in their specific job and the team leader does not exercise a lot of power over them. In relation to the information system and actually keeping the ordering process going, he does occupy an important link. His power is limited by the guiding role of the logistics managers, but he can still affect the supply chain quite strongly by his day-to-day activities and decisions.

### *Interest*

The team leader does not always see much room for improvement, also because he is mostly busy with managing small tasks while most tactical and strategic decisions are done by the logistics management. By this, he is not very interested in initiatives, but also does not oppose them.

### **Logistic and procurement management**

#### *Power*

The management has a lot of power on the long term operations of the central warehouse side of the internal supply chain. As they say they do not really have close link with the departments and thus do not directly form a power relation with the employees there.

### Interest

Because the management is very busy, they do not have a lot of time to reflect upon the internal supply chain and its policies. They are very interested in initiatives for this supply chain however because they believe there is possible improvement for everyone involved. They also indicate that efficiency itself should not be the only focus, because also other elements such as sources of frustration should be managed in the situation.

### Finance

#### Power

By nature the Finance department seems to have a lot of potential power because they can determine budgets and hold the other stakeholders responsible for their decisions. In practice this power is very seldom exercised and a confidence in the autonomy and responsibility of the stakeholders is expressed.

### Interest

Finance is interested in improving the current supply chain, although this is current not a priority for them. Concerning this improvement they also express that financial efficiency should not always be the main interest in the hospital and that for instance frustration and lack of overview can also be important aims in the improvement of the current supply chain.

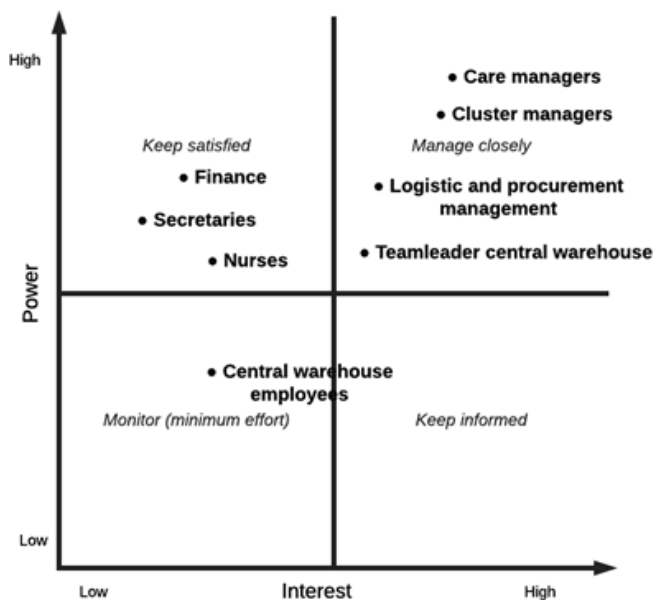


Figure 8 Stakeholders placed in interest-power matrix after analysis

## Appendix VI: Data analysis of HOH's current situation

This appendix presents the data-analysis of the internal supply chain situation in the HOH of Section 3.3 in more detail. As discussed there, this analysis is based on all the orders made by the departments stored in the VILA system and on hand-counting at the nursing departments.

### *The magnitude of the hospital's product flow*

Over 2014 and 2015, the average yearly product flow between the central warehouse and the departments consists of 16,181,494 florin, or 8,090,747 euro. These costs are divided over 81 different 'cost centers', see Table 12.

*Table 12 Overview of costs per cost category*

Category	Cost centers	Florin per year	Euro per year
Other medical departments	Blood bank; GP office; Dialysis; Anesthesia; Neuro Physiology Revalidation; Physiotherapy; Endoscopy; Ergotherapy; Heart function; Logopedics; Dietetics; Food assistance	1,876,131	938,065
Outpatient clinics	Policlinics; Poli Child; Poli Urology; Poli Revalidation; Poli Lung; Poli Gynecology; Poli Neurosurgery; Poli Internal Medicine; Poli Neurology; Poli Psychiatry; Poli MDL; Poli Wound; Poli Mother	484,024	242,012
Laboratory	Laboratory	4,302	2,151
Support	Human resources; ARBO; Procurement and logistics; Pharmacy; Reception; Maintenance and technology; Learning institutes	1,011,580	505,790
Management	All clustermanagement; Project support; Automation; Medical administration; Staff bureau	86,636	43,318
Birth, child and mother	Maternity ward; Child department; Obstetrics	355,000	177,500
Clinical ward operative	Operative II; Operative III; Operative IV	900,071	450,035
Clinical ward non-operative	Non-Operative II; Non-Operative III; Non-Operative IV	664,996	332,498



Psychiatry	PAAZ	118,092	59,046
Others	Patient Relations; Ambulatory Care	32,964	16,577
Oncology	Oncology	83,933	41,967
Diagnostics	Diagnostics	233,813	116,906
Emergency	Emergency department	406,471	203,236
Operating room	Operating Room	8,887,902	4,443,951
Intensive care	Intensive care	444,892	222,446
Kitchen	Central Kitchen; Cafeteria; Washing kitchen	590,614	295,307

As is the case in most hospitals, most costs are made in the OR. Because of the unique nature of the OR department, it was however decided together with the management that for this thesis research the focus should not be on the OR, but on the nurse wards, with a focus on the surgical clinical wards. This focus is also motivated by these departments being especially under much critique by the logistics management.

The surgical nursing wards were further examined. On average, these use more than 160,000 euro on products. The majority of the costs are made on articles of which at least 500 pieces are used per year. Products that take up a significant amount of money but are not ordered that many times per year, are mostly expensive VAC products, which only a few patients per year require, or larger products such as printers.

In the following sections, the stakeholder statements that have a quantitative aspect are briefly analyzed by means of the available data, in order to create a further understanding of the HOH's current situation.

***Stakeholder Statement: Departments hoard products, which leads to waste in the form of products going overdue or getting damaged***

In the HOH, products are not tracked after they have been transported to the department warehouses. This means no estimation can be made of how many products go overdue or become damaged and have to be thrown away. Inquiry at different people possibly involved in disposing these products also did not result in reliable estimations.

Concerning hoarding in general, some insight can however be provided. The 'hidden stashes' of which the managers speak cannot with certainty be checked, but the department warehouse and bandage carts are mentioned as places where often many extra products are placed. In order to get an indication of how many products are stored in those places, the inventory levels were hand-counted at Snijndend Unit II. The results can be found in Table 13 and will be shortly considered below.

Table 13 Level of inventory at different places at Snijdend Unit II

	Department Warehouse	Mobile boxes	Patient rooms
Average total number of products	1,330	150	260
Average total capital stored (in euros)	5,000	500	500
Average number of weeks of inventory	7	20	1.5

At Snijdend Unit II, there were 1330 products in the department warehouse, with varying package sizes, from piece size to boxes of 50 (for instance needles). The total amount of money stored in this way in the department warehouse is more than 5,000 euros. For all products, the amount that is stored is more than what is used per week, with about a 7-week storage being the median.

At the patient room cabinets, also products are stored. The department personnel have printed labels in the room closets that depict how many products should be present. The amount presented on these labels total to 240 items to be placed in total distributed over the patient rooms for the 33 patients. This would amount to a total of 395 euro available in the rooms. In reality, even more items were stored, adding to 260 items in total, for a total worth of almost 500 euro. The product levels stored in the rooms are on average enough for about one and a half week of use of those products.

The bandage carts are also mentioned by the managers as a place of hoarding. During the counting sessions, there were on average 78 items in each of the two carts at the department. The total value of these items was almost 500 euro. If we compare the amount of these items to the weekly use of those items, it can be indicated that on average there is enough in the carts for about 2 weeks of nurse service, although there are exceptions with products being just enough for 1 day and product amounts that are stored that normally require more than 20 weeks to run out.

To summarize, we have seen that more products are stored in the department warehouse, the patient rooms and the bandage carts than are needed. If we overview the total number of products stored as such in a department, we can see that there are often many more than even used per month, while the ordering period is one or two times per week. This can indeed indicate a hoarding culture in which products are stored in order to be sure to not run out of them.

Stakeholder Statement: The central warehouse runs out of products often

Stakeholders at the care departments indicate that products are too often not available at the central warehouse. By means of the available data, we can investigate how often a product was ordered by a department but could not be delivered by the central warehouse. After cleaning the data as good as possible, some insight can be created. The focus again is on the surgical nursing wards.

It appears that in total 245 times a product could not be delivered to one of the surgical nursing wards over the last two years. This means that per order on average at least around 1 product is not delivered as ordered, which is about 6% of all deliveries. This indicates that indeed the central inventory can often not fulfill a department order. A closer look at the specific items that were ordered provides more context:

In Figure 9, the times a product could not be delivered is plotted against the average number of products that are ordered for that type or product per year. It appears that many products that could not be reliably delivered were actually only used a few times per year. This could represent an outdated item that was ordered. It can be seen that in general the more often a product is used, the more often they are reliably delivered. Interesting is that two spikes in the scatter plot, at the 330 and 660 mark, represent the 'slangklem' (catheter clamp) and 'medicine cups'. Fittingly, these products were the ones that were mentioned most often by the interviewed stakeholders as to raise frustrations because they ran out and would not be available in the central warehouse reliably.

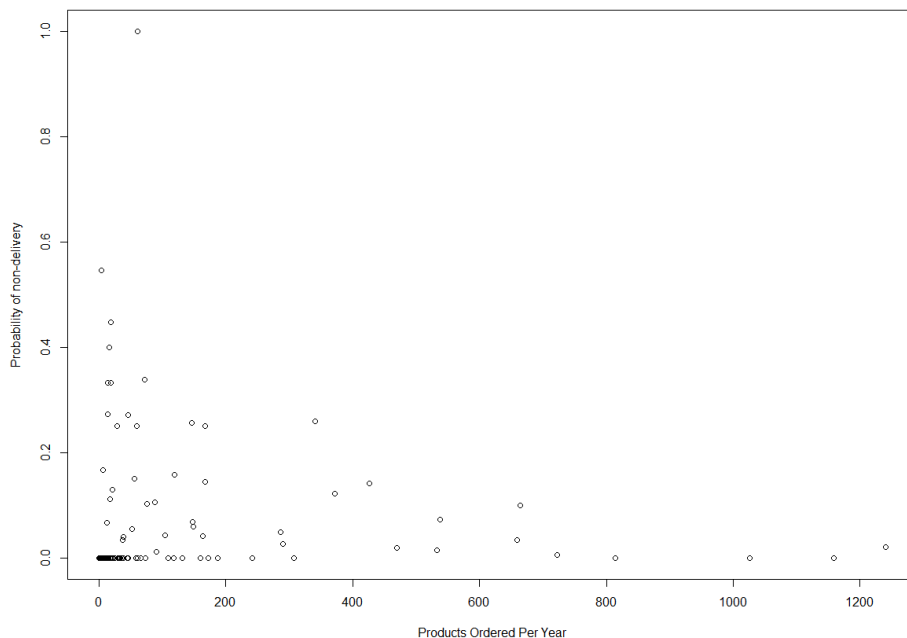


Figure 9 Orders per year compared to probability of non-delivery by central warehouse

The data shows that indeed a product could quite often not be delivered, but that the general experience by the departments is also heavily affected by a few badly delivered products.

**Stakeholder Statement:** *Departments orders do not fit the actually required amounts and fluctuate a lot over time*

Many employees in the central warehouse argue that their work is made unnecessarily difficult because of the fluctuating orders of the departments, which often do not directly correspond completely to their need. In order to create an actual image to which extent the ordered quantities fit the required amounts, much more data would be needed concerning the daily operations on the wards. The high inventory levels discussed earlier give however at least some indication that department orders are indeed not optimal in terms of efficiency. Concerning the mentioned fluctuations which complicate the role of the central warehouse, some insight can be provided by considering the order amounts:

The amounts that are ordered by departments per order period and per product can be analyzed. Figure 10 presents the total number of products per order over time for Snijndend Unit II. As can be seen, the order amounts greatly vary.

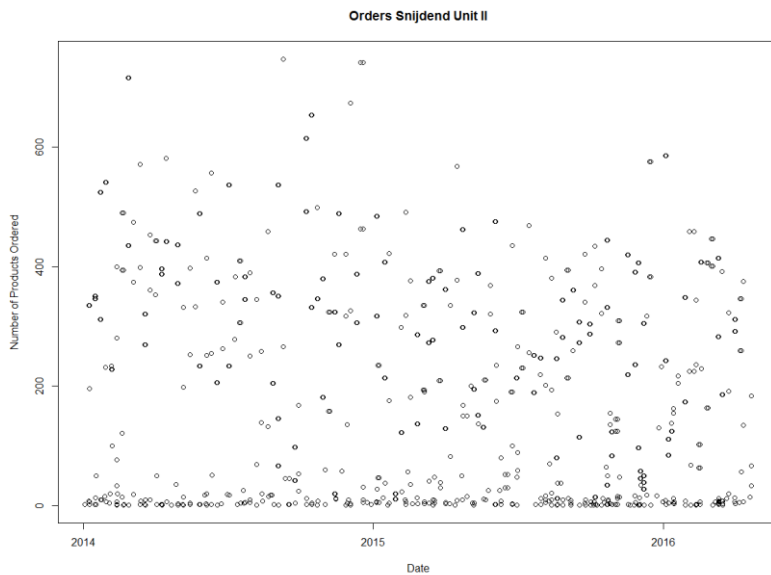


Figure 10 Variation of total product quantities per order by Snijdend Unit II

The total amount of products ordered thus indeed fluctuates for Snijdend Unit II. We can also consider to total orders per item for the hospital per order period. Figure 11 shows the number of products ordered for the five most ordered products by the nursing departments. Each of the colors in this figure presents a different product.

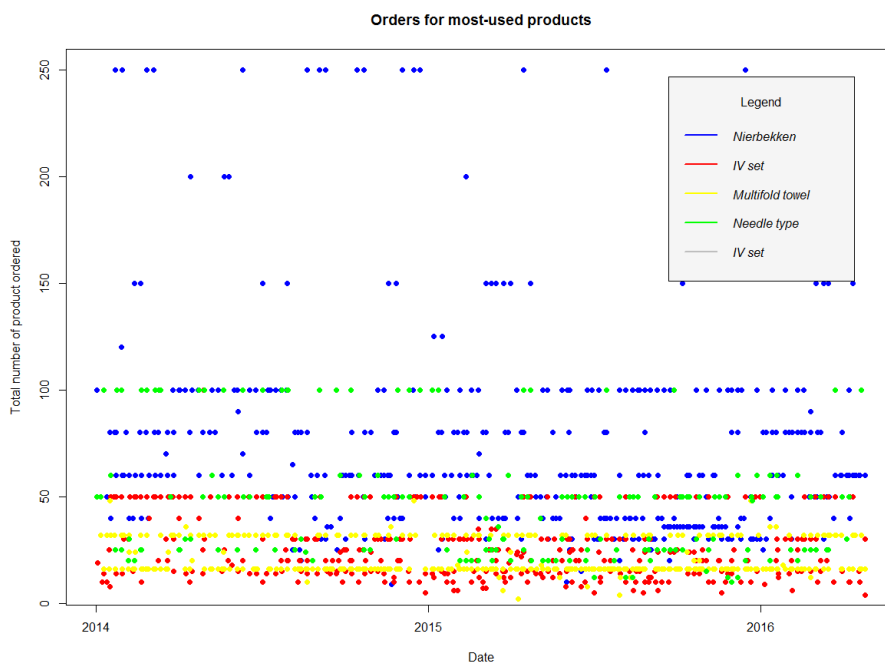


Figure 11 Variation in order quantities for most ordered products

With the data available it can thus be shown that the orders indeed fluctuate, but not the extent to which these orders correspond to the actual department needs.

**Stakeholder Statement:** *Department orders are not based on minima and maxima but on rough estimations*

In the data, the inventory levels at the moments of ordering are not available. Because the optimal order figures are dependent on both the set minimum and maximum and the number of products present at the moment of ordering, it is not possible to directly investigate whether these minima and maxima are used.

Comparing the order amounts to the minima and maxima in the system does provide us with some insight. Figure 12 shows the products that were order on average more than 10 times per week. It compares the average order to the minima and maxima for that item.

This figure shows that around half of the orders is between the minimum and maximum order levels. All other average orders are above the maximum level. In a min-max system, an order should maximally be the maximum level subtracted with the minimum level, so an order above the maximum level should only be needed in very rare circumstances.

Considering this, it appears indeed the ordered amounts are much higher than the set levels and that thus indeed the minima and maxima set in the system are not adequately followed when ordering. This is especially remarkable as the minima and maxima that were researched were also very recently updated; secretaries filled in a list with what they estimate are appropriate levels and these are set in the system by the central warehouse team leader.

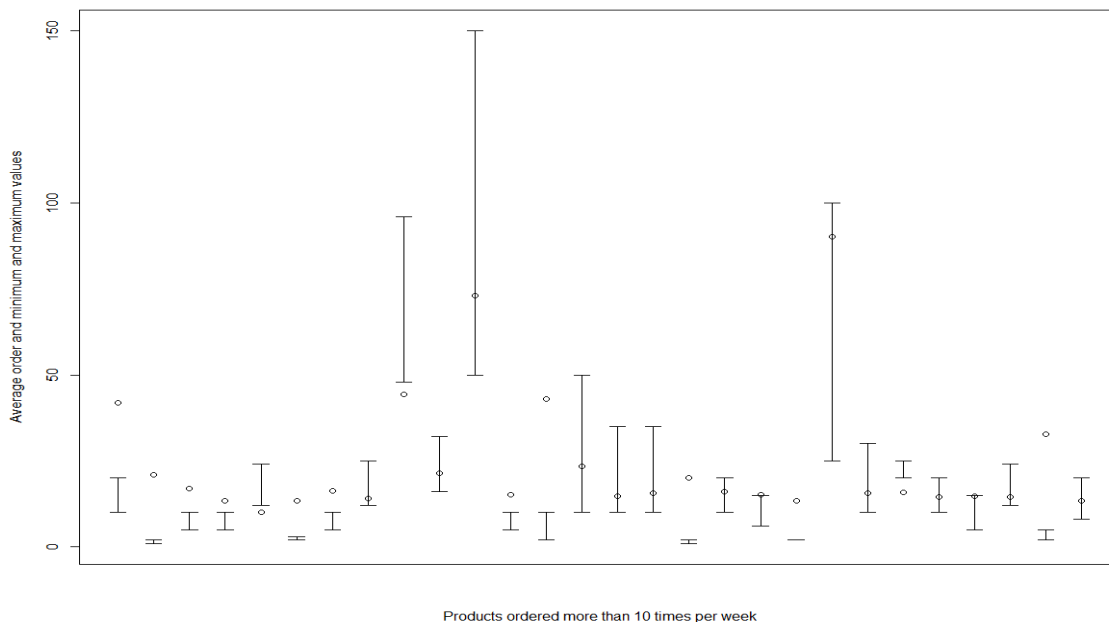


Figure 12 Average order quantity compared to set order standards

**Stakeholder Statement:** *Many emergency orders are placed, often for non-critical items*

Emergency orders are not always monitored in the central warehouse. However, by keeping track of the paper emergency order lists during a span of seven weeks, some insight can be created. During these seven weeks on average 4.8 emergency orders per day were placed. Monday and Wednesday

were the busiest, with on average almost 6 emergency orders per day, while Tuesday and Friday were the least busy.

Concerning the kind of products that are ordered with emergency unfortunately no data is available. From the tracked lists, it appears that around 10% of the emergency orders are placed by the kitchen or the food department, which according to the central warehouse employees often concern non-critical items such as specific desert types. The content of the other emergency orders is not known.

## Appendix VII: Practical guidelines for internal supply chain improvement

In order to get insight into what answers are in practice to the question *how* the hospital's internal supply chain can be improved, three logistics managers in the Netherlands were interviewed who had improved their hospital's internal supply chain in the recent decade, from Amsterdam (AMC<sup>6</sup>), Nijmegen (SMK<sup>7</sup>) and Enschede (MST<sup>8</sup>). In Section 4.1, the three most relevant guidelines for the main research question were shortly discussed. Here each of the practical guidelines expressed by the experienced managers is further discussed.

### **Practical guideline 1: Relieve care professionals from logistical tasks**

Each of the three hospitals uses a system where the central warehouse has the responsibility over all the inventory levels in department warehouses. This allows optimization in terms of the ordering and takes away logistical tasks from the nurses, so they can focus on their function as care giver. Central warehouse employees, who do not have such an education and receive a lower income, can then perform the logistical tasks. In this way every employee performs the tasks corresponding to his or her function, position and education and by focusing on this, savings can be gained in terms of time, products and frustration. The logistical manager of the AMC indicates that "the ultimate goal in an improvement project at a department is that the icon for ordering products can be removed from the [department's computer] desktop". How this was done varied per hospital, but the crucial element was generally in the design of the logistical systems. For the AMC this for instance consists of a customized system per department, while the MST has designed a hospital-wide two-bin system that should be able to disburden all care professionals because it requires almost no interaction anymore.

### **Practical guideline 2: Take away any reason for doubt in the reliability of the central warehouse**

In order to relieve the nursing personnel from all logistical tasks, the central warehouse requires their trust. The same trust is also needed to work towards a solution for the tendency of nurses to hoard products for themselves, which was a problem in each of the hospitals. The central warehouse has to show that it is always able to provide the required products in time. The manager of the AMC indicates that in order to do get such trust, it has to take away the source of any distrust completely, prove itself time and time again and not give departments and nurses any reason to store products outside the system.

As all three hospitals work with a system where the central warehouse has the complete responsibility that all products are available at the right places, all three have had to put work in establishing such a trustworthy status. This requires a good central warehouse set-up, a competent logistics team and good and smart relationships with the external suppliers. The logistical manager of the AMC indicates that the trustworthiness of the central warehouse has played a central role in improving the hospital and that this means the departments should be able to completely rely on this. Even a ten-minute late delivery should be seen as a failure of the logistics department. In order to become reliable, department orders might have to be smoothed and adjusted to each other. However, only after establishing the role of trustworthy supporter, other interventions such as lowering inventory levels can appropriately be introduced.

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<sup>6</sup> Academic Medical Center, an academic hospital with around a thousand beds

<sup>7</sup> Sint Maartenskliniek, a hospital specialized in orthopedics, rheumatology and revalidation with around 300 beds

<sup>8</sup> Medical Spectrum Twente, a top-clinical hospital with around a thousand beds

**Practical guideline 3: Think in terms of the whole process**

The internal supply chain consists of many different processes and stakeholders. In order to improve the chain, a holistic perspective should be taken to find solutions that concern all of these elements. In the SMK the routes of the employees were for instances revisited to establish round-trips that incorporate different tasks at different departments in an efficient sequence, instead of returning to their station after each task, which led to much time being saved. The manager of the AMC also indicates that changes at one link in the chain may have advantages for someone in a completely different position. A hurdle in revising the whole chain might be the financial consequences. The central warehouse might for instance have to hire one employee, while a department has to do 0.4 FTE less work. The overarching hospital system has to be able to handle such changes and the hospital structure should allow the employees to not only think in terms of their own elements and processes.

**Practical guideline 4: Use common sense and rule of thumb**

In logistics, many complicated algorithms and systems exist. The managers indicate that although these can be occasionally beneficial to use 'behind the screens', the internal supply chain should rely on aspects that can directly be understood with common sense and can rely on rules of thumb. At the AMC they for instance have one or two weeks of supply of products in the central warehouse, and they have experienced that it is important to use such relatively simple metrics instead of a figure per product that is the mathematical optimum but much hard to explain or remember. The manager of the SMK indicates that in her experience using common sense is much more important for finding ways to improve than any other knowledge. Rules such as using middle shelves for most used products, removing storage space to lower inventory levels and putting all product labels with their expiry date to the front have had the most impact in improving the system. The MST has also experienced this and one of the main reasons for their current two-bin system is that it can quickly be explained and understood and allows for little room for misunderstanding and error.

**Practical guideline 5: Involve all relevant stakeholders and focus on demonstration**

While the manager-functions in the central warehouse and hospital departments form a link in internal supply chain projects, it is important to involve the other personnel as well. As the manager of the SMK explains, all levels of employees have a role to play and should understand their role and the system in order for it to function. She also indicates that the major hurdle in improving the internal supply chain was the culture of the hospital in which employees do often not communicate about their ways of working or do not completely understand how the system could be improved. This hurdle can only be overcome by involving them and to do this, ways should be found to demonstrate the advantages. All three hospitals have for instance used price lists to show to the nursing personnel the order of magnitude of money that flows through their department every day. Both the managers of the MST and AMC indicated that it works much better if departments can be encouraged to understand the benefits of changing their ways of working instead of to pressure them into change.

**Practical guideline 6: Collaborate with external suppliers to improve own internal supply chain**

The managers indicate that while the focus of the internal supply chain is placed inside the hospital, also the external suppliers can play a role in improvement projects. In the AMC, the contracts with external suppliers formed a key to be able to make their own central warehouse completely reliable. The SMK collaborates with their supplier of linen to give each other feedback and help each other in improving the services. In these ways, the external suppliers can be the first link in an efficient internal supply chain.



## Appendix VIII: Preliminary Harris Profiles for serious game development

This appendix shows the Harris Profiles (see (Boeijen, et al. 2013) and (Roozenburg and Eekels 1998)) that were development as part of one of the first step in the development of the serious game. These are used to decide what technology would best suit the requirements for the serious game.

Table 14 Harris Profiles for serious game options

Video game		-	-	+	++	Commentaar
<i>Interaction</i>	Discussion between department employees					Only evaluation before/after
	Interaction between different kinds of employees					
<i>Insight</i>	Current ways of working					Current problems in behavior could be simulated
	Possibilities for improvement					Difference between optimal situation and choices of players could be shown
	Financial consequences					
	Non-financial consequences					It seems hard to show these problems in a natural and non-patronizing way
<i>Game elements</i>	Valuable output					
	Show the made choices in the game					
	As easy as possible to pick-up					
	Stays interesting and challenging					Because the development will require a lot of time it will be difficult to also make something that stays interesting and challenging
	Stays fun					
<i>Development</i>	Quickness of first prototype					Development is relatively complex and requires a lot of time before anything could function
	Iterative process					Every iteration takes relatively long
	After leave of Aruba still playable by the hospital employees					With good instructions, it should be possible to use the game on their own relatively conveniently
	Can be used as stand-alone simulation					A digital game could relatively easily be used as stand-alone simulation because of the simulated elements it will contain
	Possibilities for expansion					Later development by others will be complex because of the requirements for specific programs and (programming) skills
	Flexibility for new situations					A programmed situation is relatively unflexible, especially if a situation is encountered that was not accounted for before

<b>Hybrid</b>		-	-	+	++	<b>Commentaar</b>
<i>Interaction</i>	Discussion between department employees			■		A screen/game itself might draw a little more attention than the other players
	Interaction between different kinds of employees			■		
<i>Insight</i>	Current ways of working				■	
	Possibilities for improvement			■		A computer can make a suggestion, although an optimal situation is harder to simulate with a board game part
	Financial consequences			■		The computer could do this, just probably not as precise as a video game can
	Non-financial consequences			■		By physical interaction and discussion
<i>Game elements</i>	Valuable output			■		
	Show the made choices in the game			■		Procurement etc. could be monitored digitally
	As easy as possible to pick-up		■			
	Stays interesting and challenging				■	Dynamics could stay interesting and challenging because of the different possibilities
	Stays fun				■	
<i>Development</i>	Quickness of first prototype		■			A hybrid seems relatively complex to work out and parts also will have to be programmed
	Iterative process			■		Game elements could be relatively easily adjusted
	After leave of Aruba still playable by the hospital employees		■			A hybrid could be discouraging if it seems too complex
	Can be used as stand-alone simulation			■		The computer part could most probably be relatively easily transitioned to a simulation part, although this might not be very flexible
	Possibilities for expansion			■		The board game part could relatively easily be expanded
	Flexibility for new situations			■		

<b>Board game</b>		-	-	+	++	Commentaar
<i>Interaction</i>	Discussion between department employees				■	
	Interaction between different kinds of employees				■	
<i>Insight</i>	Current ways of working				■	
	Possibilities for improvement			■		Should enter by means of own insight in the game or for instance changing game rules
	Financial consequences	■				Too complex to let the players determine for themselves in the game
	Non-financial consequences			■		Frustration and impact on each other and the hospital situation could directly become clear, although there are limitations
<i>Game elements</i>	Valuable output		■			It is hard to integrate a realistic score
	Show the made choices in the game		■			Everything should be monitored by hand or by the game mechanics themselves
	As easy as possible to pick-up			■		
	Stays interesting and challenging				■	A board game can by means of changing dynamics and rules keep being challenging
	Stays fun			■		
<i>Development</i>	Quickness of first prototype				■	The first steps could already be made/discussed
	Iterative process				■	New development steps could be made fast, even on the spot
	After leave of Aruba still playable by the hospital employees		■			A manual should be very clear and even then picking it up could take relatively much time because players have to be together to play it
	Can be used as stand-alone simulation	■				Could not be used as a simulation
	Possibilities for expansion				■	New dynamics could be brought in a board game relatively conveniently
	Flexibility for new situations				■	

## Appendix IX: Serious game testing logbook

Table 15 Overview of testing and evaluation activities

Date	Kind of session	Participants (roles)	Most important insights
May 12	First test of idea to simulate nursing and secretary roles	-	That the game might quickly become complicated when the simulation of the roles have too much detail
May 20	First test of idea to incorporate central warehouse and department warehouse	Student	Nursing seems to work well with new developments during iteration, other positions might be interesting.
May 26	Game test	Student	Simulation of the roles of nursing and department warehouse seems fruitful, but it is far from a real 'game' yet.
May 27	Evaluate current serious game set-up	Doctor's intern	Set-up is interesting, specific recommendations for product and patient types.
May 30	Evaluate current serious game set-up	University professor	Much potential in current design, incorporating unexpected event could make it more enticing. Also simulating the game virtually would indeed be a very interesting step.
May 31	Evaluate current serious game set-up	Information manager	Interesting idea with a lot of potential for HOH's situation, it would be could to involve care managers in testing process.
June 2	Evaluate current serious game set-up	Serious game expert	Very interesting with much potential, in-game goals and roles should be further developed.
June 8	Evaluate idea of serious game	Nurse	Suggestions for making the game especially suited for nurses to play.
June 8	Game test	3 Research interns	The game is interesting and fun to play. The roles of department management and central warehouse should be further developed to also make those interesting for the players.
June 9	Present game set-up	3 Care managers Clustermanager Information manager	The game is based on a very good idea and has much potential. Testing sessions should be organized in the hospital.
June 15	Evaluate game set-up	Nurse	Very interesting idea, suggestions for product details that would fit the nursing role.
June 18	Game test	Student	Extensive game sessions: many aspects work very well, but some have to be perfected by keeping playing and iterating upon the game's design.

June 20	Present game set-up	Logistics manager Assistant logistics manager	The idea of the game is very interesting, also for the central warehouse employees to play and learn about the whole internal supply chain.
June 21	Game test	3 Medical students	The game is challenging, interesting and fun. The nursing role takes too much time compared to the other roles and is sometimes too difficult. In addition, the students give some suggestions concerning specific details.
June 23	Game test	2 Care managers Elder nurse Logistics manager Assistant logistics manager Information manager	The game proves it very well. It might be smart to translate it to English and there are a few suggestions concerning specifics.
July 1	Final version game test with post-play questionnaire	5 nurses Department secretary	Very positive first final version play session. The instructions in the beginning could have been more extensive and structured. Also it is clear that game sessions with nursing personnel lead to very different kinds of discussions and play styles than managing personnels. This shows the versatility of the game, but an eye should be kept on making it a good experience for both these parties if they play it.
July 5	Meeting on the games aesthetic design	Graphic designer HOH	Determine what is and what is not possible concerning printing a final version of the game for the HOH on Aruba
July 6	Meeting on final version of the game and the initiatives to use this game for the HOH after the thesis has been finished	Meeting 1: 2 Care managers Information manager Clustermanager Meeting 2: Financial director Information manager	The game's preliminary results are very good, there is a lot of enthusiasm in the hospital and a plan should be established to keep using it to reap the benefits it has to offer.
July 7	Final version game test with post-play questionnaire	5 Nurses A medical student	Another very positive session. The instruction was better than the other play session by performing the actions for the first two in-game days with the group as a whole.
July 8	Final version game test with post-play questionnaire	3 Nurses 3 Medical students	Very positive. The language barrier however is big when players have large differences in their levels of education. Event cards might make it more challenging for some players.

## Appendix X: Development of serious game mechanics

This appendix presents the development process of the serious game Care 4 Supply in more detail. To present the design decisions in a structured fashion, Schell's classification of game mechanics into seven elements is used: 'space', 'time', 'objects, attributes, and states', 'actions', 'rules', 'skill' and 'chance'. These elements together "are the core of what a game truly is" (Schell 2015, 158). For each element we discuss which relevant insights theory, practice and playtesting provided and to which conclusions this led. Figure 13 presents an overview of the set-up and Figure 14 an 'action card' to show the design decisions in the context of the game. The design decisions are evaluated in Chapter 4.

### **Mechanic 1: Space**

In the real hospital, each of the stakeholders can freely move around to perform his or her actions. In the earliest versions of the game, this was translated to a mechanic in which each player had a pawn to move over a simulated hospital simulation. From testing this, it appeared that not the specific movement in the internal supply chain is relevant for the objectives we have for the game, but which *decisions* form the reason for that movement. These decisions for instance concern how products are stored and moved between the patient room and the department warehouse and how many products are ordered by the department management and the central warehouse management, denoted by 1 in Figure 13.

*Design decision: The players' degrees of freedom in the game are focused on the decisions that have to be made in the real internal supply chain*

The analysis of the HOH's practice shows (as can also be seen in the problem tree) that the nurses' actions influence the actions (and performance of) the secretary, care manager, central warehouse employees and central warehouse management and these stakeholders also mostly affect the role of the nurses. Playtesting sessions indicated that the game became too complex if all these roles were integrated. In discussions, it appeared that these roles could best be summarized as the *department management* – concerned with the actions of the secretary and care manager in the real situation – and the *central warehouse management* – concerned with the actions of the central warehouse employees and management in the real situation. These roles can be found at 2 in Figure 13.

*Design decision: The game has three roles: the nurses, the department management and the central warehouse management*

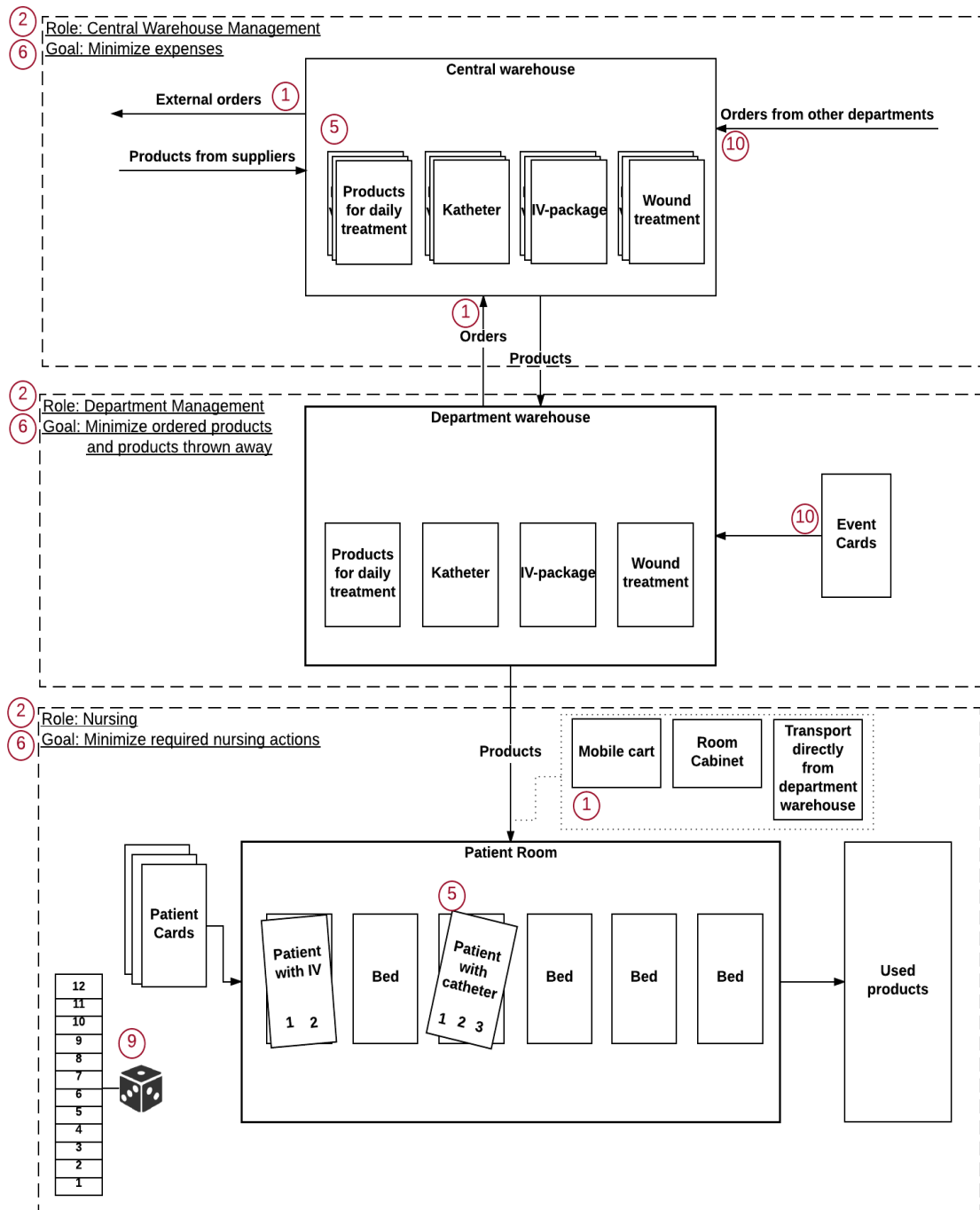


Figure 13 Overview of serious game with numbers depicting the design decisions

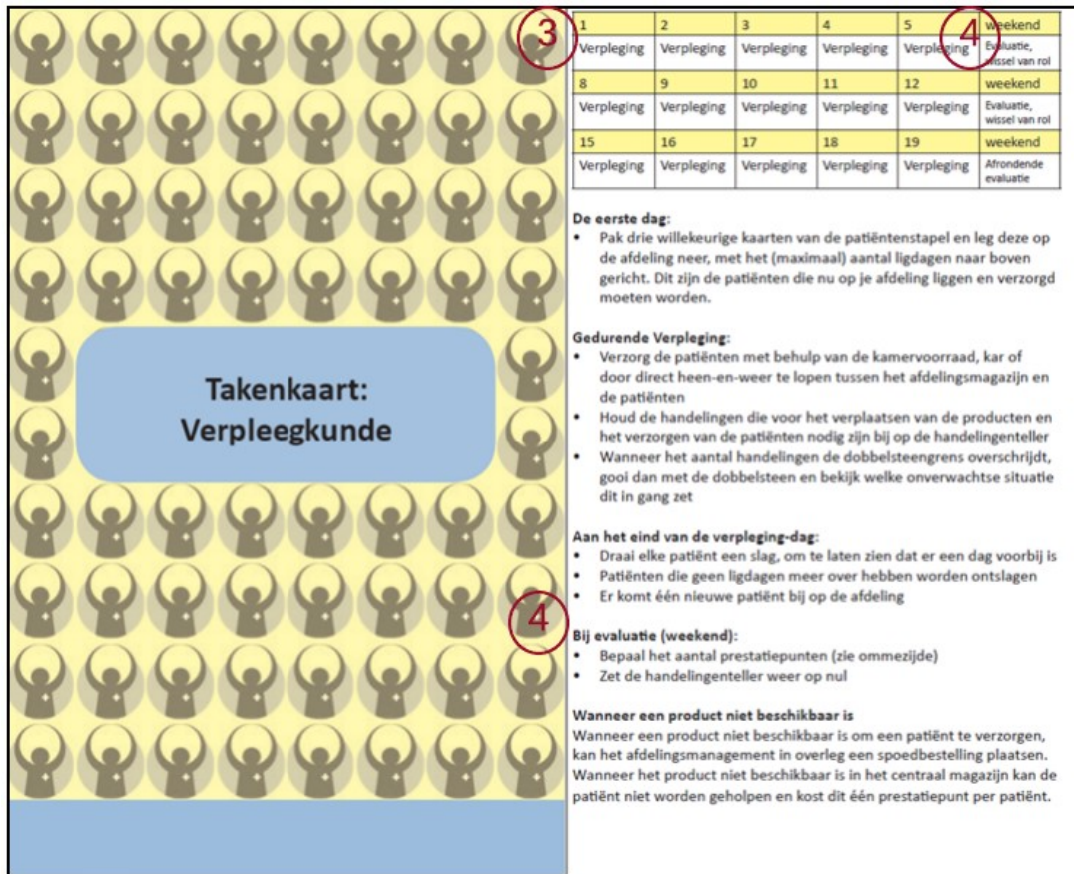


Figure 14 'Action Card' for nursing role (Dutch HOH version)

## Mechanic 2: Time

In many games (for instance Monopoly), all players have sequential turns in which they can make a decision. However, in the reality of the hospital, decisions are made on the same time by the different stakeholders. Thus, it was decided to test whether this could also be mimicked in the game. This was done by providing the players with a shared calendar that shows the day of the week, but with their own list of (possible) actions for that day, see 3 in Figure 14. While this made it possible to simultaneously make actions, in practice the players still sequentially made their actions. An important mechanic to solve this issue proved to be to give the players only four minutes per day to perform their actions. While four minutes is generally more than enough, this constraint led them to performing these actions simultaneously, thus mimicking the real every-day complexity.

*Design decision: All players have to act and make decisions simultaneously, within in-game days that take four minutes*

An important goal of the game is to allow the players to see how their actions influence the other players. Because the players are acting simultaneously, this might not always leave enough room for reflection on these influences, which is also a problem in the real situation. Because reflection should be a central point of promotion in the game, a 'weekend', see 4 in Figure 14, was added to the calendar which is used for collective evaluation.

*Design decision: After five days of action and decision making, the in-game weekends provide a moment for reflection concerning performance*



### **Mechanic 3: Objects, attributes and states**

Hundreds of different products ‘flow’ through the HOH every day. It is clear that these cannot all be ‘simulated’ in the game. Therefore, two meetings with nurses were held to determine which products could best be used in the game. Together with these nurses it was decided that the products could best be categorized as those concerning daily care (such as washing and shaving), wound care, catheters and incontinence, see 5 in Figure 13. The prices of these products for the central warehouse to order were based on the real expenses on these categories of products that are made by a department per week.

*Design decision: The game contains four types of products – daily care, wound care, catheters and incontinence material -, summarizing the products and prices in the real situation*

### **Mechanic 4: Actions**

Since situated learning is a main effective element of serious gaming, the in-game actions should be linked to the real situation and the real roles. The most relevant actions in the internal supply chain that are relevant for the problem context are thus translated to in-game actions for each of the three roles:

1. The nurses are concerned with the daily care for patients, which requires products
2. The department management orders products for the department warehouse
3. The central warehouse management orders products externally and fulfill the department orders

These actions are presented on the action cards for each role, which can of course comprise many different decisions. See Figure 13 for the nursing role’s action card as example. The other actions cards can be found in Appendix XI.

*Design decision: The actions taken in-game are based on the real actions for each of three roles*

Further aspects that were determined during the play sessions was the flow throughout the game. When players on their own played a position for a longer period of time, they sometimes lost their interest when they felt they had understood the most important aspects. By rotating the different player roles however, this brought new energy in the game. Furthermore, it was shown that if during the process of rotating no changes are made in the situation in-game, the players learned a lot because they have to ‘deal with’ the decisions the others before them in that position made.

*Design decision: The players rotate the three in-game goals so they can experience each of these*

Furthermore, it was decided that every role was played by two players. It was shown that this leads to much more discussion by the players and as players start to ‘think out loud’, they together arrive at an understanding of the most important dynamics in the game.

*Design decision: Two players together perform one of the three in-game goals.*

### **Mechanic 5: Rules**

For a serious game, there are objectives *for* the game, discussed in Chapter 2, and objectives *in* the game. The latter is of concern in Schell’s formulation of the ‘rules’ element.

One of the main problematic aspects in the HOH's situation concern the different and sometimes conflicting goals within the internal supply chain. By giving the players different in-game objectives, this aspect can be translated to the game. In this way, the players can become aware of the relation between the different stakeholders' interests. Thus, the main relevant aspects of the real situation were translated to the game for the three roles, see 6 in Figure 13. The in-game goals for the nurses concern the caring for patients in time, the department management needs to manage the department's warehouse as good as possible and the central warehouse management's goal is to be able to service every department with the minimum costs possible.

*Design decision: As in the real situation, the different roles in the game have different (sometimes conflicting) goals.*

The above decision indeed led to players aiming for different goals. It however did not make explicit what the disadvantages of striving only for one's own success; as in the real situation, the players did not see the impact of their actions on the other players but acted within their own silo. The solution was to also present a *shared* in-game goal: the performance of the internal supply chain as a whole. For this functionality, we introduced 'performance points'. Each of the role's functioning is evaluated in the weekend and on this basis, these points can be earned. These performance points are shared by each of the players and the players together track these on a performance meter which is updated in the weekends. Thus, the players now also have a shared goal: letting the hospital's internal supply chain function as good as possible. This game mechanic proved to be very important to show the dangers of only thinking in silos and the importance of being aware of the needs of the other stakeholders. Nurses could for instance try to use as few steps as possible to care for the patients, to accomplish their highest possible score. However, if they thereby problematize the warehouse management, they can actually hurt the total score of 'performance points', getting an insight how optimization of specific parts could hurt the performance of the system as a whole.

*Design decision: Each of the roles can acquire performance points by how well they accomplish their position's goals. These performance points are shared by the players and indicate how well the internal supply chain as a whole is functioning.*

#### **Mechanic 6: Skill**

The mechanic of skill shifts the focus away from the game and onto the player. The game's difficulty should be a good match to the player's skill level, so the player can stay in the 'flow channel'. The serious game we are designing should not require too much skill to start playing, since it should be accessible for all levels of education, but it should be challenging enough to stay interesting. This was accomplished by providing different 'levels' to which objectives can be accomplished. For players new to supply chain mechanics, the lower levels are possible to acquire while still understanding the most important mechanics. More experienced players can try to accomplish the highest performance for each of the positions. A beginning player for instance could accomplish to spend less than 4500 florin and thereby receive two performance points. If they are able to spend less than 3500, they receive three performance points, which is only possible in a completely well-functioning internal supply chain. The Action Cards in Appendix XI provide more insight into the specific leveled objectives.

*Design decision: There are different 'levels' to which objectives in the game can be accomplished*

As discussed in Section 4.3, a model was developed in Excel VBA. This model can simulate the consequences of the most important choices for the different players in-game. Strategies for nurses concerning the means for transportation and the ordering minima and/or maxima can be filled in the model along with the ordering strategy for the roles of the department management and central warehouse management. Hundreds of runs can then be made to determine to which values these in-game strategies lead. By investigating the optimal strategies, exact goals could be determined.

*Design decision: The in-game goals are fine-tuned by use of the simulation model*

#### **Mechanic 7: Chance**

In the internal supply chain situation in a hospital, chance is an important factor. Interviews with the nurses and care managers indicated that the role of chance is even one of the most important reasons for the current hoarding habit: the medical staff wants to be sure that if something unexpected happens, they will be able to solve that situation. To do this, they often require products, thus they make sure to have (more than) enough products near their place of working. As the unexpected complications at the nursing wards play such an important role for the current situation, these were implemented in the game, see 9 in Figure 13. Nurses were consulted to understand what kind of events should be included. Events concern the entrance of a patient, or for instance an unexpected bleeding. See the event cards in Appendix XI for examples of in-game events.

*Design decision: The nursing staff encounters unexpected situations that correspond to real occurrences*

In playtests, it appeared that not only reality was better simulated by means of the factor of chance; it also led to the players having more fun with the game, and thus a higher engagement with the simulated situation. This led to the idea of also implementing elements of chance for the other positions, see 10 in Figure 13, which indeed increased the engagement in the game. The implementation of these chances also was a way to show the players specific elements, such as possibilities for optimization or important trade-offs between the different players.

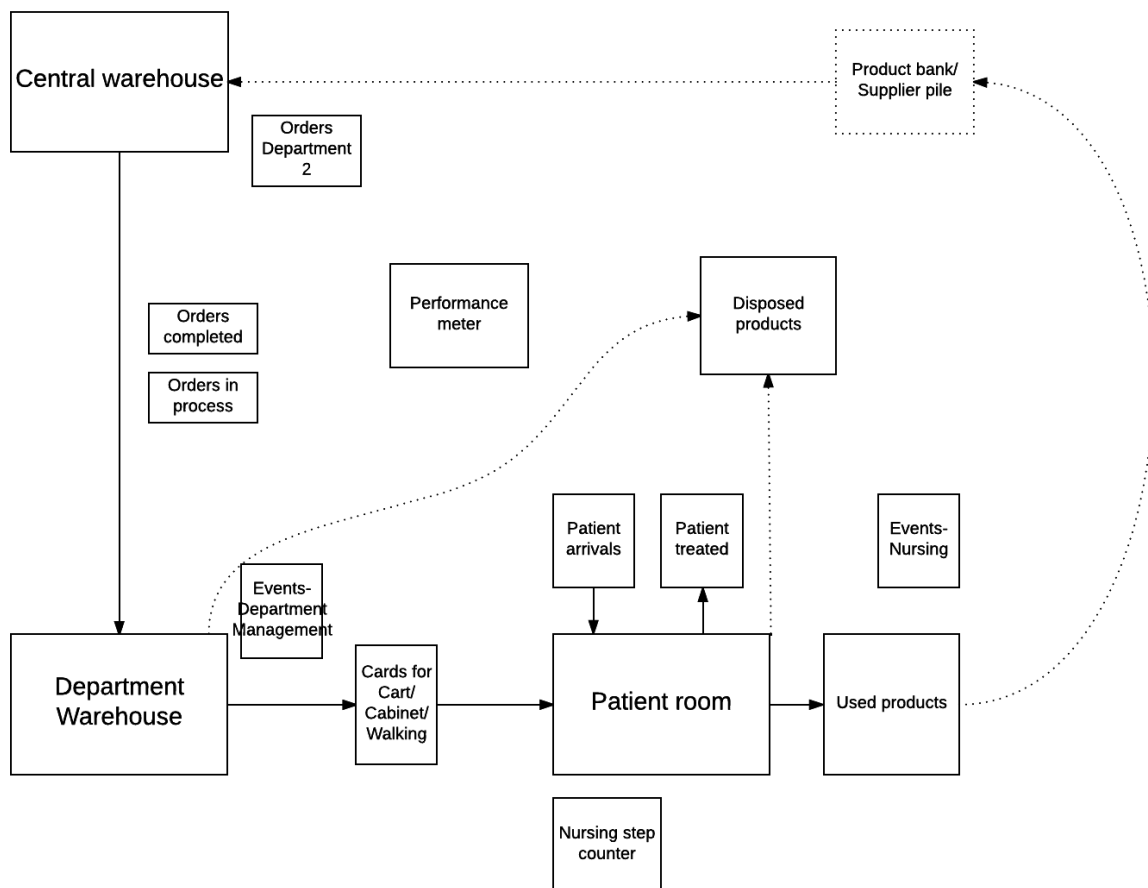
*Design decision: Chance is involved in each of the roles to create fun and challenging situations*

## Appendix XI: Serious game material

Chapter 5 demonstrated Care 4 Supply, the serious game that was developed in this thesis. This appendix contains the material to play the final prototype version of the game. It is still a prototype, because, as discussed in Section 8.3, its aesthetics will be improved to match the HOH's style. One element, the Action Card for the role of the nurses, was already designed that way. The original material was in Dutch, for more convenience for the players, but has also been translated to English for this thesis.

*Game master instructions:*

1. Prepare the playing field as shown in Figure 15
2. Default starting values if not otherwise determined with the Excel VBA simulation model are:
  - Central Warehouse: 40 Daily Treatment sets, 20 of each other product
  - Department Warehouse: 10 of each product
3. Get attention of players and read instructions below. Point at each of the words indicated **red**.
4. Go through first day with players, as discussed below. Leave room for questions and improvise accordingly.
5. After players have got used to the game, limit in-game days to four minutes, with one performance point loss if more time is needed.
6. Take the lead in the evaluation during the in-game weekends so each of the players can



*Figure 15 Overview of game board positions, arrows show normal direction of products throughout internal supply chain*

## **Welcome to Supporters of Care: The hospital's supply chain game.**

In this game, you will run a hospital and make it as successful as possible. You will nurse patients to help them recover, manage a department and buy the products that are essential for a well-functioning hospital. Along the way you will stumble upon unexpected situations, timed challenges and interesting opportunities.

This game follows the chain of products throughout the hospital: when they are bought at the central warehouse side, all the way to their actual use by the department's nurses. It is completely based on the actual situation at the HOH and the dynamics that are relevant in the practice of running the hospital.

The product chain is divided in three areas: **nursing**, **department management** and the **central warehouse**. These three areas are all part of the same hospital but all have different goals and priorities.

The players will be divided over these hospital roles. As in reality, each of these different roles has their own agenda, both in terms in what their tasks are as well as what goals they pursue. These possible actions and goals can be found on the **Action Cards**.

Each of the three roles has their own task per day. Every in-game day, which is around 4 minutes, the players can find on their Action Cards which choices, challenges or opportunities they will face that day. After each of the positions has performed their tasks, the next day will start. The days are tracked on the **Calendar**.

In the weekend, the performance of each of the three positions is evaluated and the '**performance points**' are measured in order to determine how well the hospital has performed.

The actions during the week can all be performed at the same time but communication between the different departments can be helpful to let the hospital perform as successful as possible.

In order to perform the daily tasks, different material is needed: there are **patients** and **event cards** for the nurses, **event cards** and **order lists** for the department management and **secondary orders** and **external ordering list** will help to perform the actions for the central warehouse.

Each of the explanation cards for the roles will further explain the details for each position. With the introduction you have read above, the Action Cards should give enough information to be able to play the game. And once the game has started, the challenge will begin: together let the hospital perform as good as possible! (*if applicable*: Once your team has received 15 performance points, and the hospital thus is completely successful, the number of weeks this took you will be written down and will get your teams name on the top score list!)

Below, an example of a day in the game can be found:

## Day 1

It is the first day of the game. This first day we will do all steps together and one after the other, in order for everyone to grasp what the basics are per position. Later in the game, just as in the real hospital, all positions are performing their tasks simultaneously.

### Nursing

- As can be read on the **Action Card** for nursing, every day at this position requires the patients on the department to be treated.
- Because it is the first day, the first **three patients** can be placed on the nursing ward.
- These three patients now have to be treated. On this first day, there are no products yet on the cart or in the cabinet. Thus in order to treat the patients, the products have to be moved from the department warehouse. There are different choices:
  - o The products can be carried directly between the department warehouse and the patients, which takes 1 action per product
  - o The products can first be put on the cart, than driven to the patients and used there. This takes 1 actions per *kind* of product
  - o The products can first be stored in the cabinet and then used at the patients. This takes 5 actions *not regarding the amount of products*.
- Treating each patient with the two required products also takes one action, adding to the total
- Thus, if for instance there are 2 patients with a catheter and 1 with a bleeding, then the number of actions for moving the products is

Table 16 Nursing steps per nursing choice in example

	Transporting products	Treating patients	Total actions
Carrying	6 for <i>carrying</i> (because there are 6 total products: 3 daily treatment, 2 catheter and 1 wound care)	3 (because there are 3 patients)	9
Cart	3 for using the <i>cart</i> (because there are 3 types of product: daily treatment, 2 catheter and 1 wound care)	3	6
Cabinet	5 for using the <i>cabinet</i> (because this number is independent of the number of products that is stored, with a maximum of 20)	3	8 (and up to 20 products can be stored)

- The number of actions that is taken, is tracked at the **Action Counter**. Once the **Event Line** has been crossed, the dice should be thrown in order to find out what has happened. The meaning of the number that is thrown with the dice can be found on the **Dice Event Card**.
- After the event has happened, it could be that new patients have to be treated. If this is the case, more actions might have to be used in the same manner as shown before.
- Now that the first day has passed, the following steps finish this day for the nurses:
  - o Every **Patient Card** is turned 90 degrees to show that a day has passed.

- All products used today are moved to the **Used Products Field**
- A new patient enters the department; one new **Patient Card** is placed on an empty bed.

#### *Department management*

- As can be read on the **Action Card**, for the department management, this first day is an 'ordering day'. This means that an order has to be placed at the central warehouse.
- The department management can determine how many products they want to order. They could for instance base this on how many products were taken by the nurses, by the patients they expect, by determining standard figures, or other reasoning.
- The order has to be written on the **Department Order** paper and given to the central warehouse, who will fulfill it the next day.

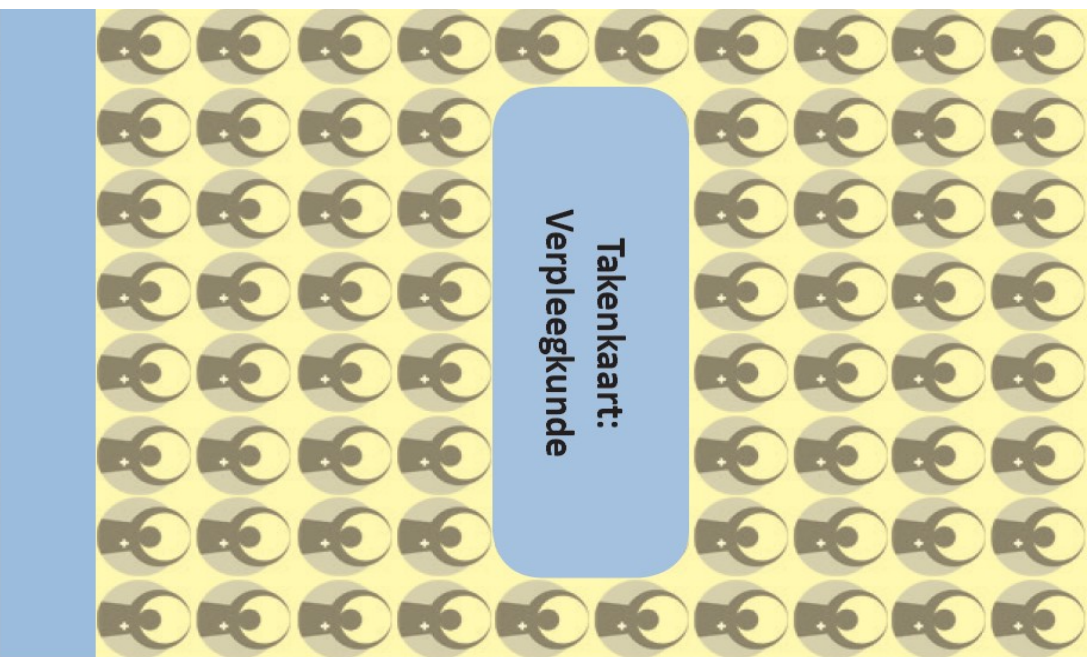
#### *Central warehouse*

- For the central warehouse, this first day on the **Action Card** says that it is an ordering day for the fictional 'department 2'. Therefore, a **Department 2 Order Card** can be drawn from the pile.
- The department 2 order has to be fulfilled by placing the relevant products on the Department 2 field.

#### *Round-up*

After the steps above, the three positions have all completed their first day. Now, the pawn can be placed on the next day of the **Calendar** and day 2 commences. Before, all players now start to perform their actions for that day, it is important to all go over the actual **Performance Point Goals** on the back of the **Action Card**. Here it says for every position what their aim is and how they will be rewarded. On the **Calendar** the weekends are displayed. In these weekends, it will be evaluated how many performance points each position has earned. All of these performance points are counted on the **Performance Point Counter**. If all the players together reach 15 performance points, the game is won.





1	2	3	4	5	weekend
Verpleging	Verpleging	Verpleging	Verpleging	Verpleging	Evaluatie, wissel van rol
8	9	10	11	12	weekend
Verpleging	Verpleging	Verpleging	Verpleging	Verpleging	Evaluatie, wissel van rol
15	16	17	18	19	weekend
Verpleging	Verpleging	Verpleging	Verpleging	Verpleging	Afrondende evaluatie

**De eerste dag:**

- Pak drie willekeurige kaarten van de patiëntenstapel en leg deze op de afdeling neer, met het (maximaal) aantal ligdagen naar boven gericht. Dit zijn de patiënten die nu op je afdeling liggen en verzorgd moeten worden.

**Gedurende Verpleging:**

- Verzorg de patiënten met behulp van de kamervoorraad, kar of door direct heen-en-weer te lopen tussen het afdelingsmagazijn en de patiënten
- Houd de handelingen die voor het verplaatsen van de producten en het verzorgen van de patiënten nodig zijn bij op de handelingsenteller
- Wanneer het aantal handelingen de dobbelsteengrens overschrijdt, gooi dan met de dobbelsteen en bekijk welke onverwachte situatie dit in gang zet

**Aan het eind van de verpleging-dag:**

- Draai elke patiënt een slag, om te laten zien dat er een dag voorbij is
- Patiënten die geen ligdagen meer over hebben worden ontslagen
- Er komt één nieuwe patiënt bij op de afdeling

**Bij evaluatie (weekend):**

- Bepaal het aantal prestatiepunten (zie ommezijde)
- Zet de handelingsenteller weer op nul

**Wanneer een product niet beschikbaar is**

Wanneer een product niet beschikbaar is om een patiënt te verzorgen, kan het afdelingsmanagement in overleg een spoedbestelling plaatsen. Wanneer het product niet beschikbaar is in het centraal magazijn kan de patiënt niet worden geholpen en kost dit één prestatiepunt per patiënt.

Figure 16 Example of in-game card design for Care 4 Supply

## Action Card: Nursing

1	2	3	4	5	Weekend
Nursing	Nursing	Nursing	Nursing	Nursing	<i>Evaluation, change role</i>
8	9	10	11	12	Weekend
Nursing	Nursing	Nursing	Nursing	Nursing	<i>Evaluation, change role</i>
15	16	17	18	19	Weekend
Nursing	Nursing	Nursing	Nursing	Nursing	<i>Final evaluation</i>

The first day:

- Draw three random patient cards and lay these on beds at the patient room, with the maximum number of days turned upwards. These are the patients who are at the department and should be cared for.

During *Nursing*:

- Care for the patients by using the room cabinet, the cart or by walking between the department warehouse and the patients
- Track the number of nursing steps required for getting the products and treating the patients on the nursing steps counter
- When the number of nursing steps reaches the line with the dice, throw the dice and look at the explanation which unexpected situation this triggers

End of every day:

- Turn each patient 90 degrees, to show that the day has ended
- Patients who do not have any days to stay left can be dismissed
- One new patient arrives at the department

Evaluation (weekend):

- Determine the number of achieved performance points (see other side)
- Reset the nursing steps counter to zero

*When a product is not available*

When a product is not available to treat for the patients, the department management could place an emergency order. When the product is also not available at the central warehouse, every patient that cannot be treated costs one performance point.

---

### Evaluation Nursing

Per week you earn 1, 2 or 3 performance points for the internal supply chain:

- 3 performance points: All patients could be treated with at least spare 8 nursing steps
- 2 performance points: All patients could be treated without requiring extra steps
- 1 performance point: All patients could be treated

## Action Card: Department Management

1	2	3	4	5	Weekend
Ordering day	Event day	Event day	Ordering day	Event day Inventories counting	<i>Evaluation, change role</i>
8	9	10	11	12	Weekend
Ordering day	Event day	Event day	Ordering day	Event day Inventories counting	<i>Evaluation, change role</i>
15	16	17	18	19	Weekend
Ordering day	Event day	Event day	Ordering day	Event day Inventories counting	<i>Final evaluation</i>

### Ordering day:

- Submit order at the central warehouse management. If there is enough stock, the order will be fulfilled the next day

### Event day:

- Draw a department event card and try to manage the event (the coming days) as good as possible

### Inventories counting:

- Count the inventory levels of the department warehouse. This is used to determine the total inventory costs during the weekend evaluation for the central warehouse

### Evaluation (weekend):

- Determine the number of achieved performance points (see other side)

### *Placing an emergency order*

Submitting an emergency order costs one performance point per type of product that is ordered. The order can directly be fulfilled by the central warehouse management.

---

## Evaluation Department Management

Per week you earn 1, 2 or 3 performance points for the internal supply chain:

- 3 performance points: You have ordered fewer than 35 products and did not have to discard any
- 2 performance points: You have ordered fewer than 40 products and had to discard a maximum of 2
- 1 performance point: You have ordered fewer than 50 products and had to discard a maximum of 5

## Action Card: Central Warehouse Management

1	2	3	4	5	Weekend
Supply Department 2	Supply Department 1	Order day for external suppliers	Supply Department 2	Supply Department 1 Inventories counting	<i>Evaluation, change role</i>
8	9	10	11	12	Weekend
Supply Department 2  Supply external suppliers arrives	Supply Department 1	Order day for external suppliers	Supply Department 2	Supply Department 1  Inventories counting	<i>Evaluation, change role</i>
15	16	17	18	19	Weekend
Supply Department 2  Supply arrives from external suppliers	Supply Department 1	Order day for external suppliers	Supply Department 2	Supply Department 1  Inventories counting	<i>Final evaluation</i>

### Supply Department 1:

- The products that have been ordered by the (players fulfilling the role of) the department management, can be delivered to their department warehouse

### Supply Department 2:

- Draw an order from the 'Orders Department 2' pile
- Deliver the products following the order to the fictional Department 2

### Inventories counting:

- Count the inventory levels of the central warehouse. This is used to determine the total inventory costs during the weekend evaluation for the central warehouse

### Order day for external suppliers:

- Place an order at the external suppliers. The order quantity is in boxes of 10 pieces. The order will be shipped in three days.

### Supply arrives from external suppliers:

- Accept the delivery from the suppliers (usually provided by the game master)

### Evaluation (weekend):

- Determine the number of achieved performance points (see other side)

### *Placing an emergency order:*

An external emergency order can be placed. When this is done, the order can be delivered the next day. Such an emergency order costs 2 performance points.

---

## Evaluation Central Warehouse Management

Per week you earn 1, 2 or 3 performance points for the internal supply chain (see cost card for the costs explanation):

- 3 performance points: You have fulfilled all department order and spend less than 3500 florin
- 2 performance points: You have fulfilled all department order and spend less than 4500 florin
- 3 performance points: You have fulfilled all department order and spend less than 5000 florin

## Central Warehouse – Cost Card

Product prices (based on real average costs per department):

<i>Product type</i>	<i>Costs per box (10 pieces)</i>
Daily treatment set including infusion	600 florin per box
Incontinence material	400 florin per box
Wound care	200 florin per box
Catheter	100 florin per box

Order costs (transportation, loading etc.):

<i>Types or products ordered externally</i>	<i>Costs</i>
1	250 florin
2	500 florin
3	750 florin
4	1000 florin







Inventory costs for central warehouse and department warehouse (maintainance, capital costs etc.):

<i>Total number of products in central warehouse and department warehouse</i>	<i>Costs</i>
Less than 20	100 florin
Between 20 and 40	200 florin
Between 40 and 60	500 florin
Between 60 and 100	1000 florin
More than 100	2000 florin

The products costs, ordering costs and inventory costs determine the number of performance points acquired in a week, see 'Evaluation Central Warehouse Management'

## **Nursing – Unexpected Situations**

Throw the dice. The number of dots determines the event:

-  When there is a bed free, a new patient arrives. This patient has to be treated today.
-  A patient is discharged a day earlier. Throw the dice to determine which patient this is. If the patient does now not have any days left, he can directly be discharged.
-  A patient has to stay a day longer. Throw the dice to determine which patient this is.
-  A patient has an unexpected complication and has to be helped today. Throw the dice to determine which product is required.
-  or  An unusual event takes place! Draw a card of the pile with 'Events – Nursing' and see what has happened!

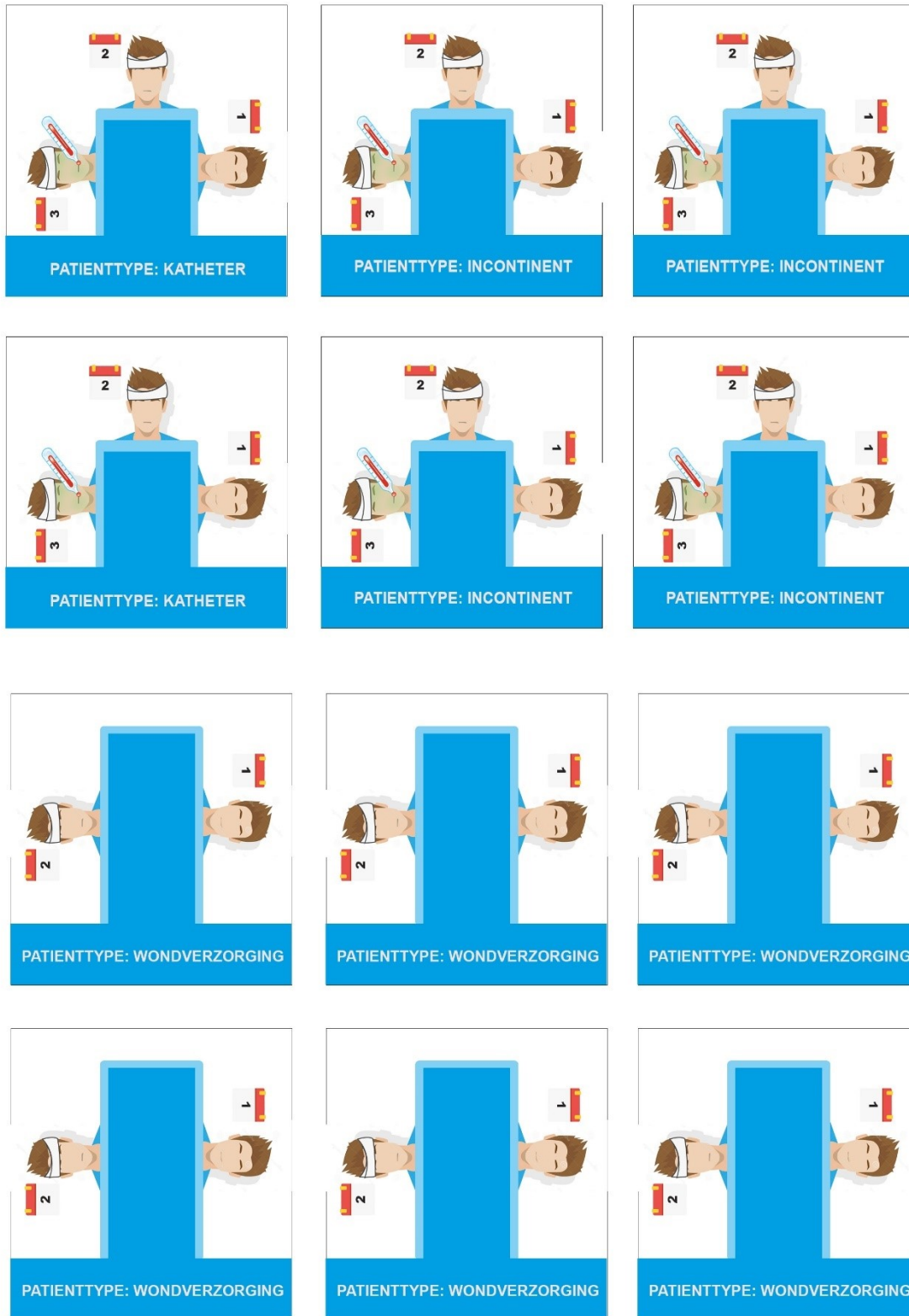


Figure 17 In-game patient cards

## Department management event cards

<p>A test is performed with a new scanning technique. The order will be as follows: Daily treatment 19 minus number of product currently at inventory, Wound care = 14-#inventory, Incontinence material = 13-#inventory and Catheters = 12-#inventory</p>	<p>A simulation of the department is run and it appears that when daily treatment sets are replenished every order period to 19, you always have enough products until the next order period.</p>
<p>The incontinence material is still at the customs. This will be delivered two days later at the central warehouse than planned.</p>	<p>A cabinet in the warehouse has broken and there is less storage room available. When you succeed to keep the inventory levels lower than 30, you receive one performance point.</p>
<p>The department warehouse employees are extremely busy. When the next period less than 20 products are ordered, the department will receive an extra performance point.</p>	<p>The department warehouse has to be cleaned. This is planned for tomorrow and the nurses will have to help out. For every 15 products in the warehouse, this takes 1 nursing step.</p>
<p>Another department has asked whether they could borrow the cart for one day. If you decide to lend it, the other department will give you a performance point. When the nurses however have to work overtime due to this, you will lose one performance point.</p>	<p>There has been a leakage in the central warehouse. The products that were in the cabinets have been saved, but the others have to be disposed. When more than 30 products are in the department warehouse, throw the dice to determine how many have to be disposed.</p>
<p>Your department is asked to test a serious game together with the central warehouse management. The meeting takes place in two days. If both of you agree to this, the order moment will be a day later and external supplies will come a day later, but you receive one performance point.</p>	<p>Yuckk, an enormous spider! It has been caught in incontinence material. One package has to be thrown away (if not available in the department warehouse, one has to be disposed from the central warehouse).</p>

Figure 18 In-game event cards 1



<p>A check has been performed. It appears that all inventories higher than 15 in the department warehouse have gone over-due. Throw a dice for every inventory level higher than 15 to determine how many products have to be discarded.</p>	<p>A colleague department requires 2 wound treatment sets for an emergency. If you are able to deliver those now, nursing will have to extra nursing steps today.</p>
<p>A check has been performed. 3 wound care products and 1 catheter appear to go over-due tomorrow. If those are not used before the end of the day, they have to be discarded.</p>	<p>The sterile services have investigated the catheters. When more than 10 catheters are piled up, little damages can occur and the products have to be discarded. All catheters over 10 have to be discarded from the department warehouse.</p>
<p>A check has been performed. 3 daily treatment sets and 1 incontinence product appear to go over-due tomorrow. If those are not used before the end of the day, they have to be discarded.</p>	<p>A snake was found at the department! A nurse has put her life at stake and caught the snake, but had to be admitted to the emergency department. Thus, tomorrow less nursing steps are available. Throw with the dice. If you throw 1, 2 or 3, there will be 1 fewer step available. Otherwise there are 2 fewer steps available.</p>
<p>The minister of public health stays at the department tonight. If she is treated in time, the department earns 500 florin extra.</p>	<p>During sleep walking a patient has disturbed the sleep of the patients. This has frustrated their recovery. Throw with the dice to determine how many patients will be dismissed a day later (counted from the first bed).</p>
<p>The department is investigated to perhaps become an example for the entire hospital. If at the next weekend less than 14 products of each kind are at the department warehouse, the department receives an extra performance point.</p>	<p>Tomorrow is a training day at the department. One of every product is needed for practice. When these are not available, an emergency order can be placed without further consequences.</p>

Figure 19 In-game event cards 2

The Aruba Run is organized! They require some wound treatment sets for this. These can be donated from the department warehouse or perhaps from the central warehouse. For every product that is donated, the dice can be thrown. When at least one of these throws results in a 6, the hospital receives an additional performance point.

500 florin of a dismissed patient has been found at the department. It requires two nursing steps to determine whose money it is and to give it back. This yields one performance point. You can also determine to keep the money and use it for the central warehouse management.

*Figure 20 In-game event cards 3*

## Nursing event cards

<p>A patient has infected all products in the room! Products in the room cabinet have to be thrown away.</p>	<p>Today a meeting is cancelled and there is extra time for nursing. Throw with the dice to determine how much extra nursing steps are available.</p>
<p>A patient has thrown up over the room cabinet! Half of the products in the room cabinet has to be thrown away, you can choose which products.</p>	<p>You are asked to assist for a hospital research. This costs 2 nursing steps, for which also the time left in the previous days can be used. When you use these nursing steps, you will receive an extra performance point.</p>
<p>The catheters turn out not be unreliable and a recall is made. When available, new version of the product can be taken out of the central warehouse and put into the department warehouse.</p>	<p>The patient in bed 2 has an unexpected bleeding and requires wound treatment. One wound treatment has to be brought to him and caring will require one nursing step. (When bed 2 is empty, nothing happens).</p>
<p>Somebody of the hospital accreditation will visit. All products that are put on top of each other can be damaged. Therefore, everywhere on the department where more than 5 products are, everything more than that has to be thrown away.</p>	<p>A patient tripped over the cart and the products fell on the ground. All products on the cart have to be thrown away.</p>
<p>A meeting is planned for nurses. If today within 4 nursing steps the day is finished, you will receive an extra performance point.</p>	<p>Tomorrow, an inspection is made and there should be no products in the room cabinets. When there are any product at the end of the current day in the room cabinet, these have to be disposed.</p>
<p>A experiment is set-up with a quatum: if the next 10 patients can be cared for in time, the hospital will receive 1000 extra florin (available for the central warehouse management).</p>	

Figure 21 In-game nursing event cards

**Product cards**

Daily treatment set	Daily treatment set	Daily treatment set	Daily treatment set
Incontinence material	Incontinence material	Incontinence material	Incontinence material
Catheter	Catheter	Catheter	Catheter
Wound care	Wound care	Wound care	Wound care

*Figure 22 In-game product cards*

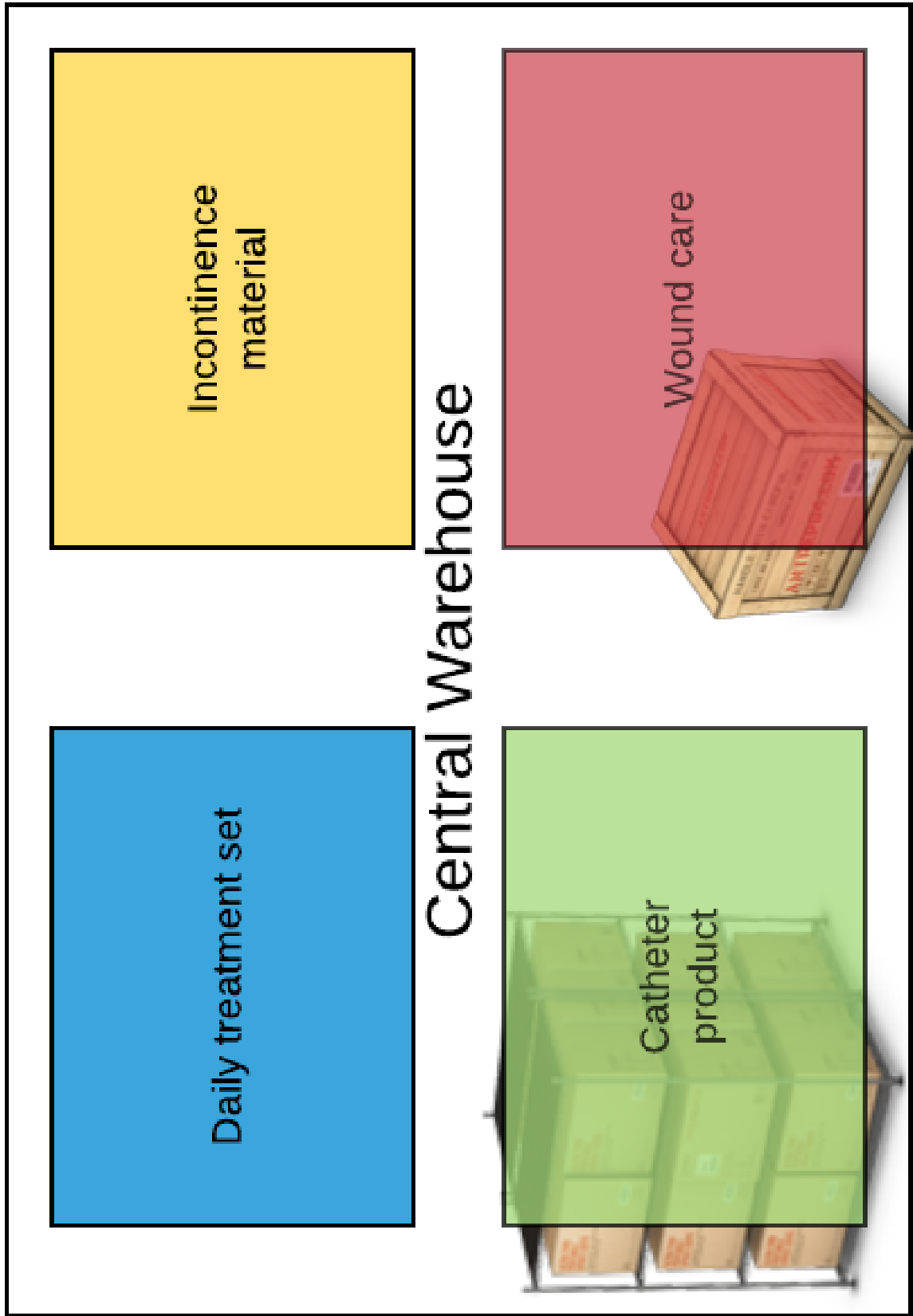


Figure 23 In-game Central Warehouse

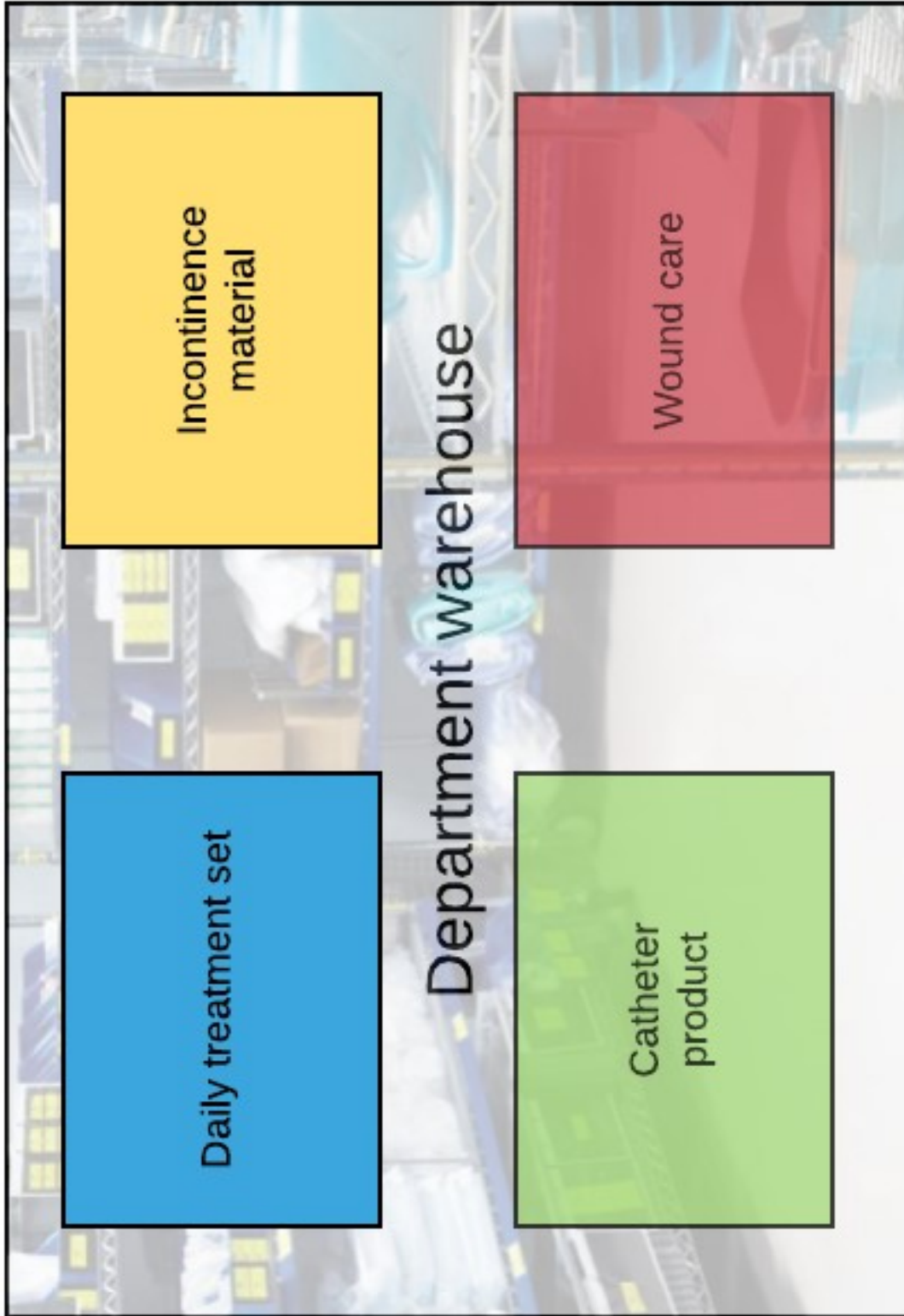


Figure 24 In-game department warehouse

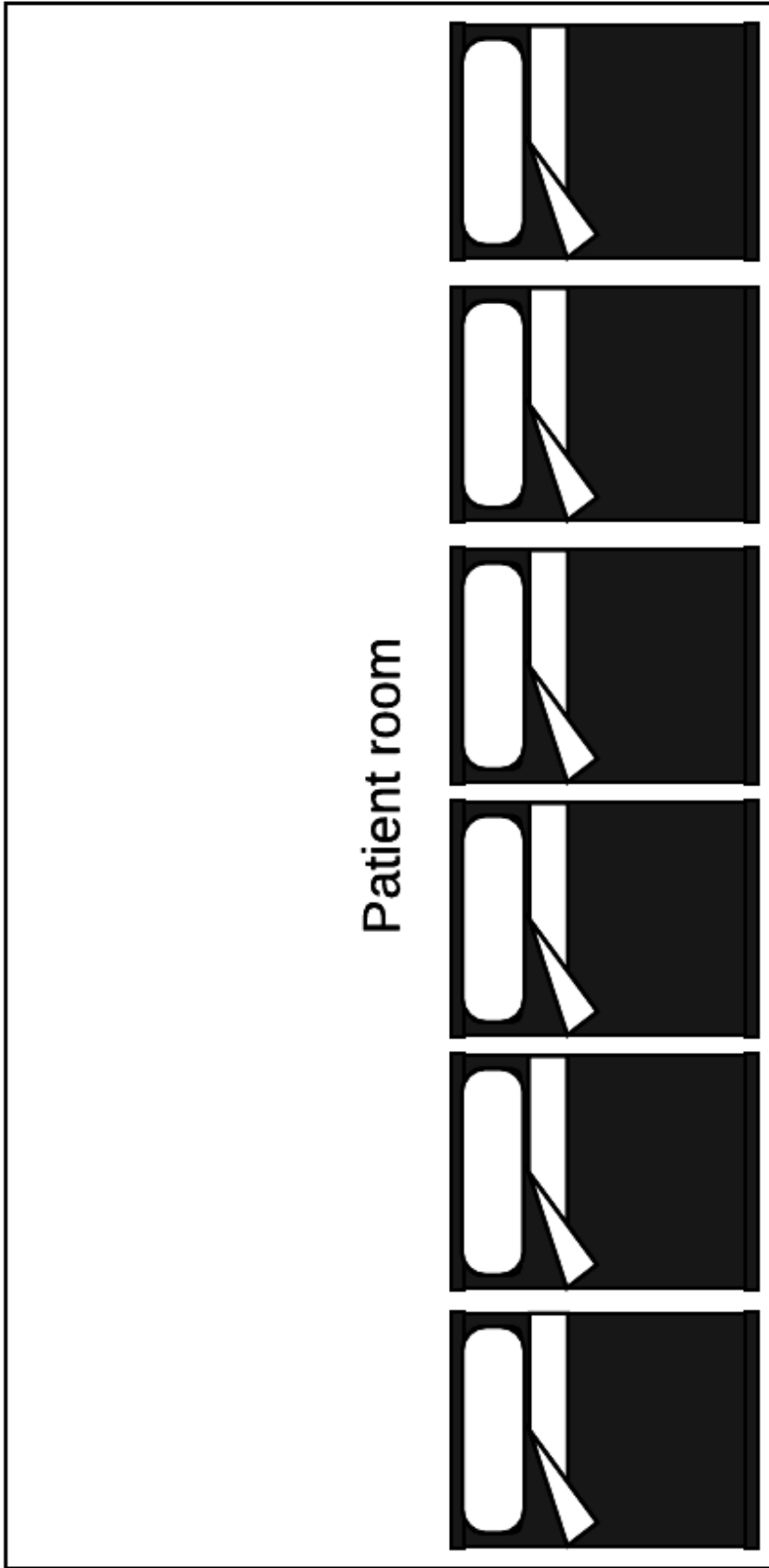


Figure 25 In-game patient room

## Disposed products



## Products used

By patients at department 1 or department 2

*Figure 26 In-game spaces for disposed and used products*



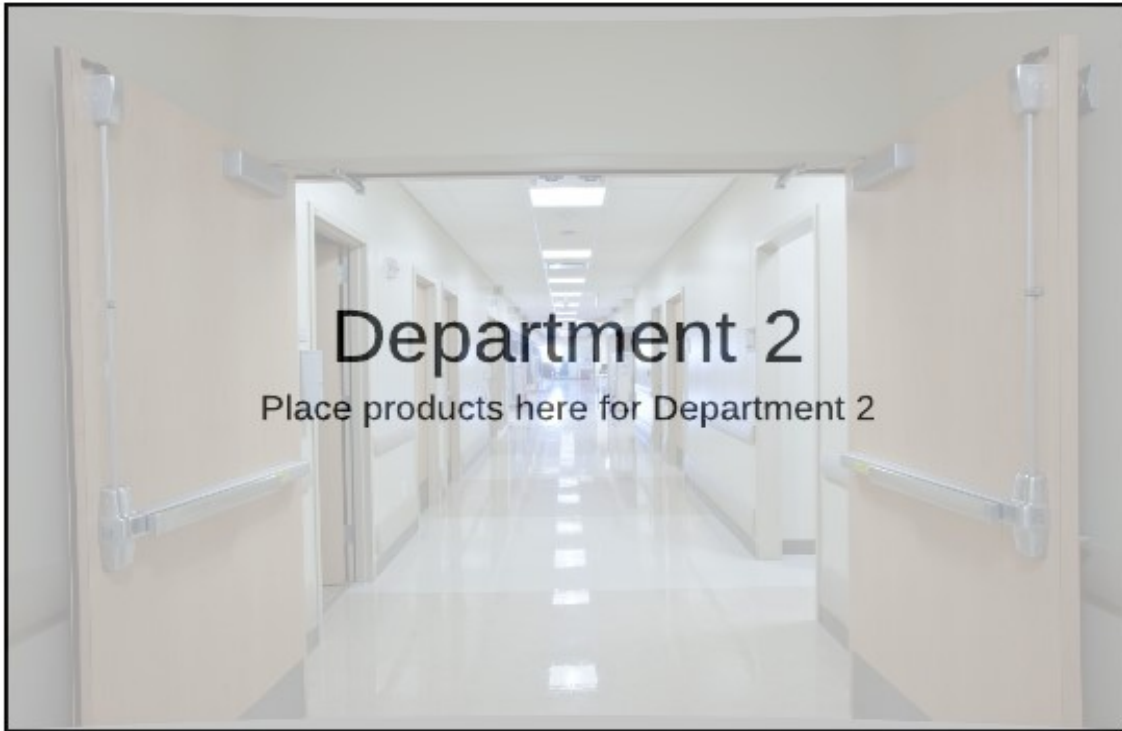


Figure 27 (Fictive) department 2



Figure 28 In-game calendar

## Appendix XII: Post-play questionnaire Care 4 Supply

This appendix contains the original post-play questionnaire used to validate Care 4 Supply.

Please fill in the questionnaire below about the serious game *Care 4 Supply* you have just played. All results are processed anonymously, so no name is required on the form.

### Question 1. I enjoyed playing the serious game

- |                       |                       |                              |                       |                       |
|-----------------------|-----------------------|------------------------------|-----------------------|-----------------------|
| 1. Strongly disagree  | 2. Disagree           | 3. Neither agree or disagree | 4. Agree              | 5. Strongly agree     |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/>        | <input type="radio"/> | <input type="radio"/> |

### Question 2. The game has increased my knowledge of the hospital's product supply chain (= the flow of products from the hospital's central warehouse to the nursing departments)

- |                       |                       |                              |                       |                       |
|-----------------------|-----------------------|------------------------------|-----------------------|-----------------------|
| 1. Strongly disagree  | 2. Disagree           | 3. Neither agree or disagree | 4. Agree              | 5. Strongly agree     |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/>        | <input type="radio"/> | <input type="radio"/> |

### Question 3. The game has increased my understanding of how the central warehouse and care departments in the hospital influence each other

- |                       |                       |                              |                       |                       |
|-----------------------|-----------------------|------------------------------|-----------------------|-----------------------|
| 1. Strongly disagree  | 2. Disagree           | 3. Neither agree or disagree | 4. Agree              | 5. Strongly agree     |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/>        | <input type="radio"/> | <input type="radio"/> |

### Question 4. Playing the game has made me think of ways in which the current situation in the hospital could be improved

- |                       |                       |                              |                       |                       |
|-----------------------|-----------------------|------------------------------|-----------------------|-----------------------|
| 1. Strongly disagree  | 2. Disagree           | 3. Neither agree or disagree | 4. Agree              | 5. Strongly agree     |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/>        | <input type="radio"/> | <input type="radio"/> |

### Question 5. I think that what was relevant in the game is also relevant in the real hospital situation

- |                       |                       |                              |                       |                       |
|-----------------------|-----------------------|------------------------------|-----------------------|-----------------------|
| 1. Strongly disagree  | 2. Disagree           | 3. Neither agree or disagree | 4. Agree              | 5. Strongly agree     |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/>        | <input type="radio"/> | <input type="radio"/> |

### Question 6. I think that playing the game was a useful experience

- |                       |                       |                              |                       |                       |
|-----------------------|-----------------------|------------------------------|-----------------------|-----------------------|
| 1. Strongly disagree  | 2. Disagree           | 3. Neither agree or disagree | 4. Agree              | 5. Strongly agree     |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/>        | <input type="radio"/> | <input type="radio"/> |

### Question 7. I would recommend my colleagues to play the game

- |                       |                       |                              |                       |                       |
|-----------------------|-----------------------|------------------------------|-----------------------|-----------------------|
| 1. Strongly disagree  | 2. Disagree           | 3. Neither agree or disagree | 4. Agree              | 5. Strongly agree     |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/>        | <input type="radio"/> | <input type="radio"/> |

**Question 8. Can you give three examples of things you have learned from the serious game?**

**Question 9. Can you give three recommendations you would do to improve the current situation in the hospital?**

**Thank you for playing the game and filling in the survey!**

**Do you have any other suggestions concerning the game or other comments? If so, please write these below. If you would like to further discuss certain feedback or ideas, please also write down your e-mail address**

## Appendix XIII: Student responses to post-play questionnaire

During the final test session of Care 4 Supply, four medical student participated. Their responses to the questionnaire are presenter here.

Table 17 Results closed questionnaire questions students

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree	Average
<b>1. I enjoyed playing the serious game</b>	-	-	-	75%	25%	4.3
<b>2. The game has increased my knowledge of the hospital's product supply chain (= the flow of products from the hospital's central warehouse to the nursing departments)</b>	-	-	-	75%	25%	4.3
<b>3. The game has increased my understanding of how the central warehouse and care departments in the hospital influence each other</b>	-	-	-	75%	25%	4.3
<b>4. Playing the game has made me think of ways in which the current situation in the hospital could be improved</b>	-	-	75%	25%	-	3.3
<b>5. I think that what was relevant in the game is also relevant in the real hospital situation</b>	-	-	25%	50%	25%	4.0
<b>6. I think that playing the game was a useful experience</b>	-	-	-	75%	25%	4.3
<b>7. I would recommend my colleagues to play the game</b>	-	-	-	75%	25%	4.3

## Appendix XIV: Open question responses by nurses and department secretary

Below are the responses to the open question 8 and 9, given by the nurses and department secretary in the three final test sessions.

Question 8. Can you give three examples of things you have learned from the serious game?

- To become aware of the costs involved (4x)
- That you have to be careful with how and how much products you use (4x)
- To work methodically, with planning and reflection (3x)
- What the ordering process looks like (3x)
- What a shame it is to waste products when they are not used correctly (2x)
- What the whole chain looks like in the HOH/the logistical steps involved (2x)
- Get an insight in the large number of products that is used in the hospital (2x)
- How to order
- How much you should order
- Communicating
- Emergency orders
- In time communicating how much material is needed
- To estimate which method is most efficient for caring for the patients
- That the position
- The dependency of central warehouse on the delivery of the external suppliers
- What the work of the central warehouse employees looks like
- How to prevent from walking too much
- That you should not put too much in the cabinets

Question 9. Can you give three recommendations you would do to improve the current situation in the hospital?

- Provide employees with information about the costs of the products and internal supply chain (2x)
- Create general working guidelines concerning the products in the hospital (2x)
- Check the products' due-date systematically
- Send extra product back to the central warehouse
- Stimulate patients to go the toilet (instead of doing it in bed)
- Work together with suppliers to get products with a late due-date
- The central warehouse should use data from material use as input for procurement
- Keep track of how many products are in a department
- Have enough inventory
- Create competitions between departments to encourage doing goods jobs concerning the products
- Set up a clinical less concerning creating awareness of what is ordered within the hospital

## Appendix XV: Overview of improvement propositions

This appendix provides an overview of propositions for the HOH to improve their internal supply chain. These propositions are based on the review of literature and practice and the empirical observations made in the HOH. Furthermore, it includes specific interventions that were proposed by stakeholders during the empirical investigation of the hospital situation. These propositions are communicated in more detail to the hospital management and the table is only meant as an rough overview of the plans developed in the research for this thesis on the improvement of the internal supply chain in the HOH.

Table 18 Overview of propositions for the HOH's internal supply chain situation

<b>Proposition 1: Create a system to control the whole internal supply chain, from the central warehouse to the actual use at the patients</b>	
<i>Prerequisites</i>	<ul style="list-style-type: none"> <li>• Thoroughly analyze alternative systems</li> <li>• Further analyze current situation concerning potential of different systems</li> </ul>
<i>Expected investment and implementation period</i>	<ul style="list-style-type: none"> <li>• Large investment</li> <li>• Long term project</li> </ul>
<i>Specific interventions proposed by stakeholders</i>	<ul style="list-style-type: none"> <li>• Implement scanning as a first step</li> </ul>
<b>Proposition 2: Improve the reliability of the central warehouse and the order policies of the departments</b>	
<i>Prerequisites</i>	<ul style="list-style-type: none"> <li>• Thoroughly review the operations of the central warehouse concerning reliability</li> <li>• Thoroughly review the operations of the relevant hospital departments concerning product use and ordering</li> </ul>
<i>Expected investment and implementation period</i>	<ul style="list-style-type: none"> <li>• Small investment</li> <li>• Middle term project</li> </ul>
<i>Specific interventions proposed by stakeholders</i>	<ul style="list-style-type: none"> <li>• Create shared inventories for seldom required items</li> <li>• Adjust opening times to nursing activity</li> <li>• Promote communication and discussion between central warehouse and care departments</li> </ul>
<b>Proposition 3: Maintain a sophisticated information system to stay in charge of the internal supply chain</b>	
<i>Prerequisites</i>	<ul style="list-style-type: none"> <li>• Analyze the different information system alternatives on the market</li> <li>• Analyze the current situation concerning the potential of implementing a new system or upgrading the current system</li> </ul>
<i>Expected investment and implementation period</i>	<ul style="list-style-type: none"> <li>• Large investment</li> <li>• Long term project</li> </ul>

<i>Specific interventions proposed by stakeholders</i>	<ul style="list-style-type: none"> <li>• Allow backorders</li> <li>• Create possibility for internal reporting on performance</li> </ul>
<p><b>Proposition 4:</b>  <b>Create clear internal supply chain leaders, a clear strategy and distribute responsibility fittingly within the supply chain</b></p>	
<i>Prerequisites</i>	<ul style="list-style-type: none"> <li>• Determine who the main supply chain leaders are in the organization</li> <li>• Together with the supply chain leaders, formulate and overall strategy and goals concerning the improvement of the internal supply chain</li> </ul>
<i>Expected investment and implementation period</i>	<ul style="list-style-type: none"> <li>• Small investment</li> <li>• Short term project</li> </ul>
<i>Specific interventions proposed by stakeholders</i>	<ul style="list-style-type: none"> <li>• Create financial responsibilities fittingly with the system</li> </ul>
<p><b>Proposition 5:</b>  <b>Use Care 4 Supply to engage all relevant stakeholders, involve them in the entire internal supply chain, improve their supply chain knowledge and enhance stakeholder relationship alignment</b></p>	
<i>Prerequisites</i>	<ul style="list-style-type: none"> <li>• Could start directly and should be sustained during change and improvement processes</li> </ul>
<i>Expected investment and implementation period</i>	<ul style="list-style-type: none"> <li>• Small investment</li> <li>• Short term project</li> </ul>
<i>Specific interventions proposed by stakeholders</i>	<ul style="list-style-type: none"> <li>• Display product prices on department warehouse cabinets</li> </ul>