Food logistics at Academic Medical Center

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Preface

I am proud to present this graduation report, which contains my research on food logistics at Academic Medical Center (AMC). This report marks the end of my eight-year studentship, with three fantastic diplomas as a result. Completing my Master's degree in Industrial Engineering and Management at the University of Twente was an exciting journey.

I am ready for the next step now. Hopefully, my report encouraged AMC to take the next step too, namely to optimize the food logistics. I hope this report provides insight into the current performance of AMC's food service regarding wholesale products and the steps which should be taken to improve this performance and to make an informed choice about the organization of interventions.

I would like to express my sincere gratitude to those who helped me during this period.

First of all, I thank Erwin Hans for his guidance throughout the project. The feedback helped me to structure and improve this report and to continue the project at tough points. I also thank my second supervisor Leo van der Wegen for his outstanding support, advice, and professional feedback.

I also thank my supervisor Hans Woolderink from IFC BV for his confidence in me by providing this opportunity and the invaluable feedback and support during the whole project. I thank Mathieu van der Maat from AMC for providing information, for all your insights, for helping me with my research and report, and for proving the opportunity to speak with stakeholders within and outside AMC.

I also thank all the persons that I have interviewed. They helped me to understand the process, performance, and planning and control of food logistics in AMC. It was a great value to speak with all these people who are, all in their own way, trying to improve the food service level and increasing the hospitality of AMC.

Finally, I would like to express my gratitude to the people dearest to me. I thank my parents and sisters for their love, wisdom, and support throughout my life. Finally, I thank my boyfriend Richard. Thanks for your help, motivation, distraction, and everything you are to me!

Enjoy reading the report!

Wendy Haas
November, 2013

Abstract

Background

The challenge for health care organizations during the upcoming decades is to deliver more patient care of at least the current quality, while efficiently allocating less financial and human resources. The bad reputation of food in the health care sector and the increased expectations of the customers makes food service an important issue for many healthcare facilities. AMC, one of eight academic hospitals in the Netherlands, wants to improve their quality of care, by achieve a higher food service level among others. They aim for hospitality and providing optimal nutrition to the patient through efficient logistic functions, in order to accelerate the recovery of patients and prevent complications.

Research problem, scope and objective

To identify problems in the logistic processes concerning food in AMC, we have conducted a preliminary research in which we have analyzed the characteristics of AMC's food logistics on process, performance, and planning and control, by performing interviews, observing, and participating at a unit. We have used the framework of Hans, Van Houdenhoven & Hulshof (2011) to structure planning and control functions and their interactions. We have assessed the current performance by operationalizing AMC's eleven KPIs into measurable units and found that the main problem is whether to hold or arrange products centralized or decentralized.

On the basis thereof, we scope our research on AMC's inventory management of wholesale products for inpatients. The objective of this research is to measure the current performance of AMC's food service regarding wholesale products and to improve this performance by organizing the logistics concerning food more efficiently. To achieve the objective of this research we have investigated what steps should be taken to improve AMC's current food logistics of wholesale products measurable and to make an informed choice about the organization of interventions.

Research approach

As in the preliminary research, we have identified the characteristics of AMC's inventory management on the process, performance, and planning and control. We have defined twelve indicators, operationalize these into measurable units, and collected relevant data to perform a baseline measurement. We have carried out a performance measurement using the operationalized KPIs. Based on the literature study, expert opinions, and our experiences, we have presented and discussed interventions for AMC and evaluated these based on acceptance and evaluation criteria. We have identified and discussed why one intervention is most suitable to improve the inventory management of AMC's wholesale products. Furthermore, we have analyzed and discussed the limitations in the availability of AMC's data. Eventually, we have designed a roadmap to manage AMC's logistic function concerning wholesale products. We have generalized the outcomes to other hospitals, so that they may also benefit from this research.

Results

We have identified the following five main steps in the logistic process of wholesale products: stock management, ordering, delivery, internal distribution, and unit related activities. We have found the indicators waste, order fill rate, and on-time shipments as main problems in inventory management of wholesale products in AMC.

Literature study has shown that current inventory models are not useful to replicate for the food business in hospitals. However, the background information in books and articles is useful as input on how to organize the logistics of food more efficiently and to argue the impact of organizing interventions. Key issues are to find the optimal balance between product availability and outdating, anticipate on expected future outdating of products, and adopting centralized control over the whole supply chain, in order to reduce unnecessary outdating and shortages, while safety stock being required to satisfy a given level of customer service also reduce. We have identified five interventions for AMC to improve the logistical process and thereby the inventory management of wholesale products:

1. Centralized safety stock. Transport between safety stock and unit kitchens by BBWs.
2. Centralized safety stock. A trolley goes along the unit kitchens to replenish BBWs.
3. Centralized safety stock and replenishment per floor. Adopting LTs.
4. Centralized safety stock per floor, using a trolley for replenishment. Adopting LTs.
5. Decentralized safety stock per unit kitchen.

Based on evaluation, it appeared that decentralization per unit kitchen is not profitable, because of the high amount of waste, the high holding costs and inventory. Interventions 1 and 2 benefit from centralization since less safety stock is being required to satisfy a given level of customer service, and processes become more efficiently by exploiting any economies of scale. There will be a tipping point where centralization per floor outweighs complete centralization. With the current knowledge, we did not know, and could not measure when this happen. Although, we have expected that Interventions 3 and 4 will outweigh Interventions 1 and 2 because of the high personnel costs in Interventions 1 and 2 by handling activities and long transport distances from CGO to the kitchen units, the increase of shortages, the intensive use of elevators, and the fact that stock is far beyond the reach of the departments. Benefits of centralization as economies of scale, closer match between supply and demand, smaller inventories, and waste reductions, will not be able to compete with these disadvantages. Interventions 3 and 4 have more potential as a recommendation and will be preferable based on the extent to which the interventions meet the MoSCoW rules, evaluation based on the assessment per KPI, and the impact of organizing the interventions.

We have compared Interventions 3 and 4. Intervention 3 benefits of a higher product availability, while the inventory reduces, it has a lower percentage waste, a trolley does not have to be purchased, and food assistants are the only employees who have access to the kitchen, in accordance with the hygiene requirements. Intervention 3 will also lead to larger cost reductions in comparison with all other interventions.

Organizing the processes as proposed in Intervention 3 will result in significant improvements for AMC compared to the current situation, because most scores in the categories Quality, Speed, and Dependability will increase, and the score of the other indicators are expected to continue at least equal. For the purpose of hospitality we have referred to the advisory report of IFC, in which various scenarios are recommended based on service levels. Intervention 3 is an excellent basis for increasing the hospitality through one of these scenarios.

Conclusion

This report have described how to measure the current performance of AMC's inventory management regarding wholesale products and how to improve this performance by organizing the logistic function more efficiently, in order to achieve a higher service level and to improve the hospitality. The absence or unavailability of data in AMC has negative consequences for conducting a performance measurement, makes it harder to gain insight into improvements, and to argue a suitable intervention. However, it appeared that organizing Intervention 3 will result in significant improvements for AMC, supports the referred shortcomings arose from the problem cluster, will achieve the highest return, is equipped with the best ingredients for a best practice and is therefore best suited to AMC. We have designed a roadmap which presented and discussed on the steps which should be taken to improve AMC's current food logistics of wholesale products measurable and to make an informed choice about the organization of interventions. When AMC decides to continue the current situation, a number of elements have to be organized to support the process. We recommend to generating useful data, use forecasting of the future consumption, reducing the inventory balance, be creative to prevent waste, and learn from the retail business. Recommendations for further research are: developing a forecasting model, conduct research on the problems arising from lowering inventories, and use the hospitality barometer of IFC BV to evaluate the service after organizing interventions.

Managementsamenvatting

Achtergrond informatie

Nederlandse zorginstellingen staan voor de uitdaging om de gezondheidszorg van goede kwaliteit, toegankelijk en betaalbaar te houden nu de vergrijzing leidt tot meer behoefte aan zorg, terwijl de financiële middelen en beschikbare menskracht afneemt. Het Academisch Medisch Centrum (AMC), één van de acht academische ziekenhuizen in Nederland, wil met een gereduceerd budget de kwaliteit van zorg verbeteren. Onder andere door het efficiënter organiseren van de voedingslogistiek. Maaltijden in gezondheidszorginstellingen hebben een zeer slechte reputatie. AMC streeft naar gastvrijheid en wil optimale voeding verstrekken aan patiënten ter bevordering van een voorspoedig herstel en ter voorkoming van complicaties.

Het probleem, onderzoekskader en doel van het onderzoek

Om inzicht te krijgen in de logistieke problemen met betrekking tot de voedselvoorziening van het AMC hebben we een vooronderzoek uitgevoerd. Door middel van interviews, observaties, en meelopen op een verpleegafdeling hebben we de kenmerken van AMC's voedingslogistiek op het gebied van proces, prestatie en planning & controle geïdentificeerd. We hebben gebruik gemaakt van het framework van Hans, Van Houdenhoven & Hulshof (2011) om de planning en controle functies, en de interacties hierin, te structureren. We hebben de huidige prestatie van AMC's voedingslogistiek beoordeeld door elf KPIs te operationaliseren tot meetbare eenheden.

Uit analyse van de logistieke problemen blijkt dat de belangrijkste onderzoeksvraag is of producten het beste centraal of decentraal opgeslagen kunnen worden. Op basis daarvan hebben we besloten ons onderzoek te richten op het voorraadbeheer van de groothandelsfunctie van voeding voor klinische patiënten in het AMC. Het doel van dit onderzoek is het meten van de huidige prestaties van het voorraadbeheer met betrekking tot groothandelsproducten en deze te verbeteren door het efficiënter organiseren van de logistiek. We hebben daarom onderzocht welke stappen moeten worden genomen om de huidige voedingslogistiek meetbaar te verbeteren en om een weloverwogen keuze te maken over de te organiseren interventies.

Methode

We hebben de kenmerken van AMC's voorraadbeheer betreffende het proces, de prestatie en planning & controle geïdentificeerd, zoals we dat ook in ons vooronderzoek gedaan hadden. Om inzicht te krijgen in de huidige prestaties van het voorraadbeheer hebben we twaalf prestatie indicatoren gedefinieerd, deze geoperationaliseerd tot meetbare eenheden, relevante gegevens verzameld en een prestatiemeting verricht. Op basis van de literatuurstudie, deskundige adviezen en onze eigen kennis en ervaringen hebben we interventies voor het AMC opgesteld. Deze interventies hebben we geëvalueerd op basis van acceptatie en evaluatiecriteria, waarnaar we tot één beste interventie kwamen. Waarom deze interventie het meest geschikt is om het voorraadbeheer van de groothandelsfunctie te verbeteren is beargumenteerd. Tevens hebben we de beperkingen in beschikbare data bediscussieerd. We hebben een stappenplan ontworpen waarin de stappen uitgelegd worden welke ondernomen moeten worden ter implementatie van de interventie in de praktijk. We hebben de uitkomsten gegeneraliseerd, zodat ook andere gezondheidzorginstellingen hun voordeel kunnen doen met dit onderzoek.

Resultaten

AMC's voedingslogistiek kent vijf fasen: voorraadbeheer, bestelling, levering, intern transport en afdeling gerelateerde activiteiten. De voornaamste problemen in dit proces hebben betrekking op de prestatie indicatoren derving, intern transport en de leverbetrouwbaarheid.

Uit de literatuurstudie is gebleken dat de huidige voorraadmodellen niet aansluiten bij de voedingslogistiek in ziekenhuizen. Echter is de achtergrondinformatie in boeken en artikelen bruikbare informatie betreffende het efficiënter organiseren van de voedingslogistiek en om de impact van verschillende interventies te beargumenteren. Belangrijke aspecten zijn het vinden van de optimale balans tussen beschikbaarheid van producten en derving, te anticiperen op de resterende houdbaarheid van producten en het toepassen van gecentraliseerde opslag en controle voor de gehele logistieke keten van voeding, om onnodige derving en tekorten te verminderen, terwijl de veiligheidsvoorraad die nodig is om te voldoen aan een bepaald service level ook zal reduceren. We hebben vijf interventies opgesteld ter verbetering van het logistieke proces en daarmee het voorraadbeheer van de groothandelsfunctie van voeding:

1. Gecentraliseerde veiligheidsvoorraad alwaar BBWs worden aangevuld.
2. Gecentraliseerde veiligheidsvoorraad alwaar trolleys worden aangevuld welke vervolgens langs de afdelingskeukens gaat om de BBWs aan te vullen.
3. Veiligheidsvoorraad en aanvullen van BBWs gecentraliseerd per verdieping. Tevens gebruikmakend van zijdelingse overslag.
4. Veiligheidsvoorraad gecentraliseerd per verdieping, aanvullen van BBWs met behulp van een trolley. Tevens gebruikmakend van zijdelingse overslag.
5. Decentrale veiligheidsvoorraad per afdelingskeuken

Uit de evaluatie is gebleken dat decentralisatie per afdelingskeuken niet rendabel is vanwege het hoge percentage derving, de hoge voorraad kosten en voorraadwaarde. Interventies 1 en 2 profiteren van centralisatie doordat minder veiligheidsvoorraad nodig is om te voldoen aan een bepaald service level en processen worden efficiënter door het benutten van schaalvoordelen. Er zal een omslagpunt zijn waarbij centralisatie per verdieping opweegt tegen volledige centralisatie. Met de huidige kennis is het onduidelijk en niet te meten wanneer dit zal gebeuren. Echter verwachtten we dat interventies 3 en 4 zullen opwegen tegen interventies 1 en 2 vanwege de hoge personeelskosten in interventie 1 en 2 door de vele handelingen en lange afstanden waarover goederen intern getransporteerd moeten worden, wegens de toename van tekorten, het intensieve gebruik van de liften en om het feit dat de voorraad ver buiten het bereik van de afdeling is opgeslagen. Voordelen van centralisatie zoals schaalvoordelen, beter afstemming tussen vraag en aanbod, kleinere voorraden en de reductie van derving zullen niet opwegen tegen de genoemde nadelen. De mate waarin interventie 3 en 4 voldoen aan de MosCow regels, de beoordeling per KPI en de impact van het implementeren van een van deze interventies maakt dan ook dat deze interventies voorkeur hebben boven de andere drie genoemde interventies.

We hebben de interventies 3 en 4 met elkaar vergeleken. Interventie 3 kent een hogere beschikbaarheid van producten tegen een lagere voorraadwaarde en een lager percentage derving, terwijl er niet geïnvesteerd hoeft te worden in een trolley en voedingsassistenten de enige medewerkers zijn die toegang hebben tot de keuken, in overeenstemming met de hygiëne-eisen. Tevens zal deze interventie leiden tot grotere kostenbesparingen vergeleken met de andere interventies.

Het organiseren van de processen zoals voorgesteld in interventie 3 zal leiden tot significante verbeteringen voor het AMC in vergelijking met de huidige situatie. De meeste scores in de categorieën kwaliteit, snelheid en betrouwbaarheid zullen toenemen, waarbij de scores van de overige indicatoren naar verwachting minstens gelijk blijven. Ten behoeve van de gastvrijheid verwezen we naar het adviesrapport van IFC, waarin verschillende scenario's worden aanbevolen op basis van service levels. Interventie 3 vormt een uitstekende basis voor het verhogen van de gastvrijheid middels een van deze scenario's.

Conclusie

In dit rapport hebben we beschreven hoe de prestaties van voorraadbeheer van groothandelsproducten voor de klinische patiënt van het AMC berekend kunnen worden en hoe men deze prestaties kan verbeteren door het efficiënter organiseren van de logistieke functie, om een hoger niveau van dienstverlening te bereiken en om de gastvrijheid te verbeteren. Het ontbreken of niet beschikbaar zijn van gegevens in het AMC had negatieve gevolgen voor het uitvoeren van een prestatiemeting, maakte het moeilijker om inzicht te krijgen in verbeteringen en om een passende interventie te beargumenteren. Op basis van de huidige inzichten is gebleken dat interventie 3 zal leiden tot significantie verbeteringen voor het AMC. Deze interventie pakt de belangrijkste problemen aan, zal het hoogste rendement behalen, is uitgerust met de beste ingrediënten voor een best practice, sluit het beste aan op de acceptatie en evaluatie criteria en is daarmee het meest geschikt voor het AMC. We hebben een stappenplan gepresenteerd en de stappen besproken die moeten worden genomen om de huidige voedingslogistiek van AMC's groothandelsproducten meetbaar te verbeteren en om een weloverwogen keuze te maken over de te organiseren interventies. Ook wanneer AMC besluit om op de huidige manier verder te gaan bevelen we aan om toch een aantal elementen beter te organiseren ter ondersteuning van het proces. We raden aan om bruikbare gegevens te genereren, gebruik te maken van voorspellingen van toekomstige consumptie, het verminderen van de voorraadwaarde, creatief om te gaan met producten die aan datum zijn ter voorkoming van derving en om te leren van de innovatieve logistieke processen in de detailhandel. Voor verder onderzoek bevelen we aan om een voorspellingsmodel te ontwikkelen en onderzoek te doen omtrent die problemen die voortvloeien uit het verlagen van voorraden. Tenslotte raden we aan om de voedingsservice te evalueren na het organiseren van de voorgestelde interventies door gebruik te maken van de gastvrijheidsbarometer van het IFC.

Food logistics at Academic Medical Center

PART I

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Chapter 1

Introduction

AMC wants to improve its food service for inpatients. Therefore, they invite IFC, which deals with the continuous development of culinary concepts, to research the hospitality of the food services in AMC. Later on, the University of Twente is involved in this collaboration, because of the expertise in logistics and to support the development of an innovative logistics process.

This report is split up in three separate parts. This part, Part one, is a preliminary research and describes the current logistic processes concerning food in AMC.

Chapter 1 describes how to identify the problems. Section 1.1 explains the motivation for this research, Section 1.2 describes the research context, Section 1.3 elaborates on the problem description, Section 1.4 gives the research objective, Section 1.5 formulates the research questions, and Section 1.6 discusses the methodology which will be used to describe the current situation.

Chapter 2 describes the process of AMC's food logistics and identifies the main problems in this process, with the aim of understanding the current performance of the food logistics in AMC.

Chapter 3 gives an identification of the core problem and describes the transition to the next two parts.

In Part two, author Wendy Haas will perform a research on how to measure the current performance of AMC's food logistics to improve this performance by organizing the logistic function concerning food more efficiently.

In Part three, author Theo Lescure will perform a benchmark study to optimize AMC's food logistics. This part is still under construction.

1.1 Motivation for this research

Hospital food has a reputation of predictable awfulness (Bender, 1984). 23 years later, patient meal delivery systems in health care still produces low patient satisfaction in comparison to the scores achieved by other hospital services and departments (Schirg, 2007). Customer expectations have risen over the years. Patients are expecting options and quality to be the norm, rather than being surprised by it (Aase, 2011). Reducing waste has become a priority in hospital food service management (Williams & Walton, 2011). The challenge for health care organizations during the upcoming decades is to deliver more patient care of at least the current quality, while efficiently allocating less financial and human resources.

1.2 Research context

We perform this research at the Academic Medical Center (AMC) in Amsterdam, one of eight academic hospitals in the Netherlands. An academic hospital, like AMC, has three major tasks. Its primary task is patient care. Furthermore, since the hospital is linked to a university, it educates and trains medical students, and carries out medical research. Finally, AMC performs top referent care: special, mostly expensive, complex, diagnostic procedures and treatments. Their focus is so much on research and education, that the knowledge and specialization level of the hospital are higher than within local hospitals. It is because of this specialty that patients are referred to an academic hospital by their physician. AMC treats 56,000 patients annually. As general hospital for the catchment area, but the majority, 60% of the patients, visit AMC for top referral patient care. In 2011, AMC counted 1,002 hospital beds, performed 387,549 outpatient visits, 31,086 day care admissions, and 30,129 clinical admissions accounting for 202,560 patient days (AMC, 2012).

AMC (2012) states that 'a professional organization that wants to be innovative, should value the improvement of various internal processes higher than the apparent convenience of old habits'. This statement creates the mission and policy principles for the upcoming five years. AMC wants to distinguish based on quality improvements using research. A solid financial policy is one of the important boundary conditions in realizing strategic goals. Therefore they collaborate with VU Medical Center (VUmc) into 'Alliantie AMC-VUmc' (AMC & VUmc, 2011).

AMC's department 'directorate services' is occupied with all logistic functions regarding food. They aim to provide the best hospitality for patients and staff, which they tend to achieve with efficient logistic functions and movements. Their vision on the food provision is to provide an optimal amount of nutrition to the patients to speed up their recovery and prevent complications (IFC BV, 2012). These mission and vision statements will prove important for our research as our interventions are useful only if they are in accordance with these statements.

1.3 Problem description

Renovation plans of the hospital building makes that the current food logistics has to be analyzed. The aim is to make improvements on the short term and to advice AMC which steps to take to make deliberate choices on how to organize a new food concept. Analysis of AMC's current food logistics shows that there is a discrepancy between the current situation and the desired situation. However, the main problems of AMC's food logistics are not known beforehand. Therefore, this part of our report focuses on mapping the current situation.

1.4 Research objective

Objective of this research is to map the performance of AMC's food logistics and to identify the current problems, in order to make a contribution in organizing this logistic function more efficiently as focus of the studies in parts two and three of this report.

1.5 Research questions

1. **What is AMC's current performance concerning food logistics?**

To have an overview of the current performance we observe the activities of AMC's food logistic processes and interview stakeholders.

2. **What are AMC's main problems in the process of food logistics?**

We make a problem cluster based on the answers as identified in the previous research question. By defining the main problems we create delimitation within this research.

Chapter 2 elaborates on these two research questions. Based on the identified problems in the second research question we focuses on finding improvements to the current performance. To justify which problem we choose to focus on, Chapter 3 investigates which problem, that can be influenced, has the highest contribution to solving the main problem.

1.6 Methodology

We undertake three separate activities to reach information on the three aspects process, performance, and planning and control, and to identify problems. First, we perform a stakeholder analysis to identify the persons to be interviewed. Based on the interviews and our observations obtained during tours of the hospital, we have made a process flow of the current food logistics of AMC, including information about product mix, demand, and supply. Second, we use the framework for health care planning and control of Hans, Van Houdenhoven & Hulshof (2011), developed for mapping organizational structures within hospital or health care organizations. This framework provides guidelines to systematically map details of processes and gives us information on the planning and control activities of AMC's food logistic function.

Third, we bring in theory about the performance measurement for which we need to elaborate further on stakeholders and identifying the Key Performance Indicators (KPIs). We describe how to provide a structured overview of these problems by making a problem cluster as method to answer research question 2. Lastly, we make a bridge to the next chapter on how to use the theories in practice.

We demarcate our research based on a consideration between the problems. Part two and three shows which problems to solve to realize the highest contribution at the lowest costs.

1.6.1 The business structure

According to Slack, Chambers & Johnston (2007), an organization can be visualized as in Figure 1. In its basic form, an organization can been seen as a 'black box' that transforms resources into an output. Based on the output one can measure how well, efficient, and effective this black box has operated, for example to measure the improvements after implement interventions.

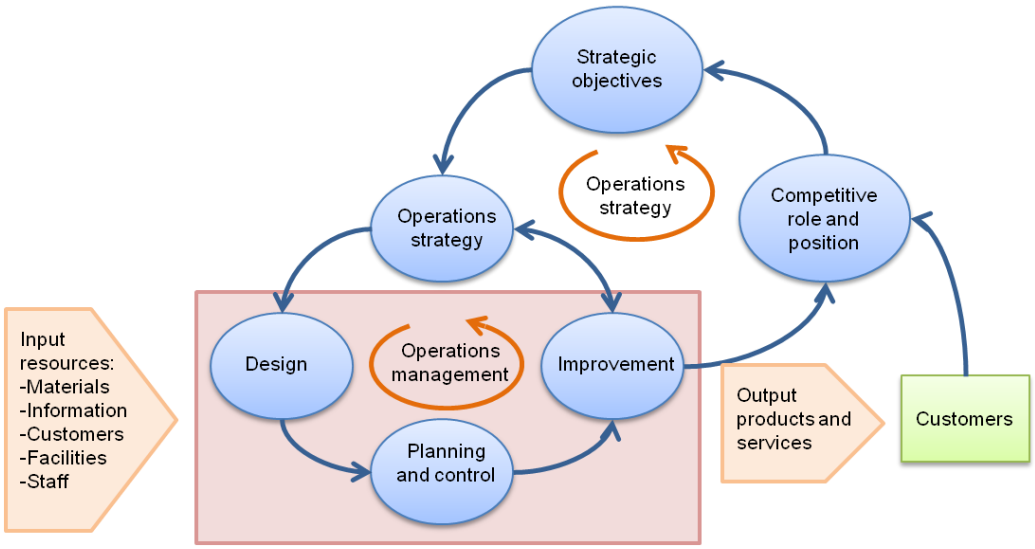

Figure 1: Operations Management Map

In order to improve the output of an organization we will analyze the activities in the black box. Then we will look at the process (how are things done?) and the planning and control activities (how is the process planned and controlled?) within the organization. In practice, changing the planning and control part is of most influence as this part decides which process to use.

1.6.2 A framework for mapping the current planning and control functions

The most well-known frameworks for planning and control within business are only focused on specific managerial functions (Hans, Van Houdenhoven, & Hulshof, 2011). This has the drawback that the frameworks will not behave adequately in practice. Therefore, Hans, Van Houdenhoven & Hulshof (2011) made a proposition for a framework that focuses on all managerial aspects at once and focuses on use within the health care sector as shown in Figure 2.

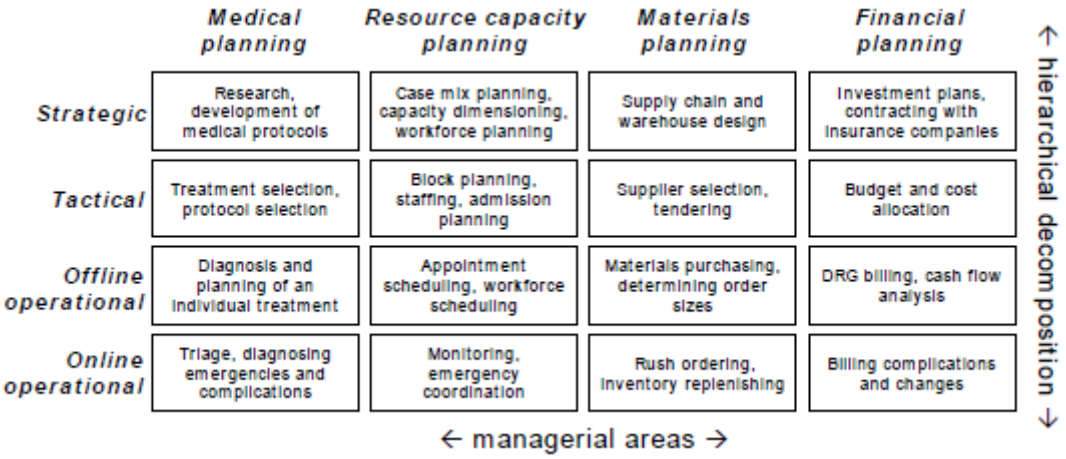

Figure 2: The framework for health care planning and control

An explanation of each of the 16 squares; The managerial areas have the following meanings:

- **Medical planning:** Commonly known as technology planning. Its function is the planning and control decision making and implementation of technologies and heuristics to smoothen the process.
- **Resources capacity planning:** Means all decisions regarding the planning of the renewable resources. So, a resource that is used and will stay available for use, like employees.
- **Materials planning:** Materials planning means the non-renewable resources. These are the resources that will be depleted after the process ends.
- **Financial planning:** This aspect of the framework addresses how the organization should manage its costs and revenues to achieve its objectives.

The hierarchical decompositions on the vertical axis have the following meanings:

- **Strategic:** Structural decision making. Decisions that are the bricks and cornerstones of the organization, like the mission statement of the organization.
- **Tactical:** The tactical level is the most intangible level. There is less uncertainty about the future events as it is at the strategic level, but there is still more uncertainty then at the operational level. This level has more flexibility in decision making then the operational level.
- **Operational:** The area that is based on the here and now. It is split into two subcategories:
    - *Offline*: The in-advance, day to day planning and decision making on a short term. There is almost no flexibility and one has to work with the current resources.
    - *Online*: The decision making a la minute.

In Chapter 2 we will use the framework to describe the current situation of the planning and control activities of AMC's logistic function concerning food, for reference department G5.

1.6.3 Performance measurement

In order to know what criteria fit a good performance indicator, one should identify properties of well-defined performance indicators are. The literature learns that characteristics and appropriateness of indicators differ based upon the purpose of measurement (Behn, 2003; Franceschini F. G., 2006; Franceschini, Galetto, Maisano, & Mastrogiacomo, 2008; Parker, 2000). KPIs meant to improve should give insight and understanding in behavior of employees and how this behavior can be influenced (Behn, 2003). Managers, for example, need indicators which reflect how their own activities influence behavior of their employees. Performance indicators are only useful for measuring systems when they have goals to reach. The goals of each performance indicators should then be reached by performing activities which aims influencing the behavior of employees in order to improve the outcome of the organization.

1.6.4 Stakeholder analysis

To identify the determination of stakeholder positions we use the typology developed by Mitchell, Agle & Wood (1997). This typology classes stakeholders based on three key attributes: Power, Legitimacy and Urgency. Power means the influence to change an organization. Legitimacy stands for connections of a stakeholder with the organization. Urgency means how soon a situation should change, regarding to the stakeholder. Combining these attributes identifies the type of stakeholder. Having just one attribute means low priority from the point of view of that type of stakeholder. Priority is high when all three attributes are present. Then, the stakeholder can be defined as definitive (Mitchell, Agle, & Wood, 1997).

1.6.5 Theory on KPIs

We choose to cluster the KPIs based on the five basic performance objectives by Slack, Chambers & Johnston (2007): Quality, Speed, Dependability, Flexibility and Costs. This to structure the KPIs and create a tightly defined set of objectives that relates specifically AMC's logistic function concerning food. Quality means the consistent conformance to customers' expectations. Speed stands for the elapsed time between customers requesting products or services and receiving them. Time aspects as throughput times from ordering to receiving goods to distribution to the individual patient will be taken into account. Dependability is delivering, or making available, products or services when they are promised to the customer. Flexibility is the degree to which an operations process can change what it does, how or when it is doing it. Costs could be split up in the costs of stock, consumption, ratio losses products by concerning the date, personnel, and overhead (Slack, Chambers, & Johnston, Operations Management, 2007).

Aside from clustering the KPIs according to the performance objectives, we formulate the KPIs so that they meet the SMART requirements in order to be a useful KPI. SMART means Specific, Measurable, Attainable, Relevant and Timely. If one of these requirements is not met, KPIs are incorrect (Bovend'Eerdt, Botell, & Wade, 2009; Shahin & Mahbod, 2007).

1.6.6 Identifying KPIs

To identify the relevant KPIs for AMC and receive a snapshot of the current processes we hold a survey with the stakeholders (Kelly, Clark, Brown, & Sitzia, 2003). We use face-to-face interviewing, because explanation of the question from both sides is necessary. The downside of face-to-face interviewing is that respondents could give social-essential answers. Good information on forehand about the independency of the researcher, and what will occur with the results, is used as a way to prevent this (Emans, 2002). Our interview is based on open ended questions only, since these kind of questions give more response and better information on the question than other ways of interviewing, such as multiple choice. Open-ended questions are more complete and clear, and standardization afterwards makes comparison of the results possible (Emans, 2002). To compare the results it is essential to interview the different people in the same way based on a structured questionnaire. Bias of the interview is prevented by evaluating the interviews afterwards based on the validity, completeness, and relevance. Ask for explanations, repeat questions to clarify, repeat answers, and summarize the results are ways to validate the answers of the respondents and make them more reliable. Finally, the conversation afterwards gives insight in rightness of the answers, because the respondent uses this moment to optimize his or her part of the interview (Emans, 2002).

1.6.7 The problem cluster

With the described methodology we gain insight in the current situation and the current problems. To order these problems we use problem clustering. Within the problem clusters, arrows are used to show the relations between cause and effect. At the top of the problem cluster is the main abstract problem as usually given by the problem owner. From there one should move backwards across the causes. The revealed problems will become abstract and measurable. To identify the problems we keep track of four guidelines (Heerkens & van Winden, 2012):

1. When possible preferably takes a cause as problem and not its created effects.
2. Do not continue to move back about causes until you reach the big bang. Stop when reaching problems that cannot be influenced because they happened to far in the past.
3. Only those cause-and-effect relations of which you are sure should be present.
4. From the problems that remain, choose the one that will have the most expected benefit from solving the main problem as defined by the problem owner.

As the problem cluster is subdue to subjectivity, looking back at the problem cluster and making changes due to new insights is a must. In order to judge the problems, we make use of KPIs as method to measure whether the logistic functions performs closer than the wanted threshold after the implementation of our interventions.

1.7 How to implement the methodology into our research

In order to find problems within AMC's logistic function concerning food we need to understand the process, performance, and planning and control activities, or the black box of Figure 1. Basically, finding out how the process works means, we have to stand in AMC's hallways and check what actually happens. As IFC has already done some intensive research on processes, we can use a lot of their data and collect the missing data. We use these data also to fill in the framework for health care planning and control to get insight in the planning and control function concerning AMC's food logistics. However, major part of this table will be filled in based on interviews with the stakeholders. To measure current performance we need to find out what KPIs are found most important by the stakeholders and rate the indicators in order of importance. Once we have a flowchart of the process, the filled in framework of the planning and control activities, and a measurement of the current performance, we use problem clustering to map the current problems in AMC's food logistics as elaborated in Chapter 2.

Chapter 2

Current situation

In order to improve the output of an organization we will analyze the activities within the 'black box'. This box has to be subdivided into a series of events: Design, Planning & Control and Improvement. Section 2.1 focuses on the design of the process, Section 2.2 discusses the current performance and identifies the KPIs, Section 2.3 explains the planning and control activities of the food logistic processes. Section 2.4 gives our problem cluster.

2.1 The logistic process of foods

Analysis of the current situation is based on stakeholder interviews and our observations of the logistic processes. We distinguish between the processes of wholesale and bread (decentralized storage), warm meals (centralized storage), and supplier logistics. Appendix I shows the flowcharts of these processes with detailed information, also a layout of the kitchen at unit G5 is given. Figure 3 shows a helicopter view of logistic processes of wholesale and bread.

Figure 3: Logistic process wholesale and bread

Stock management is the start and end of the cycle. Based on safety stock and expected demand, new stock is ordered from the supplier van Hoeckel. In the early morning orders arrive at the Central Goods receipt Office (CGO) of AMC and are distributed to the correct units by the logistic employees. At the unit kitchens orders have to be unpacked and stored. AMC uses bread serving trolleys (BBWs) to distribute the breakfast, lunch, beverages and snacks over the wards.

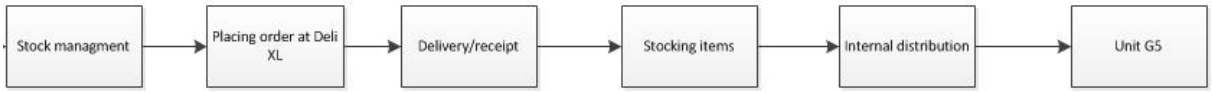

Figure 4: Logistic process warm meal

Figure 4 shows the global logistic process of the warm meals, which are stored centrally, as main difference with the wholesale products. The internal distribution has more handling activities because each evening the meals must be order picked by warehouse employees before the logistic employees can distribute to the units. So, in this process the cross docking activities has to be done internally.

Figure 5: Logistics order picking at the supplier of the wholesale

We have visited the wholesale supplier 'Sligro', which made use of digital technology and runs smoothly on their order portal 'Slimis'. Checks are done randomly and if there is ordered an unexpectedly large amount of a product. The system creates order picking lists automatically and warehouse employees pick the orders per unit. The next morning, near before the trolleys are sent, freeze products are added. The trolleys are put into the trucks which brings the orders to AMC. Figure 5 shows the order picking process at Sligro. Table 1 provides information on which days each of the products are ordered and delivered in normal settings.

	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue
Warm (order)									
Warm (delivery)									
Wholesale									
Dairy (order)									
Dairy (delivery)									
Chilled (order)									
Chilled (delivery)									
DKW (order)									
DKW (delivery)									
Freeze (order)									
Freeze (delivery)									
Bread (order)									
Bread (delivery)									

Table 1: The order and delivery days of the different food products at AMC.

2.2 Performance of AMC's food logistics

The current performance of AMC's food logistics is not currently known and could not be measured easily, due to a lack of information. This section describes which (type of) stakeholders are involved in the process and how to measure the performance of the current process based on the KPIs as given by stakeholders. This enables us selves to conduct a zero measurement.

2.2.1 Stakeholders

With the manager patient services and definitive stakeholder M. van der Maat, we discuss which stakeholders should be included. Appendix II gives reasoning of the determination of stakeholder positions based on the stakeholder typology. Table 2 shows the identified stakeholders. Further explanation of stakeholder determination is confidential and shown in Confidential Appendix I.

Function of Stakeholder	**Type of Stakeholder**
Manager Patient services	Definitive Stakeholder
Staff advisor patient services	Discretionary Stakeholder
Manager logistics service center	Dominant Stakeholder
Project manager logistics directorate services	Dominant Stakeholder
Administrative Assistant at Basic Administration Directorate Services	Demanding Stakeholder
Floor manager	Dependent Stakeholder

Table 2: Stakeholders

2.2.1 Performance measurement

We conduct face-to-face interviews with stakeholders to identify KPIs, see Appendix III.2. The downside of face-to-face interviewing is that respondents could give social-essential answers. To inform stakeholders, to set the mindset of the interviewees in the right direction, and making it easier to reach our goal (Emans, 2002) we mail about the aim of our interview, see Appendix III.1. During the interviews we respond on the given answers to obtain additional information (Fowler & Mangoine, 1990).

If we get permission, we record the interview to replay the interview and to prevent the application of an interviewer judgment about the answers (Fowler & Mangoine, 1990). Responses from the interviews are woven throughout the report while the exact answers are kept out of this report as some of the participants wanted to stay anonymous.

2.2.2 The Key Performance Indicators

Table 3 gives an overview of the KPIs. Further elaboration and definition is in Appendix IV.

Performance objectives	KPIs
Quality	Employee satisfaction
	Customer satisfaction
	Discrepancy between demand and assortment
Speed	Cycle times
	Time efficiency of employees tasks
Dependability	Amount of unavailable product from the assortment
	Amount of complete and on time internal deliveries
	Time fluctuations in service rounds
Flexibility	Flexibility in product and service
Costs	Amount of thrown away products
	Amount of food consumed by others than patients
	Costs per patient per unit

Table 3: The Key Performance Indicators

Performance indicators are not equally important. Therefore, management should assign priority to the different indicators (Fortuin, 1988). This will be done in Part 2.

2.3 Planning and control of the process

Table 4 shows the filled planning and control framework for the food logistics within AMC. This section discusses each of the attributes placed on the framework. Appendix V elaborates further on each of the attributes and explains the connections between each square of the matrix.

		Managerial areas			
		Medical planning	**Resource capacity planning**	**Material planning**	**Financial planning**
Hierarchical decomposition	**Strategic** (Long-term policy +/- 5 years)	Research, development of nutrition; Choice of IT system.	Renovation of the hospital wards; Lay out based on new food concepts dependent on the service level as determined in policy.	Storage design: Decentralized storage of wholesale products on ward pantries and BBW. Centralized in case of warm meals.	Investment plans for the new food concept when renovating the wards; Project SPA in the kitchen.
	Tactical (Within a period of one year)	AC/MP: Assortment determination.	FM/FFE: Staffing (day noon shifts) IB: Maintenance contract of BBW. Rules on how to fit up the tray. Management: distribution of tasks / responsibility in distribution process. MP: Overall staffing	Inventory management: stock levels related to storage design and service level Management/Purchasing department: Supplier selection, based on the program of requirements; FAD: Match the assortment with the demand of the patients; Tendering for outsourcing warm meals; FAD: Determining order size and frequency. Management/purchasing: Contact with suppliers and make agreements about ordering process, delivery time, frequency, method of delivery etc.	Management/Purchasing department: Financial contract with suppliers; Employee costs; The way of billing (now bit devious/ paper use).
	Operational offline (Daily)	N: Individual treatment selection, by filling in a food request form.	FM/ FFE: Roster fixed/non fixed workforce; BBW usage/availability; FA: Control night refrigerator . FA: fit up the trays for the warm meals.	FA: Determining order sizes wholesale products by using min max lists; FAD: Control and posting of wholesale orders; FAD: Ordering of warm meals G: Receipt wholesale products. D: Internal distribution of wholesale products FA: Stock replenishing; FA: Preparing meals. W: Storage, stocking and control of warm meals. W: Order picking of warm meals D: Internal distribution of warm meals	Costs of food losses; Costs of gas, water, light and electricity usage; BADS: Billing of order costs of wholesale products and warm meals for patients. LDC/FA/BADS: administration: (control, invoice and archiving of orders).
	Operational online (Daily)	FA: Take actions to realize nutrition intake of patients.	Anticipate on unexpected demand: FA: Communicate with FA's from other units about what each pantry has in stock; FA: Exchange of units in stock in case of food shortage on one unit; FA: Sent urgent backorder to FFE. FFE: Backorder of warm meals.	FA: Anticipate on wrong order deliveries and fluctuations in deliver times (can result in high work pressure); FA: Do not want to sell "no" to patients.	BADS/N: Bill the costs for wholesale products and warm meals for others than patients, i.e. guests and nurses.

Table 4: The completed health care framework for AMC List of Abbreviations: MP: Manager Patient services FA=food assistant, FAD= food administration, LSC= logistic service center, FM= Floor manager, FFE= first floor employee. N= nurse, AC = Assortment Commission, BADS: Basic Administration Directorate Services, B: Business administration office, G: goods receipt, W: Warehouse employees, D: Distribution, IB: Industrial Business.

2.4 Problem Cluster

We develop a problem cluster for the food logistics within AMC, to structure the identified problems and to identify the main problems. We distinguish the costs of the food logistic services and the hospitality, defined as the discrepancy between the product and patient wishes, as counterparts in the hospital food service. Costs are split up in material and personnel costs. Hospitality is split up in product, behavior, and environment. The main problems are written in a colored box. The problem cluster will justify which problems to choose as we elaborate in the next chapter.

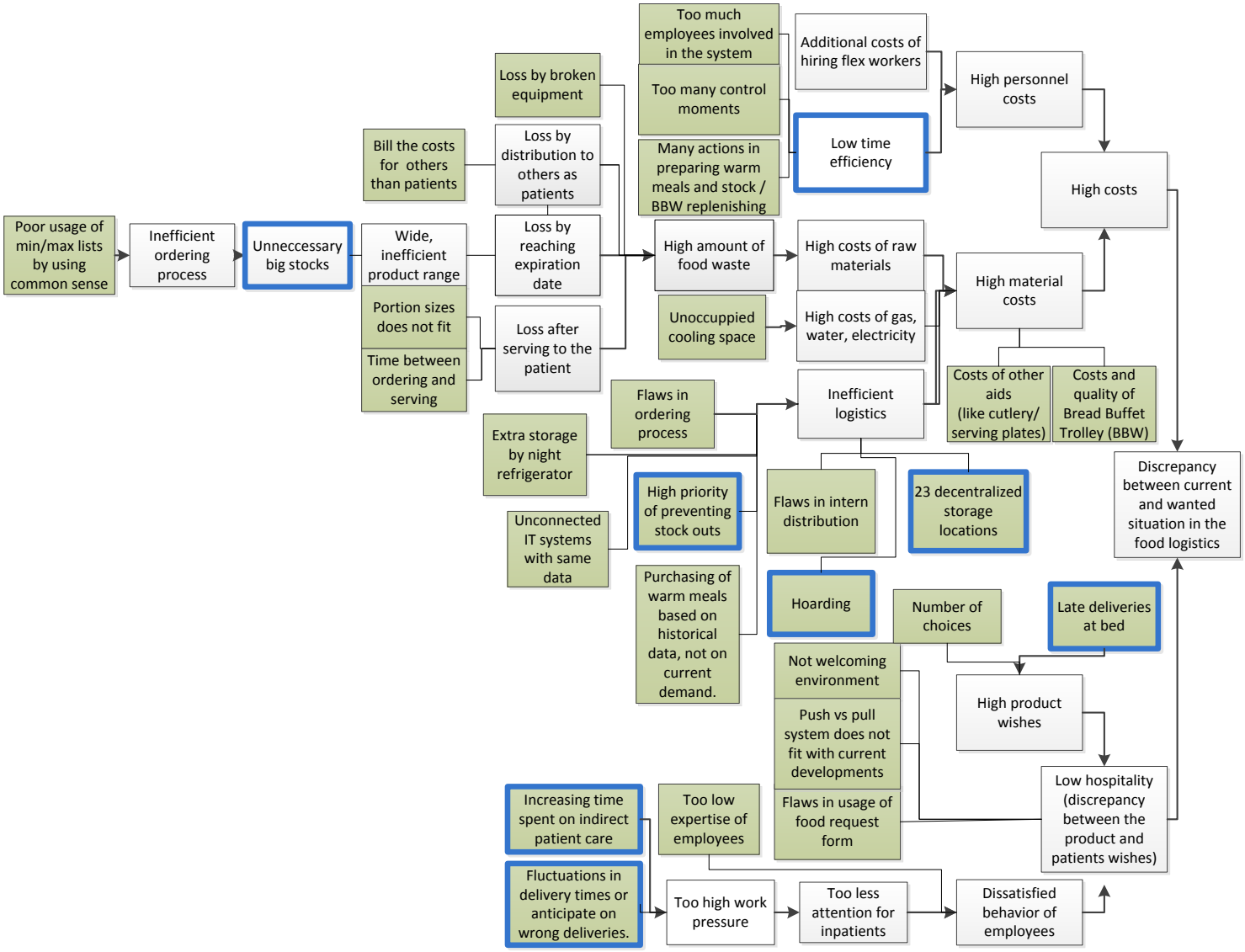

Figure 6: Problem Cluster

Chapter 3

Possibilities for further research and Conclusion of Part one

Section 3.1 analyzes the possibilities for improvements. To justify which problem we choose to focus on, we investigate which problem, that can be influenced, has the highest contribution to solving the main problem. Section 3.2 gives an conclusion on the previous chapters.

3.1 Identification of the core problem and delineation for further research

Based on the problem cluster, the core problem is the location and allocation of perishables. Related research question is whether to hold or arrange wholesale products, the BBWs, warm meals, the night refrigerator, the ordering process of meals, and the billing of improper food use on a centralized or decentralized way. In the first, author Wendy Haas will perform this research on storage policy. By narrowing the scope of this topic, the research question is: "What steps should be taken to improve AMC's current food logistics of wholesale products measurable and to make an informed choice about the organization of interventions?". Aimed to measure the current performance of AMC's food service regarding wholesale products and to improve this performance by organizing the logistic function concerning food more efficiently by changing the storage policy. In the second, author Theo Lescure will perform research on inefficiencies spread throughout the process of food service for inpatients, by making a benchmark between hospitals. Related research question is: "How to improve the process by eliminating unnecessary steps and increase its efficiency?". Major point in which time savings can be achieved is the edge where the supplier leaves its supplies at the hospital and hospital takes over the control of these supplies.

3.2 Conclusion

The purpose of Part one was to map the current processes of AMC's food logistics and to identify the main problems aiming to understand the current performance of food logistics in AMC. Chapter 1 discusses the method how this research is conducted. Chapter 2 analyzes the main characteristics of the food logistics within AMC based on the process, performance, and planning and control. We have made flowcharts of the processes and identified five main steps in the logistic process of wholesale products: stock management, ordering, delivery, internal distribution and unit related activities. In analyzing the performance of the current process we identified twelve KPIs according to the stakeholders. We have described how to perform a zero measurement of current performance, because the performance is currently not known and also not easily to measure, due to a lack of data. We have used the framework for health care planning and control to structure the various planning and control functions and their interactions. We have made a problem cluster where we distinguish the costs of the food logistic services and the hospitality, defined as the discrepancy between the product and patient wishes, as counterparts in the hospital food service. The main problem in food logistics at AMC is whether to hold or arrange the products in a centralized or decentralized way. Furthermore, the inefficiencies in the process provide opportunities for improvements. This research has helped us to define the core problem as input for further research.

Appendices

Appendix I: Flowcharts

I.1: Logistics Wholesale & Bread

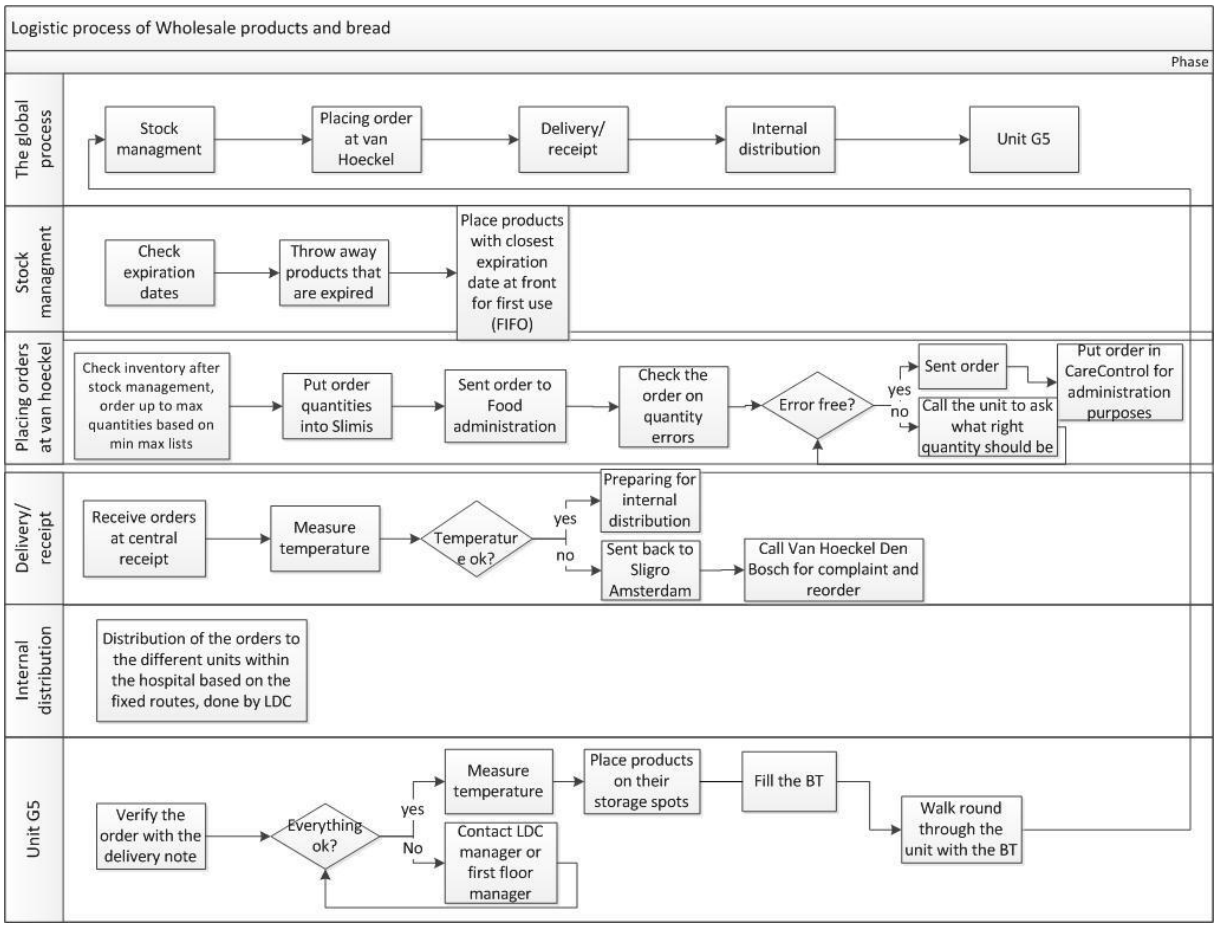

Figure 7: Flowchart of the logistics of wholesale and bread

I.2: Logistics Warm meal

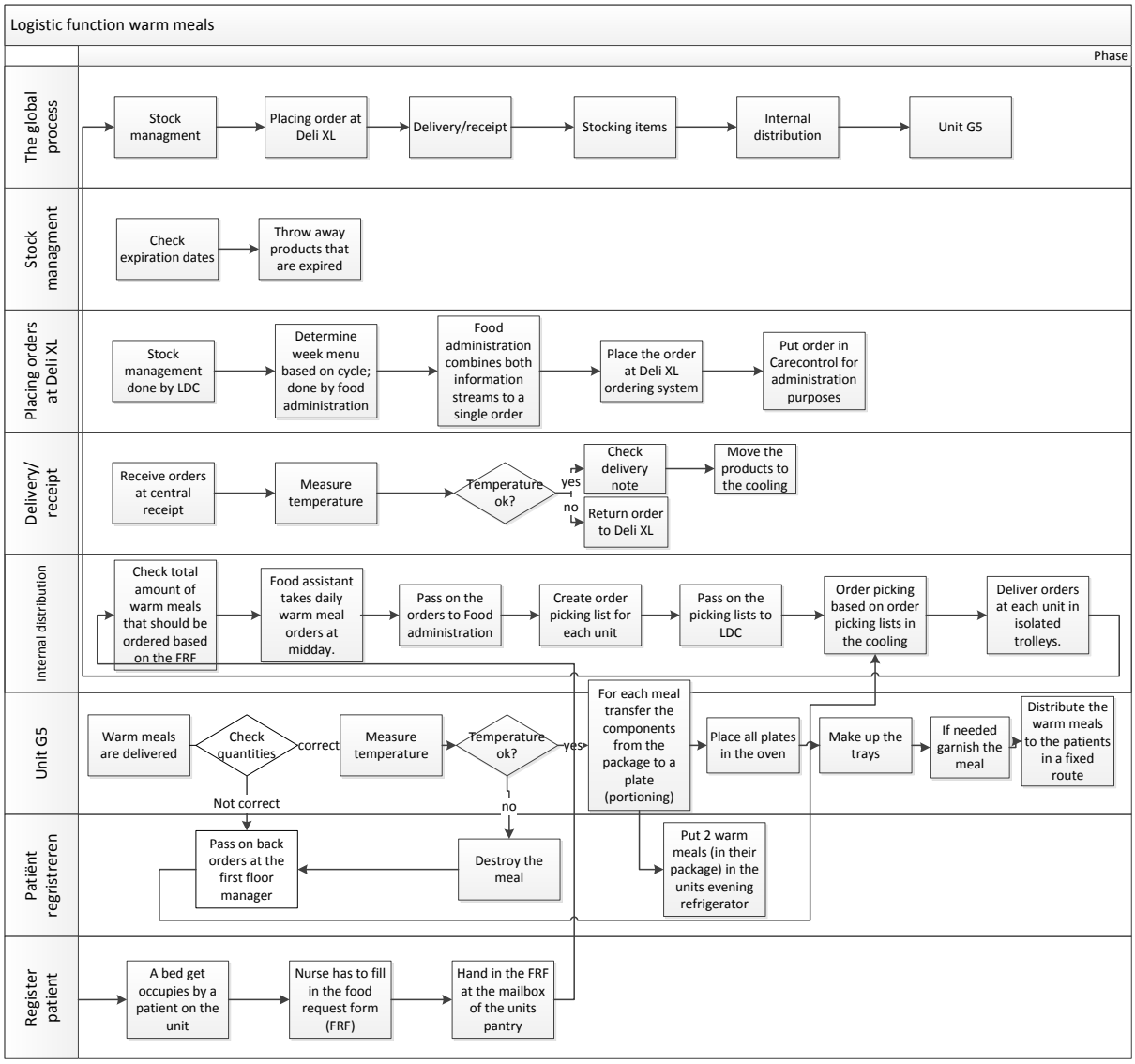

Figure 8: Flowchart of the logistics of warm meal

I.3: Lay out kitchen G5

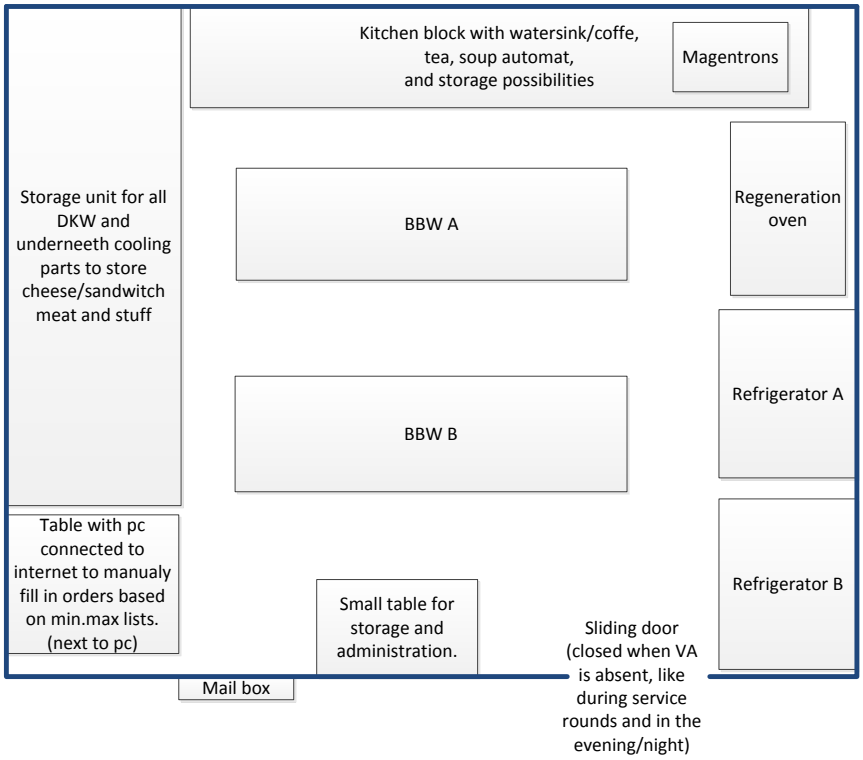

Figure 9: Lay out of the kitchen at unit G5

I.4: Logistics Supplier (Sligro)

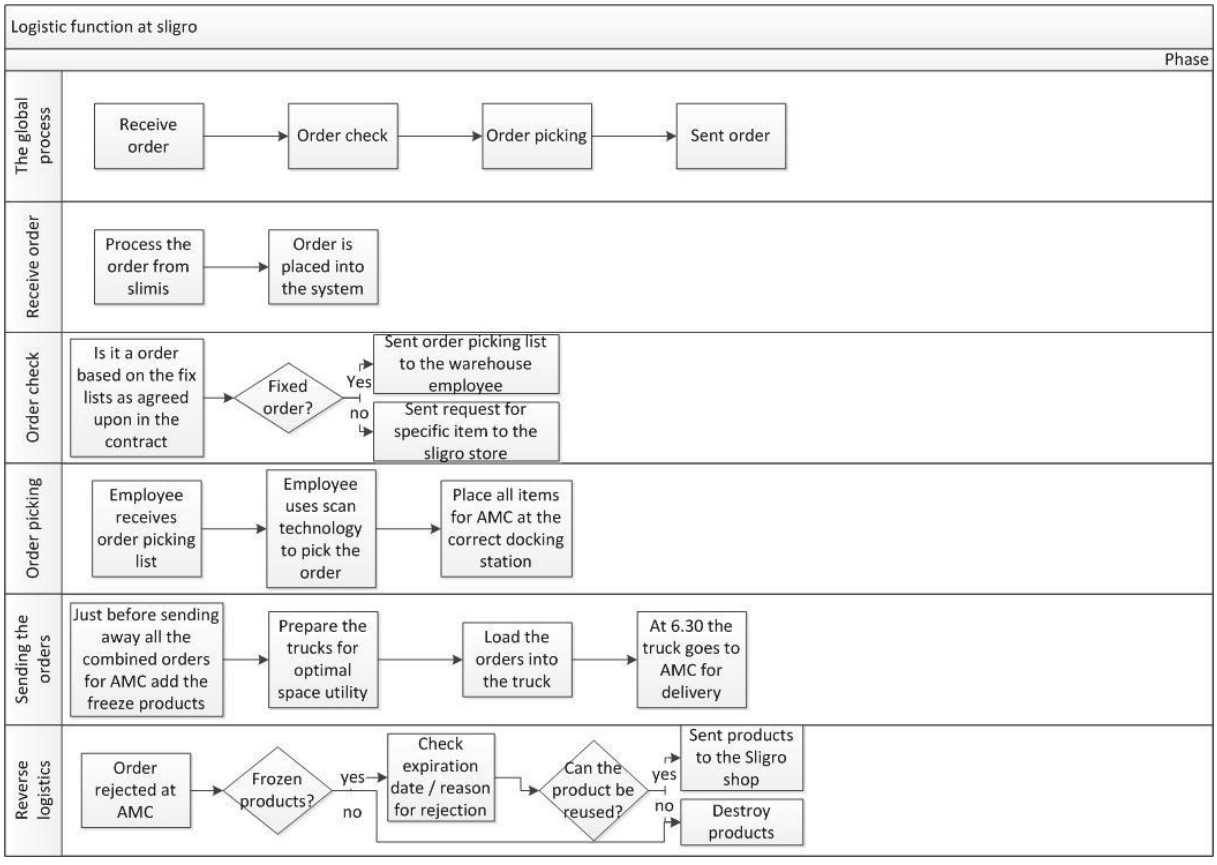

Figure 10: Flowchart of the logistic functions of the supplier

Appendix II: Stakeholder determination

Determination of stakeholder positions is done by using the typology of Mitchell, Agle & Wood (1997). This typology classes stakeholders based on the three key attributes power, legitimacy, and urgency, as shown in Figure 11.

Mr. M. van der Maat analyses the type of stakeholders based on the typology and assess the different attributes. Together with our interpretation of his argumentation we connect the different stakeholders to one of the eight types of the typology.

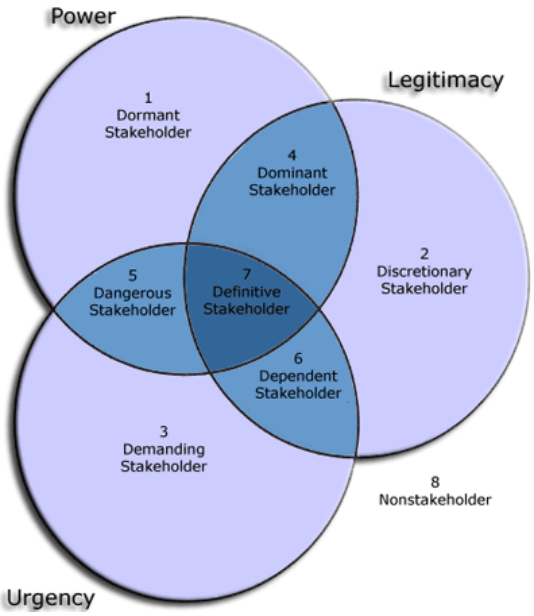

Figure 11: Stakeholder typology

Appendix III: Stakeholder interviews

III.1 Begeleidende mail

Beste medewerker van het AMC,

Wij zijn twee Master Industrial Engineering & Management studenten van de Universiteit Twente en doen onderzoek naar de voedingsservice in het AMC. Wij vragen u gaarne onderstaande tekst door te nemen ter voorbereiding op het interview wat binnenkort met u gehouden zal worden.

Aan ons is de taak voorgelegd om de huidige functies en processen rond de voedselvoorziening van de patiënten en zijn/haar mogelijke gasten in kaart te brengen. Dit zal het proces omvatten van distributeur tot aan het bord in handen van de patiënt. Nadat we dit inzicht in het proces hebben gemaakt zullen wij ons richten op verbeteringen in het proces, voor de patiënt, voor u, voor de organisatie. Hiervoor hebben wij echter uw hulp nodig.

Voor het vinden van verbeterpunten in het proces willen wij namelijk eerst weten hoe goed het proces in de huidige situatie functioneert. Dit zullen we doen aan de hand van Key Performance Indicators, ofwel KPI's. Wat? Zult u zich misschien afvragen. En vandaar dat we het hier zullen uitleggen, zodat u weet waar wij naar op zoek zijn en alvast met ons op een lijn zit.

KPI's zijn de indicatoren die volgens de stakeholders, in dit geval u, van belang zijn voor het meten van de prestaties van het proces. Via het interview met u willen wij een lijst van KPI's krijgen die wij dan in een nul-meting zullen opmeten. Hier staat de nul-meting eigenlijk gewoon voor de prestaties van het huidige systeem. Laat u vooral niet afschikken door het woord opmeten. U kunt alles waarvan u denkt dat het belangrijk is om de prestatie ervan te weten op tafel leggen. Het zal daarna aan ons zijn om alle KPI's die we van u en uw collega's ontvangen te ordenen en kwantificeerbaar te maken.

Enkele voorbeelden van KPI's: Patiënt tevredenheid, bezettingsgraad van de transportkarren, tijd van centrale voorraad naar afdeling en voorraad grootte (centraal/decentraal)

De informatie die u met ons deelt zal naar wens anoniem of anders onder vermelding van uw naam terugkomen in ons eindverslag. Dat rapport zal een adviesrapport zijn voor het AMC en tevens voor ons zal gelden als een afstudeerverslag voor onze master IE&M. Zoals net al naar voren kwam voeren wij dit onderzoek uit in opdracht van het IFC Almelo en de Universiteit Twente.

Alvast bedankt voor uw tijd.

Met vriendelijke groet,
Wendy Haas en Theo Lescure

III.2 Interview

Aim of the interview is reaching at least three performance indicators as expected by each stakeholder. As interviewers we aimed to spread these performance indicators over at least two of the five basic performance objectives.

Introduction,

What is your name? (wat is uw naam?)_____
Do you wish to stay anonymous? (wenst u anoniem te blijven in the verslag?)_____
What is your function? (wat is uw functie?)

_____

_____

How does your function relate to the food service? (hoe is uw functie gerelateerd aan de voedselservice?)

_____

_____

In what part of the food logistics are you involved? (bij welk deel van de voedsellogistiek bent u betrokken?)

_____

_____

What is your score, based on a scale 1-10, for the food logistics in general?
(Wat is uw score voor de huidige voedsellogistiek op een schaal van 1-10?) _____
On what do you base this score? (waarop is deze score gebaseerd?)

_____

What goes well/poor within the current logistic function? (wat gaat goed/niet goed in het huidige logistieke proces?)

_____

_____

What goes well/poor within the current logistic function you are involved in? (wat gaat goed/niet goed in het huidige logistieke proces in het gebied van uw betrokkenheid?)

_____

_____

What goes well/poor in coordination with the other functions within the supply chain? (wat gaat goed/niet goed in de samenwerking met de andere schakels in het logistieke system?)

_____

_____

What are, from your point of view, the factors involved in measuring the food logistics function? (wat zijn vanuit uw oogpunt gezien de factoren waarmee rekening moet worden gehouden voor het berekenen van de prestatie van de logistieke functies?)

_____

_____

Appendix IV: Elaboration of the KPIs

Quality	
Employee satisfaction	*Implementation of improvements in AMC's food logistics should at least have no negative effects on the employee satisfaction.*
	S: Several subjects include like travel distance, order lead time, work pressure; M: Travel distance: Where is the depot and what does this do with the walking distance. Order lead time: how long does it take for an item to arrive at the pantry after it is ordered. Work pressure: how many meals does a FA have to prepare for the unit. A: Employee satisfaction should be kept in mind to create support for improvements. R: Changes in food logistics could mean changes in job tasks for different employees. It is unknown how employees react on these changes. Therefore the goal is not set too high but negative effects are unacceptable. T: It is difficult to set a deadline for long time goals. Therefore it would be advised to measure the satisfaction within three to five months after implementation. So employees get used to the new situation and first flaws are solved.
Customer satisfaction	*The customer satisfaction score should be improved with 10% within three to five months after implementation of improvements in the food logistics of AMC.*
	S: Looking at the aspects product, behavior of employees, and environment. M: Based on responds to survey, as conducted by IFC. Order lead times are also important here. How long it takes from a product to arrive the patient after he ordered it. A: Customer satisfaction should be kept in mind to remain an attractive hospital within the catchment area. R: Changes in food logistics are mainly meant to improve the customer satisfaction. T: After implementation of improvements the results in improved customer satisfaction should be quick noticeable since it directly affects the food service for patients.
Discrepancy between demand and assortment	*At least 80% of the patients should be reasonable satisfied with the choice of the assortment*
	S: Ask a patient treated at unit G5, distinguish assortment of bread meals, warm meals and snacks. M: Based on responds to survey, as conducted by IFC A: Patient satisfaction should be kept in mind to stimulated nutrition intake. R: To offer hospitality it is important that AMC is aware of their efficiency of the assortment. T: Evaluation by do the same survey again will make clear if discrepancy between demand and assortment reduced.

Speed	
Cycle times: the duration a process takes from beginning until end	*The cycle times will at least not be longer than in the current situation.*
	S: distribution times of food to patient / food to section etc. M: Timing it / historical data A: Changes should not increase cycle times since this is expected as important for patients. R: Reducing cycle times will have a positive influence on the patient satisfaction. T: Measuring by a time study within three until six months after implementation.
Time efficiency of employee tasks	*Employees spent 80% of their work time on their actual job.*
	S: Employees, from floor managers to food assistants, spent more time than wanted on tasks where they are not hired for. M: Use a ratio of time spend on their actual job to total work time. Measured per employee individually for several related jobs, like food assistant, first floor employee and logistic employees. A: Set clear boundaries between the different jobs, so employees knows each responsibility and can focus on that specific tasks. If some task went wrong it is important that this will be known by management instead of having this task being taken over by another. Methods should be standardized and not dependent of the employee who is working that specific day. R: Time efficiency will lead to a more efficiently process of food logistics. T: Within three to five months after implementation of improvements the time efficiency of the several employees should be improved.

Dependability	
Amount of unavailable products from assortment	*After implementation of improvements in food logistics of AMC the amount of unavailable products form assortment should be less than 5%.*
	S: The amount of times a FA of G5 has to say no to a patient because the nutrition he/she wants is unavailable (out of stock) incl. the amount of times and time in minutes a FA have to shop at another unit with positive vs. negative result. M: Counting. A: AMC wants to provide the best hospitality for patients and an optimal amount of nutrition to the patient to speed up their recovery and prevent complications. Therefore the amount of unavailable products should be reduced to a minimum. R: Score high on this KPI will contribute to the goal of AMC as mentioned above. T: Within three months after implementation the logistic function should work well so than this KPI could be evaluated.
Amount of complete and on time internal deliveries	*The amount of complete and on time internal deliveries should be 95%.*
	S: We will look at the G5 Unit and divide the late and incomplete deliveries that arrive there by the total amount of deliveries arriving at this unit. M: Counting/historical data. A: This would be a condition in order to let the logistic function work well. R: AMC needs to rely on correct deliveries. Patients want to receive their food on indicated times. T: Within five months after implementation of improvements this percentage should be reached.
Time fluctuations in service rounds	*95% of the time fluctuations in service rounds and arrivals at the pantry should be within 2 standard deviation of the mean.*
	S: We look at the time fluctuations in start and end time of the service rounds (so breakfast/lunch/warm meals). Where it is important to search for the differences between the expected and the actual time. Including the time deviation in delivery arrivals at the pantries (internal transport). M: Time study (measure differences). Measure the mean deviation of promised arrivals each month. A: All employees together should take care of a low fluctuation in time to work as efficient as possible with positive effects on the customer satisfaction. R: Low fluctuations will make sure patients receive their orders when they expect them and thus keep patients satisfaction positive. T: Each month after implementation this value should be measured in order to know where defects occur and where to make adjustments.

Flexibility	
Flexibility in product and service	*The logistic function of food within AMC should be able to adapt for quick changes or one time requests.*
	S: We try to find how well the system reacts on unexpected events; How well does it respond to demand for products not currently in the assortment. How well is the system able to serve warm meals during irregularly times. And lastly is the system open for breakfast at later times. More customer demand operating (pull vs. push). M: Measure times needed to complete a unusual product wish, etc. A: AMC wants to provide the best hospitality for patients. Being flexible is one of the requirements the hospital should fulfill to meet the current demand of patients. R: Sometimes there are people in need of warm meals outside the usual warm meal times. To offer the correct hospitality it is important that AMC can manipulate the system a bit and make this happen. T: This should be available at all times.

Costs	
Amount of thrown away products	*The amount of thrown away products should become no higher than in the situation before*
	S: A pie chart of all thrown away food based on expiration date, defect machinery or non-eaten by the patient. M: Counting using historical data. Having different ratios based on the pie chart as mentioned. After implementation of improvements regularly counting the waste during one month. A: Improvements in the food logistics should lead to a more efficiently material planning so waste should at least be no more. R: Thrown away products lead to high costs. These costs should be saved here. T: The implementation should have direct influence on this aspect.
Amount of food consumption by others than patients	*There should be no food consumed by others than patients, until AMC decides to offer this service for a small fee. At that time the prices should be beneficial for AMC.*
	S: Split up in one ration for DKW and one ratio for warm meals. Then we can see how much of DKW and warm meals are not consumed by the intended group. M: Counting by first floor employee A: This has always been a grey area, everyone knows it happens, but there were previously no actions to prevent this while it costs AMC a lot of money. This should be an aspect of waste where to save a lot of money. R: Waste leads to high costs. These costs should be saved here. T: This could be count since the day after implementation and evaluated regularly.
Costs per patient per unit	*The integral cost per patient per unit should be at least the same. Improvements should not increase this costs.*
	S: How much does the food service for a patient cost? M:Using historical data to calculate the ration integral cost price per patient. Based on this we can compare units. Within three to five months after implementation the new ratio could be calculated and should be reduced in comparison with the old situation. A: Finding best practice of units. R: Learn from each other and analyze the differences for continues improvements. T: After three until five months after implementation the ratio costs per patient per unit should be calculated and evaluated.

Appendix V: Framework documentary

Medical planning

1. AMC wants to improve their food service continuous and invest in many research on this topic. Dietetic is responsible for the nutrition and developments on their discipline. However, the experience of patients are not only based on the product, but on the whole service including product, behavior, and environment. Therefore, in 2012 AMC invites IFC to research the hospitality of the food service in AMC. Furthermore, they invest in an internal LSS project (Lean Six Sigma) focusing on the cost differences between hospital units and the way of ordering goods. As continuation of that project they start with the project 'SPA in the kitchen' to research the improvement opportunities when using scan batches for ordering food. A student facility management researched the possibilities of a service employee instead of a food assistant for continuity in care and efficiency. Finally, students of Applied Mathematics researched the inventory control of medical disposables in AMC. These studies are done separately focusing on a part of the whole logistics. AMC uses multiple IT systems; Slimis for ordering at van Hoeckel, food application Emadows for storing patient data, CareControl for the hospitals own administration, and Bestel-XL, the ordering system for Deli XL.
   Problems:
   - *IT systems work individually, good integration misses. This causes extra handling at billing and ordering.*
   - *The environment where the patients eat is not in line with the wishes of patients.*
   - *AMC uses a push system for food services. To optimize the hospitality a pull system would be suitable.*

2. To minimize the discrepancy between the product and patients' wishes, the assortment commission evaluates and adjust the assortment on the basis of interviews with patients and the current trends in nutrition. This commission consist of a floor manager, a delegated person of the supplier, a dietician, and someone from the client board academic hospitals (CRAZ). The commission gives special attention to the menus during holiday. Since last winter, they start with a four seasons cycle for warm meals by introducing season related products. A test panel tries the new supply on forehand and determines the menus for the upcoming period.
   - *While this commission introduce many new items to the assortment, it is not exactly known how the effectiveness of the current assortment is, and which products are used so seldom that they could be substituted for another item with a higher demand. Furthermore, it appears that the menu is not known by patients. To ensure that the process meets the needs of the patient, they must be informed on the assortment on a BBW. Thereafter, the effectiveness of the current assortment should be evaluated.*

3. A food request form (FRF) is a guidance for the suitable products for that patient, which have to be filled in within 24 hours after admission of the patient. The food administration is responsible for the product information of all meals in the hospital. Together with the dieticians they made an digital overview of which products are suitable for which kind of patients. Based on this knowledge and the FRF, a food assistant can verify which products are suitable for each patient. Each change in nutrition should be mentioned by the nurse. Incorrect or too late passing this information can have big consequences for the patient.
   - *The completion of a request form is often too late or incomplete. This should have a higher priority by nurses.*

4. If there is no FRF, the food assistant consult the responsible nurse to ask what food would be suitable for that patient. Next to that, some patients need assistance with eating, which is not the responsibility of a food assistant in principle. In practice assistants take this responsibility by spending time on searching a nurse to help the patient before the meal is cold.
    - *Responsibility of assistance with eating is a structural problem on the ward and dependent of the food assistant and nurse it has consequences for the patient. Since 40% of the food assistants are flex workers, who know the patients less, there should be a structural intervention for this.*

Resource capacity planning

5. AMC has plans to renovate the hospital within the upcoming five years. A new food concept is one of the improvements to be realized by the meaning of this renovation. The lay out and investment on this concept are dependent on the service level AMC wants to realize. These aspects are determined by management based on mission statement, vision and policy.

6. AMC choses to work with one food assistant per ward per shift (with a maximum capacity of 32 patients). There are two shifts a day (from 7.15 - 14.30 and from 7.45 – 14.45). Mostly, food assistants have preferences for one of both shifts, but they should be flexible and able to do both shifts. A floor management is responsible for the food services and cleaning of a few hospital wards together. The manager patient services is responsible for the overall resource capacity planning. The workforce for the pantries is scheduled by the first floor employees in cooperation with the floor manager. In addition to the food assistants they consult the staffing agency 'Tence' or AMC flex workers (werkwinkel AMC). The AMC flex workers work a fixed amount of hours a week, aimed to create some continuity in employees on the different wards. Since a year, the first floor employee facilities floor management. They have a day and noon shift, because they have to handle operational online, for example to anticipate on unexpected demand. From a hierarchically point of view, each floor manager manages the first employees of a few units. The maintenance of the BBW is periodically organized. However, employees of the work floor experience that the BBW is often broken and leave the ward for a long time due to reparation.
    - *Increasing time spent on indirect patient care. Low time efficiency.*

7. Each two wards share a pantry. On each pantry are two food assistants. They work together but are individually responsible for a ward (south or north). 40% of the assistants are flex workers. Flexworkers from the werkwinkel are familiar with one or a few hospital wards. The continuity of Tence employees is less, these employees work on many different wards. Each pantry has two BBWs. Other materials in a pantry are: one regeneration furnace, four refrigerators, a computer, two magnetrons, two coffee bars, and one storage facility which was used as preparation desk in the past. Food assistants walk six fixed times a day a fixed route at the unit: for breakfast, lunch, dinner, and three rounds to offer some drinks and snacks. There is no possibility for patients to eat a warm meal in the afternoon. There are no rules where to start this route, near the pantry or at the end, but most assistants have some regularity for themselves. Each service round the BBW is used and after each round this BBW will be replenished. For the dinner another trolley is used for taking the serving trays separately from the BBW. This round will be done by two assistants together. Since 2012, the kitchen is closed after the working hours of the food assistants since there was many consumption by others than patients. Now, nurses can take food from the night fridge. Nurses have set a list of products which should be in the fridge.

This list differs per unit but is not dependent of the bed occupancy. Each day the fridge will be emptied and replenished by a food assistant. The products which expire will be thrown away, other products will be stored back in the BBW. This process takes a lot of time.

- *The night refrigerator.*
- *Flaws in ordering process and therefore fluctuation in delivering at the bed.*
- *Cycle times (from ordering by patient until order delivery).*
- *Too many control moments.*
- *Decentralized dishwashing.*
- *Expertise of employees.*

8. Cooperation between units by means of tracking if the products missing in your pantry are in stock on another unit and exchange these units to fulfill the wishes of patients. The first floor employee is available to realize backorders of warm meal.
   - *An overview of products in stock on the different pantries is missing.*
   - *An up to date overview would prevent a time inefficient process to tracking missing products.*

Material planning

9. The storage design of AMC is a combination of centralized and decentralized stock. Warm meals are centralized in a fridge at the basement near the CGO. Wholesale products are stored decentralized. The supplier delivers cross-docked trolleys per hospital ward. AMC chose for decentralization for wholesale as it is a big building with 95 km of walkable aisle (AMC, 2013).
   - *Decentralized stock (unit pantries).*
   - *Unoccupied cooling space.*

10. The supplier is selected based on European tendering. AMC uses different suppliers for bread, wholesale products, and warm meals. Bread is daily ordered except for Sundays. Wholesale products are delivered by cross-docking. The appointment is to order on Tuesdays, Thursdays, Fridays and Saturdays. These orders should always be placed before 11.00 AM. Delivery of these wholesale product orders happens three times a week, on Mondays, Wednesdays and Fridays. Assortment of wholesale products is set by assortment commission. Warm meals are ordered daily, delivery is two days later in the morning at the central receipt after which the meals are stored in the central refrigerator by LDC. With the exception of the Fridays, orders placed on Fridays are delivered on Tuesdays. On Mondays there are no warm meal deliveries, these happen from Tuesdays until Saturdays. AMC works with a menu card, which changes four times a year. Each day the patient has a choice of five different warm meals, 2 salads or a sandwich. There is no variation in portion size possible without creating waste costs for AMC. The contact with suppliers to make agreements about ordering process, delivery time, frequency, and method of delivery is the responsibility of the management. Each stakeholder has an own role in this process, from advice up to concrete appointments but together they are responsible for the whole process. The purchasing department of AMC is only concerned in the tendering process.
    - *Portion sizes.*
    - *Food waste before and after serving.*
    - *Time between ordering and serving.*

11. Food assistants order wholesale based on common sense. A min./max. overview, based on historical data of food consumption, should acts as a guidance for this, but in practice it has appeared that it is not used. Furthermore, the high amount of flex workers causes inefficient order sizes. Internal distribution is the responsibility of the logistic center. Food assistants have to store these goods in the pantry, based on the FIFO (first in first out) principle. After each fixed round on the ward the food assistant replenish the BBW with stock from the pantry.
    Ordering of warm meals is done by the food administration, based on a min/max list, which is based on historical data. Order sizes of are not based on bed occupancy since these meals are ordered once a week. There is such a high flexibility in warm meal consumption that they decide to set the min/max as a directive. The food administration is free to change this list. Due to the long THT of warm meals the flexibility in consumption does not directly lead to waste. Food administration make some trade-offs in ordering warm meals, for example between salads and typical winter food depending of the weather forecast. After each season the amount of food waste, which is caused by too much warm meals in stock, will be evaluated. When more than 5% of the warm meals are thrown away, because of expiring the THT, the list will be updated. Currently waste is about 3,5%. For meal components and soups the ordering process difficult due to higher difficulty in demand prediction. A higher amount of waste is accepted for these products. The daily order of warm meals by the food assistant is based on bed occupancy, the extra meals for the night refrigerator, and the amount of leftovers from the day before with passable THT. After the lunch, food assistants record the warm meal orders of patients and send this order to the food administration. The administration send this data to the logistic center to make them able to print a pick list. Finally, the warehouse employee take the meals from the central fridge in isolated trolleys dedicated to distribute to the specific units by distribution team. Food assistants have to prepare, regenerate, and garnish warm meals before distributing. The oven has a maximum batch size of 16 meals with a preparation time of 35 minutes.
    - *Poor usage of min/max lists. Usage of common sense.*
    - *Time between ordering and serving.*
    - *Many actions in preparing warm meals, like the usage of other aids(like cutlery/ serving plates)*
    - *Loss by distribution to others as patients.*
    - *Large number of deliveries each day.*
    - *Flaws in internal distribution.*

12. During the day a lot of time is spent on anticipating. It already starts in the morning where usually the deliveries to the pantries by the LSC are not on the time as indicated. This means that FAs gain a lot of work pressure because they have to store all products from the delivery and then run around the ward to still have breakfast in time for all patients, meaning no social time can be spent with the patients downgrading the hospitality. Whenever there is a shortage of warm meals within a pantry the FA searches for a desired warm meal on another pantry. Again meaning they are not available for their own ward if needed. Responding on demand for wholesale items out of stock is slim, as they are not really anticipating on this. Sometimes there is not a shortage but an oversupply, for example because of a typing error. In some cases the products will be send back to the supplier. However, the HACCP rules make this mostly not possible. The communication on this issue is between the responsible employee of the BADS and the supplier.
    - *Do not want to sell a "no" to patients*

Financial planning

13. On a long term there are investments plans to optimize the food service in AMC. Logistic improvements could be useful to save money which could be invest in the quality of hospitality.

14. AMC has a lot of suppliers and so also a lot of contracts. These contracts usually set prices for parties undergoing them, therefore finding a good contract to have the best quality/price ratio is something that takes time. Sometimes going for a bit cheaper does not pay off. As head of the service department admitted that they increased the budget for buying bread to get higher quality as the currently used bread was unwanted by most patients and so even though it was cheaper, the bread was opposing the policy of patient welfare by providing an optimal amount of nutrition to the patient to speed up their recovery and prevent complications.
    - *High personnel costs. Low time efficiency*

15. The costs of food logistics could be split up in personal and materials, where materials could be further split up in raw materials, logistic costs, and overhead (the costs of gas, water, light and electricity usage). The losses of food, before or after serving to the patient, are high unnecessary costs. The administration of invoices, control of deliveries, and archiving of orders is a responsibility of the LDC, the FA and the BADS together. For example for warm meals the FA orders the meals, this order will be send to the BADS, the BADS check these order, make an order pick list and send this to the warehouse workers. Then these employees pick the warm meals in the fridge and cross docking these in separate isolated trolleys per unit. When all warm meals are picked and double checked, one of the warehouse workers walks to the BADS to make the order definitive. The BADS scan all the orders and if correct, they fulfill the order in their IT system Care Control. When the order is not correct, for example when a warm meal is out of stock, they send the bill for control to the BADS so they can adjust it. Then a new overview is printed. The warehouse employee picks these new form, walks back to the fridge and add these new forms to the isolation trolleys. This way of working will however change as of 13-05-2013 from which point on the order pickers will be equipped with scanners and the picking lists will so be digitally approved from these scanners saving lot of walking and processing time. Finally, the isolated trolleys will be sorted per tower and transported by three LDC employees. Each tower has a fork lift used to transport all trolleys per tower in one lift. The LDC employee stores the trolley at the unit panty without contacting the FA. After 15 minutes all trolleys are distributed to the hospital. Each FA has to check the delivered meals by the form. When there are wrong deliveries the FA calls the BADS to correct the order.

16. A part of the food is used by others than patients, like nurses, other health care workers and guests. These users have to pay for this service, so the invoice of these costs should be send to the BADS which calculate these cost to the cost center of the specific ward. The nurses fill in an general request ticket for food consumption outside of the normal BBW rounds. On this tickets the name of consumer of the requested food is filled in for billing. The nurse brings the filled in request ticket to the kitchen where she gives it to the food assistant. Around noon the first floor employee collects all these tickets and brings them to the BADS. The BADS will from that point on be in charge of billing the right costs to the patient that had family visiting and eating food form the pantries instead of the restaurant.
    - *Low control of these costs while small numbers they can add up if taken together.*

Food logistics at Academic Medical Center

PART II

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Chapter 1

Introduction

This research addresses to the topic of food logistics at the Academic Medical Center (AMC) in Amsterdam. Background information and motivation for this research topic is already elaborated in previous part.

This chapter explains why this research was conducted. Section 1.1 gives the motivation for this research. Section 1.2 describes the research context. Section 1.3 explains the research problem. Section 1.4 consists of the research objective. The scope of this research is in Section 1.5. By describing the research questions, Section 1.6 gives an outline of this report. Section 1.7 explains the methodology which is used for reaching our goal for this research.

1.1 Motivation for this research

Part one described the challenge for health care organizations during the upcoming decades to deliver more patient care of at least the current quality, while efficiently allocating less financial and human resources. AMC wants to achieve a higher food service level among others by organizing the food logistics more efficiently (van der Maat, 2013). This research analyzes AMC's inventory management of food for inpatients as main problem derived from our problem cluster. To be more specific, the inventory of wholesale products, so the complete range of products concerning breakfast, lunch, and snacks inpatients can order. Nowadays, storage is decentralized and managed mainly based on common sense. Aggregate inventory, standardized ordering procedures, and central replenishment could reduce costs. With this research we can make the transition to quantitative inventory management as an improvement on the short term and to make recommendations for the organization of interventions.

1.2 Research context

This research is carried out at AMC. This academic hospital treats 56,000 patients annually. In 2011, AMC counted 1,002 hospital beds distributed over 34 wards, they performed 30,129 clinical admissions accounting for 202,560 patient days, so a hospital stay of 6.7 days on average (AMC, 2012). All of these clinical admissions have to be provided with their nutritional needs. Therefore, AMC uses bread serving trolleys (BBWs) to distribute the breakfast, lunch, beverages, and snacks over the wards. In the evening they use another kind of trolley to distribute serving trays with a complete warm meal. To prepare these meals a kitchen is located on each ward.

Most wards are on the third to the eighth floor in the three towers of the building, denoted by F, G and H in Figure 12. Each tower has a north and a south unit, these units share a kitchen. In total there are 15 kitchens. These kitchens are also storage locations for inventory related to the wholesale function. Each with their own range of approximately 130 Stock Keeping Units (SKUs). There is no central safety stock for these products, only warm meals are centrally stored.

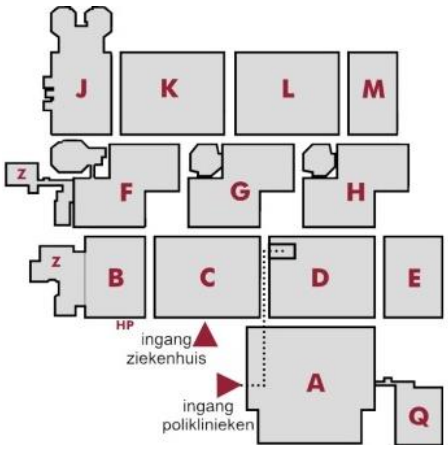


Figure 12: Map AMC;
Wards are located in towers F, G and H.

AMC's department 'directorate services' is occupied with all logistic functions concerning food. They aims to provide the best hospitality for patients and employees, which they tend to achieve with efficient logistic functions and movements. Their vision based on the food provision is to provide an optimal amount of nutrition to the patient to speed up their recovery and prevent complications (IFC BV, 2012).

1.3 Research problem

Part one described that the current food logistics has a discrepancy between the product and patient wishes, as counterparts in the hospital food service, caused by high costs and low hospitality. The costs should reduce due to current developments in health care. Hospitality should be improved to maintain an attractive hospital within the catchment area. Costs are split up in material costs and personnel costs. Material costs can be split up by high costs of raw materials and inefficient logistics. Personnel costs are influenced by low time efficiency and hiring flex workers. Raw materials and logistics have the highest contribution to the problem of high costs by high amount of food waste and big stocks. Hospitality is split up in the following aspects: product, behavior, and environment. The influence of logistic changes on improving hospitality is important to convince AMC.

Our problem cluster shows that the main problem is whether to hold or arrange perishables on a centralized or decentralized way. Therefore, this research focuses on the organization and logistics of wholesale products. The process from ordering foods at the supplier until replenishing the inventory is characterized by low time efficiency, big stocks, and dissatisfied employees. Food assistants experienced a high workload and have little time for patients due to increasingly indirect patient tasks like managing the inventory, ordering foods, and replenishing inventories. Big stocks lead to waste while inventory does not fulfill the specific needs. An unnecessary amount of low demanded products is in stock, while it would be more efficiently to use this space to store other products or to merge stock of various departments. In order to improve these operational problems, achieve a higher food service level, and increase the hospitality of AMC, while reducing costs, AMC's food logistics has to be investigated.

1.4 Research objective

At this moment, there is a lack information about the performance of AMC's food service. The goal of this research is gaining information about the performance of food service to improve the logistical performance indicators by reorganizing processes.

The objective of this research is to measure the current performance of AMC's food service regarding wholesale products and to improve this performance by organizing the logistic function concerning food more efficiently.

1.5 Research scope

The scope of this research is to determine the performance of AMC's food service regarding wholesale products intended for inpatients. The performance of all other activities within this hospital are neglected in this research. We analyze this subject from a logistic point of view.

This means that the research is conducted at the level of storage design and inventory management. We use the framework for health care planning and control (Hans, Van Houdenhoven, & Hulshof, 2011) and focus on the activities on the strategic and tactical level of material planning. Investigation on these parts of the framework will also show problems on the operational level, like order sizes, ordering process, stock replenishing, and waste. For clarification; When we mention the term 'waste' in this report, we only mean the loss of food.

The logistic movements will including the entire process from ordering foods at the supplier until replenishing the cycle- and safety inventory. Focus will be on physical and information logistics concerning food. The process of distribution to the patient, dishwashing, and clean up the used aids, like cutlery and serving plates, will not be in the focus. However, it could be a point of attention. The reference department of this research is unit G5, which is suitable because of the availability of data, since this department is often used as a reference department.

1.6 Research questions

To achieve the goal of this research we have developed research questions. The main question is:

> *"What steps should be taken to improve AMC's current food logistics of wholesale products measurable and to make an informed choice about the organization of interventions?"*

By describing the sub questions we give an outline of this report.

Chapter 2: Description of the current situation

How is AMC's inventory of wholesale products currently managed?

2.1 What steps are involved in the process of inventory management?
2.2 How is inventory management organized on the strategic and tactical levels?
2.3 What is the current performance concerning AMC's food logistics?
2.4 What is the current performance concerning AMC's inventory management?
2.5 How can improvements in material planning influence this performance?

Chapter 3: Literature study

Which results from the literature may be applied in AMC?

3.1 What are suitable methods to manage inventory of consumable goods on the strategic and tactical levels?

Chapter 4: The formulation of possible interventions

Which methods to manage inventory of wholesale products may be appropriate for AMC?

4.1 What are the priorities of acceptance criteria that determine the appropriateness of an intervention for AMC?

4.2 What are suitable methods for AMC to manage inventory of wholesale products, based on the extent to which an intervention satisfies acceptance criteria?

Chapter 5: Performance measurement

How suitable are the different interventions?

5.1 How do the different interventions influence the performance on KPIs?

5.2 How do the different interventions influence AMC's inventory management?

5.3 How do the different interventions influence AMC's food logistics in general?

Chapter 6: Design of a roadmap of what steps should be taken to improve AMC's current food logistics of wholesale products measurable and to make an informed choice about the organization of interventions?

What are the recommendations for AMC how to achieve a higher food service level among others by organizing the logistic function concerning food more efficient?

6.1 How is AMC's inventory of wholesale products currently managed?

6.2 What is proposed how to plan and control AMC's inventory of wholesale products?

6.3 What is the difference between the current situation and the desired end state?

6.4 What road to take to get to the desired end state and what are the priorities of the several actions on this road?

6.5 How to organize the implementation of these changes to create the desired end state?

Chapter 7: Conclusion and recommendations

What can be concluded on the basis of this research? What recommendations can be made on behalf of AMC and what lessons can also be useful for other organizations?

7.1 Conclusion

7.2 Recommendations

7.3 Generalization of this research

1.7 Methodology

This research will be carried out by first analyzing the processes, performance, and planning and control in detail. We perform interviews, and observe and participate in the current process to give a description of the process from ordering foods at the supplier until replenishing the cycle- and safety inventory, including related performance measurements. While we observe and participate we analyze the planning and control activities on strategic, tactical, and operational level by using the framework for health care planning and control. Finally, we assess the current performance by operationalizing AMC's Key Performance Indicators (KPIs) into measurable units and performing a measurement of current food service level. This analysis provides the input for identifying problems in inventory management of wholesale products.

Once the performance is made visible by indicators, the next step to improve this performance by organizing interventions. To learn which concepts from the literature may be applied in AMC, we analyze several books and carry out a literature search. Different databases are used to find literature. Such as Google Scholar, Scopus, Web of Science, PubMed, and Business Source Elite (Becht, 2013).

We choose the databases Scopus and Web of Science since these are widely used in management science and are easily accessible by UT students (Amrit, 2013). Using these databases gives a holistic view of literature on inventory management of consumable goods.

Then, we present and discuss different possible interventions based on the literature, expert opinions, and our experiences. Opinions of experts are known by the interviews with the key stakeholders in Part one. Our experiences comes mainly from participating at the units and visiting other hospitals and suppliers, but also from previous experiences in health care. We determine the suitability of these interventions, corresponding the acceptance and evaluation criteria, and make clear which intervention may be appropriate for AMC. Eventually, we design a roadmap to manage AMC's logistic function concerning wholesale products to explain the steps AMC should be taken to improve the food logistics measurable and to make an informed choice about the organization of interventions. Additionally, we analyze and discuss the limitations in the availability of AMC's data as condition for improvement. The conclusion and recommendations give an overview of the suggestions for improvement for AMC. We generalize this research as useful experiences for other hospitals and health care organizations.

Chapter 2

Current situation

This chapter provides insight into the current situation. Section 2.1 illustrates the steps involved in the process of inventory management from ordering foods at the supplier, until replenishing, including related performance measurements, which are mentioned in this report as baseline values. Section 2.2 elaborates on the planning and control activities on the different hierarchical management levels using the framework for health care planning and control. Section 2.3 analyzes the current performance on AMC's food logistics and operationalizes the KPIs of inventory management to assess the current performance of AMC's inventory of wholesale products.

2.1 Process description

Part one gives a detailed process flow and elaborates on the logistic process regarding wholesale products. This section briefly recapitulates on that and elaborates this process further by adding some baseline values and other facts of process management. The overall process is shown again in Figure 13. At each section the relevant part of the process flow is shown in detail.

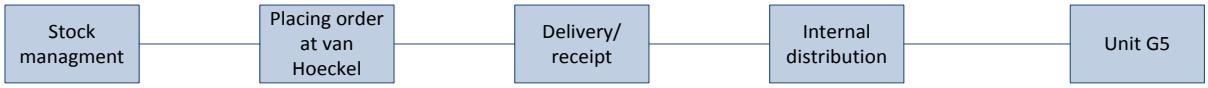


Figure 13: Overall process flow AMC's wholesale logistics

2.1.1 Basic values of current process

Of the approximately 100 SKUs on unit G5, half have a longer shelf life than 30 days, see Figure 14. However, these perishables are responsible for the highest costs. Confidential Appendix II and Table 5 show a Pareto analysis of the products ordered in 2012 by the departments FGH5. Although the data does not fit to a Pareto distribution, the analysis shows that a majority of the total costs, about 60%, is given to products with a relatively short shelf life.

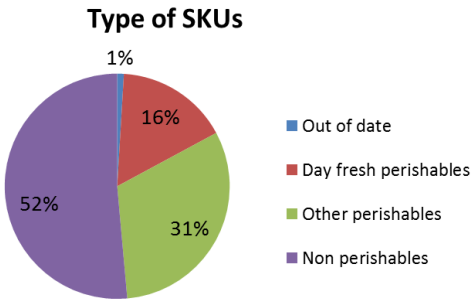


Figure 14: Type of SKUs on a unit

Product group	%	Cum. %
Meats and Cheese	23.15 %	23.15 %
Bread and pastry	22.39 %	45.54 %
Dairy products	15.41 %	60.95 %
Diet & Reform, Eco & Bio	9.16 %	70.12 %
Vegetables & Fruit	8.26 %	78.38 %
Coffee & Tea	6.85 %	85.23 %
Beverages	6.27 %	91.50 %
Butter, Egg, Oil and Grease	4.57 %	96.07 %
Snacks	2.10 %	98.17 %
Grocery products	1.74 %	99.92 %
Others	0.08 %	100.00 %

Table 5: Turnover per product group

The perishable and diet products together count for 80% of the costs. Adequate control, focusing on perishables is needed in order to reduce waste and optimize the management of inventories. However, observations learns that even products with a longer shelf life require attention. The inventory builds up because one is forced to purchases in lots that are larger than those demanded by the customer.

Remarkable is that there are only small differences in the monthly order as shown in Confidential Appendix II. While the number of admissions varies during the year. There are no data available on the monthly loss.

2.1.2 Stock management

Figure 15 shows the stock management process in detail. Table 6 shows the corresponding baseline values.

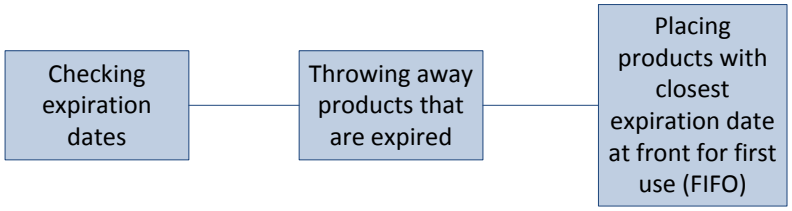


Figure 15: Stock management process

Baseline values (AMC, 2013)	
Time	8:00 PM
Duration (time frame)	[3 ; 5,4]
Duration on average	5 minutes
Employees	1 food assistant

Table 6: Baseline values stock management

While every evening the remaining shelf life of products is checked, the day shift checks this again. Food assistants records the amount of waste per product while food administration digitalize this information to have insight in the waste over the years. By observing and participating at the units we know that the registration of waste at the units could be done more accurately. The internal LSS project (2011) examined the waste as registered by food assistants, which means, the loss by reaching expiration date. Then the amount of loss products (in €) is compared with the amount of fresh products they ordered (in €) in that same time period as shown in Table 7.

Location	Waste
Average	≥ 11%
G5	9.1%
FGH5	6.6%
AMC	7.1%

Table 7: Amount of waste in AMC

Since the registration by food assistants is not accurately done in practice, and because of the strange calculation the LSS project (2011) use to measure the percentage of waste, we estimate that the actual waste is many times higher. Therefore we set the average waste higher than actually measured, namely ≥ 11%.

2.1.3 Ordering foods at the supplier

AMC's wholesale products are ordered at supplier van Hoeckel. The ordering process is split up in two separate activities: placing an order and checking that there are no typos made in the order, as shown in Figure 16.

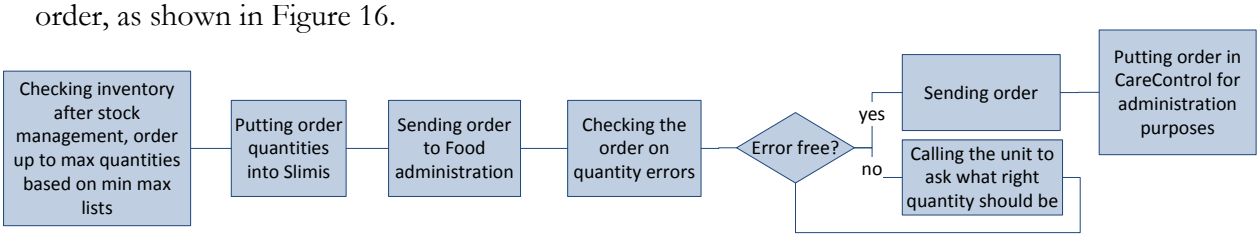


Figure 16: The process of ordering foods at the supplier

One food assistant counts the current inventories of the corresponding products and says it out aloud. A colleague sitting at the desk considers the quantities to order based on experiences, in case of permanent staff, or based on preset order quantities, in case of flex workers. These amounts are put into Slimis, the ordering system of van Hoeckel. This system narrows the assortment to a limited range for food assistants in line with the demand of the patients.

Food assistants send the order to the food administration, which verifies the order on quantities and send the orders to the supplier, which deliver the products cross-docking to the hospital. The food administration puts the orders in CareControl also, for administrative purposes

1. Placing orders at van Hoeckel

AMC uses the (R,s,S) inventory model as ordering policy for wholesale products. This means that, with an interval of R periods (on fixed days each week), is considered whether the inventory is below the minimum(s). If stock of a corresponding item is below that preset minimum, one should order up to the maximum(S). The hospital uses an order schedule so that food assistants know which products could be ordered on each day. AMC distinguishes the product groups: bread, daily fresh products, chilled food, and other wholesale products. Van Hoeckel ensures next day delivery for six days a week as shown in Figure 17. Orders on Fridays and Saturdays will be delivered at Mondays, except bread, which will be ordered on Fridays and delivered on Saturdays for the whole weekend.

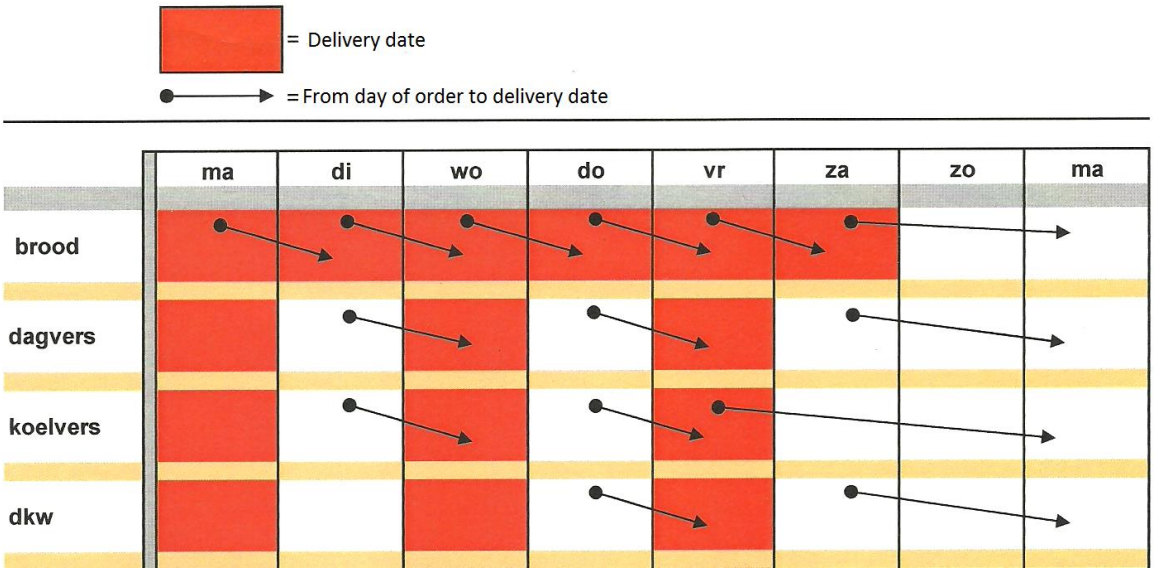


Figure 17: AMC's ordering schedule for wholesale products (AMC, 2013)

After participating at a unit a time study was performed on the ordering process. While there is a min./max. list, which should be used as an indicator of the order quantities, we have seen that food assistants mainly order at their own discretion. Since only a few products have to be ordered, the duration is lower than measured in the time study of AMC (2011), see Table 8.

Baseline values	(AMC, 2011; AMC, 2013)	Own observations
Time	8: 45 – 10:15 AM	9:23 – 9:37 AM
Duration (time frame)	[14,5 ; 21,8]	[5 ; 14]
Duration on average	18,16 minutes	8 minutes
Employees	2 food assistant	2 food assistants

Table 8: Baseline values placing an order

2. Control

Food administration control all orders from the kitchens. Daily, approximately 50% of the orders are adjusted (AMC, 2011). Orders should be sent to van Hoeckel before 11 AM to ensure next day delivery. However, time study shows that this activity occurs between 11 AM and 12 AM (AMC, 2013).

Baseline values (AMC, 2011; AMC, 2013)	
Time	11:00 – 12:00AM
Duration (time frame)	[2,9 ; 4,2]
Duration on average	3,6 minutes per unit
Employees	1 food administration

Table 9: Baseline values controling orders

2.1.4 Delivery by van Hoeckel / receiving of goods

Van Hoeckel delivers dedicated to AMC at 7:15 AM. The employees at the Central Goods receipt Office (CGO) are responsible for accepting the goods, making sure everything is present, and recording the temperature of products. We know that this is a stressful moment; A lot of handling activities are taking place, while the patients are waiting for their breakfast. The time of supplying is unfortunate, but necessary so that bread and wholesale products could be transported together.

Baseline values (AMC, 2013)	
Time	7:25 - 7:35
Duration on average	7,7 minutes to sort per tower
Employees	1 logistic employee

Table 10: Baseline values of the delivery process by van Hoeckel / receipt of goods

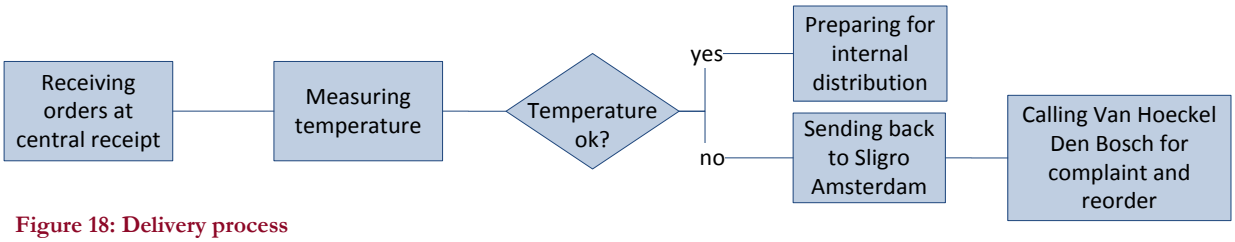


Figure 18: Delivery process

After receiving the goods and performing a small check, the cross docking trolleys are sorted per tower and prepared for internal transport.

2.1.5 Internal distribution

The duration of internal distribution is approximately 25 minutes. Since elevators are continuously used during transport, the lift capacity for other tasks is less.

Distribution of the orders to the different units within the hospital based on the fixed routes, done by LDC

Figure 19: Internal distribution process

Baseline values (AMC, 2011; AMC, 2013)	
Time	7:00-7:15
Duration on average	1,65 minutes per unit
Employees	3 logistic employees

Table 11: Baseline values of internal distribution process

2.1.6 Replenishment process

Delivering at the units is between 7:30 and 7:45 AM. Time study of AMC (2011) have learned that orders are usually on time with a maximum of 15 minutes too late. Except from bread, food assistants are independent of this delivery. Safety stock is sufficient to prepare BBWs for distributing breakfast.

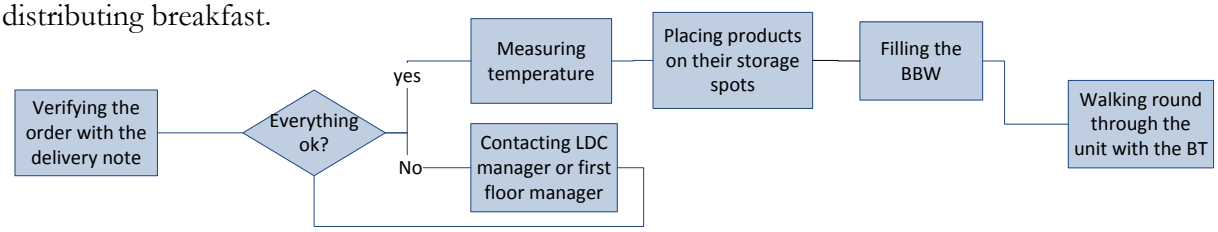


Figure 20: Replenishment process

However, assistants unpack the trolleys before serving the breakfast, because they have to performs a check if everything is present and measures the temperature of products as required by the Hazard Analysis and Critical Control Point (HACCP). AMC (2011) has found that the delivery note is signed for control, but food assistants have not actually checked once. Due to cross docking, all type of products are spread through the trolley and should be replenished to ensures an acceptable temperature of chilled food.

While the operational tasks are out of scope of this research, the influence of changes in material management on operational tasks is of importance for this research. Currently, there is a great discontent among the food assistants, on various issues (AMC, 2011).

Baseline values (AMC, 2011; AMC, 2013)	
Time	7:30 – 8:00
Duration on average	17,8 minutes
Employees	2 food assistants

Table 12: Baseline values replenishment process

2.1.7 Other flows within this process

Some other flows are out of scope. However, these are important when organizing interventions:

- **Back orders:** If the delivery does not correspond with the order, the food administration send a rush order or a back order. Mostly a back order is sufficient. Inventory at the different kitchens satisfies the shortage until the next delivery day. Unfortunately, there is no data on how often a back order occurs, what the throughput time between ordering and delivering is, and what the consequences of shortages are. However, high inventories prevents problems being noticed. We expect back orders became a problem when lowering inventories and reduce the amount of storage locations.
- **Rush orders:** Necessary when not enough bread has been delivered, or another highly important product, where AMC cannot be without one day.
- **Packaging (returned):** Sending back of packaging is a movement that is beyond the scope of this research. When changing the process flow this logistic flow should be keep in mind.

2.2 Planning and control activities

To demarcate the scope of our research we use the framework for health care planning and control as shown in Figure 21 (Hans, Van Houdenhoven, & Hulshof, 2011). We elaborate further on the strategic and tactical level of material planning as these are the parts within the scope of this research.

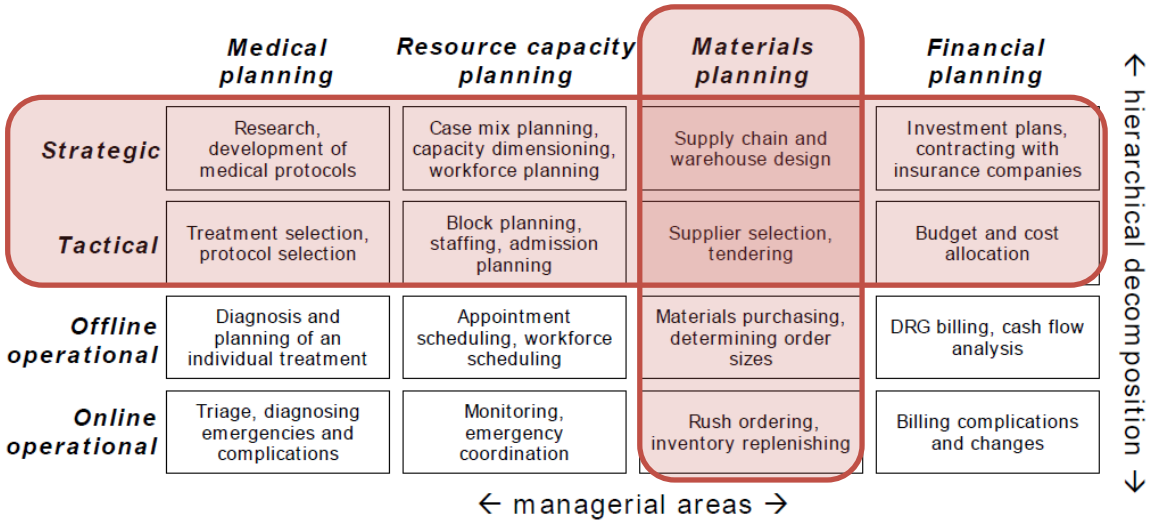
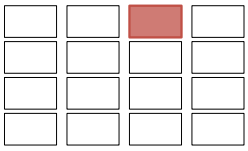


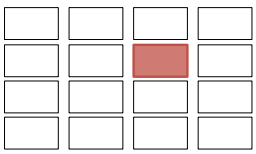
Figure 21: Framework for Planning and Control, applied to AMC

2.2.1 The strategic level of materials planning



Strategic planning of materials means the planning of non-renewable resources, in this case the strategic planning of wholesale products. On a strategic level one focuses on supply chain aspects and design of the warehouse. With regard to AMC, the main issue is the storage design of wholesale products. In the current situation the wholesale products are stored decentralized on ward pantries (safety inventory) and in a BBW (cycle or on-hand inventory).

2.2.2 The tactical level of materials planning



The original framework refers to tactical materials planning in case of supplier selection and tendering. AMC should take part in an international tendering. Supplier selection is based on the program of requirements. Management and purchasing department together are responsible for tendering, contracting, agreements about ordering processes, delivery time and method, and determining order sizes and frequencies in consultation with the supplier. The contract has a duration of 36 months, after which it can be extended twice with a maximum of twelve months. Current contract of wholesale products runs until February 28, 2016. This agreement states that each order should have a minimum purchase value per load of € 300 (van Hoeckel, 2013).

Since AMC's stock levels of wholesale products are closely related to the storage design and service level, we add inventory management as a tactical material planning problem. Frequency of orders varies by product as shown in Figure 17.

The contracted supplier has close contact with the food administration because they are responsible for connecting the assortment with the demand of the patients. This contains seasonal modifications and continuous changes, for instance due to the change in the eating habits of people over the years. Food administration is also responsible for the control of the quantities to be purchased and making orders definitive.

2.3 Current performance

We want to perform a zero measurement of AMC's food logistics performance to get insight in the current situation. This process is complicated due to the absence of the necessary data. AMC uses no indicators to measure performance. Therefore, we start by defining indicators and operationalizing these indicators into measurable units. Furthermore, the necessary data has been collected or measured as described in the next section. Another factor that complicated the measurement process is the excessive stock. High inventories prevents (productivity) problems being noticed. 'Reducing the level of inventory allows operations management to see problems in the operation and work to reduce them' (Slack, Chambers, & Johnston, 2007). The problems arising from lowering inventories could give rise to a follow-up study.

2.3.1 Performing a baseline measurement

To perform a baseline measurement we cluster KPIs according to the performance objectives, and formulate them so they meet the SMART requirements. We ask M. van der Maat to verify the KPIs and to distribute 100 points over the different KPIs as method to give a weight to each criterion (Heerkens & van Winden, 2012). Baseline measurement is based on the data of the LSS project (2011), data from the SPA in the kitchen project (2012), two days of participation at unit G5 and performing a time study, information from the IFC report (2011), and information obtained in interviews with stakeholders.

Since not all criteria are measurable during the short time study, some values are estimates as explained in the relevant sections. We compare the score of baseline measurement with the norm and margin as set by van der Maat (2013) and multiply the baseline score times the weight. In the future, these values can be compared in order to understand the trends over time. Currently, this total value provides insight into the potential for improvement.

Only the KPIs with high potential for improvement are interesting for this research. The weight per criterion is thereby the most important factor: The score can be a value of 1, 3 or 5. When the weight of a criterion is 0.01, the final score can fluctuate between 0.01 (1*0.01) and 0.05 (5*0.05). When the weight is 0.2, the final score can fluctuate between 0.2 (1*0.2) and 1.0 (5*0.2). So, the minimum of the last mentioned criterion is higher than the maximum of the first one. Therefore, the criterion with high weight and low scores have the highest potential for improvements.

We aim to create an intervention in which the separate KPIs improve to all satisfaction of the stakeholders. When half of the KPIs scores high, while the other half scores low, on average the intervention will score well. However, this is not a desirable situation. Therefore, we evaluate each KPI separately and seek for an intervention in which all KPIs score above average. However, the overall score should improve the score of current situation.

2.3.2 Baseline measurement of AMC's food logistics

Part one describes the KPIs of AMC's food service as shown in Figure 22. Appendix I shows an extensive elaboration of the definition, measurement method, norm, margin, and reason to include each KPI.

KPI	Weight
1. Employee satisfaction	0.23
2. Customer satisfaction	0.23
3. Discrepancy between demand and assortment	0.04
4. Cycle times	0.04
5. Time efficiency of employee tasks	0.23
6. Amount of unavailable products from assortment	0.03
7. Amount of complete and on-time intern deliveries	0.04
8. Time fluctuations in service rounds	0.01
9. Flexibility in product and service	0.03
10. Amount of thrown away products	0.08
11. Amount of food consumption by others than patients	0.03
12. Costs per patient per unit	0.01

Figure 22: Overview KPIs of AMC's food logistics

AMC has twelve KPIs on food logistic. Most of these KPIs could be measured on an interval or ratio level. We score four KPIs based on an ordinal level due to a lack of data on these aspects. Three KPIs together contribute to 70% of the weights, namely the employee satisfaction, customer satisfaction, and time efficiency of employee tasks. The scores of KPIs are confidentially and shown in Confidential Appendix III. Three KPIs scores below standard. The employee satisfaction scores a 6.7 while the norm is at least a 7.0. The amount of discarded products is 7.1% while the norm is ≤ 5%. Finally, the amount of food consumption by others than patients is 10% as measured in the LSS report, while the norm is ≤ 3%. 'Only 45% of the costs per kitchen is actually consumed by the patient' (AMC, 2011). The remaining part is waste, loss, consumption during night shifts, or consumption by nurses, food assistants, other employees, and family. On highest positive influence are the customer satisfaction and the time efficiency of employee tasks. However, even these indicators need some improvements to satisfy the norm.

Based on this baseline measurement the employee satisfaction has the highest potential for improvement since this indicator scores low and have a high weight. Because of our logistic focus, based on our problem cluster, and after consultation with AMC, we decide to focus on the question whether to hold products in a centralized or decentralized way as main problem within AMCs food logistics, and focus on inventory management of perishable wholesale products.

2.3.3 Performing a baseline measurement of AMC's inventory management

Since we scope our research on the inventory of wholesale products we formulate additional KPIs as actual KPIs of AMC's inventory management regarding wholesale products verified by M. van der Maat., see Figure 23. These KPIs are operationalized into measurable units in the same manner as the previous KPIs. For an extensive elaboration on the definition, measurement method, norm, margin, and reason to include each KPI see Appendix II.

KPI	Weight
1. Waste	0.2
2. Order fill rate	0.2
3. BBW Inventory	0.07
4. SKUs in-stock percentage	0.04
5. On-time shipment	0.2
6. Out-of-stocks	0.2
7. Backorders	0.05
8. Inventory turns	0.01
9. Inventory balance	0.01
10. Days of supply	0.01
11. Holding costs	0.01

Figure 23: Overview KPIs of AMC's inventory management

Interventions related to the location and allocation of products will not influence all single KPIs. While the impact of centralization on the KPIs waste and holding costs will be great, the order fill rate and on-time shipment will not be influenced. Although the last two KPIs have a great weight by AMC, the main problem in this case is the discrepancy between the high costs and low hospitality which would be solved by reducing waste and organizing the logistic function concerning food more efficiently.

Five KPIs are measured on an ordinal level due to missing data on these aspects. Others are measured on a higher measurement level. Four KPIs together contribute to 80% of the weights, namely the indicators waste, order fill rate, on-time shipments, and out-of-stocks. The four aspects of the category 'costs' count together for just 4%. This indicates that cost savings are not that relevant as long as the costs remain under the available budget.

We perform a baseline measurement, but the scores of KPIs are confidentially and shown in Confidential Appendix IV. We find that four KPIs score below standard. First, the waste scores far below the norm. This is related to the way of measurement as explained above. Moreover, high amounts of waste is caused because food assistants forget to do the plug into the socket. Furthermore, despite of the FIFO policy, AMC (2011) and we both found that items in inventory and BBW are outdated. Second, the costs aspects scores bad. However, the costs aspects are not of that influence on the total score. On highest influence, and therefore the main focus of this research, are the indicators waste, order fill rate, and on-time shipments.

Conclusion

Part one analyzed the main characteristics of AMC's food logistics based on process, performance, and planning and control. By baseline measurement we identify employee satisfaction as the highest potential for improvement since this indicator scores low and have a high weight. However, we saw that the most important logistic question is whether to hold or arrange the products in a centralized or decentralized way as shown in the problem cluster. In Part two, the scope is narrowed and more characteristics regarding AMC's inventory of wholesale products are analyzed in the same manner. Eleven KPI's related to this smaller scope are conceived. The extent to which improvements on the strategic and tactical level of material planning influence the performance as measured by KPIs, differs because of the weights per KPI. On highest influence, and therefore the main focus of this research, are the indicators amount of stocks, the order fill rate, and on-time shipments.

The next chapter describes what the literature addresses on strategic and tactical inventory management of wholesale products. Based on the literature study, AMC's current process flow of the logistic process regarding wholesale products and our observations and experiences, we analyze possible ways to improve the logistical performance indicators by organizing interventions. By KPIs we calculate the influence of the different improvements on a strategic and tactical level of material planning on AMCs performance. This enables AMC to make informed choices to improve the current situation of inventory management.

Chapter 3

Literature study

Food inventory management faces major challenges by uncertain demand, perishability, and high customer service level requirements (Minner & Transchel, 2010). This chapter presents the literature review on food inventory management related to AMC's specific supply chain management characteristics: multi echelon, a combination of random and fixed shelf life, periodic review policy, stochastic demand distribution, and loss of sales to a shortage of stock. Section 3.1 describes the used search strategy. Section 3.2 analyses the found literature. Section 3.3 explains what the literature contributes to the practice of AMC.

3.1 Search strategy

This literature study aims to figure out what suitable methods are to manage inventory of consumable goods on a strategic and tactical level. We study four books on supply chain management and inventory control, which give a good insight in both topics in general. However, there is a shortcoming on the focus of consumable goods and waste reduction relevant for this research. Therefore, additionally we search in the databases Web of Knowledge and Scopus and use (combinations of) the keywords: (Cycle and Safety) Inventory, Supply Chain, Replenishment decisions, Aggregating orders, Product availability, Service level, Review policies, Consumable goods, Perishable, Food, Serving trolleys, Tactical/Operational, Central/Decentral, Aggregating, Order sizes, Storage design, Hospital, EOQ/Little's Law and synonyms of these. Forward and backward citations are analyzed and included as we consider that these items could add substantial value. Figure 24 shows an elaboration of the search strategy.

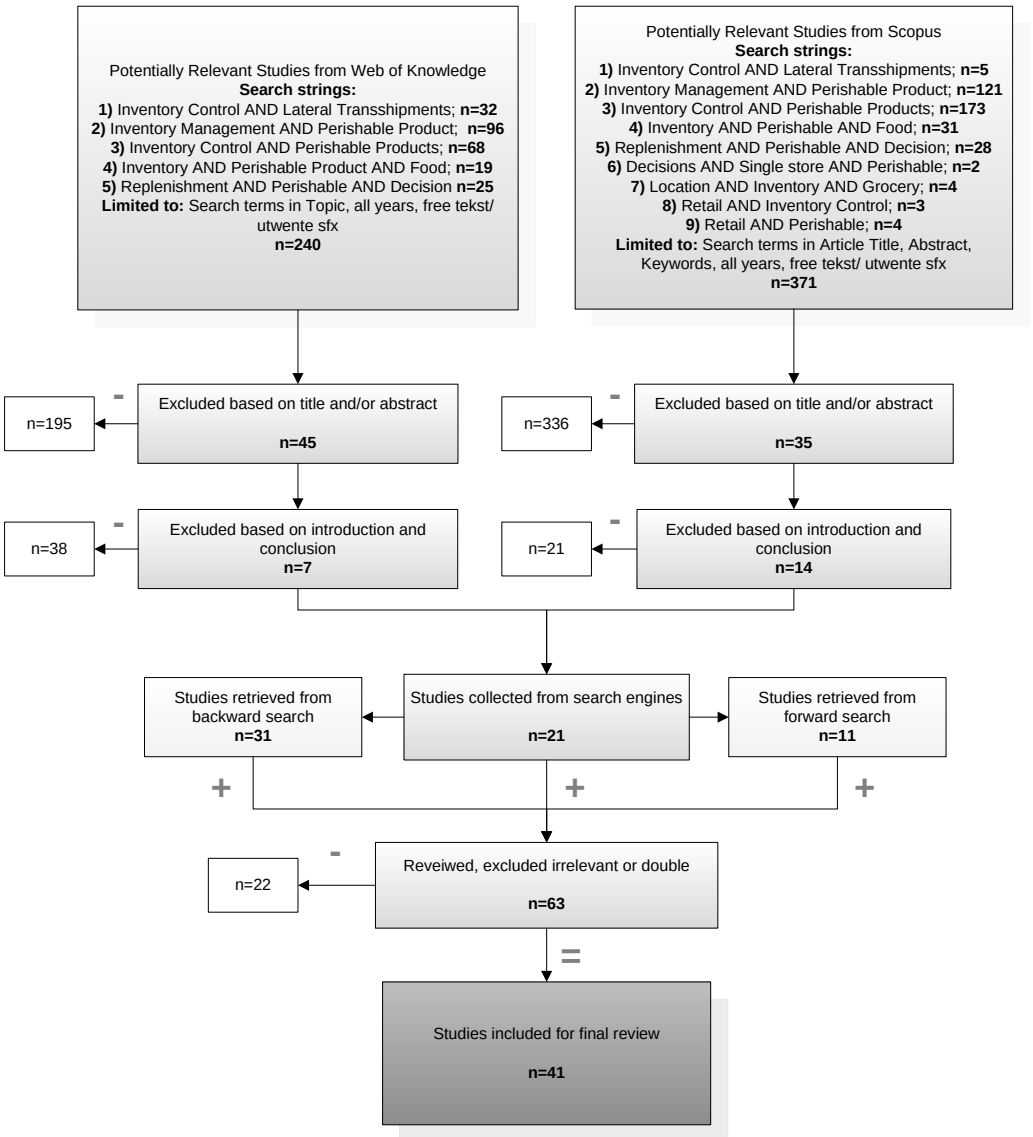


Figure 24: Literature search strategy

We analyze the books and 41 selected articles in a structured manner, see Appendix III. We include only the articles on inventory management which match closely with AMC's specific supply chain characteristics: multi echelon, a combination of random and fixed shelf life, periodic review policy, stochastic demand distribution, and loss of sales to a shortage of stock. First we discuss the results obtained by analysis of the books, reviews, and articles per main topic. At the end we argue what the books and articles contribute to our research.

3.2 Main results obtained by analysis of the books

'Inventory is created to compensate for the differences in timing between supply and demand' (Slack, Chambers, & Johnston, 2007), because demand forecasts are uncertain and a product shortage result if actual demand exceeds the forecast demand (Chopra & Meindl, 2001). Chopra & Meindl (2001) have stated that, as uncertainty in supply or demand increases, in case of high replenishment lead times, high lead time variability, and/or high desired product availability, the required level of safety inventory increases. Inventory is always bigger in case of a periodic review policy, compared to a continuous review policy, for the same lead time and level of product availability. Additionally, the inventory builds up because one is forced to purchases in lots that are larger than those demanded by the customer. 'It is only by tackling the causes of inventory that it can be reduced' (Slack, Chambers, & Johnston, 2007). Therefore, they have advised to make a Pareto analysis which indicates the quantity of items used multiplied by their price.

3.3 Main results obtained by analysis of the reviews

One of the first researchers studying optimal stocking policies for perishable items with a fixed lifetime and a first-in-first-out (FIFO) policy is Nahmias (1982). Later on, Raafat (1991) has completed an survey on mathematical inventory models of deteriorating items and noticed that there is a need for simpler heuristics or approximations useful in daily practice. Ten years later, existing models and their performance were discussed by Goyal & Giri (2001). Bijvank & Vis (2011) have included lost-sales settings and analyzed different replenishment policies. Bakker, Riezenbos, & Teunter (2012) have analyzed models for inventory control with perishable items including innovations with great opportunities for inventory control, like Radio Frequency IDentification (RFID). Amorim et al., (2013) have highlighted the importance of managing perishability in many different supply chains. Their review on perishability issues in production and distribution planning, classified based on multiple process features, is useful in choosing a relevant model for in hospital setting. Stanger et al., (2012) have focused on inventory management of packed red blood cells in hospitals. The trade-off they made between shortage and wastage could be applicable in food inventory management.

In both cases just-in-time management is not suitable because the products have high out of stock costs, due to the consequences of an inventory shortage. However, foods could be substituted and have less risks as blood in case of a stock out. Paterson et al., (2011) have addressed a lot on lateral transshipments (LT), pooling, and aggregating product. Since the demand of food is highly variable, the benefits of LT or pooling would be high in terms of costs and service level. Pooling inventory forecast is usually more accurate since it tends to have a smaller error relative to the mean (Chopra & Meindl, 2001).

The reviews give a good impression of the literature on inventory management of perishables throughout the years and contributes to make deliberate choices of articles to include.

3.4 Main results obtained by analysis of the articles

Inventory management of perishables is a widely researched topic, but many articles on this topic are not directly useful for our research. Relevant literature on inventory management of food in a hospital setting is limited and therefore a difficulty in this research. Of the included articles we search for the research that manage perishable inventory in a useful manner for in hospitals.

3.4.1 Articles on inventory location and allocation

In supply chain management there are basically two types to distinguish depending upon how to store goods and decisions are made, namely decentralized or centralized. Duan & Liao (2013a) have studied the effect of different demand patterns, capacity constraints, and storage locations on the inventory costs by adopting the (s,S) ordering policy where both the moment of ordering and the order size may vary. This policy is not in line with most hospital settings and it would not even be desirable. Therefore, the model they used is not useful for in practice. Duan & Liao (2013b) have compared storage policies to tackling the problem of uncertain demand, limited shelf life, and high customer service level requirements of highly perishable products by realizing a close match between supply and demand. They have used a simulation optimization approach based on a metaheuristic algorithm which goes too far to model for our research, but could be useful in the future. The research of Ketzenberg & Ferguson (2007) matches also closely with the practical situation and presents useful benefits of centrally managing perishables. However, the simulation study they have carried out is too extensive to use in our research.

3.4.2 Articles on perishable inventory

Perishables are items with a high deterioration rate which mostly requires specific storage conditions to slow the deterioration rate. For perishables it is usually impractical to reorder products with the same obsolescence date. Mostly, perishables are defined based on their shelf life of less than or equal to 30 days (Donselaar, Woensel, Broekmeulen, & Fransoo, 2006).

Key issue in managing perishable inventory is to find the optimal balance between product availability and outdating (Blake, Heddle, Hardy, & Barty, 2009; Donselaar & Broekmeulen, 2012; Stanger, Wilding, Yates, & Cotton, 2012; Minner & Transchel, 2010). Outdating becomes expensive by increasing assortment, contributing to an increasing number of slow moving perishables, and so an increase of food wastage (Ketzenberg & Ferguson, 2007; Broekmeulen & van Donselaar, 2009). While the stock out penalty costs are difficult to determine, reaching the required service level asks for a certain level of product availability (Blake, Heddle, Hardy, & Barty, 2009; Broekmeulen & van Donselaar, 2009). A model to determine order quantities that satisfy service level requirements could closer meet defined bounds on outdates and shortage levels than focusing on costs of both aspects (Blake, Heddle, Hardy, & Barty, 2009; Minner & Transchel, 2010).

3.4.3 Articles on lateral transshipments

'LTs are stock movements between locations in the same echelon of an inventory system' (Paterson, Teunter, & Glazebrook, 2012). Allowing LT between storage locations at the lowest echelon is a way to reduce safety stock while maintaining customer service levels (Diks & de Kok, 1996; Evers, 1996; Paterson, Teunter, & Glazebrook, 2012). In particular when reduction of the number of stock keeping facilities is unacceptable. LT allows to continue operating all of this stock keeping locations at the same on-hand availability while reducing safety stock.

There is a gap in the literature concerning the impact of LT for perishables (Cheong, 2013). Thereby, articles cannot be extended to a general multiple location system due to supply chain characteristics and specific assumptions in their cost parameters (Herer & Rashit, 1999). In addition, identical locations could have different optimal replenishment policies (Olsson, 2009). It will be expected that a higher uncertain demand leads to lower customer service and more LTs (Banerjee, Burton, & Banerjee, 2003). Behavior of buyers is an important factor in predicting the demand (Ali, Madaan, Chan, & Kannan, 2013). Supply chain management can improve service levels significantly by reducing uncertainties (Vorst, Beulens, De Wit, & Van Beek, 1998). The availability of real time information is set as requirement for obtaining these advantages.

3.4.4 Articles on Retail

Challenging problems in retail operations are product substitution (Smith & Agrawal, 2000) and clearance sales pricing which need to be analyzed simultaneously with replenishment and inventory management (Minner & Transchel, 2010). Seasonal products and substitution have great influence on inventory control of perishables (Ali, Madaan, Chan, & Kannan, 2013).

'Ignoring product substitutions in managing the inventories may result in sub-optimal performance' (Tan & Karabati, 2013). Furthermore, RFID technology is of great impact on supply chain management of perishables (Bertolini, Ferretti, Vignali, & Volpi, 2012/2013). This technology provide up-to-date insight in the current stock height and enables to adopt a management policy which order products automatically at a variable moment when inventory level drops below a preset minimum(s). So, adopt a (s,S) inventory management policy where both, the moment of ordering and the order size may vary, to order always up to the max(S), or a (s,Q) policy to order a fixed order size(Q) which meets the order units of the supplier.

3.5 Overview of useful information for our research

The literature addresses useful knowledge on location and allocation of products, perishable inventory management, LTs in a supply chain, logistics in a retail setting, and reviews on these topics since 1982. However, just a few theoretical perishable inventory models developed focus on food inventory management. The models requires a reasonably idea of holding and ordering costs and accurate information that indicates the actual level of stock and sales. Since these data is not always available in hospitals, this would be a problem (Slack, Chambers, & Johnston, 2007). Moreover, inventory problems were mostly solved by dynamic programming or a simulation study. In practice it is more common to use simple heuristics to obtain an approximate intervention (Axsäter, 2006). Duan and Liao (2013) have called for the development of a generic model. Because of the limitations in availability of data and the requirements of models, mainly the theory behind the various concepts will be used in this research.

3.5.1 Theory on inventory location and allocation

A way to reduce the safety inventory while product availability remains is by aggregating inventory. 'Centralized supply chains are more cost-effective than decentralized ones' (Duan & Liao, I, 2013a). In decentralization there is no consultation between the different locations. Locations could be seen as independent companies aimed to minimize their own inventory costs. Adopting centralized control over the whole supply chain reduces the system expected outdate rate and the mismatch between demand and supply becomes smaller, while keeping sufficiently high fill rate at each entity (Duan & Liao, II, 2013b). Inventory consolidation by centralized stocking results in a reduction in safety stock being required to satisfy a given level of customer service (Evers, 1996), and processes become more efficiently by exploiting any economies of scale (Chopra & Meindl, 2001). Centralization is especially beneficial in case of unstable demand patterns (Duan & Liao, 2013a), when products have a short shelf life, large batch sizes, and the penalty for mismatches in supply and demand are large (Ketzenberg & Ferguson, 2007).

It is not appropriate to manage reductions across all products due to the different characteristics and requirements. For example, by specializing the distribution network with fast-moving items stocked at decentralized locations while slow moving items stocked centralized. Other method is to account for the fact that by packaging of the supplier the mismatch between supply and demand becomes bigger.

3.5.2 Theory on perishable inventory

Inventory management is a trade-off between shortage and wastage (Stanger, Yates, Wilding, & Cotton, 2012). Since several foods are highly substitutable, for these products the consequences of shortages will outweigh the wastage. Due to increasing awareness on corporate social responsibility, organizations should avoid waste by taking preventive measures. Duan & Liao (2013b) have advised an age-based policy to reduce waste of perishables. Checking residual shelf life and anticipate on expected future outdating of products results in less unnecessary outdating and shortages (Haijema, I, 2011). Duan & Liao (2013b) have described the reduction in expected outdated rate while keeping sufficiently high fill rate, by adopting centralized control over the whole supply chain. In addition, LTs can achieve significant savings (Hu, Watson, & Schneider, 2005). 'Layout changes which bring processes closer together, improvements in transport methods and workplace organization can all reduce waste' (Slack, Chambers, & Johnston, 2007).

3.5.3 Theory on lateral transshipments

A transshipment policy could be effectively used to reduce safety stocks while maintaining customer service levels. LTs between facilities allows a firm to continue operating all of its stock keeping locations at the same level of inventory availability, while reducing its safety stock requirements (Evers, 1996). The transfers between the entities leads to the lowest stock losses for an acceptable number of transshipments each week (Mercer & Tao, 1996) and improves the inventory availability dramatically (Needham & Evers, 1998). Proactive transshipments would be especially beneficial in case of highly variable demand. The benefits associated with LT are the savings of fixed and variable replenishment costs (Herer & Tzur, II, 2003). This benefit increases with the number of locations (Paterson, Kiesmüller, Teunter, & Glazebrook, 2011). In particular when reduction of the number of stock keeping facilities is undesirable. The difference in costs of holding inventory at the warehouse versus the lower echelons is an important aspect. Wee and Dada (2005) have advised that 'for large enough penalty costs of stocking out it will be economical to use some sort of pooling policy'. If costs of LTs are equal or smaller than the holding costs plus stock out costs then a model with LTs seems to be a cost effective way of reducing inventories (Hu, Watson, & Schneider, 2005).

Benefits of avoiding shortages without additional safety stocks, higher product freshness, improving customer satisfaction, and saving replenishment and management costs will outweigh the chain cost increases, as the additional transshipment costs (Vorst, Beulens, De Wit, & Van Beek, 1998; Burton & Banerjee, 2005; Lee, Jung, & Jeon, 2007; Paterson, Teunter, & Glazebrook, II, 2012; Banerjee, Burton, & Banerjee, 2003; Herer & Tzur, II, 2003).

3.5.4 Theory on Retail

Innovations in retail industry, like the RFID technology, are developments which goes further than the current logistic process of food in hospitals and are therefore still a step too far for this research. Sales pricing is not a relevant topic for in hospitals. This could be an item in the future when a hospital decides to sell products to patients or visitors in a sort of restaurant setting.

Conclusion

Literature study learns that current inventory models are not useful to replicate for the food logistics in hospitals, while the food business as in the retail setting is even not useful for in a hospital setting because retail is more innovated. So, to give answer on the research question what suitable methods are to manage inventory of perishables we conclude that the found models are not useful to replicate. However, the background information is useful as input on how to organize the food logistics more efficiently and to argue consequences when organizing interventions. Highlights of what has been discussed regarding the food logistics are:

- Stock has an important function. It compensate for the differences in timing between supply and demand, because demand forecasts are uncertain and a product shortage result if actual demand exceeds the forecast demand.
- The required level of safety inventory depends upon uncertainty, replenishment lead times, lead time variability, desired product availability, review policy, and packaging.
- Key issue in managing perishable inventory is to find the optimal balance between product availability and outdating. Checking residual shelf life, anticipate on expected future outdating of products, and adopting centralized control over the whole supply chain reduces the unnecessary outdating and shortages while keeping sufficiently high fill rate.
- Centralized supply chains are more cost-effective than decentralized ones. Centralization reduces the safety stock being required to satisfy a given level of customer service. It is especially beneficial in case of unstable demand patterns, when products have a short shelf life, large batch sizes, and the penalty for mismatches in supply and demand are large.
- LT between storage locations is a way to reduce safety stock, create higher product freshness, and saving replenishment and management costs, while maintaining customer service levels.

Chapter 4

The formulation of possible interventions

Before we formulate possible interventions to improve the logistical processes, we need to define requirements that must be met in order for an intervention to be considered acceptable to key stakeholders. Section 4.1sets some acceptance criteria which indicates the minimal set of requirements that must be met in order for a particular intervention to be worth implementing. We discuss these acceptance criteria by using the MoSCoW technique (Stapleton, 2005), to determine the order of importance for the requirements. Section 4.2 discusses different methods to manage inventory of wholesale products and determine the appropriateness of an intervention by considering the extent to which an intervention satisfies the boundary conditions, priorities, and wishes. Section 4.3 describes the process flows of the interventions.

The MoSCoW technique does not lend itself to incorporating change requests, since it was difficult to ascertain its value and the need for incorporating it within the current practice (Kukreja, Boehm, Payyavula, & Padmanabhuni, 2012). The decision theory will therefore not judge solely on the MoSCoW prioritization. In Chapter 5, evaluation criteria scores how well an intervention performs..

4.1 Prioritization of acceptance criteria using the MoSCow technique

To ensure that an intervention will fit in the organizational and practical context of AMC, MoSCoW analysis divides requirements into four categories in order of importance, from required to luxury (Heerkens & van Winden, 2012). This technique doesn't make it possible to capture the true value of the requirements, although a structured way to assess possible interventions will be achieved. These categories are (Heerkens & van Winden, 2012):

- **Must have:** This condition is non-compensatory. Requirement must be satisfied in the intervention to be considered a success. It would be impossible to manage without having to comply with this requirement.
- **Should have:** Represents an attribute of high priority that should be included in the intervention if it is possible. We can manage without for at least a while. In the long term these priorities could become mandatory.
- **Could have:** Describes an attribute of low priority which add business benefit but can be easily omitted. It will be included if time and resources permit.
- **Won't have:** Describes luxury demands of stakeholders on which they have agreed not to be implemented within a given period. This wishes may be considered for the future.

In the next section we discuss these categories in view of AMC.

4.1.1 Operationalization of the requirements into categories

The main precondition for an intervention is that it still meets the HACCP requirements. In 2011, AMC has developed additional requirements to improve the food logistics. Goals as mentioned in this assignment and some other restrictive conditions are added as acceptance criteria. Relevant 'Must have' conditions for this research are (van der Maat, Opdrachtforumulering Voedingslogistiek, 2011; van der Maat, 2013):

Condition	Description
Food service in general	Patient centered; Meets the guidelines for optimal nutrition and has a positive contribution to the healing process, well-being of the patient and, also the prevention of complications.
No major renovation	A renovation is planned for 2016/2017. Until then no major renovation work on the unit kitchens would be conducted. The upcoming years only small changes (within a small budget) would be advised. Major changes should be planned in the future.
Issuance of food by the food assistants.	While logistic employees would be able to do tasks of food assistants, the issuance of food need still to be done by assistants.
Internal shipments should be flexible and reliable.	Food logistics processes must be designed in a way that there are opportunities to introduce new products and adapt seasonal changes, to up-date the range of goods stocked and to adjust the number of patients served.
Less stock outs; Less waste	Efficient ordering process, reduction of the amount of stock outs by optimizing inventories, and being able to obtain out-of-stock items. Minimizing the amount of products wastage. Both related to the efficiency of the assortment.

Table 13: 'Must have' conditions

Relevant 'Should have' conditions for this research are (van der Maat, Opdrachtforumulering Voedingslogistiek, 2011; van der Maat, 2013; IFC BV, 2012):

Condition	Description
Lift capacity	The lift capacity must be taken into account. So, centralized storage locations interventions on a same floor would outweigh interventions where lifts should be used often.
Optimization of inventories	The order and stock positions must closely match with the consumption of each unit.
Eliminating unnecessary actions	Reducing handling costs, efficient process.
Visitors	There should be a clear policy on the possibilities and rules of eating with visitors. This could be further developed in line with the hospitality wishes of the hospital.

Table 14: 'Should have' conditions

'Could have' conditions are of low priority. However, to become a hospital that excels in the field of nutrition even these conditions could become rather important(van der Maat, Opdrachtforumulering Voedingslogistiek, 2011; van der Maat, 2013):

Condition	Description
Less administrative burden	Less paperwork and less administrative tasks should improve time efficiency of food assistants.
Less adjustments	Daily adjustment should not be necessary anymore by introducing standardized processes. Controlling orders by food administration should be done randomly.
Making registration of consumption, waste and stock outs possible in an easy way.	Insight into the process gives opportunities for improvements.

Table 15: 'Could have' conditions

The 'Want to have' conditions are from the hospitality research of Saxion (Koerhuis, 2012) and the additional research by IFC BV (2012). Some relevant conditions for this research are:

Condition	Description	Explanation
Product	More extensive assortment	Patients have indicated that the breakfast and lunch assortment is limited.
	Short throughput time between ordering and delivering	
Environment	Possibilities to eat in a restaurant	35% of the patients likes to eat in a restaurant.
	Possibilities to eat with visitors or other patients	47% of the patients likes to eat with visitors or other patients.
Behavior	Increasing time food assistants have to serve the patients	Food assistants have too little time to serve their meals. Snacks are not actively provided.
Food service in general	Hospitable	Even for visitors.

Table 16: 'Want to have' conditions

4.2 Formulation of suitable methods

This section discusses different methods to manage inventory of wholesale products and determine the appropriateness of an intervention by considering the extent to which an intervention satisfies AMC's boundary conditions, priorities, and wishes.

Based on the literature there are several options to manage perishable inventory. In many situations, centralized storage and control in a supply chain outweigh decentralization. AMC is such a big building that there will be a tipping point where central storage not always outweighs decentralization, because of the extra transportation costs. Therefore, the option centralization per floor is added as comparable with centralization in a smaller organization. We analyze possible ways to improve the logistical performance based on the literature study, AMC's current process, and our observations and experiences. We identify five possible interventions for AMC to manage their inventory of wholesale products:

1. Safety stock is stored centralized, BBWs will be transported from central stock to unit kitchen and back.
2. Safety stock is stored centralized, BBWs will be replenished by a trolley that goes along the various departments.
3. Safety stock is stored per floor, BBWs will be replenished centralized per floor. Adopting (pro/re) active LTs.
4. Safety stock is stored per floor, BBWs will be replenished by a trolley that goes along the various kitchens. Adopting (pro/re) active LTs.
5. Safety stock is decentralized per unit kitchen, where all handling activities take place.

We subject these five interventions to further investigations. Since AMC does not want to carry out major renovations and assuming that they do not want further outsourcing, only these interventions will be within the possibilities of AMC.

The next section gives and overview of the process flow for each intervention and shows where activities take place: centralized for the entire hospital, centralized per floor or decentralized. If safety stock is stored centralized, the corresponding activities as ordering and replenishing take place at a central location in the hospital. This centralized location could be near to the CGO in the basement of the building. However, it could also be at the middle floor of the building in the middle tower, or at each floor in the middle tower in case of centralization per floor. In decentralized storage the kitchens on each floor will be used as storage locations.

4.3 Process flow description

Schematically representation of the five possible interventions is in Figure 25. Delivery, receipt, and control of the goods is always centralized at the CGO. Orders should be checked immediately on completeness and temperature should be measured. The trolleys with products must be transported as soon as possible due to the rising temperature of chilled goods. At the storage location the temperature should be measured again to ensure these is still acceptable.

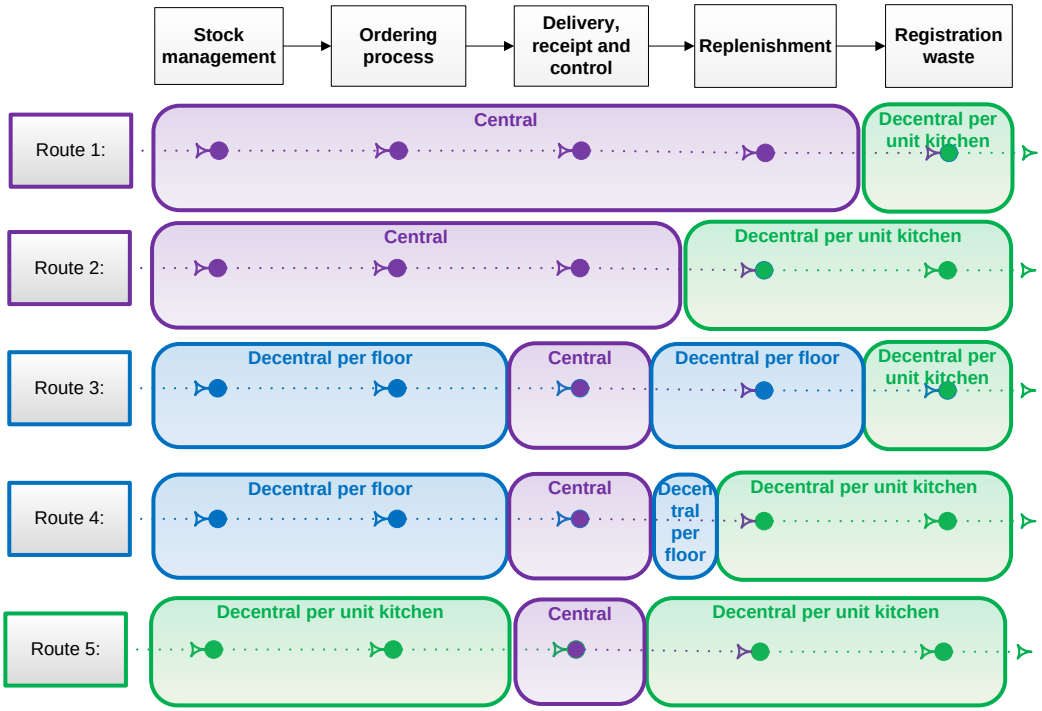


Figure 25: Possible interventions by organizing processes differently

The final step in the process includes stock management of the BBW, controlling of FIFO policy, and removing and registering food waste. This step is decentralized per unit kitchen for all interventions. Issuance of food is always done by food assistants, which are still responsible for checking the expiration date by serving patients.

The other steps in the process could be centralized, centralized per floor, or decentralized. For Interventions 1 and 2, most activities are centralized, in Interventions 3 and 4, the main activities are centralized per floor, while in Intervention 5 most activities are decentralized. We elaborate further by explaining the process flow of each intervention and discussing the appropriateness of an intervention by considering the extent to which an intervention satisfies the acceptance criteria. Furthermore, we assess for each step in the process the impact of each intervention.

4.3.1 Explanation of the process flow of Intervention 1

In this intervention the control activities and storing of safety stock is organized centrally. The internal distribution consists of transporting BBWs to the relevant departments. There are still some fast movers which could not be saved in the BBW during the whole process due to a limited (chilled) room at the BBW. These products and some extra inventory are transported with the BBW. When BBWs arrive at the unit kitchen they are almost ready for serving the patients. Products such as coffee and tea are stored at the decentralized unit kitchens and should prepared by food assistants. The transported fast movers have to replenished after transporting. However, replenishing could possibly be done after serving the patients.

This intervention requires a centralized storage location. Unit kitchens does not need to be renovated. The choice of storage location will influence the investments. A storage location at the middle floor will be a bigger renovation, while the benefits afterwards will be higher in comparison with a centralized storage location in the basement. The food service in general will be at least as in the current situation. This intervention will have a high burden on the elevators. It has no influence on the policy with regard to visitors. However, other 'should have' conditions will be met in this intervention: the inventories reduce, and unnecessary actions will be eliminated. In addition, by centralize activities, the administrative burden and adjustments will possibly reduce since just one person is responsible for this activities for all units together. Lastly, food assistants have fewer indirect patient tasks, so they have more time to serve to their patients.

4.3.2 Explanation of the process flow of Intervention 2

Stock management and ordering process are done in the same way as the previous intervention. The difference with Intervention 1 is the way and location of replenishment. Intervention 2 uses a trolley with on-hand inventory to replenish the BBW at the units. This trolley is easier to transport, can deliver per pieces instead of over packs, and deliver based on the stock height of on-hand inventory in a BBW. Ordering is done centralized based on the safety inventory at central storage location. Extra inventory, as chilled products, are also delivered this way. Logistic employees are responsible for checking FIFO replenishment and the expiry date of products.

Same renovations as in the first intervention are needed. Unfortunately, this intervention needs lift capacity while the stock height and waste will remains the same. The administrative burden for food assistants will reduce, because they are no longer responsible for the ordering process.

4.3.3 Explanation of the process flow of Intervention 3

The main tasks are organized centrally per floor. BBWs will be replenished at the tower G where safety stock is stored and the process from ordering to replenishing take place. By delivery safety stock, only the elevators in tower G need to be used. Further transport of BBWs is on the same floor. Preparation of coffee and tea is still done at the unit kitchens, as in Intervention 1.

Just a small renovation will prepare the unit kitchens, in tower G, as storage locations. Because of the higher throughput of products, as expected in this intervention, the flexibility and reliability of internal shipments increases. The stock height of items will be lower than in the current situation, so modifications in the assortment can be carried out quickly. Lift capacity increases, since mainly the elevator of tower G will be used. The amount of waste will reduce and shortages become less due to LT. Depending on how AMC wants to extend this intervention, the wishes of patients to eat in a central location with others could be fulfilled by starting with this intervention.

4.3.4 Explanation of the process flow of Intervention 4

This intervention is comparable with Intervention 2, but now the safety stock is centralized per floor. This means extra handling in the process since goods are transported from CGO to decentral safety stock where the trolleys will be replenished, to visit the unit kitchen to replenish the BBWs. Advantages, as compared with Interventions 1 and 2, are the transshipments on the same echelon and storage near to the customers. The elevators will be used less, while the inventories reduce. In comparison with Intervention 3 the acceptance is less, due to the extra safety stock on trolleys and extra handling, while optimizing the stock is not that huge.

4.3.5 Explanation of the process flow of Intervention 5

The current situation is shown in Intervention 5. The main activities from stock management and ordering foods at the supplier until replenishing are done decentrally at the unit kitchens. Food assistants are responsible for many tasks in the process while they should spend their time at the wards to serve the patients. Actually, unit kitchens are not suitable as storage location for safety stock and as replenishment location. The furniture is not designed for this way of working. In addition, staff influence the order quantities, while it is intended to standardize these quantities, based on historical data. The frequent use of elevators in this intervention is a big disadvantage, the waste is high as well as the administrative burden and adjustments. To achieve a higher food service level among others it would be advised to organize the logistic function concerning food more efficiently by choose one of the four other interventions.

4.4 Impact of changes in inventory management on the process flow

This section elaborates all steps of the process flow separately.

4.4.1 Stock management

AMC would benefit from centralized control and storage of safety stock because many activities as checking the expiration dates, thrown away products that are expired, and placing products FIFO, will efficiently be done at one central location. Because AMC is a big building, centralize the activities of stock management per floor will be more efficiently as centralize these activities for the whole hospital, due to the huge walking distances from the central location to each unit kitchen and additional personnel costs for transport. For items with a large case pack size comparing with the average demand during shelf life or comparing to the storage possibilities in a BBW, it would beneficial to centralize safety stock. Supply chain management can improve service levels significantly by reducing uncertainties with a smaller inventory. Reducing inventories and introducing (proactive) transshipments, to react on the highly variable demand would be beneficial.

4.4.2 Ordering process

When the products are replenished at one central location, the ordering process should also be done there. It will be more efficiently to introduce scan batches instead of Slimis anyway to speed up the ordering process. AMC wants to remove employee dependent aspects as much as possible. Therefore, scan products and order a predetermined amount based on prospective data will improve this process. Availability of historical data useful in predicting demand is a prerequisite for the successful execution of this method. Furthermore, research on a case specific forecasting model would recommended. When reducing the number of storage locations, while maintaining customer service levels, a transshipment policy could be effectively used to reducing safety stocks. Furthermore, ordering based on one central inventory or a few central inventories will benefit from economies of scale. Nowadays, AMC uses the ordering scheme as presented earlier. AMC could decide to standardize the ordering processes based on historical data and make adjustments only once a week. On the other hand, for the purpose of reducing the system expected outdate rate, it would be more efficiently to make daily orders possible, due to big inventories and high uncertainties. Desired situation for in the future is an automatic ordering system ordering variable order quantities. These developments will have to go in cooperation with the supplier.

4.4.3 Delivery, receipt and control

The logistic employee transfers the products and replenish the safety stock right after. When the safety stock is separated from the unit kitchens it is no longer a problem to replenish during rush hours. However, the process should be organized in such a way that the BBWs are prepared before the rush moments.

4.4.4 Replenishment

Dependent of the storage policy, the products are transported to their destination where replenishment take place. The policy determines how further internal transport looks like. In case of centralization, storage is near to the CGO and further internal distribution is just the distance from central storage to the unit kitchens by using a trolley or BBW. At centralized storage per kitchen, the trolleys with goods are right after receiving transported to the decentral storage location and from there transported by BBW, or the trolleys are transported from CGO to the unit kitchens where replenishment will be done. While the last intervention has the most handling activities, distribution at the same floor makes transport more efficiently and faster. This intervention could outweigh the disadvantages of the other interventions when looking at the holistic process.

4.4.5 Registration waste

Waste registration should be done at both, cycle and safety stock. At the safety storage location one should check the expiration date and sorting products FIFO. Food assistants check products at the on-hand inventory since they are responsible for the products they serve to the patients.

Conclusion

This chapter discusses the acceptance criteria by using the MoSCoW technique. Taking the MoSCoW rules into account, we formulate five different interventions for AMC to manage inventory of wholesale products, from complete centralization until the current decentralized method. From the literature is known that, based on the characteristics of AMC, it would beneficial to centralize safety stock. Especially, the items with a large case pack size comparing with the average demand during shelf life or comparing to the storage possibilities in a BBW. Centralization have several advantages for AMC in comparison with decentralization:

- Many activities such as checking the expiration dates, thrown away products that are expired, and placing products FIFO, will efficiently be done at one central location.
- Service levels can improve significantly by reducing uncertainties with a smaller inventory.
- Benefit from economies of scale.
- When the safety stock is separated from the unit kitchens it is no longer a problem to replenish during rush hours.

Disadvantages are:

- Investments, of a central storage location and other intervention dependent interventions.
- Stock is stored far from the patients.

We have evaluated the impact of each intervention on the five steps of the process and formulate the advantages and disadvantages of each intervention on these steps as shown in Table 17.

Intervention	Main advantages	Disadvantages
1	Less inventory, reducing waste and holding costs. Eliminating unnecessary actions. Food service level at least as in the current situation. Reduction of administrative burden. Less administrative adjustments. Fewer indirect patient tasks for food assistants, so more time to serve patients.	Requires a centralized storage location. Backorders become important. High handling and related personnel costs due to the long transport distances. High burden on the elevators.
2	Small reduce of waste and holding costs. Trolleys are easier to transport, can deliver per pieces instead of over packs, and deliver based on the stock height of on-hand inventory in a BBW.	High shortage rate. High handling and personnel costs due to additional intermediate storage and transportation to centralized storage location. Needs lift capacity. Stock height and waste will remains nearly the same.
3	Reducing costs by centralization: Smaller inventory, waste reduction, savings of waste, reduction of cost aspects as holding costs, transportation costs and inventory balance. Higher time efficiency of employee tasks. Shortage of stock become less due to LT. Inventory near to the consumers. Only the elevators in tower G need to be used. Just a small renovation will prepare the unit kitchens as stock keeping locations. The wishes of patients to eat in a central location with others could be fulfilled by starting with this intervention.	Less reduction of centralization in comparison with complete centralization policy.
4	Reducing costs by centralization, LT, inventory near to the consumers. Less use of elevators. Smaller inventory.	Less reduction of centralization. Extra handling costs because of additional intermediate storage. Higher safety inventory as Intervention 3.
5	No changes, products near to the patients.	High amount of waste, big inventories, low food service level, high costs, high work pressure of mainly indirect patients tasks, as experienced by food assistants, responsible, dependent of delivery times, shortages, high inventory turns, and high inventory balance. Staff have influence on order quantities. Frequent use of elevators. High administrative burden and high amount of adjustments.

Table 17: Advantages and disadvantages of interventions

Chapter 5

Performance measurement

The previous chapter elaborates on methods for AMC to improve the logistical performance of inventory management concerning wholesale products. A prioritization of the requirements using MoSCow rules results in five different appropriate interventions. Suitability of the interventions differs. Section 5.1 elaborates on the impact of the interventions for each KPI. Furthermore, this chapter evaluates on the basis of the criteria as formulated in Section 2.3.3, which describes the set of requirements that will be used to choose between multiple interventions (International Institute of Business Analysis, 2009). As mentioned in that section, we limit ourselves to the KPIs which have received the highest weight. These are the KPIs among the categories Quality, Speed, and Dependability. With respect to the other indicators, we will assume that these will not score more worse than in the current situation. An overview of evaluation criteria from which the scoring proceed is shown in Appendix II. Section 5.2 discusses the scoring per intervention. The score of Intervention 5 is already known since this is the current situation and therefore the score is as baseline measurement. Section 5.3 evaluates the impact on food logistics processes to identify a proposed intervention in Section 5.4.

5.1 Scoring per KPI

Per KPI we discuss the impact of the interventions.

5.1.1 Waste

The total amount of (un)avoidable food waste (warm meal, wholesale products and bread) is far above AMC's target, as measured in baseline measurement. Since AMC aims to reduce avoidable waste, it is important to include preventive measures when organizing interventions. We expect waste reduction by adopting an age-based policy; Nowadays, products are ordered in the morning. Since the residual shelf life is not checked, one cannot anticipate on expected future outdating, resulting in unnecessary outdating and shortages. While the actual amount of waste can only be measured by implementing centralized control, based on literature is predicted that centralization will reduce AMC's waste of wholesale products. Anyway, it is unlikely that the amount of waste will increase in each of the interventions. When reduction in the number of storage locations is undesirable, as in AMC, LTs could be effectively used to reduce safety stocks, and consequently the amount of waste, while maintaining service levels.

5.1.2 Order fill rate

Replenishing BBWs from safety stock could be done in the evening, because the BBW has a refrigerator. Then, BBWs are almost prepared when food assistants are going to use them the next morning. Almost, because AMC chooses to serve fresh bread daily. For Interventions 1 and 3, right after the delivery of bread, BBWs are transported to their destination and food assistants can start with distributing. In Interventions 2 and 4 only bread should be transported to the units. We recommend to adopt another policy to be independent of deliveries during rush hours. Only as food assistants can start on time with distributing breakfast, there are opportunities to add a second round, for the purpose of hospitality. Assuming interventions are still dependent of the delivery of at least one supplier, score of interventions remains the same. However, appointments with a single supplier will improve the order fill rate in comparison with the current situation.

5.1.3 BBW inventory accuracy

A BBW is designed for storing on-hand inventory of perishables. The storage facilities of a BBW should be enough to serve the patients at one unit (max. 32 patients for G5) for at least one day. However, food assistants refill BBWs after each service round. Therefore, a shortage of stock means that the replenishment of products happens not accurate, a product is out of safety stock, or products are not enough replenished due to the limited storage facilities on a BBW. Reposition of the inventory on a BBW is recommended, as the demand of patients has changed, but storage locations are not adapted to this change.

Slow movers are prominently present on a BBW while new, high demanded products have limited storage capacity. Furthermore, assistants simply not offer some products or flex workers are not familiar with the unit specific products, so they do not know that they have to replenish these items. When organizing an intervention, replenishment becomes a task of logistic employees. Assuming they replenish like food assistants are doing, this will not influence the accuracy of inventories and the score of this KPI remains the same. However, AMC aims to reduce inventory costs, so it would be beneficial to use historical data and replenishing a BBW based on pre-determined quantities in order to improve this KPI.

5.1.4 SKUs in-stock percentage

AMC prefers high inventories above a shortage of stock. Assuming AMC is continuing this policy, the score of this KPI remains the same, because the interventions will not influence this KPI. However, it is recommended to use a forecasting model which uses historical data to match the demand and supply closer.

5.1.5 On-time shipment

In current procurement contract is agreed that van Hoeckel delivers three times a week dedicated to AMC at 6:30 AM on the indicated days (van Asselt, 2013). A delivery is only reliable if the product, quantities, temperature and expiration date are 100% correct and arrives within five minutes before/after appointment time (AMC, 2010). Interventions will not influence the on-time shipment. However, by organizing interventions, the consequences of this KPI could be negligible and the weight of this KPI should be discussed.

5.1.6 Out-of-stocks

Food assistants have mentioned that, if delivery is accurate, the amount of shortages is negligible. The ordering process depends on the specific employee that places the order. However, AMC outweighs the product availability above shortages and store big inventories on each unit kitchen. These high inventories neglect the real problems in the ordering process. AMC aims to reduce experience dependency and would order based on historical data. If BBW's inventory accuracy remains as in current situation, the score for this indicator will not change for any intervention. While this accuracy depends on delivery, replenishment, and several other factors which will change by interventions, we assume that product availability in Interventions 1 and 3 remains the same and logistic employees replenish BBWs as food assistants currently do. In Interventions 2 and 4 a logistic employee takes all types of SKUs with them on a trolley to replenish BBWs and do not know the needed quantities of each SKU. Therefore, we expect an increase of shortages. Intervention 4 adopts a transshipment policy which enables to react on this shortage.

5.1.7 Backorders

Due to the large inventories of wholesale products at 23 different storage locations, spread through the hospital, backorders are actually only relevant when there is no bread delivered. All other backorders have, to a certain extent, no hurry. In Interventions 1 and 2 the reliability of backorders will become more important since the central safety stock is the only safety stock of the hospital. Backorders should be delivered the same day, due to the costs and consequences of a shortage. In Interventions 3 and 4 LTs could prevent from backorders. Units can transship with other units and receiving the backorder a next delivery day is early enough.

5.1.8 Inventory turns

Inventory turns indicates the duration that products are in stock. The higher this value, the shorter products are stored, the better. For AMC, it is not desirable to have the highest possible inventory turns, because of the high stock out costs and consequences of shortages. However, high inventories are expensive and have the risk of becoming obsolete. It is difficult to balance these two aspects and to realize the optimal target. In decentralized storage the inventory turns might be higher while product availability remains equal. We choose an inventory turns of at least 10, so ten times a year the complete inventory is sold, and not more than 24. Based on the cost of sales in 2011 and 2012 for the units FGH5, divided by the inventory balance of these units in 2013, we identify an inventory turns of respectively 27 and 29 times a year. This high value might be caused by and inaccurate inventory balance, the annual costs of sales including also other products than included in inventory balance, or the high waste of (expensive) products. The exact cause of this value is not known, but such an high value seems unreliable, because of the big inventories and slow throughput of single products.

Interventions will optimize the inventory turns by achieving a reduction of inventory balance and waste. In Interventions 1 and 2, the overall stock reduces because of centralized storage. We expect that in Intervention 1 the inventory will be sold between the 16 and 23 times a year (on average ones a 2-4 weeks). The lots in which AMC is forced to purchase match closer with those demanded by the customer, since products are meant for all units together instead of a few patients at one unit.

In Intervention 2, there is some extra safety inventory stored on a trolley to replenish the different units. Therefore, a lesser increase of the inventory turns is expected, in comparison to the first intervention. In Intervention 3, centralization leads to a decrease of stock height and one can better respond on the demand of patients. This intervention leads to the lowest inventory, with the highest inventory turns, without negative consequences for product availability.

However, looking at the entire hospital, the inventory turns of the several centralized locations together will be at least as high as in Intervention 1. Intervention 4 has also a lower inventory due to the centralization, but lesser benefits due to the extra inventory on trolleys.

5.1.9 Inventory balance

We have calculated the inventory balance by multiplying the amount of products in inventory with the value of each of these products. Based on calculations of 2012 and 2013 we know that the inventory balance of wholesale products and bread, for the units FGH5, is more than € 5,000. Based on previous section is known that the inventory balance for all interventions reduces due to the centralized storage of stock. Since Interventions 2 and 4 need extra inventory on trolleys, the inventory balance will reduce, but less extremely. Therefore, we predict that inventory balance will not reduce significantly in comparison with the current situation.

5.1.10 Days of supply

Actually, AMC aims to serve patients in their nutrition needs without inventories (van der Maat, 2013). However, AMC is forced to purchase in lots larger than those demanded by the customer. Inventories guarantee a several product availability to react on the mismatch between supply and demand. Since a shortage of inventory should be prevented, inventory of less than one day is unacceptable. Since all interventions outweigh the product availability above shortage of products, the days of supply become more than one day.

5.1.11 Holding costs

While the actual values of holding costs for storing foods on the several locations within AMC are unknown, AMC aims to reduce holding costs. All interventions aim to reduce these costs by aggregating inventories, to achieve a lower inventory balance and waste, so that the holding costs will also reduce. For Interventions 2 and 4 the additional storage on trolleys will increase the holding costs. Therefore, we expect that the overall holding costs for this intervention remains the same, while for Interventions 1 and 3 these costs reduce significant.

Category	KPI	Target / Goal Points: 5	3	1	Weight	Intervention 1 Values	Score	Total	Intervention 2 Values	Score	Total	Intervention 3 Values	Score	Total	Intervention 4 Values	Score	Total	Intervention 5 Values	Score	Total
Quality	**1. Waste** *(Incourante voorraad)*	≤ 5%	6%-10%	≥ 11%	0.2	Less than in current situation	3	0.6	Less than in current situation	3	0.6	Much less than in current situation	5	1	Much less than in current situation	5	1	≥ 11%	1	0.2
Speed	**2. Order fill rate** *(% orders compleet op tijd)*	Always on time	Usually on time	Rarely on time	0.2	Usually on time	3	0.6	Usually on time	3	0.6	Usually on time	3	0.6	Usually on time	3	0.6	Usually on time	3	0.6
	3. BBW Inventory accuracy *(voorraadbetrouwbaarheid)*	100%	95%	< 95%	0.07	100%	5	0.35	100%	5	0.35	100%	5	0.35	100%	5	0.35	100%	5	0.35
	4. SKUs in-stock percentage *(% SKU's op voorraad)*	100%	95%	< 95%	0.04	100%	5	0.2	100%	5	0.2	100%	5	0.2	100%	5	0.2	100%	5	0.2
Dependability	**5. On-time shipment** *(Leverbetrouwbaarheid)*	Always on time	Usually on time	Rarely on time	0.2	Usually on time	3	0.6	Usually on time	3	0.6	Usually on time	3	0.6	Usually on time	3	0.6	Usually on time	3	0.6
	6. Out-of-stocks *(Aantal keren buiten voorraad)*	100%	95%	< 95%	0.2	100%	5	1	95%	3	0.6	100%	5	1	100%	5	1	100%	5	1
Flexibility	**7. Backorders** *(Naleveringen)*	Same day	Next day	Later	0.05	Backorders get very high priority	1	0.05	Backorders get very high priority	1	0.05	LT instead of backorders	5	0.25	LT instead of backorders	5	0.25	Next delivery day	1	0.05
Costs	**8. Inventory turns** *(Omloopsnelheid voorraad)*	16-23	11-15	≤ 10 , ≥ 24	0.01	11-15	3	0.03	16-23	5	0.05	16-23	5	0.05	≤ 10 , ≥ 24	1	0.01	29	1	0.01
	9. Inventory Balance *(Voorraadwaarde)*	≤ 1000	1001-5000	≥ 5001	0.01	≤ 1000	5	0.05	1001-5000	3	0.03	1001-5000	3	0.03	≥ 5001	1	0.01	€ 5,183.39	1	0.01
	10. Days of supply *(# dagen voorraad)*	Sameday	> 1 day	< 1 day	0.01	> 1 day	3	0.03	> 1 day	3	0.03	> 1 day	3	0.03	> 1 day	3	0.03	17	3	0.03
	11. Holding costs *(Voorraadkosten)*	Lower	The same	Higher	0.01	Lower	5	0.05	The same	3	0.03	Lower	5	0.05	The same	3	0.03	Higher	1	0.01
	Overall score:							3.56			3.14			4.16			4.08			3.06

Table 18: Performance measurement of the interventions

5.2 Scoring per intervention

Table 18 shows the performance measurement per KPI for each proposed intervention. We evaluate each KPI separately, but seek for the intervention in which the KPIs among the categories Quality, Speed, and Dependability score above average and also the practical application seems favorable, while the overall score should improve the score of the current situation. This section evaluates the performance of each intervention.

5.2.1 Complete centralization

1. Intervention 1

In this intervention the safety stock is stored centrally, where BBWs will be replenished.

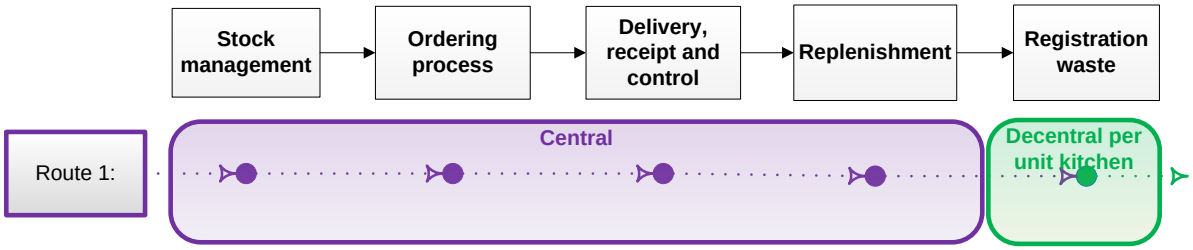


Figure 26: Process flow of Intervention 1

Intervention 1 benefits from the waste reduction, but reliability of backorders become of high importance, because it is impossible to transship with other storage locations due to the single storage location. Whether the reduction of cost aspects outweigh the additional handling costs in comparison with the current situation, Intervention 5, should be evaluated.

2. Intervention 2

In this intervention the safety stock is stored centralized and BBWs will be replenished by a trolley that goes along the various departments.

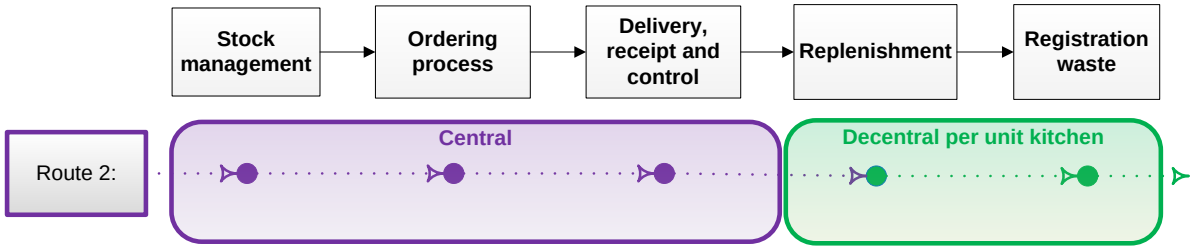


Figure 27: Process flow of Intervention 2

Intervention 2 has some benefits of reducing waste and the improvement of several cost aspects, while the product availability increases. However, the handling costs will increase and the reliability of backorders become of high importance.

For both interventions holds that the other indicators are expected to remain the same, or at least not deteriorate compared to the current situation.

Since AMC wants to achieve a higher food service level among others (van der Maat, 2013), Intervention 1 will be preferred above the second due to the higher shortage rate in the second. The holding and transportation costs of both interventions will increase. It is difficult to estimate and impossible to calculate which intervention has the highest increase. It appears that centralization of stock for the entire hospital is not profitable due to the long walking distances to transport goods and all the consequences that this brings with it.

5.2.2 Centralization per floor

3. Intervention 3

The safety stock is stored per floor and BBWs will be replenished decentralized per floor. In addition, we adopt (pro/re) active LT.

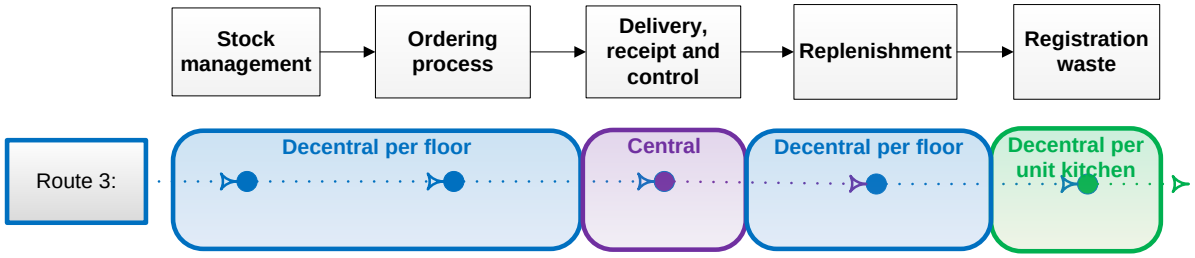


Figure 28: Process flow of Intervention 3

Intervention 3 has the greatest benefits from waste reductions. Besides the savings of waste also other cost aspects will be improved in this intervention comparing to the current situation.

4. Intervention 4

The safety stock is stored per floor and BBWs will be replenished by a trolley that goes along the various kitchens. In addition, we adopt (pro/re) active LT.

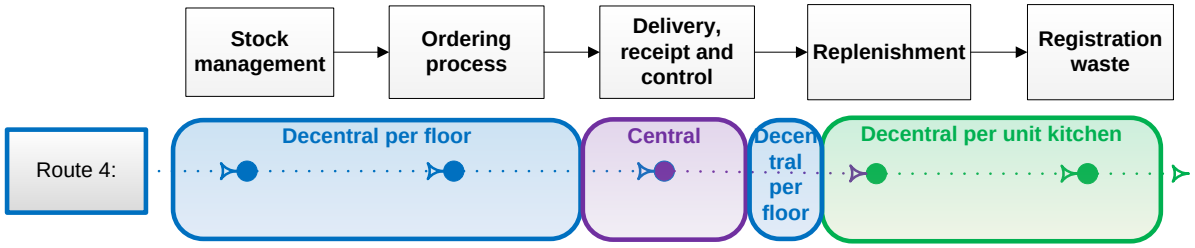


Figure 29: Process flow of Intervention 4

Intervention 4 has relatively less advantages of the reduction in waste in comparison with Intervention 3. It seems that the cost aspects improved lesser than the previous intervention. It appears that based on the measurement per KPI and the high costs because of complete centralization, these interventions are more profitable than Interventions 1 and 2.

For both interventions holds that the indicators not discussed are expected to remain the same, or at least not deteriorate compared to the current situation as shown in Table 18.

5.2.3 Decentralization

5. Intervention 5

Safety stock is decentralized per unit kitchen, where all handling activities take place.

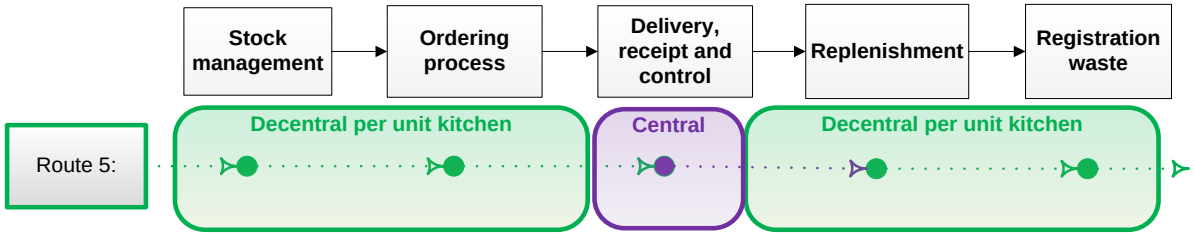


Figure 30: Process flow of Intervention 5

Intervention 5 is known as the current situation. It appears that decentralization per unit kitchen is not profitable based on the measurement per KPI. The waste and all cost aspects are higher than in each of the other interventions. Organizing interventions will result in significant improvements for AMC.

5.2.4 Other flows

We have discussed only the steps from stock management until the registration of waste. However, there are some other flows within this process which are not in the focus of this research, but still important to evaluate, such as safety stock at the units, the registration of consumption, clearing up the patients tables, dishwashing, invoicing, and delivery of suppliers.

Safety stock at the units

Regardless of the intervention, it would be beneficial to have a small safety stock on each unit. Some products could be more efficiently stored at the units due to the short shelf life or products must be chilled. Furthermore, the on-hand inventory of coffee and tea should be stored at the kitchens. AMC could even decide to store drinks at the units since transport of these items per BBW is not preferable. The chilled storing facilities in a BBW are limited. Therefore, we recommend to keep a refrigerator at the kitchen to store on-hand inventory. The chilled inventory at the kitchens should be minimal in order to benefit from the advantages of pooleing. So, safety stock of dairy produce, including advanced medical nutrition, will be stored in safety stock and only the expected demand of chilled products for one day is stored in the refrigerator.

In the evening, BBWs are complemented at centralized storage location. However, there should be some inventory on-hand to serve the patient who is back from surgery, or one who have a hypoglycemia. For Interventions 1 and 2 it would be efficient to take the products with a shelf life of today out of the BBW to serve these products in case of the situations as above. For Interventions 3 and 4 the safety stock is within walking distance so extra inventory for if the BBWs are complemented is not necessary.

The registration of consumption

It could be beneficial to have insight in the consumption per unit. For Interventions 3 and 4 it would be necessary to registry the consumption in order to enable efficient LT. However, for all interventions an accurate insight in inventory will improve the inventory management. Direct, or indirect as historical data on which the order quantities will be based in the future.

Clearing up the patients tables and dishwashing

After serving the patients, the trays with plate, cutlery, waste etc., are collected by clearing trolleys. So, after collecting, food assistants should sort the items and thrown the waste away before start dishwashing. Improvement could be to use a 'debrasseer' trolley which enables to combine the collection with sorting the items and thrown waste directly away. The crates wherein plates and cutlery are collected can then be placed directly in the dishwasher, which reduces handling costs and time. Currently, dishwashing is done at each unit kitchen. AMC could decide to store the dishwasher near to the replenishment locations, to replenish the plates and cutlery simultaneously with foods. When food is stored centralized per floor, it would be beneficial and more efficiently to do the dishwashing also centrally and fewer dishwashers are necessary. In centralization for the entire hospital it would take too much time and becomes inefficiently.

Invoicing

Difficulty of centralization could be the invoicing. Nowadays, each unit is responsible for their own costs on foods. When store the inventory other than on the units, the costs of foods should be split up between these units. The bill could be split based on the consumption in history, which is an approximation. Otherwise the registration of consumption becomes importantly in order to calculate the exact costs incurring to the right departments.

Delivery of suppliers

Six days a week, bread is delivered, all other wholesale products are delivered on Monday, Wednesday and Friday. AMC has decided to set fixed days to order products from specific product groups as shown in Figure 17. It would be beneficial to simplify this process and order all possible items three times a week, while delivery is each next day.

5.3 Impact on food logistic process

While the food logistic KPIs are not meant to score the performance of several interventions as done in previous section, the several interventions will influence the food logistic process. Therefore, we analyze the impact on AMC's food logistics in general.

- **Employees satisfaction.**

  Since this criterion has a high weight, there is potential for improvements on this area. While employee satisfaction is not in our focus, based on the arguments that the various stakeholders gave to support their score, we expect an increase of this indicator by optimizing the inventory management. Since the frustration of processes not run as they should is one of the main reasons. However, the score of this KPI will decrease first, because innovations may give resistance.

- **Customer satisfaction**

  This is an important criterion to remain an attractive hospital within the catchment area. Improving inventory management will not directly affect this score, because the aspects product, behavior, and environment will not change dramatically. We aim to reduce the amount of stock-outs by optimizing the inventories. Since this is only a small part of the customer satisfaction this improvement will not influence the satisfaction score.

- **Discrepancy between demand and assortment**

  There will be no changes in the discrepancy between demand and assortment arising from the research on inventory management of AMC's wholesale products.

- **Cycle times**

  This KPI will remain unchanged. Using a BBW realizes the shortest cycle times possible.

- **Time efficiency of employee tasks**

  By organizing interventions we aim to improve the time efficiency of employee tasks. Since this criterion has a high weight, this improvement will have major impact.

- **Amount of unavailable products from assortment**

  A more accurate score of this indicator can give a better measurement of performance of the actual product availability, in order to say something about the impact on this indicator.

- **Amount of complete and on-time internal deliveries**

  This indicator is not in the scope of our research and will therefore remain unchanged.

- **Time fluctuations in service rounds**

  A more accurate score of this indicator can give a better measurement of performance of the actual product availability, in order to say something about the impact on this indicator.

- **Flexibility in product and service**

  This indicator is not in the scope of our research and will therefore remain unchanged.

- **Amount of thrown away products**

  This indicator is in scope of our research and operationalized as KPI on inventory management. In previous section we already explained the expected impact on this criterion.

- **Amount of food consumption by others than patients**

  For this indicator we recommend first to draft a policy regarding the rules and regulations of food consumption by visitors. Depending of this policy it is useful to measure the amount of food consumed by others. We will not focus on this aspect in our research.

- **Costs per patient per unit**

  Many changes in all of the interventions will lead to cost savings. This criterion on the level of food logistics in general will have one of the greatest benefits of improvements in the process of inventory management. However, the weight of this criterion is the lowest of all, so the impact of improvements is negligible when measuring per KPI. By interviewing the stakeholders we know that the costs per patient should not reduce drastically, but they want to spend their money differently. Reducing costs by optimizing inventory management saves money for hospitality. Therefore, the intervention that will lead to cost savings will have a positive appeal to the management.

5.4 Proposed intervention

This section provides insight into the reason why we propose a specific intervention, by analyzing the different interventions on acceptance and evaluation criteria, the impact of organizing interventions, and an estimation of the expected costs per intervention.

5.4.1 Interventions aimed at centralization

Chapter 3 discusses the benefits of centralization based on the literature. The advantages as reduction of safety stock, reducing waste, which contains both, products whose expiration date has passed as the unused products after distribution, a more efficiently processes, and economies of scale, while keeping sufficiently high fill rate, will improve the performance of AMC's inventory management significantly. Especially, since the benefits increase due to the unstable demand pattern, short shelf life of products, large batch sizes, and the large penalty for mismatches in supply and demand. Also, the food assistants perform more efficiently by reducing time spending on these indirect patients tasks and have some extra possibilities to create hospitality.

The benefits of centralization per floor are smaller than centralization for the entire hospital, because stock is stored at several storage locations. However, the risk of shortages is lower and if there is a shortage, LT can prevent from backorders, which is in line with the aim of AMC to achieve a higher food service level among others (van der Maat, 2013). Furthermore, the handling and transportation costs, and related personnel costs will be lesser as in Interventions 1 and 2.

If AMC adopt centralized control, like Interventions 1 or 2, we recommend the following:

- Reducing handling costs by store large batch sizes without repackaging to smaller quantities. The throughput of products will be high. Large batch sizes will match closer to the demand.
- In Intervention 2, of each SKU one or more batch sizes will be stored on a trolley to replenish the units. To reduce the transportation costs it is necessary that the trolleys are big enough to transport this quantities since exact demand of units is not known on forehand.

If AMC chooses to adopt centralized control per floor, as Interventions 3 or 4, we recommend the following:

- In order to adopt a LT policy which performs well, it would be advised to register the consumption per unit. Insight in stock height per storage location enables efficient LTs.
- Adopting a kanban system like the two-bin system. During several hospital visits, as at ZGT (hospitals in Hengelo and Almelo), we have observed the use of a two-bin system. Such a system works on the principle that the storage location of on-hand inventory and the safety stock are near to each other and both as large as necessary storage capacity to store one order unit of the supplier. Once the on-hand inventory is out of stock, one uses the safety stock and order a new order unit. Therefore, storage capacity must be large enough to store at least two units for each SKU. These developments will have to go in cooperation with the supplier. A kanban system would be useful for AMC by several reasons:
  - It will speed up the ordering process since counting the items is not necessary anymore.
  - Ordering could be done by a logistic employee since order quantities are fixed
  - It is a simple and effective system to manage the inventory.

  In addition to this kanban policy, an electronic ordering process would be advised, as tested during the pilot of the 'SPA in de kitchen' project in AMC. In this project, logistic employees scan articles that drop below the minimum stock height and order up to the maximum per SKU. This pilot shows a substantial reduction of wastage while the time needed for the process from ordering to replenishing reduces significant (AMC, 2013). These data should be revised due to some doubts about these facts. However, we expect that a combination of the use of a kanban system and a standardized, electronic ordering process will lead to significant reductions in handling costs.

The impact of centralization on the daily practice will be great. At least, the changes in work processes and modifications to the building have a major impact. Reduction of the system expected outdate rate and safety stock, and exploiting any economies of scale will reduce several cost aspects. However, the personnel costs for handling and transporting activities will increase.

To what extent the benefits of centralization outweigh the additional costs of handling and transportation, need to be balanced. For Interventions 1 and 2 it is impossible to test this through a pilot, but the benchmark of Part three can provide useful information to make an informed choice. We recommend to test Interventions 3 and 4 through a pilot on one floor.

5.4.2 Interventions aimed at decentralization

Based on our analysis of each KPI, it appears that decentralization per unit kitchen is not profitable. The waste and all cost aspects are higher than in each other intervention, while Intervention 5 will not lead to the desired improvements. Moreover, decentralized storage will not benefit from adopting a kanban system, because order units are too large in comparison with the demand per kitchen. It appears that a kanban policy will not be profitable due to the high holding costs and waste by big inventories. Nowadays, many products are ordered only if the safety stock level is low. This is possible because of the large on-hand inventories of products on the BBW. Moreover, the storage capacities of a unit kitchen is insufficient to be able to comply with the principles of kanban. So with the current packaging this policy will be impossible.

5.4.3 Proposal for organizing intervention

There will be a tipping point where complete centralization outweighs centralization per floor and vice versa. With the current knowledge we do not exactly know, and cannot exactly measure when this would happen. We expect that Interventions 3 and 4 will outweigh Interventions 1 and 2. The long distances from CGO to the kitchen units and related transportation costs due to centralization to one location, the high personnel costs related to handling activities, the intensive use of elevators, and the impact, because stock is far beyond the reach of the departments, are reasons which make interventions 1 and 2 unfavorable. Furthermore, we expect an increase of shortages in comparison with the current situation, while the associated costs will increase. Benefits of centralization as economies of scale, closer match between supply and demand, smaller inventories, and waste reductions will not be able to compete with this disadvantages. So, it appears that Interventions 1 and 2 are not profitable.

Interventions 3 and 4 have more potential as a recommendation and will be preferable based on acceptance and evaluation criteria, and the impact of organizing interventions. To what extent the benefits of centralized storage, control, and replenishing per floor, outweighs the additional costs of handling and transportation, when replenishing by trolleys, need to be balanced. However, looking at the impact of Interventions 3 and 4 it would be clear that Intervention 3 is best applicable in practice.

Benefits of Intervention 3 in comparison with Intervention 4 are the lower percentage of waste, a trolley does not have to be purchased, and food assistants are the only employees who have access to the kitchen, in accordance with the hygiene requirements. Intervention 3 will also lead to larger cost reductions in comparison with all other interventions, because each unit should transport their BBWs to the central storage location, instead of one trolley transported over all units. The extra handling costs of replenishing trolleys will outweigh the transportation costs. Food assistants can pick up the BBWs at the beginning of their shift and at the end of the day they can bring the BBW back to the storage location, in order to reduce these transportation costs. AMC could also decide to replenish BBWs by logistic employees after they distributed the warm meals to the departments, and take another trolley for distributing the drinks.

Organizing the third intervention, by storing inventory and replenishing BBWs centralized per floor, will result in significant improvements for AMC. The total score of this intervention will increase compared to the current situation, because most scores in the categories Quality, Speed, and Dependability will increase and the score of the other indicators are expected to remain the same, or at least not deteriorate compared to the current situation.

Intervention 3 supports the referred shortcomings arose from the problem cluster. To emphasize some aspects: It reduces the time food assistants spend on indirect patient tasks, this gives opportunities to increase time spend on direct patient care and to improve the hospitality. By organizing the processes as proposed in Intervention 3, the problem of fluctuations in delivery time by the bed is over, and finally, the centralized storage policy will increase the availability of products, while the inventory reduces. For the purpose of hospitality on Intervention 3 we refer to the advisory report of IFC, in which various scenarios are recommended based on service levels. Intervention 3 provides an excellent basis for each of the scenarios. For example, the central inventory per floor could eventually be converted into an centrally located restaurant. We would like to see patients and visitors have the opportunity to eat a meal together. Given the patient, and thus their visitors, come from far, consuming a meal together is valuable as described in Koerhuis (2012). However, due to the limited budget it would not be realistic to focus on incremental renovations now. Priority in this research is on improvement within a limited budget. Management is responsible to deal efficiently with the benefits gained by improvements in inventory management.

Conclusion

This chapter elaborated on the evaluation criteria which describe the set of requirements that will be used to choose between multiple interventions. We have limited ourselves to the KPIs which have received the highest weight, the KPIs among the categories Quality, Speed, and Dependability and assumed that the scores of other indicators will remains at least the same. The practical application of the several interventions are also discussed. We have shown how performance of the KPIs could be improved by organizing interventions. Finally, we made a proposal for improvements which, in our view, will be most suitable for AMC. However, it is not up to us to make this definitive choice. Other flows discussed are not in the focus of this research and therefore not mentioned in this conclusion.

Interventions 1 and 2 benefit from centralization since smaller safety stock is being required to satisfy a given level of customer service and processes become more efficiently by exploiting any economies of scale. Centralization is especially beneficial in a supply chain with unstable demand patterns, when products have a short shelf life, large batch sizes, and the penalty for mismatches in supply and demand are large. Therefore centralization would be a good intervention for AMC.

The main disadvantage of this storage policy is that backorders become of high priority and it is still a question if the reduction in handling and holding costs outweigh the transportation costs, due to the long distances between central storage location and departments. Therefore, centralization per floor would be more beneficially for AMC as recommended in Interventions 3 and 4. The risks of shortages reduces and backorders have lower priority in these interventions. Moreover, the transportation costs are lower in comparison with Interventions 1 and 2. This means a higher efficiency of employee tasks while the elevators will be used less. Furthermore, we expect that a combination of the use of a kanban system and a standardized, electronic ordering process will lead to significant reductions in handling costs. With the current available data, it is unclear which intervention will achieve the highest return on both short and longer term. Therefore, it is impossible to indicate a best practice for AMC. However, we have shown that Intervention 3 best suited for AMC since this intervention is equipped with the best ingredients for a best practice.

Chapter 6

Design of a roadmap

With this research we have made some suggestions on how to measure AMC's current food logistics of wholesale products and how to make an informed choice about the organization of interventions with respect to wholesale products. This chapter designs a roadmap which describes in detail how the implementation of the detailed interventions within the organization is going to take place, aims to realize improvements on the logistic process of inventory management of foods. In order to make this roadmap, we recap on the current situation, the desired end state, and the gap in between, to identify the road which has to be taken. Prioritization of the several actions of this road indicates the order in which the activities should be taken. This elaboration will give an overview of the concrete steps for in the future in order to create the desired end state.

Motivation

This change plan focusses refers to AMC's food service regarding wholesale products intended for inpatients. Focus is on planning and control activities on the strategic and tactical level of material planning, so changes will be at the level of storage design and inventory management. We have analyzed several options to identify recommendations and organization interventions. However, the decision maker decides independently to implement the best intervention. We have written this change plan before decision making, so we are limited in the extensiveness of our report. The aim of this roadmap is to create a practical overview of the steps to be taken to get insight in the requirements, process steps, and consequences, which can be used as a guide when performing the implementation, irrelevant of the intervention to choose.

6.1 Current situation

The department directorate services aims to achieve the best hospitality for patients and employees with efficient logistic functions and movements, to provide an optimal amount of nutrition to the patient to speed up their recovery and prevent complications (IFC BV, 2012). The business objective of AMC regarding food services is to achieve a higher food service level among others by organizing the food logistics more efficiently (van der Maat, 2013). To identify the current food service level we have analyzed the current situation on process, performance, and planning and control, and identify problems. We have found that performance measurement is not easily possibly currently, but we have gained some insight by performing a baseline measurement. The four steps Plan, Do, Check and Act of the Deming Cycle of improvement describes per KPI how this baseline measurement is not a snapshot only but a drive to improve organizational performance continuously (Slack, Chambers, & Johnston, 2007).

6.2 Definition of the desired end state

Clarifying AMC's business objective, we describe the specific goals objectively by acceptance and evaluation criteria. The main preconditions for improvement are the HACCP requirements. AMC has set some additional acceptance criteria according to MoSCoW categories.

Must haves:
- Patient centered
- No major renovation
- Issuance of food by food assistants
- Internal shipments should be flexible and reliable
- Less stock outs & waste

Should haves:
- Lift capacity
- Optimization of inventories
- Eliminate unnecessary actions
- Visitors policy

Would haves:
- Less administrative burden
- Less adjustments of orders
- Making registration of consumption, waste and stock outs possible in an easy way

Want to have:

- *Product:* More extensive assortment and shorter throughput time between ordering and delivering
- *Environment:* Possibilities to eat in a restaurant and to eat with visitors or other patients
- *Behavior:* Increasing time food assistants have to serve the patients
- *Food service in general:* Hospitable, even for visitors

The eleven KPIs as elaborated in Section 2.3.2 are:

1. Waste
2. Order fill rate
3. BBW inventory accuracy
4. SKU's in-stock percentage
5. On-time shipment
6. Out-of-stocks
7. Backorders
8. Inventory turns
9. Inventory balance
10. Days of supply
11. Holding costs

6.3 Conduct Gap Analysis

Even when AMC decides to continue with Intervention 5, information provision, introducing new technologies, and organizing the internal process differently can lead to a more efficiently process. For all other interventions the changes become bigger. We analyze the gap between the current situation and the desired end state, based on information provision, organizational changes, architectural imperatives, billing method, and new technologies.

6.3.1 Information provision

The limited presence and availability of data in AMC complicates has negative consequences for conducting a baseline measurement and makes it harder to gain insight into improvements. The lack of data makes it unable to apply a model from the literature to calculate optimal location and allocation of products, to adjust for perishability, or to calculate whether LTs are beneficial. Therefore, we conduct a gap analysis of missing data needed for performance measurement, to support the process and adequately facilitate a successful practice. For each KPI we analyze which information must available for administrative purposes and to optimize the food logistics.

1. Waste

We do not rely on the current way of recording and calculating the percentage of waste. What we really want to know is the amount of food waste with respect to the amount of food consumed. Accurate registration of consumption and the amount of waste before and after distribution to the patients, is then a requirement.

2. Order fill rate

By time studies in 2011 and 2013 we know that the internal shipments are usually on time. However, in both cases it is a snapshot of some supplies for a certain period of time. Given the weight assigned to this indicator it is important to obtain a good performance measurement of the on-time shipments and record this value daily.

3. BBW inventory accuracy

Based on observations we know that the inventory accuracy is close to 100%. However, an accurate value of this indicator can be calculated by dividing the actual stock on a BBW per SKU by the demand per SKU, multiplying by 100%. Therefore, one must constantly be aware of the stock height, and the demand per SKU should be calculated based on historical data.

4. SKUs in-stock percentage

This indicator of the completeness of safety inventory can be calculated in the same way as the previous indicator, by replacing the term 'stock on a BBW' by 'safety stock'. Be aware of the safety stocks is easier than the actual stock on a BBW, assuming an up-to-date registration of stock heights. This indicator is important in reducing costs by decreasing the inventory to a minimum with respect to a certain service level and reducing overstocking to reduce waste.

5. On-time shipment

One of the requirements which makes a delivery considered to be reliable is delivering within the correct time window. While AMC assigned a high weight to this indicator, it is not updated daily or delivering actually takes place within this timeframe. To check whether the supplier achieves this objective and to get insight in the performance of this indicator it is wise to introduce continuous registration of the timeframe in which the truck arrives at the CGO.

6. Out-of-stocks

By observations we know that the availability of products is close to 100%. However, we would like to know how many product shortages occurs exactly, because of the high weight that is assigned to this indicator. Therefore, AMC needs to register the shortage per service round. However, we recommend to consider a lower norm for this indicator due to the extremely high costs of this target and it is unclear whether this outweighs the benefits. Most foods are highly substitutable. 'In making a decision on how much to purchase (and therefore, how much in stock), management must try to identify the costs which will be affected by their decision' (Slack, Chambers, & Johnston, 2007).

Aspects that should be taken into account are the factors that, directly or indirectly, determine the inventory costs, namely: Cost of placing the order, price discount costs, stock-out costs, working capital costs, storage costs, obsolescence costs and operating inefficiency costs (Slack, Chambers, & Johnston, 2007).

7. Backorders

To respond on patient whishes the ability to obtain out-of-stock items is an important indicator. AMC must be able to rely on their suppliers and should receive backorders of high priority within a certain timeframe. In addition, it is still sensible to be independent of backorders and control the extent to which the supplier complies with the on-time shipments.

8. Inventory turns

The inventory turns gives indicates the duration that products are in stock. It is difficult to set an interval value for this indicator and realize the optimal target of balancing between shortages and wastage. We predict inaccurateness in the current measurement of inventory balance and recommend to get insight in the inventory balance and inventory turns to be able to react on the throughput of products, and to figure out of which products the current stocks are too high.

9. Inventory balance

AMC aims for a minimum inventory balance to reduce holding costs and waste. We calculate the inventory balance by counting all products in inventory and dividing these amounts by their price. AMC uses the difference between the min and max as the average stock height. Since the min./max. lists are not used that frequently we doubt the accuracy of this average. Moreover, this calculation is wrong, because the safety stock is neglected. We recommend to gain better insight in the value of all products in inventory to use as historical data and evaluation criterion.

10. Days of supply

To reduce the risk of excess and obsolete inventory, we recommend to measure the rate at which inventories are sold. We have measured the value of daily consumption and divided this value by inventory balance. However, insight in the amount and value of all products in inventory, combined with registration of the consumption, will give an accurate result of this indicator.

11. Holding costs

Holding costs are the costs of carrying one unit in inventory for a certain period of time and consist of the costs of capital, the costs of physically storing the inventory, and the costs that result from the product becoming obsolete.

Due to missing data, it is difficult to give an indication of the current holding costs. These costs are necessary in order to calculate the Economic Order Quantity (EOQ), the quantity of items to order that supposedly minimizes the total costs of inventory management (Slack, Chambers, & Johnston, Operations Management, 2007). While the EOQ may not be the optimal formula for the purpose of perishables, any other formula will count with the inventory costs.

We recommend AMC to get insight in their costs of capital, of physically storing the inventory, and the costs of obsolete products, to enable applying models and calculating the optimal inventory level.

Generalization of the various problems

This section explains which information is missing in AMC and argues why we recommend to measure certain values continuously and make them available and useful to people who have to use it and can benefit from this information.

- A great part of the missing data is related to the limited use of digital resources, while the availability and accessibility of data are considered as important in the (purchasing) process of inventory. 'It serves different objectives and can be used by several people and departments to better perform their tasks' (Telgen & Schotanus, 2012).
- The provision of information on basic logistic values will give a better performance measurement and therefore an opportunity to improve the entire process.
- Irrelevant of the intervention adopted, the registration of consumption, for the purpose of billing per unit, is the main gap in information provision. We recommend an automated ordering system, or using scan cards and creating automatic orders. This will make the purchasing function more efficiently, enables to measure this process, and realizes to which extend the purchasing function is effective.
- In case of centralization per floor an up-to-date overview of stock heights per product is needed for the purpose of LTs and will contribute to a more efficiently process.
- AMC sets high targets. There is no insight in the feasibility and costs related to these targets, such as the feasibility and costs when striving for an availability of 100%.

To gain a better understanding of the entire procurement process, we advise to analyze all elements of the purchasing function, as could be performed by using the racecar model. However, a quick scan of the procurement professionalism could also be performed by the QIP-model as designed by Boernama (2010) which especially focuses on the professionalism of the purchasing function of an organization in the health care sector (Boernama, 2010).

6.3.2 Organizational changes

The organizational changes at the different levels in the framework, but also the operational processes and the functions of workers will undergo changes. Management should decide who becomes responsible of the storage location and has to take care of receiving goods, storing goods at the central storage location, replenishing the BBWs, and ordering products at the supplier.

In case of centralization per floor, maybe the food assistants of the G-units can do these tasks in addition to direct patient tasks, because they have years of experience with these activities. But, the storage location does not need to be manned during the day. So, possibly logistic employees could fulfill these tasks and become responsible for all storage locations to get routine in their work and speed up the process. The use of scanning equipment is highly recommended, while a fully automatic process, with digital ordering options, is the desired end state. It adds value as AMC ultimately more demand-oriented starts to work, instead of the current supply-oriented policy.

6.3.3 Architectural imperatives

The building will have to undergo small changes to fulfill the preconditions of relevant intervention. For example, a central storage location (per floor) should be prepared. Depending on the reduction in inventory level, the kitchen, in its current state, will be sufficient as central storage location per floor for the three departments. Possibly, the furniture must be replaced partly in order to utilize the space efficiently. Working with a kanban system is already tested by the project group 'SPA in the kitchen', which performs a pilot study at the G5. They have concluded that, in combination with the use of scanning equipment, the current format is not efficient anyway. We expect the area of a kitchen as sufficient storage location for the entire floor, possible that the format undergoes changes. This will require a small investment per floor.

6.3.4 Billing method

The current billing method per kitchen is not possible when the stocks are centralized. Assuming that registration of consumption is possible by new technologies, the costs of consumption can be divided proportionally.

6.3.5 New technologies

Management must decide about purchasing new technologies. New technologies are useful in each of the interventions. For example, to registry consumption automatically, make electronic ordering possible, automatic orders, digital ordering possibilities for patients, up-to-date insight in stock height of safety stock and in BBWs, and trends in consumption.

For example, digital ordering options have many advantages as they accelerate the process, the administration becomes paperless, and to provide an optimal amount and type of nutrition to each individual patient one can limit the choice of patients by a diet focused menu. The menu should matches the specific diet of each individual patient, because food assistants have insufficient knowledge to encourage patients to eat that which promotes the healing process (AMC, 2011).

Furthermore, at some units, food assistants get information about patients provided regarding (changes in) the appropriate diet, fasting notifications or when a new patient is admitted. However, in most departments is little interaction between nursing and food assistants and food assistant will not actively try to obtain this information. Improved technologies should overcome these shortcomings and improve the patient centeredness of AMC's food services. The implementation of new technologies could benefit the efficiency of the process, but these improvements have not all the same priority. Other technologies missing in the current process, which have a high priority, are mainly important when food assistants should order products which are still stored at the kitchen. This could be by using Slimis, but products may also be ordered from the central storage location, so ordering products is fully implemented from a central location to exploiting any economies of scale. ICT technologies should make this possible.

6.4 Prioritization of the steps on the road and discovering the optimum sequence

We have demonstrated that Intervention 3 is best suited to AMC and will also achieve the highest return. Irrelevant of the chosen intervention, the entire operational process from ordering until replenishing will have to be adjusted. This section identifies the steps to be taken in general, in order to come from the current situation to a desired end state. We choose not to evaluate each intervention separately, because current data are insufficient to assess the impact of different implementations exactly. We discuss the order in which the activities have to be accomplished.

First, the management will be informed of the proposed intervention and be convinced of the benefits. Furthermore, the planning and control of processes must change to ensure operational changes. Decisions should be taken regarding the implementation of the various operational activities and the acquisition of new technologies to support this process. In case of centralization per floor, it is recommended to start with a pilot for one floor. For full centralization, it is wise to start with a limited number of departments. Prior to the pilot, the building will have to undergo changes. Depending on the reduction in inventory level, the kitchen in its current state will be sufficient as central storage location per floor for the three departments. However, a successful pilot requires a small investment per floor to make the current layout efficiently. The several interventions should be extended after filtering out teething. During the pilot can be started with the generation of valuable data. A number of elements, as described in Section 6.1.3, have to be organized properly to support the process and adequately facilitate a successful practice.

Moreover, information is needed in order to apply a model from literature to calculate optimal location and allocation of products, to adjust for perishability, or to calculate whether LTs are really beneficial.

Assuming that registration of consumption is possible by new technologies, the costs of consumption can be divided proportionally. Otherwise management should think about a different way of billing.

6.5 Developing the roadmap

The roadmap of Figure 31 will support AMC in the continuation of the process of this research. The duration of the various steps are not commensurate with the figure. The figure shows how the steps successively should take place.

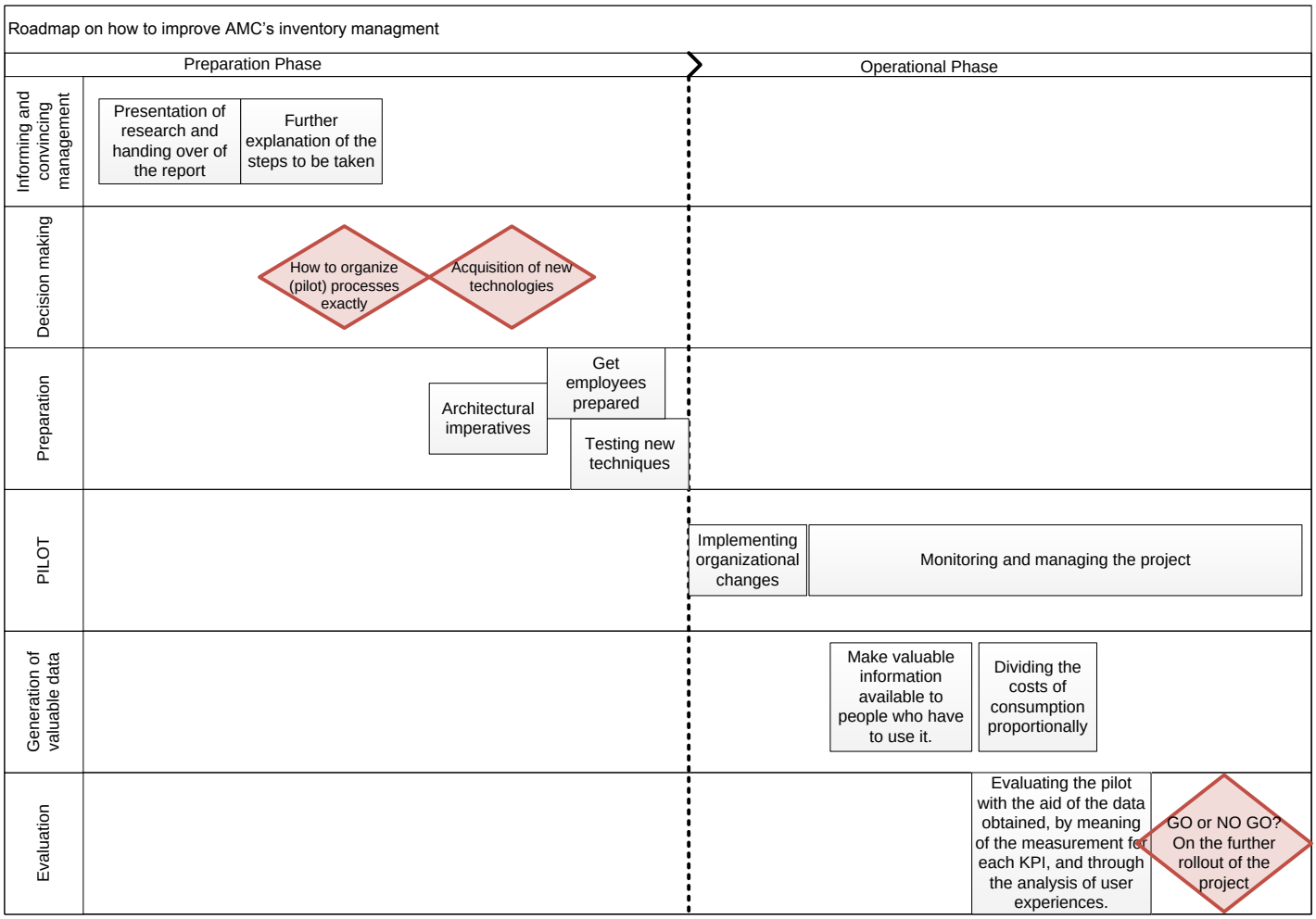


Figure 31: Roadmap on how to improve AMC's inventory management

Chapter 7

Conclusions and recommendations

The challenge for health care organizations during the upcoming decades is to deliver more patient care of at least the current quality, while efficiently allocating less financial and human resources. This report have described how to measure the current performance of AMC's food service regarding wholesale products and how to improve this performance by organizing the logistic function concerning food more efficiently, in order to achieve a higher service level and to improve the hospitality. Furthermore, we have elaborated on the steps which should be taken to improve AMC's current food logistics of wholesale products measurable and to make an informed choice about the organization of interventions.

7.1 Conclusion

We have analyzed the characteristics of AMC's food logistics on process, performance, and planning and control, by using the framework of Hans, Van Houdenhoven & Hulshof (2011). We have identified five main steps in the logistic process of wholesale products: stock management, ordering, delivery, internal distribution, and unit related activities. We have defined indicators and assessed the current performance by operationalizing the elven KPIs into measurable units and collected relevant data to get insight in the current performance. It appeared that the indicators waste, order fill rate, and on-time shipments are the main problems in inventory management of wholesale products in AMC as discussed in Chapter 2.

Literature study(Ch.3) has shown that current inventory models are not useful to replicate for the food business in hospitals. However, the background information in books and articles is useful as input on how to organize the logistics of food more efficiently and to argue the impact of organizing interventions. Key issues are to find the optimal balance between product availability and outdating, anticipate on expected future outdating of products, and adopting centralized control over the whole supply chain, in order to reduce unnecessary outdating and shortages, while safety stock being required to satisfy a given level of customer service also reduce. Based on the literature study, AMC's current process flow of the food logistics, our observations and experiences, we identified five interventions for AMC to improve the logistical process (Ch.4):

1. Centralized safety stock. Transport between safety stock and unit kitchens by BBWs.
2. Centralized safety stock. A trolley goes along the unit kitchens to replenish BBWs.
3. Centralized safety stock per floor. BBWs will be replenished centralized per floor. Adopting (pro/re) active LTs.
4. Centralized safety stock per floor. A trolley goes along the unit kitchens to replenish BBWs. Adopting (pro/re) active LTs.
5. Decentralized safety stock per unit kitchen.

We have evaluated these interventions based on acceptance (Ch.4) and evaluation criteria (Ch.5). It appears that decentralization per unit kitchen is not profitable based the high amount of waste and costs in comparison with the other intervention. Centralization is especially beneficial in a supply chain with unstable demand patterns, when products have a short shelf life, large batch sizes, and if the penalty for mismatches in supply and demand are large. Interventions 1 and 2 benefit from centralization since less safety stock is being required to satisfy a given level of customer service and processes become more efficient by exploiting any economies of scale. There will be a tipping point where centralization per floor outweighs complete centralization.

With the current knowledge, we did not know, and could not measure exactly when this would happen. Although, we have expected that Interventions 3 and 4 will outweigh Interventions 1 and 2 because of the high personnel costs in Interventions 1 and 2 by handling activities and long transport distances from CGO to the kitchen units, the increase of shortages, the intensive use of elevators, and the fact that stock is far beyond the reach of the departments. Benefits from centralization as economies of scale, closer match between supply and demand, smaller inventories, and waste reductions, will not be able to compete with these disadvantages. Interventions 3 and 4 will be preferable based on the extent to which the interventions meet the MoSsCoW rules, evaluation based on the assessment per KPI, and the impact of organizing the interventions.

We have compared the Interventions 3 and 4 (Section 5.4). Intervention 3 benefits of a higher product availability, while the inventory reduces, it has a lower percentage waste, achieve larger cost reductions, a trolley does not have to be purchased, and food assistants are the only employees who have access to the kitchen, in accordance with the hygiene requirements. By organizing the processes as proposed in Intervention 3, by storing inventory and replenishing BBWs centralized per floor, will result in significant improvements for AMC, because most scores in the categories Quality, Speed, and Dependability will increase, and the score of the other indicators are expected to remain the same, or at least not deteriorate compared to the current situation. Intervention 3 supports the referred shortcomings arose from the problem cluster, will achieve the highest return, and is equipped with the best ingredients for a best practice. For the purpose of hospitality we have referred to the advisory report of IFC, in which various scenarios are recommended based on service levels. Intervention 3 is an excellent basis for increasing the hospitality through one of these scenarios.

For the continuation of this research we have advised to first take several decisions regarding to the implementation of various operational activities and the acquisition of new technologies to support the logistic process, before starting with a pilot and generate valuable data. This, and other suggestions for improvements, on how to manage AMC's logistic function with respect to wholesale products, is described in a roadmap (Ch. 6). Within this roadmap, we made a distinction between the preparatory phase and the operational phase, in which the following steps should be taken: informing and convincing management, decision making, preparation, conducting a pilot, generation of valuable data, and evaluation.

Even if AMC decides to continue with current situation, some elements should be reorganized to support the process and to achieve a successful practice. Therefore, irrelevant of the intervention adopted, we have recommended interventions per KPI as shown in Table 19.

KPI	Recommendation
Waste	Anticipating on expected future outdating of products
	Adopting centralized control over the whole supply chain
	Adopting a LT policy
Order fill rate	Adopting another policy for bread products and organizing an intervention to avoid that food assistants are dependent of deliveries during rush hours.
BBW inventory accuracy	Adjusting the position of inventory on a BBW since the demand of patients is changed during the years
	Let replenishment become a task of logistic employees
	Using historical data and replenishing a BBW based on pre-determined quantities
% SKUs in-stock	Using historical data to match the demand and supply closer
On-time shipment	Ensuring that you are independent of delivery times
Out-of-stocks	Reducing the dependency of experiences and base orders on historical data.
Backorders	Preventing backorders by LTs
Inventory turns	Searching for an optimal balance between stock outs and shortages.
Inventory balance	Reducing inventory balance when centralizing inventories
Days of supply	Outweigh the product availability above shortage of products
Holding costs	Centralizing inventories to reduce the holding costs

Table 19: Interventions per KPI

Evaluation of the pilot could be done by using the operationalized KPIs. Management is responsible to efficiently deal with the benefits achieved by improvements in inventory management.

7.2 Limitations

Main limitations to this research:

- Only two days of participation at unit G5 to perform a time study.
- The availability and accessibility of data.
- Relevant literature on inventory management of food in a hospital setting is limited.
- Current inventory models are not useful to replicate for the food business in hospitals.
- High inventories prevents (productivity) problems being noticed.

7.3 Recommendations

Observations, participation, the literature search, analysis, calculations, and especially the many discussions with stakeholders and others, within and outside the organization, as the supplier, other hospitals, and the manager of an AH to go, results in many recommendations on what steps should be taken to improve AMC's current food logistics of wholesale products measurable and to make an informed choice about the organization of interventions. Improve the process by using the roadmap as a guide is the main recommendation. Section 7.3.1 describes some other recommendations for in practice, while Section 7.3.2 discusses recommendations for further research.

7.3.1 Recommendations for in practice

- All employees are motivated to increase the hospitality. However, AMC should introduce a 'trigger' to motivate people actually improve the food services. We propose to entering a reward element, like winning a cake for the best registration of waste.
- Generating useful data and make them available. That we are unable to measure performance should be an eye opener and so a recommendation in itself. Perhaps, the most important recommendation at this time.
- Reduce the inventory balance by reducing the amount of storage locations. 23 safety storage locations and at least as many BBW's is inefficient.
- Use forecasting of the future consumption.
- Be creative; Making toast of stale bread, offering sandwiches when the remaining shelf life of ham or cheese is short, making a smoothie with remaining fruit, surprising patients, preventing waste, and creating hospitality.
- Introducing more luxurious sandwiches and other readymade products. Patients are positive about the current sandwiches, while readymade products saves a lot of time for assistants. Luxurious sandwiches could also be prepared at central stock location on each floor.
- Considering to make food assistants be part of the team and let them be jointly responsible for the budget. This will reducing the improper use.
- Learning from the retail business, especially from the AH to go, since they also have to deal with changing customers, high flow, limited storage capacities, (daily) fresh products, wholesale products and other perishables and non-perishables.

7.3.2 Recommendations for further research

- Developing a forecasting model for the required level of safety inventory of foods, distinguishing for daily fresh, dairy produce, wholesale, and non-perishables, which depends upon uncertainty, replenishment lead times, lead time variability, desired product availability, review policy, and packaging. This model should include the characteristics of a patient, such as age, illness, nutritional assessment score, etc. and should also respond to changing bed occupancy and other environmental factors as described in the literature.
- Conducting a research on the problems arising from lowering inventories.
- Using the steps of the Deming Cycle, as described per KPI, to improve organization performance continuously.
- Use the hospitality barometer of IFC BV in evaluating the food service after organizing interventions.

7.4 Generalization of this research

This research provides insight for AMC into what steps need to be taken with regard to improvements in food logistics for the wholesale function, to improve the existing situation measurable, and to make an informed choice about the organization of interventions.

The most valuable in this research for the IFC is perhaps the systematic approach to mapping the processes and the way of management within a complex situation with associated performance indicators, in order to discover and identify the problems herein.

Moreover, this research have a certain value for other health care institutions and hospitals. This section generalizes the problem of inventory management of perishables, to support the health care sector, to improve the food services for the purpose of saving costs, but mainly for the purpose of hospitality.

7.4.1 Lessons learned for other hospitals and health care organizations

The bad reputation of food in the health care sector, in combination with the risen expectation of customers makes food service an important topic for many health care facilities. The structural approach for mapping of the current situation by process, performance, and planning & control, and identify problems using the general business problem solving (ABP) technique is useful in each other setting. The formulation of acceptance and evaluation criteria is also widely useful to assess several interventions and make a deliberate choice between interventions. Furthermore, the design of a roadmap is a way to clarify the necessary steps to reorganize the current situation into the desired end state.

Not only the used methodology, but also results are generalizable to other settings. In this research was particularly clear that the availability and accessibility of data are important to understand the operational processes and therefore an opportunity to improve the entire process. Improve the food service requires changes in logistics. The logistics of food is neglected in the literature. However, the background information on location and allocation of products, perishable inventory management, LTs in a supply chain, and logistics in a retail setting addresses useful knowledge for organizing the logistic process of food more efficiently in, for example, the health care sector. Examples of useful findings for each organization dealing with perishables are:

- Key issue in managing perishable inventory is to find the optimal balance between product availability and outdating. Checking residual shelf life, anticipating on expected future outdating of products, and adopting centralized control over the whole supply chain reduces the unnecessary outdating and shortages while keeping sufficiently high fill rate.
- The required level of safety inventory depends upon uncertainty, replenishment lead times, lead time variability, desired product availability, review policy, and packaging.
- Centralized supply chains are more cost-effective than decentralized ones. Centralization results in a reduction in safety stock being required to satisfy a given level of customer service. It is especially beneficial in case of unstable demand patterns, when products have a short shelf life, large batch sizes, and the penalty for mismatches in supply and demand are large.
- LT between storage locations is a way to reduce safety stock, create higher product freshness, and saving replenishment and management costs, while maintaining customer service levels.

Finally, irrelevant of the intervention to organize and the setting where food should be distributed, keep the following recommendations in mind:

- Anticipating on expected future outdating of products.
- Centralizing inventories to reduce the inventory balance and holding costs.
- Overall it is beneficial to adopt centralized control.
- Searching for an optimal balance between stock outs and shortages.
- Outweigh the product availability above shortage of products.
- Adopting a LT policy and preventing backorders.
- Anticipating on the changes in demand of patients.
- Replenishing is a task of logistic employees.
- Replenishing based on pre-determined quantities.
- Ensuring that you are independent of delivery times.
- Reducing the dependency of experiences.
- Using historical data to match the demand and supply closer.

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Glossary

Definitions

A lot or batch size
The quantity that a stage of the supply chain either produces or purchases at a given time (Chopra & Meindl, 2001).

Cycle inventory
Inventory that occurs when one stage in a process cannot supply all the items it produces simultaneously and so has to build up inventory of one item while it processes the others (Slack, Chambers, & Johnston, 2007).

Echelon
The different levels in a supply chain. Between the echelons transshipments of goods or commodities occurs. In intra-echelon flows, goods are transship between stocking point, within the same echelon. A higher echelon is characterized by suppliers, while multiple retail locations are at the lower (Burton & Banerjee, 2005).

Fast-moving items
Fast-moving items are high demanded items and therefore they are sold quickly (Chopra & Meindl, 2001).

Kanban
'A Japanese manufacturing system in which the supply of components is regulated through the use of an instruction card sent along the production line' (Oxford Dictionaries, 2013).

Lateral transshipment
'Lateral transshipments (LT) are stock movements between locations in the same echelon of an inventory system' (Paterson, Teunter, & Glazebrook, 2012). In a situation in which customer demand is greater than on-hand inventory at a primary stocking facility, inventory from other (secondary) locations can be used to avoid a stock out (Evers, 1996).

- *Proactive transshipments:* Occur at fixed time points. Deliveries and transshipments are made before demand is realized.
- *Reactive transshipments:* Can happen at any time. When a retailer is out of stock, it requests an emergency delivery to other retailers. (Cheong, 2013)

Safety inventory

Safety inventory is the average inventory remaining when the replenishment lot arrives (Chopra & Meindl, 2001). This inventory compensates for unexpected fluctuations in supply and demand (Slack, Chambers, & Johnston, 2007).

The cycle- and safety inventory of bread meal products

AMC uses BBWs to distribute the breakfast, lunch, beverages and snacks over the wards. All products present in these BBWs could see as cycle inventory. All inventory stored out of the trolley, so in the pantries in the kitchen, could see as safety inventory.

Wholesale products

The products that patients can order for breakfast, lunch or snack, as they are in the BBW.

Deteriorating goods

'Decay or deterioration is defined as any process that prevents an item from being used for its intended original use such as spoilage, as in perishable foodstuffs, fruits and vegetables' (Raafat, 1991).

Perishability

'The main difference between perishables and non-perishables is the 'Shelf Life'. The shelf life of a product is measured in days, counting from the day it is produced until the product becomes unacceptable for consumption or obsolete. We define perishables as items with a shelf life less than or equal to 30 days and if the high rate of deterioration at ambient storage conditions requires specific storage conditions at the store and/or at the consumer to slow the deterioration rate' (Donselaar, Woensel, Broekmeulen, & Fransoo, 2006).

Replenishment options (Minner & Transchel, 2010)

- FIFO (First In First Out) = assumes that the oldest unit in stock first sold.
- LIFO (Last In First Out) = assumes that the last delivered unit is sold first.

Replenishment policies (Chopra & Meindl, 2001)

- **Continuous review**: Inventory is continuously tracked, and an order for a lot size Q is placed when the inventory declines to the reorder point ROP.
- **Periodic review:** Inventory status is checked at regular periodic intervals, and an order is placed to raise the inventory level to a specified threshold.

Slimis

Name of the ordering system of supplier 'van Hoeckel'.

Slow-moving items
Items with a low demand and typically have a high coefficient of variation (Chopra & Meindl, 2001).

SPA in the Kitchen project *(SPA = Scan, Plan, and Replenish)*
A project to organizing a scan assortment for items stored and used in unit kitchens, aimed to:

- Standardizing and optimal use of storage capacity in the kitchens
- Matching supply to the specific needs of the kitchen
- Better registration
- Reducing waste
- Applying new technologies in the kitchens

Due to the practical implications this pilot has resulted in a NO GO. However, attending these meetings and analyzing the outcomes of this project has provided us many insights into the operational problems and possibilities useful for our research (AMC, 2013).

Stock out
if a customer order arrives when product is not available.

Product availability / customer service level
The fraction of customer demand that is satisfied from available inventory.

List of abbreviations

BBW: Brood Buffet Wagen (Bread Serving Trolley). A BBW is a mobile stock that meets patients nutritional needs without lead time between ordering and delivering.

KPI: Key Performance Indicator.

CGO: Centraal Goederen Ontvangst (Central Goods receiving Office).

RFID: Radio Frequency IDentification.

HACCP: The Hazard Analysis and Critical Control Point requirements as set and checked for compliance by the Dutch Food and Consumer Product Safety Authority.

SKU: Stock Keeping Unit (Mantel, Schuur, & Heragu, 2007). A common term for a unique numeric identifier.

EOQ: Economic Order Quantity. The quantity of items to order that supposedly minimizes the total costs of inventory management (Slack, Chambers, & Johnston, Operations Management, 2007).

Public Appendices

Appendix I: Food logistic KPIs

Plan & Do		Check					Act	
Specific		Measurable		Attainable		Relevant	Timely	Weight
Category	KPI	Definition	Measured by	Norm	Marge	Reason to inlcude	Frequency	
Quality	**1. Employee satisfaction** *(Medewerker tevredenheid)*	Several subjects include like travel distance, order lead time and work pressure.	Differs per subcategory	Employees should score at least a 7.	≥ 9 7/8 ≤ 6	The implementation of improvements in the food logistics of AMC should have at least no negative effects on the employee satisfaction.	Quarterly	0.23
Quality	**2. Customer satisfaction** *(Klant tevredenheid)*	Looking at the aspects product, behaviour of employees and environment.	Score based on responds to survey IFC in 2012.	Satisfaction should be improved with 5% within 12 months after implementation.	≥ 4.5 3 - 4.5 ≤ 3	Customer satisfaction should be kept in mind to remain an attractive hospital within the catchment.	Quarterly	0.23
Quality	**3. Discrepancy between demand and assortment** *(Efficiëntie van het assortiment)*	Efficiency of the assortment.	Based on responds to survey IFC.	At least 90% of the patients should be reasonable satisfied with the choice of the assortment.	≥ 90% 80% - 90% ≤ 80%	To offer hospitality and to stimulated nutrition intake it is important that AMC is aware of their efficiency of the assortment.	Quarterly	0.04
Speed	**4. Cycle times** *(Doorlooptijden)*	Distribution times of food to patient / food to section etc.	Timing it / historical data	The cycle times will at least not be longer as in the current situation.	Shorter The same Longer	Reduce cycle times will have a positive influence on the patient satisfaction.	After 6 months	0.04
Speed	**5. Time efficiency of employee tasks** **(***Tijdsefficientie)*	Use a ratio of time spent on their actual job to total work time.	Measured per employee individually for several related jobs.	Employees have spent at least the same amount of time on their actual job.	Shorter The same Longer	Be more time efficient will lead to an efficient process of food logistics.	After 3-5 months	0.23
Dependability	**6. Amount of unavailable products from assortment** *(Producten buiten voorraad)*	Out of stocks	Counting	98% should be available from the assortment.	≥ 98% 95% -98% < 95%	AMC want to providing the best hospitality for patients therefore the amount of unavailable products should be reduced to a minimum.	After 3-5 months	0.03
Dependability	**7. Amount of complete and on-time intern deliveries** **(***Leverbetrouwbaarheid)*	Indicator of the on-time shipments of suppliers.	Counting/historical data.	The amount of complete and on time internal deliveries should be at least 98%.	≥ 98% 95% -98% < 95%	This would be a condition in order to let the logistic	After 3-5 months	0.04
Dependability	**8. Time fluctuations in service rounds** *(Tijdsverschillen start service ronde)*	We look at the time fluctuations in start and end time of the service rounds.	Time study	10% of the time fluctuations in service rounds should be within 2 standard deviations of the mean.	≥ 10% 10% - 5% < 5%	Low fluctuations will make sure patients receive their orders when they expect them and thus keep patients satisfaction positive.	After 3-5 months	0.01
Flexibility	**9. Flexibility in product and service** *(Flexibility aanbod)*	We try to find how well the system reacts on unexpected events.	Measure times needed to complete a unusual product wish.	The logistic function of food within the AMC should be able to adapt for quick changes or on time requests.	Same day Next day Later	AMC want to providing the best hospitality for patients. Being flexible is one of the requirements the hospital should fulfill to meet the current demand of patients.	After 3-5 months	0.03
Costs	**10. Amount of thrown away products** *(Verspilling)*	Amount of food waste compared to the total amount of residual waste.	% (un)avoidable food waste compared to the total amount of residual waste.	The total amount of food waste should be below 5%.	≤ 5% 6%-10% ≥ 11%	To reduce the costs by shrinkage.	Monthly	0.08
Costs	**11. Amount of food consumption by others than patients** *(Gebruik voeding door anderen dan patienten)*	Amount of food used by others compared to the total amount of food	Using registration forms	The food consumed by others is less than 2%.	≤ 2% 2%-5% ≥ 5%	To reduce the costs of food consumption	After 3-5 months	0.03
Costs	**12. Costs per patient per unit** *(Kosten per patiënt)*	The average costs of feeding one patiënt during one day.	Total amount of food consumption devided by the amount of patients.	The integral cost per patient per unit should decrease.	Decrease Remains the same Increase	Many actions together should lead to a reduction of the costs per patiënt.	After 3-5 months	0.01

Table 20: Elaboration and reasoning to include food logistic KPIs

Appendix II: Inventory management KPIs

Plan & Do		Check					Act	
Specific		Measurable		Attainable		Relevant	Timely	Weight
Category	KPI	Definition	Measured by	Norm	Margin	Reason to inlcude	Frequency	
Quality	**1. Waste** *(Incourante voorraad)*	Amount of food waste compared to the total amount of residual waste.	Calculate the percentage unavoidable and avoidable food waste compared to the total amount of residual waste.	The total amount of food waste should be below 5%.	≤ 5% 6%-10% ≥ 11%	To reduce the costs by waste	Monthly	0.2
Speed	**2. Order fill rate** *(% orders compleet op tijd)*	Indicator of the intern on-time shipment.	Register what time the order is delivered in the kitchen.	100 % of the intern shipments should be on-time and complete.	Always on time Usually on time Rarely on time	To garantee a certain level of product availabiltiy and prevent late service rounds in case of dependability of deliveries.	Quarterly	0.2
	3. BBW inventory accuracy (*voorraadbetrouwbaarheid*)	Indicator of the immediately availability of products directly served from BBW.	$\frac{The\ actual\ stock\ on\ BBW\ per\ SKU}{Demand\ per\ SKU} * 100\%$	100% of the products should be directly available from BBW.	100% 95% < 95%	Efficient service rounds.	Monthly	0.07
	4. SKUs in-stock percentage *(% SKU's op voorraad)*	Indicator of the completeness of safety inventory.	$\frac{The\ actual\ safety\ stock\ per\ SKU}{Demand\ per\ SKU} * 100\%$	Optimal level of product availability per SKU is 100%	100% 95% < 95%	To decrease the inventory to a minimum with respect to a certain service level and reduce overstocking at the same time to reduce waste.	Monthly	0.04
Dependability	**5. On-time shipment** *(Leverbetrouwbaarheid)*	Indicator of the on-time shipments of suppliers.	Register what time the truck arrives at the central goods receipt.	On average ≥ 98 % of the supplier shipments should be on-time.	Always on time Usually on time Rarely on time	To garantee a certain level of product availablilty.	Quarterly	0.2
	6. Out-of-stocks *(Aantal keren buiten voorraad)*	Indicator of the availability of products.	Count all out of stocks during service rounds.	100% should be available from the assortment.	100% 95% < 95%	To garantee a certain service level.	Monthly	0.2
Flexibility	**7. Backorders** *(Naleveringen)*	The ability to obtain out-of-stock items.	The time between the backorder and receiving of the order.	Backorders should received the same day	Same day Next day Later	To respond to patientwhishes.	Quarterly	0.05
Costs	**8. Inventory turns** *(Omloopsnelheid voorraad)*	Total number of times the inventory is sold.	$\frac{Annual\ cost\ of\ sales\ for\ FGH5}{Average\ inventory\ FGH5}$	The turnover should be at least 10 times a year	16-23 11-15 ≤ 10 , ≥ 24	To figure out of which products the current stocks are too high and to make an inventory layout using a Pareto analysis.	Quarterly	0.01
	9. Inventory Balance *(Voorraadwaarde)*	Total (purchasing) value of products in inventory.	# SKUs in inventory * Value of SKUs	Inventory Balance should below € 1.000	≤ 1000 1001-5000 ≥ 5001	To decrease the inventory balance to a minimum.	Quarterly	0.01
	10. Days of supply (*# dagen voorraad*)	Indicator of the rate at which stocks are sold in amount of days products in inventory.	$\frac{Total\ Inventory}{Average\ daily\ consumption}$	Optimal level of days of supply is just 1 day.	Same day > 1 day < 1 day	To reduce the risk of excess and obsolete inventory.	Quarterly	0.01
	11. Holding costs *(Voorraadkosten)*	Cost of carrying one unit in inventory for a specified period of time.	A combination of cost of capital, the cost of physically storing the inventory, and the cost that results from the product becoming obsolete.	Holding costs should be lower than in the current situation	Lower The same Higher	To calculate the optimal order quantity.	Quarterly	0.01

Table 21: laboration and reasoning to include inventory management KPIs

Appendix III: Elaboration of literature study

We separate the eight literature reviews and analyze these to determine scope, method, results, and conclusion.

Reference	Restriction	Method	Relevant results	Conclusion of the research
Reviews				
Perishable inventory models				
(Nahmias, 1982)	Fixed-lifetime perishable inventory models under the assumptions of first-in-first-out (FIFO) issuing policy and fresh supply.	Reviews the current literature on ordering policies for perishable inventories.	Although it seems that blood inventory have dominated the interest of researchers and underlie most of the theoretical perishable inventory models developed, Nahmias expect that food management problems would have a far greater economic impact. For most fixed life inventory problems, it is always optimal to issue the oldest items first (FIFO).	Determination of good ordering policies for a fixed life time commodity when there is a positive lead time for placing an order and inventory levels are reviewed continuously.
(Raafat, 1991)	Continuously deteriorating inventory mathematical models where the deterioration is considered as a function of the on-hand inventory.	Reviews literature on continuously deteriorating mathematical inventory models.	A complete and up-to-date survey of literature on deteriorating inventory models. Papers that consider the effect of deterioration as a function of the on-hand level of inventory are addressed.	Many papers provide complicated equations to determine the optimal order quantity, inventory cycle time, and replenishment policy. There is a need for simpler heuristics or approximations of deteriorating inventory to consider the effects of multiple-item stocking environments.
(Goyal & Giri, 2001)	Review the advances of deteriorating inventory literature after Raafat's survey.	Analyze the main contributions in modeling deteriorating inventory in the field of inventory theory.	Overview of the most relevant articles in the period from 1991 to 1999	Up-to-date review of deteriorating inventory literature.
(Bijvank & Vis, 2011)	Include lost-sales settings.	Classified the literature addressing lost sales inventory systems and discussed these literature for continuous and period review inventory systems with different types of replenishment policies.	Lost-sales inventory systems require different replenishment policies to minimize costs compared to backorder systems.	For each classification and type of replenishment policy they discuss the available models and their performance.
(Bakker, Riezebos, & Teunter, 2012)	Models for inventory control with deteriorating items that have been published since Goyal and Giri's review.	A comprehensive literature review of models for inventory control with deteriorating items.	More readily available information, such as RFID facilitates integration down the SC, with great opportunities for inventory control of perishables.	An up-to-date review of deteriorating inventory literature succeeding the work of Goyal and Giri.
(Amorim, Meyr, Almeder, & Almada-Lobo, 2013)	Review on SC planning problems that may benefit from tackling perishability explicitly. Focus is on handling perishability by analytical planning models.	A review on different planning models that handle perishability issues in production and distribution.	It draws the community attention to the importance of managing perishability in many different industries' SC by showing its relevance and by reviewing the literature related to production and distribution planning.	The review classified production and distribution planning models dealing with goods subject to physical deterioration.

(Stanger, Yates, Wilding, & Cotton, 2012)	Literature review on inventory management of red blood cells in hospital transfusion laboratories to derive principles of best practice and makes recommendations that will reduce losses by outdating kept to a minimum.	Comparison of 7 case studies, to identifying drivers for low wastage and good inventory management practice, with the current literature on inventory performance of perishables.	• (blood) Inventory management is a trade-off between shortage and wastage. • Just in time management is not suitable for products with high out of stock risks/ costs, like blood inventory, due to the consequences of an inventory shortage. • Providing an useful evaluation of models identified in perishable inventory literature. • Providing a summary of key findings and recommendations from the 7 case study interviews. • A list of useful references.	Good performance is driven by the quality of transfusion laboratory staff, who must be skilled, regularly trained, and experienced. Transparency of the inventory and simple management procedures also facilitate good performance.
Lateral transshipments (LT)				

(Paterson, Kiesmüller, Teunter, & Glazebrook, 2011)	Focus is on:
	• Proactive LT
	  ○ Ordering not considered
	  ○ Ordering considered
	• Reactive LT
	  ○ Periodic ordering
	  ▪ 1 vs. 2 Echelons, centralized
	  ▪ Decentralized
	  ○ Continuous ordering
	  ▪ Complete vs. Partial pooling
		Categorize current literature on LT, so that differences can be understood and gaps within the literature can be identified.	A varied range of industries apply LT for many different types of inventory systems. (pro/re) active LT help to reduce costs or increase service levels in a SC. In the retail sector handling costs are often dominant. Therefore the use of proactive transshipments, which reduce overall system costs, is most useful in that environment and would be especially beneficial in case of highly variable demand. This benefit increases with the number of locations. However, the added flexibility of allowing these LT leads to a difficult to control and optimize inventory system. Complete pooling is only beneficial when holding and backordering costs are large compared to transshipment costs.	A review of proactive LT, reactive transshipments under periodic review ordering, and reactive transshipments under continuous review ordering.

Table 22: Elaboration of literature study: Reviews

Distinguishing the remaining articles is based on their main focus, namely the location and allocation of items, perishable inventory management, LTs or retail management. Then we classify the articles based on supply chain management specific characteristics, like single or multi echelons, fixed or random shelf life, periodic or continuous review policy, demand distribution, loss of sales or backorders in case of a shortage of stock, and the model intervention approach. Each article we review to find out what type of research method is used, which results are relevant for our study, and what the main conclusion of the article is.

Reference	Single / multi-echelon	Fixed / random shelf life	Periodic / continue review	Demand distribution	Loss of sales / Backorders	Model intervention	Method	Model		Relevant results	Conclusion of the research
								Input	Output		
Articles focusing on inventory location and allocation											
S= Single echelon, M=Multi echelon | F=Fixed shelf life, R=Random shelf life | P= Periodic review policy, C=Continue review policy; D= Deterministic, S=Stochastic | L=Loss of sales, B=Backorders | H=Heuristic, A=Approximation.											
(Duan & Liao, I, 2013a)	M	-	P	D	L	H	A simulation-based optimization framework for SC inventory model.	• Demand data • Capacity constraint • Control strategy • Allocation rule.	• Near-optimal policy • Inventory cost • Ordering pattern • Cost distribution • Internal service level.	Centralized control is especially beneficial in case of unstable demand patterns. For decentralized SCs, it is feasible to coordinate the whole system by designing an incentive mechanism which will benefit all members in the system.	Proposed framework is designed to find sufficiently good interventions for a decentralized or centralized SC inventory problem. Overall it is beneficial to adopt centralized control. Realize cost savings is dependent upon the demand patterns.
(Duan & Liao, II, 2013b)	M	F	P	S	B	H / A	A simulation optimization framework is proposed for SC inventory management of highly perishable products.	• A maximal allowable shortage level • 3 order-up-to policies • Decentralized vs. centralized control • Different levels of the fill rate constraint.	• Expected system outdate rate and shortage rate.	Adopting centralized control over the whole platelet SC reducing the system expected outdate rate while keeping sufficiently high fill rate at each entity.	Centralized control coordinates the SC well so that the demand and the supply are matched closely. Employing a policy without age consideration in centralized control can achieve a lower system outdate rate than those policies with age consideration in decentralized control.
(Ketzenberg & Ferguson, 2007)	M	F	P	S	L	-	Simulation study	• Coefficient of variation • Expediting cost • Product lifetime • Supplier margin • Retailer margin • Batch size	To address the value of information and value of centralized control.	The highest benefit of centralized control in SC is when products have a short shelf life, large batch sizes, highly uncertain demand and the penalty for mismatches in supply and demand are large. Small holding costs compared to the costs of a shortage leads to little incentive to minimize inventories other than for reasons of shelf space. In addition outdating of perishables have negative influence on service levels and does increase the overage cost.	Presents the importance of information sharing and centralized control in the SC and identify conditions under which benefits are realized.

Table 23: Elaboration of literature study: Articles focusing on Inventory location and allocation

Reference	Single / multi-echelon	Fixed / random shelf life	Periodic / continue review	Demand distribution	Loss of sales / Backorders	Model intervention	Method	Model		Relevant results	Conclusion of the research
								Input	Output		
Articles focusing on Perishable Inventory											
S= Single echelon, M=Multi echelon | F=Fixed shelf life, R=Random shelf life | P= Periodic review policy, C=Continue review policy; D= Deterministic, S=Stochastic | L=Loss of sales, B=Backorders | H=Heuristic, A=Approximation.											
(Blake, Heddle, Hardy, & Barty, 2009)	-	F	P	S	L	H	Simulation study (VBA)	• Bounds on out dates and shortages.	• Ordering policy • Minimization of the overall number of orders.	An objective based on meeting target outdate and shortage rates, instead of cost minimization, can simplify the problem and its intervention for the platelet inventory and ordering problem. The consequences of a lost sale is obviously quite large, but difficult to calculate. The overall costs of a unit outdated is also difficult to determine.	A model which determines whether a jointly feasible policy can be found on each day of a cyclic, one-week planning problem. The larger the demand, the easier it is to find a jointly feasible policy. The simulation suggests that days of zero demand make it difficult to find good ordering policies.
(Broekmeulen & van Donselaar, 2009)	S	F	P	S	L	H	Discrete Event Simulation Model. Run four scenario's to determine for each parameter setting the optimal safety stock level SS, which minimized the average simulated costs.	• Product lifetime • Mean week demand • Coefficient of variation • Case pack cover • Lead-time • Review period • Week pattern • Cost ratios of outdating, lost sales, and holding cost.	• Long-term average costs • Optimal safety stock level	The cost reductions are especially large for products with a short shelf life, when Last In First Out policy is used, a large lead-time, a few review periods, if out dating have big consequences and/or when the retailer aims for a high product availability.	This paper suggests a replenishment policy for perishables which takes the age of inventories into account. It will be shown that in an environment, which contains important features of the real-life retail environment, this new policy leads to substantial cost reductions compared with a policy that does not take into account the age of inventories.
(Donselaar, Woensel, Broekmeulen, & Fransoo, 2006)	M	F	C	-	L	-	Uses empirical data to discuss on the desired inventory control strategy for perishables based on literature.	• Description of the main logistic characteristics • Inventory control rules for perishable items	• The desired inventory control strategy for these items.	Waste of perishables can reduces by substitution, especially for items with a short shelf life (like bread) or with a case pack size, which is relatively large compared to the average demand during the shelf life.	Supermarkets have different product groups, each having different logistics characteristics, and therefore need different inventory control rules.

(Donselaar & Broekmeulen, 2012)	S	F	P	S	L	A	Study of relationships between key performance indicators and system parameters for an inventory system with a perishable product.	• Product availability • Product lifetime • Mean daily demand • Variance-to-mean ratio • Case pack size • Lead-time • Review period	• Relative outdating • Different values for the safety stock were evaluated for every combination of input parameters.	Ratios between fill rate, safety stock and relative outdating for single products. Even the reductions in safety stock in case of a pre-set limit of outdating percentage is calculated.	Derived approximation for relative outdating is applicable for a wide range of perishables. It enables retailers to make trade-offs between the relative outdating and the customer service level, when making strategic or tactical decisions on the (re)design of the perishable inventory system.
(Haijema, II, 2013)	-	F	P	S	B	H	Dynamic programming and simulation.	• Costs ratios • Mean demand • Coefficient of variation • LIFO vs. FIFO • Allow ordering on (days) • Maximum shelf life	Optimal ordering policy based on: • Outdating (%) • Shortage (%) • # Orders Costs	The improvement of the (sd,Sd,qd,Qd) policy is big in cases of high outdating and shortages and low order frequency. Thus when shelf life is short and demand is highly uncertain, and frequent replenishment is inefficient or impossible.	Ordering policy that minimizes the expected average costs per period.
(Prastacos, 1981)	S	F	P	S	B	A	Modeling	Different allocation and distribution options.	• Expected shortages • Expected outdates	Optimal allocation policy minimizes the expected average shortages and the expected average outdates in the region.	Present an integrated allocation and distribution model for a perishable product to be distributed to a set of locations with random demands.
(Ali, Madaan, Chan, & Kannan, 2013)	S	R	C	D	B	-	Modeling	Demand rate and other (location) parameters;	Optimal replenishment schedule	This study proposed that for deteriorating items the original Wagner–Whitin approach can be extended as has been done in inventory followed shortage (IFS) replenishment policy under both inflationary and time discounting environments. Variations in ordering size, frequency of the orders, and service levels are permitted in this model.	Provide an optimal replenishment schedule considering deterioration and shortage with time-adjusted value using a logistic approach. The authors mention that buying behavior of users plays an important role in predicting the demand and correspondingly the inventory of the system.

(Stanger, Wilding, Yates, & Cotton, 2012)	S	F	P	-	L	-	Case study	• Stock levels • Replenishment orders • Inventory management principles • Inventory management tools and equipment • Allocation of units to patients.	• Human resources and training: experienced staff; • Target stock levels and order patterns; • Collaboration across departments; • Transparency of inventories; • Simple inventory procedures; • Strict focus on monitoring of remaining shelf life.	Managerial changes and training issues have a significant impact on waste reduction and inventory management performance in perishable SC and are critical for good inventory performance. Staff should be able to make deliberately inventory decisions resulting in improved performance and reduced wastage. However, as the case studies focus on the blood SC, some caution needs to be applied in generalizing these findings beyond the specific context studied.	Due to high complexity in inventory models it is difficult for practitioners to apply these models and algorithms. Implementation of the theory in simple management procedures is needed. Even as training and awareness of the challenges of perishable inventories. Simple inventory processes must be embedded in day-to-day business. In combination with skilled and experienced staff this will lead to good performance in perishable inventory management.
(Li, 2007)	S	F	*	S	L	A	Mathematically	*Cycle review vs. continuous review policies	Analyze joint decision of cycle service level for typical perishable products.	Service design of replenishment policy based on joint decision of cooperation in SC results in increasing customer satisfaction and enterprise profitability.	Cooperation based on cost sharing stimulates and increases the retailer service level and lot size compared to non-cooperation.

Table 24: Elaboration of literature study: Articles focusing on Perishable Inventory

Reference	Single / multi-echelon	Fixed / random shelf life	Periodic / continue review	Demand distribution	Loss of sales / Backorders	Model intervention approach	Method	Model		Relevant results	Conclusion of the research
								Input	Output		
Articles focusing on Lateral Transshipments – *Perishability included*											
S= Single echelon, M=Multi echelon | F=Fixed shelf life, R=Random shelf life | P= Periodic review policy, C=Continue review policy; D= Deterministic, S=Stochastic | L=Loss of sales, B=Backorders | H=Heuristic, A=Approximation.											
(Banerjee, Burton, & Banerjee, 2003)	M	-	P	S	B	-	Exploratory simulation study	• Number of locations • Order size variability • Demand uncertainty • Supply lead time • Lateral shipment policy	Per location: • Avg. inventory level • # stock outs • Avg. units of shortage • Avg. unit days of shortage • Avg. transshipment activity	If the benefits of avoiding retail level shortages outweigh the additional delivery costs resulting from transshipments, customer service may be enhanced significantly, without additional safety stocks.	This study has examined the effects, of two lateral (intra echelon) shipment approaches in a two-echelon SC network, through a series of simulation experiments under different operating conditions.
(Burton & Banerjee, 2005)	M	F	P	S	B	H	Simulation study	• 24 environmental factor level combinations	Total cost, as a function of: • Avg. unit days of shortage per retailer • Avg. number of LTs per retailer.	LT have substantial appeal, unless such shipments are prohibitively expensive. If the benefits of avoiding retail level shortages outweigh the additional delivery costs resulting from transshipments, customer service may be enhanced significantly, without additional stocks.	The paper has examined the relative effectiveness of two lateral (intra-echelon) shipment approaches in two-echelon SC networks, characterized by a single supply source at the higher echelon and multiple retail locations at the lower.
(Vorst, Beulens, De Wit, & Van Beek, 1998)	n / a	n / a	C	n / a	n / a	n / a	Simulation study	• Order forecast horizon • Input data • Administrative and decision processes • Inherent uncertainties	Trade-off between service levels and total chain costs. Performance indicators: • Inventory level and product freshness at DC and outlet	The availability of real-time information systems is found to be a requirement for obtaining efficient and effective SC management concepts.	Reduction of uncertainties may improve service levels significantly, although current SC configurations restrict possible benefits.
(Haijema, I, 2011)	n / a	F	P	S	B	*	*Stochastic dynamic programming	• Demand rate • Weekly costs • % above optimum • Outdating • Shortages	Trade-off between outdating and shortages to achieve an optimal issuing policy for perishables with a short shelf life. This policy may perform	Thus optimal issuance provide benefits at the economic and environmental level as well as increases the customer service level since it reduces the shortages significant and may reduce the outdating by lowering the stock levels.	While this article is focusing on blood products one expect that similar results may obtain for other perishables, like fresh food, dairy products, fruit and vegetables, as these products have a short life time while replenishments may not happen all weekdays and shops may be open seven days a week.

									better than FIFO and LIFO issuance.		The issuance in such shops is than controlled by a careful allocation of products to the forward and reserve inventories.
(Mercer & Tao, 1996)	M	-	P	S	B	-	Extensive calculations	Data stream of actual demands for a typical product.	Forecasts are made over different time periods for production planning, warehouse allocations and transshipments.	Transfers between all the depots lead to the lowest stock losses for an acceptable number of transshipments each week.	For various production frequencies and levels of stock the forecast models were analyzed.
(Minner & Transchel, 2010)	S	F	P	S	L	H	Simulation	• Several assumptions • Demand distribution • Service level • Ordering decision • Fill-rate • Inventory depletion rule.	To determine order quantities that satisfy certain service level constraints.	While many food retail operations are centralized coordinated by a depot, an extension to multi-echelon food inventory is a promising area for service-level based approaches.	A constant-order policy might provide good results under stationary demand, short shelf-life, and LIFO inventory depletion.
(Cheong, 2013)	M	F	C	S	L	A	Iterative intervention approach	Analyze different transshipment policies of perishables based on the impact of inventory replenishment decisions among retailers.	Optimal replenishment and transshipment decisions in order to reduce surplus, shortage, or outdating inventory costs	Transshipments can help to reduce the amount of outdated goods at a retailer if the initial inventory level at the retailer is high. The total expected cost can be reduced through transshipments.	An intervention approach for a two-location system as a special case and numerical examples in order to highlight the potential value of implementing transshipments for perishables.
Articles focusing on Lateral Transshipments – *Perishability excluded*											
(Tiacci & Saetta, 2011)	S	-	P	S	L	H	Simulation study	• Annual demand • Lead time • Unit stock out cost • Lead time demand • Coefficient of variation • Demand distribution parameters.	Effectiveness of a non-lateral shipment policy (NLS) compared to the preventive transshipment heuristic (PTH)	The application of PTH brings significant reductions of overall costs with respect to a non-lateral shipment policy.	The PTH, for balancing inventories among different locations at the same echelon in order to prevent stock outs, considers the impact on expected costs when deciding when and how much to transship, contrarily to other heuristics for preventive transshipment, whose decisions are based on expected stocks or service levels.
(Herer & Rashit, I, 1999)	S	-	P	S	L	-	Modeling. Focus is on transshipments between multi locations at the same echelon.	• Location characteristics	• Optimal replenishment and transshipment policy • Total expected cost	The existence of no negligible fixed and joint replenishment costs and their impact on the optimal replenishment policy in a two-location inventory system with stock transshipments	The article shows how each location plays the role of a secondary, random supply source for the other location, and how this affects the optimal inventory levels at the locations under the different replenishment possibilities.

(Herer & Tzur, II, 2003)	S	-	C	D	L	H*	*An optimal and a heuristic algorithm in a dynamic deterministic demand environment evaluated by computational tests.	Several locations, each of which has a known demand for a single product for each period in a given finite horizon.	Consider replenishment, transshipment and inventory holding costs, with respect to the different locations.	The benefits associated with transshipments is the saving of fixed and possibly variable replenishment costs. The cost of transshipments is associated with fixed and variable components of transferring the stock among locations.	Focus is on movement of a product between locations at the same echelon level. The computational tests of this research demonstrate that the heuristic performs extremely well.
(Hu, Watson, & Schneider, 2005)	S	-	P	S	B	A	Simulated	• Demand distribution • Inventory shortage cost • Number of stores • Unit transshipment costs • System ordering setup cost • Mean of demand • Unit inventory holding cost	Comparison of an approximate optimal policy for the centralized ordering, multi-location inventory systems, with a simplified policy that assumes free and instantaneous transshipments.	If transshipment costs outweigh the holding plus stock-out costs then a model without transshipments would be beneficial. Generally, using transshipments seems to be a cost effective way of reducing inventories for situations with many locations where transshipment costs are small relative to the stock-out plus holding costs.	When determining reorder points for a large number of stores with high stock-out costs, transshipment costs should not be ignored, even if they are small. The higher these costs, the more likely that no transshipments take place and higher safety stocks for the stores are used instead. For a large number of stores with high stock-out costs, significant savings can be achieved if a low-cost transshipment is available.
(Jönsson & Silver, 1987)	M	-	P	S	B	-	Mathematical	• # periods/ order cycle • Lead time from supplier to central warehouse • Internal(distribution or transshipment) lead time • # Branch warehouses • Avg and SD of demand • Desired service level.	Two centralized inventory control systems are compared for each set of data.	Redistribution system becomes advantageous in situations with high demand variability, a long planning horizon, many branch warehouses, a high service level and short lead times.	The comparison shows that for the same service level the redistribution system gives a considerably smaller investment in inventory than does the system without redistribution. However, additional costs of transshipments between branch warehouses are incurred.
(Lee, Jung, & Jeon, 2007)	M	-	P	S	B	-	Simulation study	• Number of retailers • Review period • Lead time for LT • Order-up-to level • Holding cost • Penalty cost • Transportation cost • Ordering cost	Performance measured as total cost of the SC. Made up of holding, backorder, transportation, and ordering costs.	Various proposed LT policies have the disadvantage of not suitably responding to customer demands.	Prove efficiency of different transshipment policies by comparing performance of simulation experiments. LT policies can maximize customer satisfaction and reduce management costs.

(Diks & de Kok, 1996)	M	-	P	-	B	H	Monte-Carlo simulation to determine all the control parameters, so as the desired (different) service levels are attained at the retailers at minimal expected total costs.	• Integral order-up-to-level • Parameters of allocation policy at the CD • Parameters of the rebalancing policy at the retailer.	• Different service levels. • Total costs	Insight into the conditions under which transshipments could be useful.	The transshipment model becomes advantageous in situations with many retailers, a high service level, mean demands per period of the same size, and the central depot located as close as possible to the supplier.
(Evers, 1996)	S	-	C	D	B	H	Simulation study to indicate whether the portfolio effect model can be used to determine the percentage reduction in safety stocks resulting from the implementation of a transshipment policy.	• #markets in the system • Avg. demand at market • Coefficient of variation of demand • Avg. lead time at facility • Coefficient of variation of lead time • Proportion of avg. demand at market i retained at facility i	The model suggests, that certain factors significantly affect the ability to reduce safety stocks through the use of transshipments.	This model is a suggested approach for comparing the benefits of transshipments with the costs of transshipments. Inventory consolidation results in less safety stock being required to satisfy a given level of customer service. LTs between facilities allows a firm to continue operating all of its stock keeping locations at the same level of inventory availability while, at the same time, reducing its safety stock requirements.	The coefficient of variation of demand, the coefficient of variation of lead time, the proportion of demand at market i retained at location i, and the average lead time significantly affect the level of safety stock savings achieved. So, when reduction in the number of stock keeping facilities is unacceptable, a transshipment policy could be effectively used to reduce safety stocks while maintaining customer service levels.
(Needham & Evers, 1998)	M	-	C	S	B	*	*A numerical approach to dynamically determine replenishment quantities for perishable items and to provide a meta model for use as a managerial decision aid.	• Average lead time • Coefficient of variation of lead time • Average daily demand • Coefficient of variation of daily demand.	• Initial demands • Unfilled demands • Expedited shipments • Emergency transshipments • Orders placed • Inventory levels • Other relevant system measures • Total cost associated with each transshipment policy	Most critical element of management's decision with respect to transshipments is the determination of the stock out costs. Since this factor is the primary determinant affecting the decision to use transshipments.	As penalty costs outweigh the cost of the item, the use of transshipments becomes cost effective. Transshipments dramatically improve inventory availability. The fill rates associated with not using transshipments were lower than those with using transshipments.

(Olsson, 2009)	S	-	C	S	both	*	*Stochastic dynamic programming	• Lead time for normal replenishments • Customer arrival intensity • Arrival intensity for outstanding orders • Reorder point • Batch quantity • Holding, Ordering & Transshipment costs • Lost sales cost per unsatisfied demand	To derive optimal replenishment policies for the locations allowing transshipments.	An (R,Q) inventory policy may be a reasonable choice of replenishment policy when the demand rate is relatively low.	The (R,Q) inventory system as well as the overall optimal policy are not always symmetric even though the locations are identical. So one cannot in general assume that the locations should have the same optimal replenishment policy when they are identical.
(Paterson, Teunter, & Glazebrook, II, 2012)	S	-	C	S	B	A	Simulation study	• Arrival rate • Geometric distribution parameter • Lead time • Backorder cost • Transshipment cost (per item and per transshipment separately)	• Costs • Service levels • Fill rates (the percentage of demand filled immediately from stock on-hand or via transshipment)	The benefits of reactive LTs can be enhanced by the development of a new type of policy, which incorporate a proactive element. This policy can significantly alter the optimal reorder point when compared to no-LTs. Part of the savings achieved is because lowering the safety stock required throughout the system and the improved efficiency of the transshipment process. The benefits growing with the number of locations.	A transshipment policy which balance the cost of transshipment with the benefits as improved service levels, a reduction in safety stock levels and/or reduction of the cost of operating the system.
(Wee & Dada, 2005)	M	-	P	S	both	-	Modeling, focused on the role of LTs in a multiple retailer network in order to find optimal policies for transshipping inventory in a retail network.	A set of easily computable conditions.	The role of LTs in a system of n-retailers who stock a good to determine the optimal LT policy.	If the cost of holding inventory at the retailer outweigh the holding costs at the warehouse, then it will be economical to use a sort of pooling policy.	Structural results that help identify conditions under which a warehouse should be open: How this decision is influenced by the total number of retailers, and how this decision is related to the degree of correlation of demand between retailers.

Table 25: Elaboration of literature study: Articles focusing on Lateral Transshipments

Reference	Single / multi-echelon	Fixed / random shelf life	Periodic / continue review	Demand distribution	Loss of sales / Backorders	Model intervention	Method	Model		Relevant results	Conclusion of the research
								Input	Output		
Articles focusing on Retail Management											
S= Single echelon, M=Multi echelon | F=Fixed shelf life, R=Random shelf life | P= Periodic review policy, C=Continue review policy; D= Deterministic, S=Stochastic | L=Loss of sales, B=Backorders | H=Heuristic, A=Approximation.											
(Tan & Karabati, 2013)	-	-	P	S	L	A	A computational study	Impact of: • Profit margins • Inventory holding and substitution costs • Service level constraints	On: • Order-up-to level • Expected profits	When product substitutions were ignored in inventory management this would lead to a sub-optimal performance. Indirect a retailer can affect the decisions of a customer through his decisions of inventory management.	By incorporate substitution of different products a retailer may increase its expected profit, and the performance of the inventory system can be improve .
(Bertolini, Ferretti, Vignali, & Volpi, 2012/2013)	M	F	C	S	B	-	Pilot study	Analyze the impact of RFID technology on the supply chain of fresh perishable products.	• Out-of-stock rate • Waste • Capital holding costs • Sales turn over • Efficiency	This article give insights in the benefits that can be achieved by using RFID technologies in the retail sector. In a supply chain of fresh perishable products they conduct a pilot and found an overall increase in sales turnover of 1.75%. This is particular due to the major benefits in sales turnover, split up in out-of-stock reduction, efficient shelf inventory management and, waste reduction. They observed even so a relevant improvement in product freshness of 18%.	Besides the mentioned benefits, a higher accuracy of perishables inventory management provides possibilities for further significant savings.

Table 26: Elaboration of literature study: Articles focusing on Retail Management

Reference	Chapter	Relevant results
Books		
(Chopra & Meindl, 2001)	3: Supply Chain Drivers and Obstacles	In a SC which requires a high level of responsiveness to the customers, inventory should be located close to the customer in order to achieve this responsiveness. Inventory is a method to solve the mismatch between supply and demand and anticipate of future demand. Reduce inventory can be used to make processes more efficiently for example by centralized stocking and exploiting any economies of scale. Supply chain managers should therefore made a trade-off between responsiveness by store more inventory and efficiency by store less inventory. These decision should be based on divers components: The amount of cycle inventory (trade-off between holding costs and ordering costs), safety inventory (trade-off between inventory costs and losing sales due stock outs) and whether or not to build seasonal inventory (trade-off between cost of carrying additional seasonal inventory and cost of having a more flexible production rate).
	7: Managing Economies of Scale in a Supply Chain: Cycle Inventory	On the pages 169-171 the factors influencing the inventory costs are presented. Overall conclusion of this chapter is that it is better to have one bag of items as on-hand inventory for several units than to order one bag for each unit separately. Of cause this is the case for products were the demand of the several units is lower than the amount of items in one bag. So this could be relevant for consumable products like honey cups, sprinkles, jam, sugar sachets, etc.
	8: Managing Economies of Scale in a Supply Chain: Safety Inventory	For any supply chain, there are two key questions to consider when planning safety inventory: (1)What is the appropriate level of safety inventory to carry? (2) What actions can be taken to improve product availability while reducing safety inventory? The appropriate level is determined by the uncertainty of demand or supply (p.182/183) and the desired level of product availability (out of inventory), measured by product fill rate, order fill rate, and cycle service level on page 183. Improvement is possible by take into account the fact that supply chain demand is lumpy, adjust inventory policies if demand is seasonal, use simulation to test inventory policies, start with a pilot, monitor service levels, and focus on reducing safety inventories.
	9: Determining Optimal Level of Product Availability	A supply chain needs to achieve a balance between the level of availability and the cost of inventory. The optimal level of product availability is one that maximizes supply chain profitability. Factors affecting optimal level of product availability are the costs of overstocking and the cost of under stocking the product. With reduced demand uncertainty, a supply chain manager can better match supply and demand by reducing both over- and under stocking. A manager can reduce demand uncertainty via the following means: (1) Improved forecasting, (2) Quick response, (3) Postponement, (4) Tailored sourcing.
(Slack, Chambers, & Johnston, Operations Management, 2007)	6: Supply network design	Reasons for taking a supply network perspective: - It helps an understanding of competitiveness, - It helps identify significant links in the network, - It helps focus on long-term issues.
	12: Inventory planning and control	Inventory is created to compensate for the differences in timing between supply and demand. Inventory costs calculations are on page 373, EOQ on page 374 It would be useful to do a Pareto analysis to categories the different products. This could be done by a Usage value, see pages 388-389. It is a term used in inventory control to indicate the quantity of items used or sold multiplied by their value or price The authors explains that it is an assumption that managers have a reasonably accurate idea of costs such as holding cost or order cost and have accurate information that really does indicate the actual level of stock and sales. Otherwise this would be a significant problem for inventory managers to analyze and improve the situation.
(Winston, 2003)	Chapters 13-16	The EOQ formula en the News Vendor Problem are useful items covered in this book.
(Axsäter, 2006)	4: Single-echelon systems: Deterministic lot sizing	In this chapter the classical EOQ model and the Wagner-Whitin algorithm are explained. The Wagner-Whitin algorithm and other exact methods are in most circumstances computationally feasible, in practice it is more common to use simple heuristics to obtain an approximate intervention.

Table 27: Elaboration of literature study: Books

Confidential Appendices

Confidential Appendix I
Explanation Stakeholder determination

Ms. F. Bakker is discretionary stakeholder because of her advisory function in several project groups around the food in AMC. Mr. Boer and Mr. Brandao are dominant stakeholders where Mr. Boer has a hierarchically higher status and more power and legitimacy as Mr. Brandao. While, Mr. Brandao is as dedicated project leader of the project 'SPA in the kitchen' of high important for this research. The administrative assistant is demanding stakeholder, but due to the low power, dependent of the other stakeholders. Changes in the logistic process will positively influence his function and therefore there is a certain urgency for a change. The floor manager is hierarchically below the other two managers and has less direct relations to the logistics of food. The floor managers undertake the burden of the current situation as they are focused on the problems on operational level. This person was therefore identified as dependent stakeholder.

Stakeholder		Power	Legitimacy	Urgency	**Type of Stakeholder**
Name	**Function**				
Mr. M. van der Maat	Manager Patient services	+	+	+	Definitive Stakeholder
Ms. F. Bakker	Staff advisor patient services	+/-	+/-	+/-	Discretionary Stakeholder
Mr. M. Boer	Manager logistics service center	+	+	+/-	Dominant Stakeholder
Mr. I. Brandao	Project manager logistics directorate services	+/-	+/-	+/-	Dominant Stakeholder
Anonymous	Administrative Assistant at Basic Administration Directorate Services	-	-	+/-	Demanding Stakeholder
Anonymous	Floor manager	+/-	+/-	+/-	Dependent Stakeholder

Table 28: Stakeholder determination

Confidential Appendix II

Pareto analysis & Turnover

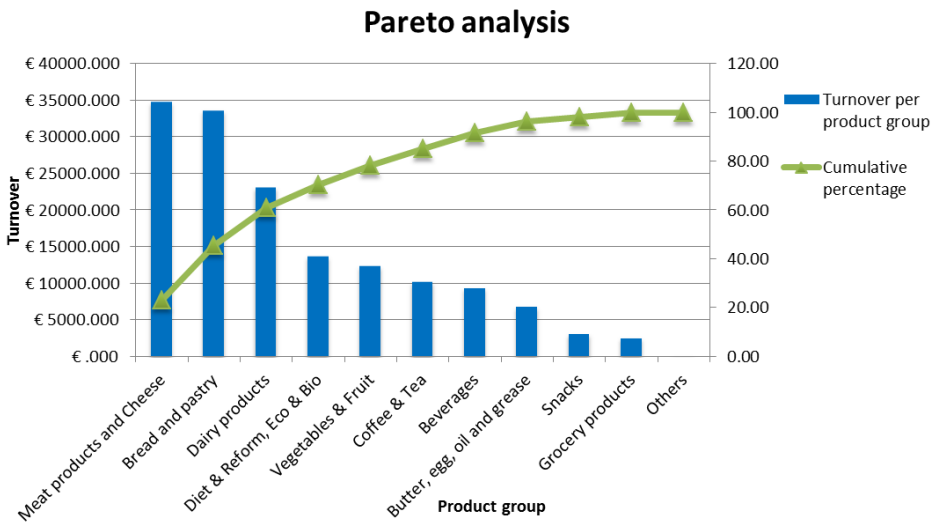

Figure 32: Pareto Analysis

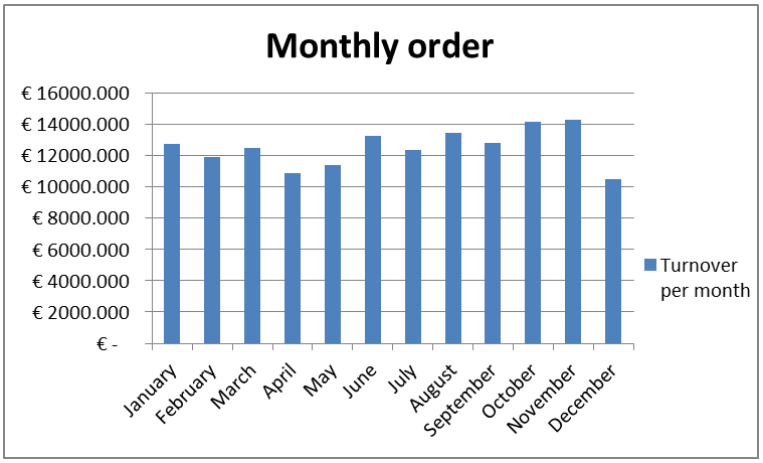

Figure 33: Montly order

Confidential Appendix III: Baseline measurement food logistics

Category	KPI	Target / Goal Points: 5	3	1	Baseline meassurement (2013)	Score	Weight	Total
Quality	**1. Employee satisfaction** *(Medewerker tevredenheid)*	**≥ 9**	**7 - 8.9**	**≤ 6.9**	**6.7**	1	0.23	**0.23**
				Mean *(score between 1-10)*	6.7			
	2. Customer satisfaction *(Klant tevredenheid)*	**≥ 4.5**	**3 - 4.5**	**≤ 3**	**3.6**	3	0.23	**0.69**
				Mean *(score between 1-5)*	3.61			
				Standard deviation	0.65			
	3. Discrepancy between demand and assortment *(Efficiëntie van het assortiment)*	**≥ 90%**	**80% - 90%**	**≤ 80%**	**89%**	3	0.04	**0.12**
				Mean (score between 1-5)	*3.67*			
				Standard deviation	*0.852*			
Speed	**4. Cycle times** *(Doorlooptijden)*	**Shorter**	**The Same**	**Longer**	**As short as possible by BBW**	5	0.04	**0.2**
				Cycle Time	*Using a BBW realises the shortest cycle times possible.*			
	5. Time efficiency of employee tasks (*Tijdsefficientie)*	**Shorter**	**The Same**	**Longer**	**61%**	3	0.23	**0.69**
				Total work time (day shift)	13.15			
				Direct patiënt tasks	8.00			
Dependability	**6. Amount of unavailable products from assortment** *(Producten buiten voorraad)*	**≥ 98%**	**95% -98%**	**< 95%**	**100%**	5	0.03	**0.15**
				# available products from assortment	*measured by observations*			
	7. Amount of complete and on-time intern deliveries (*Leverbetrouwbaarheid)*	**≥ 98%**	**95% -98%**	**< 95%**	**100%**	5	0.04	**0.2**
				# out of stocks during service rounds	*measured by observations*			
	8. Time fluctuations in service rounds *(Tijdsverschillen start service ronde)*	**≥ 10%**	**10% - 5%**	**< 5%**	**≥ 10%**	5	0.01	**0.05**
				# time fluctuations in service rounds within 2 standard	*measured by observations*			
Flexibility	**9. Flexibility in product and service** *(Flexibility aanbod)*	**Same day**	**Next day**	**Later**	**Differs per product /request**	3	0.03	**0.09**
				Time needed to complete a unusual product wish	*measured by observations*			
Costs	**10. Amount of thrown away products** *(Verspilling)*	**≤ 5%**	**6%-10%**	**≥ 11%**	**≥ 7.6%**	1	0.08	**0.08**
				G5	9.1%			
				FGH5	6.6%			
				AMC	7.1%			
	11. Amount of food consumption by others than patients *(Gebruik voeding door anderen dan patienten)*	**≤ 2.9%**	**3%-4.9%**	**≥ 5%**	**10%**	1	0.03	**0.03**
				Food consumed by others	*measured by LSS project*			
	12. Costs per patient per unit *(Kosten per patiënt)*	**Decrease**	**Remains the same**	**Increase**	**€ 20.98**	3	0.01	**0.03**
				Total costs of consumption bread meals and snacks per	€ 1,431,213.00			
				Amount of patients per year:	68228			
						Total score baseline measurement:		**2.56**

Table 29: Schematical representation baseline measurement of AMCs food logistics

Confidential Appendix IV: Baseline measurement inventory

Category	KPI	Target / Goal Points: 5	3	1	Baseline meassurement 2013		Score	Weight	Total
Quality	1. Waste (*Incourante voorraad*)	≤ 5%	6%-10%	≥ 11%	≥ 11%		1	0.2	**0.2**
				G5	9.1%				
				FGH5	6.6%				
				AMC	7.1%				
Speed	2. Order fill rate (*% orders compleet op tijd*)	Always on time	Usually on time	Rarely on time	Usually on time		3	0.2	**0.6**
				Appointment	[7:30;7:45]				
				Time Study	[7:30;8:00]				
	3. BBW inventory accuracy (*voorraadbetrouwbaarheid*)	100%	95%	< 95%	100%		5	0.07	**0.35**
				The actual stock on BBW per SKU	*measured by observations*				
				Demand per SKU					
	4. SKUs in-stock percentage (*% SKU's op voorraad*)	100%	95%	< 95%	100%		5	0.04	**0.2**
				The actual safety stock per SKU	*measured by observations*				
				Demand per SKU					
Dependability	5. On-time shipment (*Leverbetrouwbaarheid*)	Always on time	Usually on time	Rarely on time	Usually on time		3	0.2	**0.6**
				Appointment	7:15				
				Time Study	7:30				
	6. Out-of-stocks (*Aantal keren buiten voorraad*)	100%	95%	< 95%	100%		5	0.2	**1**
				# out of stocks during service rounds	*measured by observations*				
Flexibility	7. Backorders (*Naleveringen*)	Same day	Next day	Later			1	0.05	**0.05**
				The time between backorder and receiving order	*next delivery day*				
Costs	8. Inventory turns (*Omloopsnelheid voorraad*)	16-23	11-15	≤ 10 , ≥ 24	27	29	1	0.01	**0.01**
				Annual cost of sales for FGH5	€ 150,344.54	€ 150,344.54			
				Average Invetory FGH5	€ 5,545.74	€ 5,138.39			
	9. Inventory Balance (*Voorraadwaarde*)	≤ 1000	1001-5000	≥ 5001	€ 5,183.39		1	0.01	**0.01**
				Amount of SKUs in inventory	390				
	10. Days of supply (*# dagen voorraad*)	Sameday	> 1 day	< 1 day	17		3	0.01	**0.03**
				Total Inventory FGH5	€ 5,138.39				
				Average daily consumption	€ 296.13				
	11. Holding costs (*Voorraadkosten*)	Lower	The same	Higher	Too high		1	0.01	**0.01**
				Cost of capital	*Holding costs should reduce by achieve a reduction of inventory balance and waste.*				
				The cost of physically storing the inventory					
				Cost that results from the product becoming obsolete					
						Total score baselinemeasurement:			**3.06**

Table 30: Schematical representation baseline measurement of AMCs inventory management