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BY
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AALBORG UNIVERSITY
DENMARK

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This thesis has been submitted for assessment in partial fulfillment of the PhD degree. The thesis is based on the submitted or published scientific papers which are listed above. Parts of the papers are used directly or indirectly in the extended summary of the thesis. As part of the assessment, co-author statements have been made available to the assessment committee and are also available at the Faculty. The thesis is not in its present form acceptable for open publication but only in limited and closed circulation as copyright may not be ensured.

ENGLISH SUMMARY

Reducing food waste is a major problem within foodservice operations, particularly in hospital foodservice operations. Danish hospitals experience large amounts of food waste whilst numerous patients eat inadequately, resulting in undernutrition, poorer clinical outcomes and increased healthcare costs. Danish hospital foodservices have implemented strategies such as trolley meal delivery in order to reduce plate waste. Despite this, food waste generation continues to be a problem. Advances in information and communication technologies (ICT) have not yet been fully explored as a potential mechanism to reduce waste in hospital foodservices. This research aimed to explore perceived barriers and practices affecting food waste generation and investigated whether a developed ICT assisted tool could provide opportunities to reduce food waste in the hospital meal service. The thesis consists of four papers, I, II, III and IV. These are referred to by their numerals. These studies are described in the following summaries.

Paper 1: This study aimed to explore and understand foodservice professionals' experiences and perceived barriers towards strategies to reduce food waste in large scale institutional kitchens. Explorative semi-structured individual interviews were conducted with eight foodservice professionals from four different foodservice institutions. The results revealed nine main themes: forecasting and portion flexibility; routine monitoring; current strategies in use; enhancing internal awareness; collaboration through communication; taking on responsibility; attitude and habits; regulatory constraints; and competing priorities. The theme of routine monitoring revealed the need to develop innovative tools for staff to monitor food waste and empower them to take actions to reduce food waste. In addition to the themes, findings highlight the importance of understanding barriers to overcome the challenges foodservice professionals face in reducing food waste and set a benchmark for successful strategy implementation.

Paper II: This study investigated the generation of food waste from the trolley at the ward level in a hospital in order to provide recommendations for how practice could be changed to reduce food waste. Three separate focus group discussions were held with four nurses, four dietitians and four service assistants engaged in food service at the hospital. Furthermore, single qualitative interviews were conducted with a nurse, a dietitian and two service assistants. Observations of procedures around trolley food serving were carried out during lunch and supper for a total of ten weekdays in two different wards. All unserved food items discarded as waste were weighed after each service. The findings indicate that trolley food waste generation is a practice associated with limitations related to the procedures of meal ordering. These include portion size choices and delivery, communication, tools for menu information, portioning and monitoring of food waste, as well as the use of unserved food. Hence, initiating positive changes in relation to these factors can be

a way forward when developing strategies to reduce trolley food waste at the ward level.

Paper III: In this paper we present the development of the Dietary Intake Monitoring System (DIMS) as a tool to improve routine monitoring by capturing accurate data on a patient's meal before and after consumption for the assessment of food choice, food intake and plate waste. The DIMS consists of a digital camera, weighing scale, infrared thermometer, radio-frequency identification (RFID) reader, and a user RFID transponder card. The digital camera and weighing scale capture a digital photograph and measure the weight of content on a patient's plate before and after consumption. The temperature of food prior to consumption is also recorded with the aid of an infrared thermometer. The DIMS prototype can provide accurate data in a quick and easy manner that can facilitate routine food waste monitoring in hospital settings.

Paper IV*:* The aim of this study was to investigate meal portion sizes served, the contribution of individual meals to recommended energy and protein intakes, and plate waste in patients screened for nutritional risk by NRS-2002. The study further aimed to investigate the applicability of the dietary intake monitoring system (DIMS) to monitor nutrition intakes and plate waste in hospital. A prospective observational cohort study was conducted in two wards over five weekdays using the DIMS to collect paired before-and after-meal consumption photos, and measures the weight of plate contents. Data on portions served and plate waste was analyzed using mixed linear models. At supper, there was no difference in the median value for the served meal portions between the two groups, but lower consumption among patients at nutritional risk (189g versus 267g, $P = 0.032$) contributed significantly more food waste, energy and protein waste compared with the patients not at risk. Linear mixed model showed that there is positive relationship between meal portion size and plate waste ($P = 0.002$) and at supper, it is predicted that nutritional risk patients are likely to waste more food ($P = 0.001$). Being at nutritional risk further increased the extent of waste, regardless of the portion size served. The DIMS as an innovative technique might be a promising way to monitor plate waste for optimizing meal portion size servings and minimize food waste.

DANSK RESUME

Madspild er et betydeligt problem inden for storskala madservice og det gælder ikke mindst mad på hospitalet. Danske sygehuse oplever store mængder madaffald, mens mange patienter på samme tid har et utilstrækkeligt kostindtag. Det resulterer i underernæring, dårligere kliniske resultater og er med til at skabe øgede udgifter for sundhedsvæsenet. Dansk hospitalskøkkener har allerede implementeret strategier såsom levering af maden til afdelingerne i madvogne for at reducere spildet ved forudportionering på tallerkener fra køkkenet. Trods dette forstætter madspild med at være et problem. Fremskridt inden for informations- og kommunikationsteknologien (IKT) er et endnu ikke udforsket område når det gælder intelligente værktøjer til at reducere madspild på hospitalet. Dette PhD projekt har haft til formål at undersøge personalets opfattelse af de barrierer og den praksis, der påvirker madspildet og har undersøgt, om et IKT assisteret værktøj kan bidrage til at reducere madspild på hospital. Afhandlingen består af fire artikler, benævnt I, II, III og IV. Undersøgelserne er beskrevet i de følgende fire afsnit.

Artikel 1: Denne undersøgelse havde til formål at undersøge og forstå madprofessionelles erfaringer og oplevede barrierer omkring strategier til at reducere madspild i store institutionskøkkener. Semistrukturerede individuelle interviews blev gennemført med otte madprofessionelle fra fire forskellige institutioner. Resultaterne identificerede ni hovedtemaer: prognosticering og portions fleksibilitet; rutinemæssige monitorering; anvendte praksis strategier; motivation og holdning; samarbejde gennem kommunikation; ansvarliggørelse; holdning og vaner; lovgivningsmæssige begrænsninger; og andre konkurrerende prioriteter. Temaet ”rutinemæssig monitorering” pegede på behovet for at udvikle nye værktøjer til overvågning af madspild. Ud over disse temaer, peger resultaterne på vigtigheden af at forstå barrierer til at overvinde de udfordringer de madprofesionelle står overfor når det gælder om at reducere madspild og sætte standarder for succesfuld strategi implementering.

Artikel II: Denne undersøgelse så på hvorledes madaffald opstår i og omkring madvogne på sygehus afdelingerne og havde til hensigt at udvikle anbefalinger til, hvordan praksis kunne optimeres med henblik på at reducere madspild. Der blev afholdt tre separate fokusgruppeinterview med fire sygeplejersker, fire diætister og fire serviceassistenter, som alle var engageret i madservering på hospitalet. Desuden blev der gennemført individuelle kvalitative interviews med en sygeplejerske, en diætist og to serviceassistenter. Observationer af procedurerne omkring servering af maden fra madvognen blev udført under frokost og aftensmad på i alt ti hverdage og på to forskellige afdelinger. Alle fødevarer der blev sendt til kassering som affald blev vejet. Resultaterne viser, at madspild fra madvognen til dels opstår som en konsekvens af begrænsninger i forbindelse med eksisterende procedurer for måltids bestilling. Disse omfatter valg af portionsstørrelse, kommunikation, levering, redskaber til menu information, udportionering på afdelingen og

monitorering af madspild, samt genbrug af ikke-serveret mad. Ændringer i forhold til disse faktorer kan være en vej frem, når det gælder om at udvikle strategier til at reducere madspild på afdelings niveau.

Artikel III: I denne artikel beskrives udviklingen af monitoreringsværktøjet Dietary Intake Monitoring System (DIMS) som et redskab til at forbedre rutinemæssig monitorering ved at registrere nøjagtige oplysninger om en patients måltid. Registrering sker før og efter servering og bruges til vurdering af valg af portionsstørrelse, fødevarer, kostindtag og tallerkenspild. DIMS applikationen består af et digitalt kamera, digital vægt, infrarødt termometer, radio-frekvens identifikations (RFID) læser, og et brugerspecifikt RFID transponder-kort. Det digitale kamera og vejningen danner tilsammen et billede tallerkenen før og efter servering. Temperaturen af fødevarer før forbrug registreres samtidig ved hjælp af et infrarødt termometer.DIMS prototype kan levere præcise data på en hurtig og nem måde, der kan medvirke til at lette den rutinemæssige monitorering at madspild på sygehuset.

Artikel IV: Formålet med denne undersøgelse var at undersøge hvorledes størrelsen af de enkelte måltider der blev serveret, bidrog til det anbefalede energi og protein indtag, samt omfanget af tallerkenspild hos patienter i ernæringsrisiko,ved hjælp af NRS-2002, som det er standard praksis ved indlæggelse. Undersøgelsen havde endvidere til formål at undersøge anvendeligheden af DIMS applikationen til monitorering af kostindtag og tallerkenspild på hospitalet. En prospektiv observations undersøgelse blev gennemført på to afdelinger over fem hverdage. Ved hjælp af DIMS applikationen indsamledes parvise før-og efter-måltids fotos til bestemmelse af energi- og proteinindtag og madspild. Studiet viste at der ved aftensmaden, ikke var nogen forskel mellem størrelsen af de serverede portioner mellem gruppen af patienter i ernæringsrisiko, og de der ikke var i ernæringsrisiko. Imidlertid spiste patienterne i ernæringsmæssig risiko mindre (189g versus 267g, P = 0,032) og bidrog dermed til væsentligt mere madspild sammenlignet med ikke-risiko pateinter. Lineær mixed models viste en positiv sammenhæng mellem portionsstørrelse og madspild (P = 0.002), således at jo større portion der blev serveret jo mere madspild genereredes. Patienter, i ernæringsmæssig risiko var mere tilbøjelige til at forårsage madspild i form af energi og proteinspild til aftensmåltidet end patienter som ikke var i ernæringsrisiko (P = 0.001). At være i ernæringsmæssig risiko forøger yderligere omfanget af madaffald, uanset den serverede portionsstørrelse. De konkluderes at DIMS applikationen er en lovende og innovativ teknik til at kunne monitorere madspild og til opmærksomhed på optimering af måltidets portionsstørrelse. Derved forventes DIMS at kunne medvirke til minimering af madspild på hospital.

PREFACE AND ACKNOWLEDGEMENTS

This PhD thesis was accomplished at the Department of Planning and Development, Aalborg University, between 2012 and 2015. The thesis was supervised by Professor Bent Egberg Mikkelsen, Mette Holst, Research coordinator and Professor Henrik Højgaard Rasmussen. The work presented in this thesis is part of the FoodServinSPIRe project of the InspireFood program funded via Danish Agency for Science, Technology & Innovation.

This PhD project was part of the project FoodServInSPIREe, initiated by Professor Bent Mikkelsen, in which my role was to focus on the aspect food waste reduction in hospital. I had developed a passion towards this topic long before the project began. With a background in environmental health, I knew the impact of climate change on our environment, a topic which has recently gained global attention and that has raised some awareness about food waste. My interest in this field grew stronger as a dietitian gaining in-depth insights into food waste and the considerable challenges it presents, particularly in the hospital food service industry. Despite my background in environmental health, dietetics, and public health, I did not realize that this project would end up involving technological innovation to address food waste reduction, and the project presented an interesting and challenging journey.

The ideas about technological responses to hospital food waste developed in this thesis were emphasized initially but it was not very clear as to which path to take to achieve this. Once the final idea about this had arisen from two different exploratory studies within the foodservice and healthcare profession, the challenge was to find an innovative partner who could believe in our idea. This took a great deal of effort and building a sufficiently strong case for a potential partnership exhausted my energy and consumed a considerable portion of the 3 years allocated to the PhD. I had to organize several projects meetings for student projects, innovation firms to partner and at different conferences until I had a break through when a Syscore came on board to develop DIMS and the project was back on track. My PhD study has been a fascinating and challenging journey from the very first day to the end. I am very glad to able to share my experience in the form of this thesis which could only be accomplished with support of many people. I would like to thank all those who have assisted in one way or the other over the years. First of all, I am very grateful to the Almighty God from whom I obtained my daily strength from the beginning to the successful completion of my PhD.

Some people deserve special a mention; my sincerest thanks must first go to Professor Bent Egberg Mikkelsen for his effort in securing funds for the FoodServInspire project and for acting as my main supervisor. He helped me to realize my research interests and his commitment to the application of intelligent devices for improving hospital foodservice was very inspiring to the DIMS development.

I am deeply indebted to Mette Holst, as co-supervisor and contact person at the Aalborg University hospital. She has been a pillar throughout the project and her input went beyond the academic borders to personal inspiration. Her kind and expert advice during my fieldwork in Aalborg hospital, her objectivity, precise comments and encouraging feedback motivated me and will not be forgotten.

I am very thankful to Professor Henrik Højgaard Rasmussen as co-supervisor for his critical review of my research, encouraging me to keep on track. His positive attitude and guidance made a huge difference. His directions towards vital improvements regarding to the thesis structure in the final stages of the project is greatly appreciated.

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Finally to my wife Sarah I thank you for your love throughout the light and dark days of this work as well as your continuous intercessional prayers for grace to complete this PhD.

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CHAPTER 1. INTRODUCTION AND BACKGROUND

1.1. INTRODUCTION

Generating unnecessary food waste has been widely acknowledged as problematic, not only because it is linked to financial loss and climate impacts but also because wasting food raises serious social concerns when the nutritional needs of the world's rapidly growing population are not met (Stuart, 2009). A number of recent policy papers address this problem in different parts of the food system such as retail, food manufacturing, domestic and food service. Potential solutions, mitigations and remedies have been discussed (European Commission, 2010; European Union Committee, 2014; Lipinski, Hanson, Lomax, Kitinoja, Waite, & Searchinger, 2013). In 2012 the European Parliament made a resolution calling for the implementation of a coordinated, national-level strategy to reduce food waste at every stage of the food chain. Following this, the European Commission proposed a 50% reduction in food waste by 2025, a policy recommendation to facilitate food waste prevention (European Parliament Resolution (2011/2175 (INI)). Along the hierarchy of prevention, source reduction options are carried out which include the process of engaging in practices that reduce the amount of food waste prior to recycling or disposal. This seems to be the most desirable option for waste reduction in the foodservice. The hospital, which contributes the highest amount of food waste among the food service sector, generates up to 40% of food waste. Thus, the potential exists for a substantial reduction in food waste by concentrating on this sector (P. Williams & Walton, 2011).

Over the years, foodservice professionals have tried different strategies to reduce food waste in order to minimize the direct negative impact on health care budgets and the related impact on the environment, as well as for the fear of losing credibility of corporate social responsibility status. In hospitals, many patients are at nutritional risk, meaning that they eat too little to maintain nutritional status, putting them at risk of complications related to undernutrition. This problem is controversial in that much food is wasted in the same setting. Strategies have been sought to improve patient nutrition intake. These strategies include flexibility of portion size ordering, portion size reduction, options for selective menus, increasing the choice of food items and improved food quality. Improvements in forecasting demanded meals and changes to meal delivery systems have been sought, amongst many other initiatives.

Despite the range of strategies and efforts made by foodservice professionals, food waste in the hospital setting has not seen much of a reduction over the past decades. The ongoing increases in food waste generation makes the reduction of food waste in hospitals an important issue for all foodservice managements. An increasing

focus on environmental, health, and economic aspects has prompted hospital foodservice management to begin seeking innovation in the practice of serving meals to patients, where there may be potential to reduce the amount of food waste.

The aim of this PhD thesis was to explore how food waste reduction can be achieved without compromising patients' food intake through the exploration of an ICT assisted monitoring innovation.

1.2. BACKGROUND

Global efforts to reduce food waste in all sectors within the food supply chain have recently increased due to the tremendous negative environmental, financial and social impacts of food waste (European Commission, 2010; P. Williams & Walton, 2011). The increased priority for food waste reduction has been highlighted in a recently published European Union directive, which mandates member states to initiate strategies towards reducing avoidable food waste (European Commission, 2010; Marthinsen, Sundt, Kaysen, & Kirkevaag, 2012; European Union Committee, 2014). The directive is a clear indication that food waste generation in the EU over recent decades continues to be a major threat to the foodservice, with the hospital foodservice being most affected.

CHALLENGES OF FOOD WASTE REDUCTION STRATEGIES

Despite several strategies to reduce food waste in the foodservice sector, with some having been successfully implemented, food waste remains a challenge. Evidence suggests that food waste generation in the health care foodservice has not declined in recent decades, raising several valid questions as to why adopted strategies have not been able to reverse the trend.

1.2.1. CLINICAL ISSUE AND NUTRITIONAL RISK COMPLICATING STRATEGIES FOR FOOD WASTE REDUCTIONS

According to Williams & Walton (2011), food waste related to clinical issues is the most challenging issue in food waste reduction. Approximately 30% of hospitalized patients are at nutritional risk, often experiencing eating problems, unpredictable changes in appetite, and requiring different food items and services, making the development of strategies to ensure relevant food is provided but does not become wasted very challenging (Dupertuis et al., 2003; J. Edwards & Hartwell, 2003; J. Edwards & Hartwell, 2006; McWhirter & Pennington, 1994). When healthy people receive too little to eat, the body adapts by draining the fat deposits and reducing energy consumption. The latter can occur by reducing activity and thus energy requirements. In sick people, where the body is metabolically more active regardless of physical activity, this adjustment tends not to occur. In acutely ill, hospitalized patients, energy metabolism and the degradation of body tissues

increases as a result of the endogenous stress response. Hormonal changes during disease can have metabolic impacts and may affect appetite regulation, usually suppressing the appetite. Furthermore, many treatments for disease may lead to a reduced appetite through their impact on the ability to taste food or by increasing satiation before the body has satisfied the need for nourishment. The automatic regulation of hunger and thirst are inoperative, leading to a low appetite and thus an intake below requirements. Meanwhile, the diseased body does not reduce its combustion in a similar manner, but metabolizes muscles before fat when not provided with sufficient energy. Undernutrition and the breakdown of body tissues leads to impaired immune function, reduced mobilization, worsening lung function, heart failure, increased frequency of infections (eg. pneumonia and urinary tract infections), slower healing of tissues and an increased risk of infections of surgical wounds. Other consequences for the individual are prolonged rehabilitation and frequent readmissions (Barton, Beigg, Macdonald, & Allison, 2000; Thibault et al., 2011). Thus, complications of not meeting nutritional requirements include weakening of the immune system, increased risk of infection, poor wound healing and an increased risk of mortality (McWhirter & Pennington, 1994). Low food intake may be influenced by a patient's underlying medical conditions and can be a result of poor appetite, lack of sensitivity to taste, chewing problems and difficulty in swallowing food. It can be difficult to address these issues in order to have an immediate impact on a patient's food intake (P. Williams & Walton, 2011).

There is also a significant increase in the incidence of altered depression in patients at nutritional risk. Studies have shown an increased risk of mortality in patients who are undernourished when compared to patients with a good nutritional status (Holst, Mortensen, Jacobsen, & Rasmussen, 2010: Hiesmayr et al., 2009). The risk is increased particularly in older patients (aged over 70 years) and in patients who also have chronic disease (Stratton & Elia, 2007; The Danish National Board of Health 2008).

1.2.2. NUTRITIONAL REQUIREMENTS

Nutritional requirements are defined as the body's need for energy (KJ) and protein in order to preserve form and function. Both are calculated per kilogram of bodyweight per day if the patient is of a normal weight. Some adjustments are made if the person is very under- or overweight. When the patient is admitted to hospital, a screening for nutritional risk is made. In Denmark, the screening tool used is the NRS-2002 (J. Kondrup, Rasmussen, Hamberg, Stanga, & An ad hoc ESPEN Working Group, 2003). If the patient is found to be at nutritional risk, requirements are calculated and monitoring of nutrition intake is recommended to see if the patient fulfills requirements. Nutritional requirements differ between individuals, but it is possible to standardize energy-and- protein requirements to a certain extent. This is often carried out for practical reasons such as in the case of limited dietitian resources, and is often done in hospitals (K. Kim, Kim, & Lee, 2010). Portion sizes

of foods on the menu are therefore standardized to provide the required nutrients and this standardized portion is ordered for a diverse set of patients. It is expected that this portion will meet all of the patients' nutritional requirements. According to Kim et al., (2010), foodservice quality is the provision of meals to patient's which meet their nutritional requirements. Foodservice quality will fall short if the food served does not meet patients' nutritional requirements or if patients consume less than the portion provided. Kim et al., (2010) revealed food service quality problems to be the result of patients not consuming the entire standardized meal portion, and therefore recommended nutrients. In all four of the hospitals included in the study, patients were found to consume fewer nutrients than served (Kim et al., 2010). This demonstrates that the hospital foodservice is faced with a complex task in terms of reducing food waste. Dietary and nutritional requirements can vary within very short periods of time which can make it difficult to select the optimal type of menu and portion size to be prepared and served for individual patients. Furthermore, a patient's nutritional requirements often do not correspond to the amount of food a patient's condition may permit them to eat. Whether the setting of a minimum standard for the preparation of food should be based on amount served or consumed has been questioned (Frost, 2003). The multifaceted nature of the healthcare foodservice extends beyond just the preparation and serving of food, to the responsibility of providing optimal nutritional meals to facilitate patient recovery (Sullivan & Atlas, 1998). It is therefore no surprise that the edible food waste generated across the entire hospital food system, from preparation to the end of consumption, can be as much as 60 percent of the total amount of food provided (Sonnino & McWilliam, 2011; P. Williams & Walton, 2011).

1.2.3. FORECASTING MEAL DEMANDS

At ward level it is the food service system that determines the type and amount of food items to be served to patients. The procedure of forecasting meal demands for several days ahead of the proposed serving day usually coincides with changes in a patient's condition. This can limit the capability of foodservice managers to optimize resources for meal production. The inability to accurately forecast patients meal demands has been identified as a reason for overproduction and too large servings, known to be major contributor to hospital food waste (Goonan, Mirosa, & Spence, 2014; K. Kim et al., 2010). A study by Kim et al., (2010) showed that forecasted values were used to place orders for advanced purchases and subsequent meal preparation. Staff may become aware of a new development in the ward concerning changes in a patient's circumstances within the period from when the order is made until preparation and serving, and duly inform the kitchen staff to take corrective measures. The kitchen, however, were not able to make such changes because all of the purchased ingredients had already been prepared, thereby resulting in food waste (Kim et al., 2010). Strategies to improve forecasting methods at the ward level in order to minimize inaccuracy of estimated meal

demands have been recommended in different studies (Goonan, Mirosa, & Spence, 2014; Kim, Kim, & Lee, 2010).

1.2.4. MEAL ORDERING

Methods of meal ordering may vary. Sullivan (1998) listed six different steps that are likely to be included in the meal ordering procedure: obtaining diet orders from physician; interviewing patients to determine food item preferences prior to preparation; reporting patient information in the catering system; planning a menu based on patient preferences; and finally serving the meal to patients (Sullivan & Atlas, 1998). Depending on how the meal ordering is practiced, the key component is the involvement of patients. A study by Patch et al., (2003) at three different hospitals in Australia showed that 20-35% of hospitalized patients were not given the opportunity to select meals from the hospital menu (Patch, Maunder, & Fleming, 2003). Limiting patients from choosing between meal options may lead to dissatisfaction and meal rejection. Consequently, this may lower patients' food intake and increase food waste.

1.2.5. COMMUNICATION BETWEEN WARD AND KITCHEN STAKEHOLDERS

The hospital food service involves multiple stakeholders and how they collaborate to reduce food waste may depend on the kind of communication existing between the ward and the catering department. Communication barriers between ward and catering staff have been recognized as contributing to food waste generation for decades. Observations made by Frost (2003) indicate a lack of good quality scientific evidence to improve communication systems between the ward and catering system as a strategy to reduce food waste (Frost, 2003). The communication gap in the hospital can results in meals being supplied to patients who have already been discharged or who are not required to eat because of a scheduled investigation. The issue of ordering more meals than required and an inability to cancel was formerly described in studies by Edwards (J. S. Edwards, Edwards, & Salmon, 2000; J. Edwards & Hartwell, 2003). Hartwell et al., (2006) considered communication between the ward and kitchen as fragmented such that information is disseminated without any structure, even though the process of delivering meals is a multi-disciplinary service, involving different stakeholders in the serving of patient meals (H. J. Hartwell, Edwards, & Symonds, 2006). Communication between staff and patients is an important part of nutritional care. Patients require nutritional information to make informed decisions, for example when choosing what they want and what is best for them to eat whilst in hospital. They need information about the possibility to order excess meals and some patients may need information about the nutrient content of the meals served. However, a study found that menus did not to provide information about ingredient use and nutritional content, which made it difficult for patients to order meals that

suited their needs (Naithani, Whelan, Thomas, Gulliford, & Morgan, 2008). Another study by Lassen et al., (2005) revealed that one-third of patients had found information about a menu themselves, either at a notice board or through the assistance of other patients. Patients who did not find any menu information prior to consumption expressed that they would have liked to have that information on the menu (Lassen, Kruse, & Bjerrum, 2005).

1.2.6. REGULATION ON REUSE OF UNSERVED FOODS

The re-use of food is a potential strategy for food waste prevention but the extent to which this can be done depends on food safety. This makes food safety regulation a powerful tool as it determines how and what type of food leftovers can be reused, and thus not wasted. In hospitals, food safety and hygiene regulations do not currently permit the reuse of unserved bulk meals from the food trolley in order to prevent potential contamination (Goonan et al., 2014; Waarts et al., 2011).

MEAL DELIVERY SYSTEM AND FOOD WASTE

There is a wide spectrum of strategies related to food service, from plated systems to bulk food service or room service, assisted ordering and feeding. Meal delivery systems that allow patients to select their meal at the point of serving have gained popularity in hospital foodservice. These have been implemented to increase intakes and minimize food waste (Mahoney, Zulli, & Walton, 2009). This concept encourages patients to participate in decisions relating to their food choice and portion sizes. This can make them feel part of the meal delivery process and more likely to accept the meal served on the plate. As patients are given the opportunity to select meals from a fixed prescribed hospital menu, it can improve food intake and nutritional outcomes (Mahoney et al., 2009). It may also be appreciated and seen as a privilege, especially when it comes from the hospital menu. Several studies have evaluated the impact of this type of meal delivery system (Freil, Allerup Nielsen, Biltz, Gut, Egberg Mikkelsen, & Almdal, 2006; Hackes, Shanklin, Kim, & Su, 1997; H. J. Hartwell & Edwards, 2003; H. J. Hartwell, Edwards, & Beavis, 2007; Kelly, 1999; Marson, McErlain, & Ainsworth, 2003).

1.2.7. TROLLEY MEAL DELIVERY SYSTEM

In Denmark it is estimated that more than 65 percent of hospital foodservices have implemented the bulk delivery concept (Engelund, Lassen, & Mikkelsen, 2007). One bulk concept is the trolley meal delivery system, which is rated above the plated system in terms of improving patients' food intake and reducing plate waste reduction (Almdal, Viggers, Beck, & Jensen, 2003; Freil, Nielsen, Biltz, Gut, Mikkelsen, & Almdal, 2006; Hansen, Nielsen, Biltz, Seidelin, & Almdal, 2008). Several hospital studies have shown that conversion of the plated system to the trolley meal delivery system resulted in less plate waste after implementation (Freil,

et al., 2006; H. J. Hartwell & Edwards, 2003; Marson et al., 2003; A. Wilson, Evans, & Frost, 2000; A. Wilson, Evans, & Frost, 2001). A review by Williams & Walton (2011) reported six studies which compared the trolley system to the plated system and demonstrated a significant reduction in plate waste (P. Williams & Walton, 2011). In the plated meal system, standard portions are served directly from a central kitchen, thereby limiting the flexibility of portion control. This has been found to contribute to plate waste generation. Plate waste reduction in the trolley meal delivery system is attributed to procedures which encourage the patients' choice of food items and portion size at the point of serving. Under this system, meals ordered for bulk supply from the kitchen are based on standardized portion items. Thus, serving a reduced portion in accordance with patient choice generates unserved food on the trolley, and the patient is served a reduced amount of energy and protein. The unserved food that is discarded after the meal session is what accounts for trolley food waste. Trolley food waste has been shown to be up to 27 percent and, in addition to plate waste, to increase the total amount of food waste generated. The trolley food waste contribution to total food waste has been reported by a study that found the trolley meal delivery system to generate more food waste than the plated system (J. S. Edwards & Nash, 1999). However, patients' food intake and satisfaction is rated above the plated system. As much as plate waste reduction could be achieved through allowing patients to choose smaller portion sizes, it increases the possibility of patients not receiving the daily recommended intake of total energy and protein (Freil, Allerup Nielsen, Biltz, Gut, Egberg Mikkelsen, & Almdal, 2006; Mahoney et al., 2009; Marson et al., 2003). This can further compromise attempts to minimize protein and energy malnutrition. Nevertheless, opportunities to decrease unnecessary food waste from the trolley meal delivery system might arise through good management practice (P. Williams, Kokkinakos, & Walton, 2003).

1.2.8. ROOM MEAL DELIVERY SYSTEM

With the room service meal delivery system, patients can select foods from a menu in their room, which are then delivered within 45 minutes. All selected food is individually evaluated to ensure that it satisfies the patient's dietary requirements and allergy compliance (Kuperberg, Caruso, Dello, & Mager, 2008). A reduction in plate waste was found in studies comparing a room service meal delivery system, which allows a pre-selection of food items not less than 24 hours prior serving to other systems. Factors accounting for the decrease in plate waste included the a la carte menu style, improved food choices, a reduction in the duration of time between food being ordered and served, and the elimination of the uniform plates served to patients (Kuperberg et al., 2008; McLymont, Cox, & Stell, 2003). Although there are significant benefits such as patient satisfaction and an increase in energy intake, there are challenges to its implementation. The challenges relate to the substantial capital and human resource cost due to the inability to control the quantity of food ordered by patients (Sheehan-Smith, 2006).

1.2.9. THE STEAMPLICITY CONCEPT

The steamplicity concept, developed in the United Kingdom, uses a static extended menu choice with improved patient ordering procedure and a new cooking process. In the steamplicity concept, pre-plated meals are sealed and distributed to wards. These can remain chilled for four days. In the event of individual patients making a meal request at short notice, the meal is reheated in a microwave at a temperature above 75 degrees Celsius before serving the meal to the patients. Plate waste from the steamplicity was found to be 5.5 percent lower than cook-chill food preparation served through the trolley system (J. Edwards & Hartwell, 2006).

1.2.10. MEALS ON WHEELS

Meals on wheels is another meal delivery system introduced in a Belgium hospital, amongst other places. This replaced the old system, which allowed patients to order meals 24 hours prior to serving. The Meals on wheels concept makes it possible for meals to be ordered and delivered to patients by their bed side. It was found that the average daily intake among patients served by Meals on wheels increased in grams and there was a reduction in food waste. Reasons for the difference could be due to the patient orders being followed immediately by serving, which corresponds to the patients' current appetite (Goeminne, De Wit, Burtin, & Valcke, 2012).

Interestingly, the implementation of these new systems seemed to reduce food waste in most instances. However, the none of these meal delivery systems eliminated food waste completely. Other opportunities to further reduce food waste are often overlooked because an evaluation to determine their contribution to food waste and opportunities for reduction once they are established is not usually carried out in practice. An approach to determine how an adopted meal delivery system can contribute to food waste generation within the entire practice of patient meal service is essential in order to identify opportunities to reduce food waste.

1.2.11. THE INFLUENCE OF ROUTINE MONITORING ON FOOD WASTE REDUCTION

Currently, the routine monitoring of food waste has been recommended as a priority in the hospital foodservice industry. This is believed to provide continuous feedback to enable foodservice management to modify policies and develop strategic planning to reduce food waste (Díaz & García, 2013; Iff et al., 2008). Measuring the quantity of food waste generated from the meal service system is an attempt by itself to find solutions to reduce food waste. Foodservice professionals may conduct plate waste assessment as part of practice analysis to address foodservice quality issues, evaluate patient preferences, and improve portion size accuracy as well as food waste reduction. Plate waste assessment is predominately

conducted using three key methods: the weighed method; 24-hour recall; and the visual observation or the photographic method (Connors & Rozell, 2004; Díaz & García, 2013; Nichols, Porter, Hammond, & Arjmandi, 2002; P. Williams & Walton, 2011; Williamson et al., 2003).

The weighed method, which is the most accurate method, requires the collection and measurement of all food waste, either the total bulk for the entire patients on the ward or food remaining on the individual plate. This method requires significant resources and its implementation can interrupt or delay routine food service operations (P. Williams & Walton, 2011). Furthermore, it may require a large space to hold the soiled plates and becomes practically impossible to carry out for a large number of patients in a hospital setting.

The retrospective 24 hour food recall depends on a patient's ability to recall portion sizes discarded as plate waste for the past 24 hours. It is very subjective and data may be insufficient for specific foods.

The visual observation method uses different scales with portion size estimates for plate waste. This can introduce intra-observer reliability due to subjectivity bias. Another method which seems to have gained much interest from researchers conducting large scale dietary assessment in the institutional setting is the digital photographic method (Williamson et al., 2003). This method is similar to direct visual observation, which employs trained personnel to identify food selection on the plate, and estimate portions left on the plate. As the weighed method may be impracticable for regular monitoring, most foodservices will prefer the visual method as an appropriate alternative (P. Williams et al., 2003).

1.2.12. THE IMPLEMENTATION OF ROUTINE MONITORING USING ICT

Though there are existing methods and tools that can be adopted for monitoring purposes, the disadvantages associated with using these methods might be part of the reason why they have not been widely adopted for routine food waste monitoring in the hospital setting. Some attempts have been made to improve these methods. For example, information and communication technology (ICT) has been used to minimize the time constraints and burden that foodservice professionals face with the paper and pen approach of data entry, which is itself related to error (Ngo et al., 2009). The gold standard approach of the weighed method has been adapted using ICT via the connection of a digital scale to a personal computer through which subjects can scan the barcode of the food item placed on the scale in a codebook (Kubena, 2000). However, barriers in relation to logistics, cost and the portability of such a device have been identified as a limitation for developing this as a preferred method for widespread use in large institutional settings. A radio-frequency identification (RFID) technology-enabled system implemented in a

foodservice setting led to a reduction in staff work related to data entering and enhanced accurate meal forecasting based on reliable data captured in the systems (Vrbancic, 2009). ICT technology such as the RFID technique has changed the face of accurate data collection in many hospitals by minimizing time required and the error related to data acquisition. However, RFID potentials have not yet been fully explored in the hospital foodservice in an attempt to find innovative solutions to the current challenges related to the monitoring of food waste. Literature on the potential of ICT to facilitate monitoring of either food intake or food waste through the acquisition of accurate data in the hospital foodservice seems limited. In order to integrate routine monitoring as part of practice, an alternative tool that is convenient to use, less interruptive to the serving procedure, and that has the capacity to collect accurate data needed for developing strategies to improve menu planning and reduce food waste, will be needed.

Therefore, the main aim of this research was to explore perceived barriers and practices affecting food waste generation and to investigate how a developed ICT assisted tool could provide opportunities to strategize waste reduction in hospital meal service.

1.3. OBJECTIVES OF THE STUDY

The objectives of the study are therefore derived based on this main goal and are as follows:

1. To explore and understand Foodservice professionals' experiences and perceived barriers towards food waste reduction.

2. To investigate practices that explain the extent of trolley food waste generation and obtain staff opinions about how the practices could eventually be changed in order to reduce food waste.

3. Based on insights from objectives 1 and 2, to identify opportunities for developing an ICT assisted solution that can enhance food waste reduction.

4. To examine: (a) the portion size served, consumed and wasted in relation to the patients' nutritional status, (b) the extent to which the size of meal portions served contributed to the patients' daily recommended intakes of energy and protein, and (c) the predictive effect of the portion size served on plate waste generation. Furthermore, to explore the applicability of the DIMS (Dietary Intake Monitoring System) as an innovative technique for monitoring the amount of plate waste in a hospital setting.

CHAPTER 2. THEORY

2.1. THEORETICAL FRAMEWORKS

The study took place in a hospital, a complicated setting with regard to food service. The kitchen, where the food is produced is similar to an industry-like setting, with a large production capacity and a strict economic frame; there are issues of food waste and a many rules and regulations for hygiene and food safety. Most of the production and service staff are poorly educated, and they do not see the final result of their work when the food is served to the patients. A few service staff serve the food to patients but these are affiliated with the department for cleaning and other services. On the other hand, there are the nursing and physician staff members in the departments. These are highly educated, although food and nutrition is not their main field of interest or education. In the kitchen as well as at the wards, the dependence on technology and innovative solutions is strong. Looking at this complicated setting, I used a combination of practice theory and innovation concepts to identify the different elements linking the practice of food waste generation and the changes that may be required in order to reduce food waste in this composite organization.

2.1.1. PRACTICE THEORY

Practice theory, is well developed within the social sciences, and has been applied in different fields, most recently in consumption and innovation studies (Hargreaves, 2011; Pantzar & Shove, 2010; Shove & Pantzar, 2005a; Warde, 2005). The practice theory was chosen as part of the theoretical approach for this study because it draws its strengths from using practice as a unit of analysis to enhance the understanding of organization phenomena rather than foodservice professionals' behaviors (Nicolini, 2012; Reckwitz, 2002a). The practice focuses on the actions, doings or activities required in the hospital foodservice to accomplish the end result of serving nutritionally adequate meals to patients. However, if the expected output tends to generate food waste, this is an undesirable outcome for the hospital foodservice. Once the food waste generation becomes routine in the daily operations in the hospital foodservice system, it deviates from just an individual behavior issue to more of a practice-oriented understanding. Although the emphasis is on practices, it requires an individual to perform the various tasks that make a practice. According to Warde (2005) the key implication of practice theory is that the source of behavioral change is dictated by transforming practices. In the case of hospital foodservice, practice contributing to food waste is the target for change.

Several authors have defined practice in different ways, mainly focusing on the components or elements involved in the practice or the connection between the elements making a practice (Reckwitz, 2002; Shove & Warde, 2002). Shove and

Pantzar's framework (2005) provides an understanding of practices as an assemblage of images (e.g., meanings, symbols), skills (e.g., forms of competence or procedures) and stuff (e.g, materials, technology) that are dynamically incorporated by practitioners through routine and repeated performance (Pantzar & Shove, 2010; Shove & Pantzar, 2005). The links between these elements are then (re)produced and maintained by practitioners. In this understanding, practices thus emerge, stabilize and ultimately erode out as the links between elements are made and broken (Hargreaves, 2011). According to Pantzar and Shove, (2010), a practice is formed, maintained and can be changed as the link between the elements are made or broken (Pantzar & Shove, 2010). Pantzar and Shoves' framework as shown in figure 1 explains the concept of proto-practice, practice and ex-practices. In proto-practice the elements have been identified to exist and have not yet integrated to form a practice. Practice will be formed once the links between the elements are established and integrated into a routine performance that can be repeated and reproduced. In the ex-practice stage, the elements are disintegrated from each other. For a practice to continue to exist, it should be stable and reproduce through maintaining the integration of the elements. However, if the practice should be innovated for a new outcome, it requires replacement of elements, making or breaking the links between the elements.

Framework of elements linking to form practice

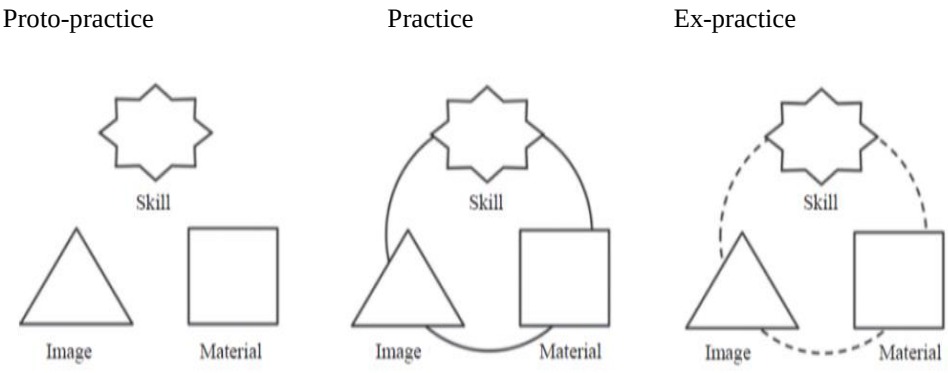

Figure 1. Elements at proto-practice, practice and ex-practice. (Source: Shove and Pantzar, 2005).

As in the case of the hospital food service system, any practice generating food waste can be considered as unsustainable and will require changes to become more sustainable. The study adopts the approached developed by Shove and Pantzar in order to map the elements and their linkages related to the patient meal service that contributes to food waste generation at the ward level. These elements and their linkages are expected to be innovated in order to decrease food waste. By implication, practice change for a desirable outcome calls for new ideas, strategies

and tools, and has its foundation in innovation concepts. The concept of innovation therefore remains a key component when finding approaches to practice change.

2.1.2. INNOVATION THEORY

Several scholars, including Nelson and Winters (1977) and Rogers (2010) have used the term innovation differently, according to Rogers, (2010) innovation is a broad concept and can be defined as "an idea, practice, or project perceived as new by an individual or other unit of adoption"(Nelson & Winter, 1977; Rogers, 2010). Recently, Omachonu and Einspruch (2010) have attempted to define healthcare innovation as:

…the introduction of a new concept, idea service, process or product aimed at improving treatment, diagnosis, education, outreach, prevention and research, and with the long term goal of improving quality, safety, outcomes, efficiency and cost (Omachonu & Einspruch, 2010) .

This definition is lacking the incorporation of development, although they include this in their process of healthcare innovation. With the inclusion of this into a hospital foodservice, innovation can be considered as the development or adoption of a new concept, idea, service, process or product aiming to improve treatment, diagnosis, nutritional care, food intake and reduce food waste. It is important to recognize that innovation covers novelty, application and may be of benefit to the end user (Lansisalmi, Kivimaki, Aalto, & Ruoranen, 2006). Information on the process of innovation in healthcare is less reported in literature according to Omachonu and Einspruch (2010). Innovation mostly goes through the process of problem identification, idea generation and evaluation, development, testing, commercialization and diffusion (Varkey, Horne, & Bennet, 2008). The process of initiating innovation can begin from the users' perspective or through systematic, research-based inquiry and a process of knowledge translation, made available for use by practitioners in their daily work. The most important factor in the first stage is the recognition for the need to innovate. This can arise if an existing innovation that can solve a related problem already exists or if there is an existing problem requiring an innovative solution. In both cases, technology is vital to drive the process (Omachonu and Einspruch, 2010). Sources of innovation, including employee know-how and interaction to discover how to solve problems in organizations, are considered the genesis of innovation or external relationships. It could also be an interaction between users and suppliers (Von Hippel, 1988). In healthcare, innovations are initiated by stakeholders including hospital management, foodservice professionals, nurses, doctors and patients. Identifying the need for innovation, either by stakeholders or by external sources, presents the challenge of how to meet the needs in a complex organization. Usually, there would first be an assessment of whether the needs can be met internally or whether external partnership is required and, if possible, innovation strategies would be

developed and tested before implementation. In situations where the internal structure is not capable of meeting the innovation needs, an external company specialized in health innovation will be involved in the process of seeking a solution. Therefore the conceptual model of the process of health care innovation as illustrated in figure 2 was adopted for this research.

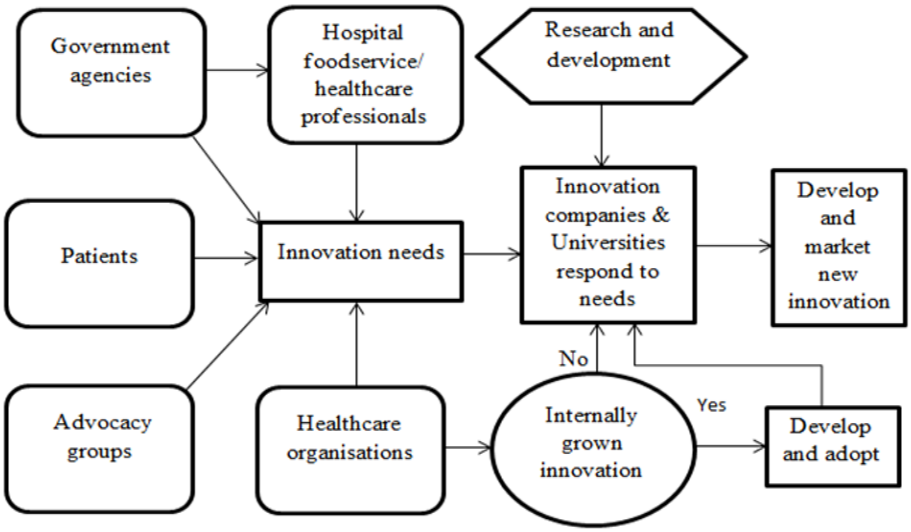

Figure 2. Conceptual model of the processes and stakeholders of health care innovation (modified version of Omachonu and Einspruch, 2009)

CHAPTER 3. METHODOLOGY

3.1. RATIONALE FOR RESEARCH METHODOLOGY

The food waste generation trend in the hospital setting makes it valid to investigate alternative means of achieving a reduction in food waste. Reducing food waste in the hospital may be more demanding than what can be achieved by only taking one decisive ontological or epistemological point of view, which makes the pragmatic approach more appealing. Using "whatever works" in a systematic, mindful and obvious way to answer the research question is the sound basis for the purpose of this study. This way of thinking is inspired by the thinking of the pragmatic philosopher Charles Sanders Peirce in the early 1870`s. It is also inspired by contemporary philosophers such as Tashakkori and Teddlie (1998) who believe that the researcher should have the liability to study something of interest or that seems to be of great value. They also believe in using different methods if necessary, in a manner that can produce results, have a positive impact on the problem under study, or result in positive change to the society (Abbas Tashakkori & Charles Teddlie, 1998). The pragmatic paradigm provides more opportunity for this complicated organization and field than a specific one. Thus, a combination of different methods can be used to obtain the necessary knowledge and develop potential strategies to facilitate practice change and reduce food waste. With this perspective, the research question remains the most important determinant of the research design (Giddings & Grant, 2007). The type of methodology parallel to this pragmatic viewpoint is the mixed methods approach, which is the approach adopted for this research.

3.2. RESEARCH DESIGN

This study adopted a case study approach with mixed methodology, which embraces both qualitative and quantitative methods in a single study or series of studies to investigate the same underlying concept or achieve a range of outcomes (Creswell, 2002; Greene, Caracelli, & Graham, 1989; Leech & Onwuegbuzie, 2009). The paradigm that allows the combination of qualitative and quantitative research methods in a single study is the pragmatism approach (Mason, 2006; Morgan, 2007). Researchers who are grounded only in qualitative and quantitative paradigms may find that their methods oppose each other. The pragmatic believes that the two paradigms can co-exist and that employing a mixture of both methods can yield complementary results (Greene et al., 1989). The aim and underlying objectives of this research, together with the complex setting, require the combination of both qualitative and quantitative research methods and thus, maximizes the synergistic benefit from the integration of constructivist and post-positivist paradigms (Rocco, Tonette S Rocco Tonette S, Bliss, Linda A Bliss Linda A, Gallagher, Pérez, & Prado, 2003).

Qualitative and quantitative methods were combined using an exploratory sequential design (Ivankova, Creswell, & Stick, 2006). With this exploratory sequential design, two phases were considered. The first phase was used to meet the objectives 1 and 2 which were qualitative by nature as the aims were to understand experiences, barriers and opinions. With this as point of departure and the limited information in the literature relating to barriers to strategies for reducing food waste, foodservice is in general considered an exploratory case. The outcome of the qualitative studies was to inform the development of an instrument or tool for the quantitative phase. This phase was very inspirational for the project, seeking to develop an innovative tool to improve practices leading to reduced food waste generation, but unclear about the needs of the hospital food service professionals. In our case, we identified this study as developmental as it involved the production of new devices, tools, systems, or methods on the basis of systematic application of scientific knowledge obtained from phase 1 (objectives 1 and 2).

Including the design and development of prototypes and processes can be an extensive task. In other words, this phase can be classified as being exploratory, engineering, and operational (Nunamaker Jr & Chen, 1990). The empirical evidence from the two qualitative studies in phase 1 was instrumental to inform the needs of practitioners as a monitoring tool that can facilitate change of practice to reduce food waste in the hospital setting (Greene et al., 1989). As the project was driven by innovation, communication technologies were identified as a means to achieve a technologically-enhanced monitoring tool. In the second quantitative phase, the developed tool was used to collect data on plate waste and investigate the effect of meal portion size servings from the food trolley on plate waste.

3.3. ETHICAL CONSIDERATIONS

A request for ethical approval for the study was submitted. The response from the committee secretariat was as follows:

Based on the information provided, the Secretariat believes that this project not covered by the Committee Act definition of a health science research. The project will therefore not be notified to and approved by the Committee, see Committee Act § 14 paragraph. 1, § 2, No. 1-3 and can be applied without additional feedback from the Research Ethics Committee of North Jutland. 2013.07.02.

Data security: The study has been reported to the Danish Data Protection Agency as"Strategies to reduce for food waste at Aalborg University Hospital". It is covered by the Region North Jutland umbrella report regarding Data Protection Agency-Health Scientific research in North Jutland (2008-58-0028).

3.4. METHODS

3.4.1. PAPER 1: EXPERIENCES, PERCEIVED BARRIERS AND FOOD WASTE REDUCTION

An exploratory qualitative case study was adopted in order to gain an in-depth understanding of foodservice professionals' experiences and their perceived barriers towards strategies of reducing food waste in large-scale institutional kitchens. The study used an initial sampling approach to select the cases as large institutional kitchens and the representation of these kitchens by their staff at a food waste conference organized by Aalborg University, Agrotech and the EIR organization (Empowering Industry and Research). Two participants, consisting of a kitchen leader and employee, were selected from each of the four cases, (a) a private central kitchen, (b) a nursing home centralized kitchen, (c) a nursing home kitchen decentralized kitchen, and (d) a central hospital kitchen. These two key participants from each of the settings were familiar with their institution food waste reduction activities. The data for this study was collected using explorative, semi-structured individual interviews. The interviews were conducted at the participants' workplace (the kitchen) and audio taped.

The interviews were transcribed verbatim. Open coding was performed by assigning codes to the transcribed data from which general themes were developed, using QSR Nvivo 10. Thereafter, a focused coding was performed to ensure that the agreed general themes represent the entire data. This continued with the process of repeatedly reading through data and compared emerging categories to the existing ones until all the data were covered under the themes. Excerpts were then assigned to the themes and cross-checked for accuracy.

3.4.2. PAPER II: PRACTICE AND TROLLEY FOOD WASTE

A single case study approach was employed in this study. The study was based in Aalborg university hospital, specifically in a medical gastroenterology ward with a satellite kitchen and a surgical gastroenterology ward without a satellite kitchen. These wards were considered representative of other wards at the hospital. Three focus group sessions were conducted separately with four nurses, four dietitians and four service assistants, respectively. The focus group interviews were conducted using a semi-structured interview guide. Four individuals were interviewed in-depth to compliment the focus group discussions. Selected participants for the individual interviews were two service assistants from satellite and non-satellite wards, a nurse working as a nutrition coordinator for wards and a dietitian with a managerial role from the central kitchen. A semi-structured interview method was used to gain an understanding of each participant's involvement with the trolley food serving and food waste generation at the ward level. Interviews took the form of face-to-face conversations and were audio recorded. The observations around trolley food

serving were carried out on the two wards. Ten meal sessions made up of lunch and supper were observed for five separate weekdays in each ward. To gain insight into the quantity of trolley food waste from the two wards, the unserved food that was discarded as waste from lunch and supper meal sessions was measured for 5 days in each of the wards.

Focus group sessions and the interviews recorded were transcribed verbatim. The focus group and individual interviews and the observation data were coded using NVIVO 10 software. The Shove and Panthzer (2005) framework for practice served as a guide for themes that inductively emerged. Coded text segments were reviewed several times to identify commonalities and patterns within the text segment (Grbich, 1999). These processes led to the formation of five key themes which captured the overall findings within the numerous text segments in relation to the practice of trolley food waste generation. Exemplar quotations were assigned to the themes.

3.4.3. PAPER III: DIMS AND PLATE WASTE ASSESSMENT

In this study, the DIMS was developed based on input from the hospital foodservice and other health care professionals. As shown in figure 3, the DIMS was piloted as a new tool for capturing accurate data on plate waste needed for routine monitoring. A medical gastroenterology ward in Aalborg University hospital was selected for the pilot test study. In this ward, patients can choose their meals directly from the food trolley and are served by healthcare staff. The contact person at the hospital identified potential patients for the study. Prior to the measurements, participants were briefed about the purpose of the study before agreeing to participate.

The DIMS was used to record plate contents before and after consumption for the 23 participants at supper meal sessions. The DIMS application created 23 matched folders with photos of the content on a patient's plate before and after consumption. The DIMS application then automatically generated a name for each folder by using the patient's RFID code, date and time of measurement. The paired folder including the before and after measurements for each patient meal was assessed to deduce the patient's choice of food item, plate waste, food intake and the temperature of the food before consumption.

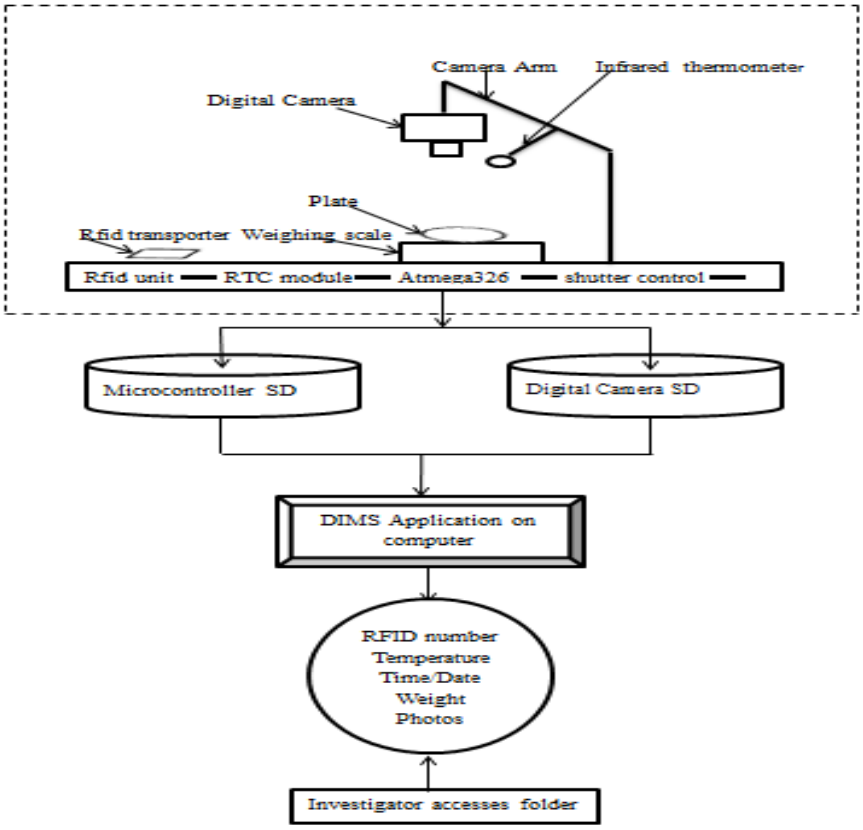

Figure 3. The Dietary Intake Monitoring System (DIMS) for plate waste assessment

3.4.4. PAPER IV: MEAL PORTIONS, PLATE WASTE AND NUTRITIONAL RISK STATUS

A prospective observational cohort study was conducted in two wards over five weekdays. A total of 71 participant patients whose lunch and supper meals were served directly from the hospital food trolley, were included. Patients on special diets or who were not served from trolley meal delivery were excluded from this study. Enrollment was open as incoming patients were identified and invited to join the study. Prior to the study, a list of patients available on the ward was used to contact each individual and the study objective was explained in detail. This included details regarding the application of DIMS for collecting pictures of plate content and clarifying that no physical images of the patients would be taken. The information was also given to all patients in the form of a leaflet, after which they

provided oral consent to participate in the study. All patients who gave consent to participate in the study were eligible. The DIMS was used to collect paired before and after meal consumption photos and measure the weight of plate contents for five consecutive lunch and supper meal sessions. Data on patients' age, gender, body-mass-index (BMI), nutritional risk status and daily energy and protein recommended intake, were provided by the research contact person from patient hospital records.

The weight of each food item was estimated from the reference weight obtained from the kitchen. The total weight of all the food items on the plate was expected to correspond to the total weight recorded by the DIMS. Estimating the weight of a single portion of each food item on the plate in this manner was helpful to ensure that it was equivalent to the actual total portion size measured.The equivalent energy and protein content of each food item was then calculated.

Patient characteristics were analyzed as descriptive statistics. Categorical variables were compared using the chi squared and student's t-test for continuous variables. The Shapiro-Wilk test was performed to check for normality and as majority of the data were not normally distributed results were presented as median and inter-quartile range. Mann – Whitney U test was used to compare the difference in results between nutritional at risk and not at risk patient group. To examine the relationship between meal portion size serve and plate waste among patients of different risk status a mixed-effects model analysis was used. Further analysis was done to include patient nutritional risk status, gender, age, BMI as factors and covariates in the models to examine its influence on the relationship between plate waste and meal portion size served. The repeated and unbalanced nature of data as patients were enrolled and dropped out at different stage of study made the mixed effect model appropriate for the statistical analysis. All data analyses were performed using SSPS 22.0 statistical software (SPSS Inc., Chicago, IL, United States).

CHAPTER 4. RESULTS

4.1. PAPER I: EXPERIENCES, PERCEIVED BARRIERS AND FOOD WASTE REDUCTION

The study aimed to explore foodservice professionals' experiences and perceived barriers towards food waste reduction. The key themes that emerged from the data analysis are presented in figure 4 to facilitate the understanding of participants' experiences and perceived barriers towards strategies to reduce food waste.

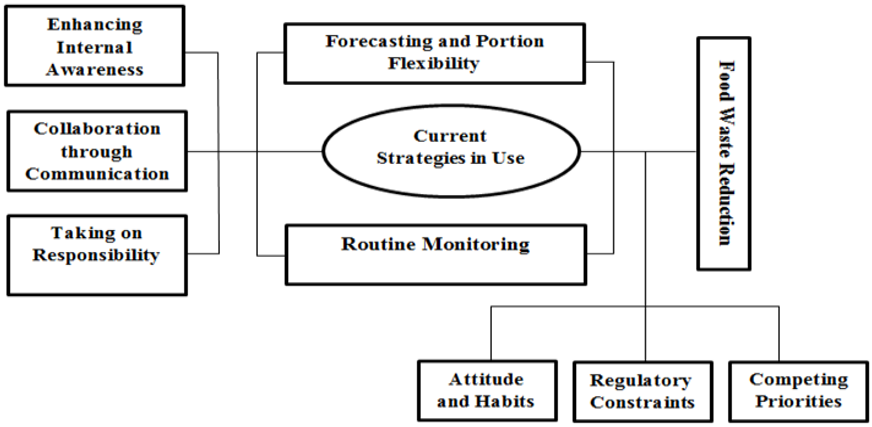

Figure 4. Themes relating to foodservice professionals' experiences and perceived barriers towards strategies to reduce food waste

4.1.1. FORECASTING AND PORTION FLEXIBILITY

The number of customers expected to eat the ordered food was perceived as a challenge by most of the participants because it may be inaccurately determined. Participants from the hospital foodservice setting believed that a patient's health condition is unpredictable and can have an influence on their meal choice and intake. They believed that what patients request at the time of ordering a meal and what patients actually want by the time the food is delivered from the central kitchen, may not correspond.

4.1.2. ROUTINE MONITORING

Monitoring of food waste was identified as one of the activities performed by the foodservice professionals in order to reduce food waste. Most of the participants who had experienced weighing food waste were of the perception that it did not

enhance routine monitoring in the foodservice setting. In the hospital central kitchen, it was revealed that a bin had been purposely provided to cater for food waste. This initiative is believed to offer staff the opportunity to visualize the food waste from their production. This initiative was considered a burden for staff who had to separate non-food waste and food waste into different bins.

4.1.3. CURRENT STRATEGIES IN USE

This theme was least commented on by the hospital participants whilst the other participants indicated that they use unserved foods in an acceptable way for customers. The participants from the private central kitchen explained that they have taken the initiative to reduce food waste from the buffet servings. In the nursing home with a decentralized kitchen, one participant revealed that leftover sandwiches are prevented from being wasted by making them available to those that might need them.

4.1.4. ENHANCING INTERNAL AWARENESS

It appeared that all of the foodservice professionals were highly aware of food waste. They attributed this to media highlights on the impact of food waste on the environment, the economic loss to foodservice budgets associated with food waste, and ethical concerns. They related this to both external awareness and internal awareness within their institution due to insight into the levels of food waste generation within the foodservice setting. They believed that internal awareness should be important to help staff to make a conscious effort to reduce food waste.

4.1.5. COLLABORATION THROUGH COMMUNICATION

Communication that may transpired within the foodservice setting to promote collaboration towards food waste reduction was found to be in two forms: among staff, including foodservice professionals and other professionals, and between foodservice professionals and their customers. Participants from the hospital kitchens identified a lack of communication between kitchens and departmental staff which hindered collaborative efforts to reduce food waste. The hospital kitchen leader expressed concern about not being informed about food waste issues from departments as it is only done when they are lacking food for patients.

4.1.6. TAKING ON RESPONSIBILITY

Most of the participants perceived activities related to reducing food waste as a work responsibility, not assigned to individual staff. They felt that this makes it less mandatory and more willingness to take on the responsibility to ensure food waste reduction is required. The perception of the leader and employee of the hospital

central kitchen was that ward staff members did not take ownership for food waste; instead they consider any activities relating to food waste as the responsibility of the kitchen staff.

4.1.7. ATTITUDE AND HABITS

Potential economic benefits were believed to be the main influence on attitudes towards engaging in food waste reduction and the major focus of the foodservice, whilst less attention has been given to the environmental, moral and ethical consequences of wasting food. It was revealed that an individual's food wasting habits affect how they react to food waste reduction. According to the hospital central kitchen leader, staff members who throw food away may have developed a habit, which they might find difficult to change.

4.1.8. REGULATORY CONSTRAINTS

Regulatory constraints were perceived by most participants to limit the extent to which good quality unserved food could be used for other meals. In accordance with the hospital food safety and hygiene regulation, unserved food returned to the kitchen cannot be used in other meals. The employee participants felt challenged by this regulation and expressed an interest to find other uses for the unserved foods in the ward, rather than returning it to the kitchen.

4.1.9. COMPETING PRIORITIES

Leaders from the various foodservice settings considered customer satisfaction as very important to their operations. They regarded activities that needed to be carried out to achieve this as their main priority over others, such as reducing food waste. Food waste, therefore, receives less attention in order to not limit their ability to meet customer's needs. Considering the possible benefits, and the fact that the foodservice setting stands to gain from reducing food waste, it could easily be considered as a priority by the management. The hospital central kitchen leader took the view that the management had been overwhelmed with dealing with other priorities of the organization, and therefore focused less on food waste reduction.

4.2. PAPER II: PRACTICE AND TROLLEY FOOD WASTE

Paper II investigated the practices contributing to trolley food waste generation and elicited staff opinions about how the practice could eventually be changed in order to reduce food waste. The analysis of interviews supplemented by the observation data generated five main themes. These key themes highlighted the elements in the practice of trolley food waste generation at the ward level, as illustrated in Figure 5.

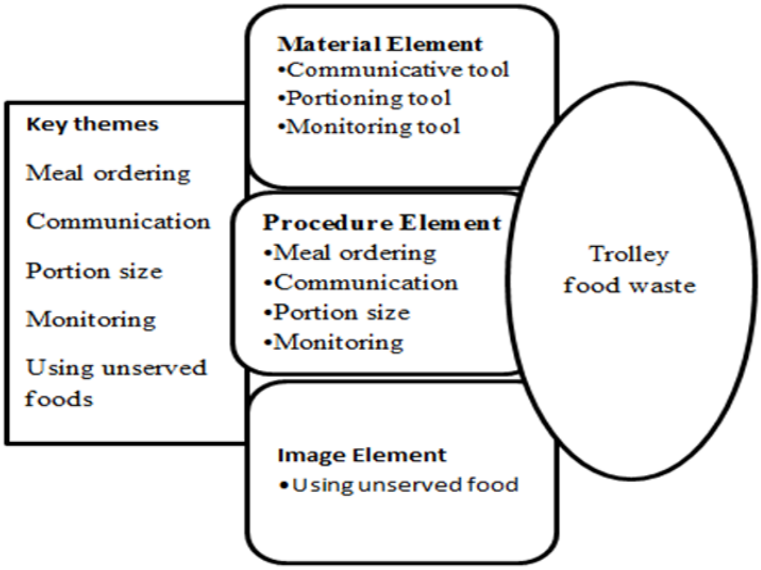

Figure 5. Key themes and practice elements of trolley food waste

4.2.1. MEAL ORDERING

The procedure of ordering meals for patients from the kitchen was seen as a non-flexible practice. It takes a minimum of three days in advance to order food for patients from the central kitchen and this has to be done through the menu planning tool ("master cater system"). Cancellation of meal orders reported from the ward prior to the beginning of the day's meal serving cannot be easily changed as meals might already be prepared for distribution. This was perceived as a major challenge because the ordering of meals a long time in advance did not give staff the opportunity to determine the exact number of patients likely to be on the ward on the day of serving.

4.2.2. PORTION SIZES

The findings revealed that meals were ordered based on standard nutritional requirements, which are then translated into predetermined portion sizes. The predetermined portion size removed the flexibility in portion size servings of some food items to the extent that service assistants were limited in their ability to accurately estimate portion size needs for the patients. It was considered a challenge for nurses and service assistants to adjust portions size for patients with poor appetites closer to mealtimes without contributing to trolley food waste. It was observed that patients communicated their preferred portion to the service assistant at the point of serving.

4.2.3. MONITORING

Service assistants indicated that there was no established means of monitoring food waste, either by visual estimation or weighed method on the ward. At the kitchen level, it can only be assessed by looking at the trolley containing food waste when it is sent from the ward but there is no opportunity to observe it when disposed at ward level. Observations made at meal sessions confirmed that service assistants at wards with a satellite kitchen did not record unserved food on the trolley before discarding it as waste. It was evident that monitoring food waste at the ward level was not part of the ward routine, or a described task for them to take care of.

4.2.4. COMMUNICATION

Staff, including nurses, dietitians and service assistants expressed their concerns about the difficulties of transferring information about patients' schedules that could interfere with their mealtimes between the ward and the kitchen. They considered this as contributing to food waste generation. The hospital menu information tools were observed to have limited vital information such as portion sizes, photographs of the food items and the corresponding nutritional values. These limit a patient's ability to make an informed decision on selecting an adequate portion size or to gain knowledge about its nutrient contents prior to serving.

4.2.5. USING OF UNSERVED FOODS

The participants' comments revealed that hospital food safety and hygiene regulations make it impossible to return unserved food to the kitchen to be used in other meals. The positive perception expressed by participants tended to conflict the act of discarding good quality food and employees felt challenged to find other uses for the unserved foods in the ward, rather than returning it to the kitchen in accordance with this regulation. Commenting on this theme, nurses and service assistants were of the opinion that unserved food could be put to better use in order to benefit patients and generate additional income to the hospital foodservice.

4.2.6. TROLLEY FOOD WASTE MEASUREMENTS

On average, a meal consisting of five different food items generated 2853g of trolley food waste for every 5680g of food served in the satellite ward. In the non-satellite ward, 2274g of the 5440g of food served was disposed as waste. A total average of 11,580g of food served at the supper meal session at the satellite ward, comprised of 5 food items, resulted in 5832g of waste. At the same meal session in the non-satellite ward, the average amount of food wasted from serving 10,735g of 5 menu items was of 6937g.

4.3. PAPER III: DIMS AND PLATE WASTE ASSESSMENT

In our pilot test, we found that the DIMS was able to capture photo/images and measure the weight of the content of a patient's plate before and after consumption in less than 4 seconds. The process of measuring plates did not obstruct the serving of meals at the ward. The process of matching before and after measurements was done by the DIMS application. The DIMS application grouped the paired measurements in separate folders and made it easy to compare before and after meal consumption measurements. Thus, providing the ability to forecast the amount of food and what would expectedly be eaten by an individual patient, or which food items were popular or not so popular.

4.4. PAPER IV: MEAL PORTION, PLATE WASTE AND NUTRITIONAL RISK STATUS

4.4.1. PATIENT CHARACTERISTICS BY NUTRITIONAL RISK STATUS

A total of 256 meals were analyzed from 71 patients admitted over a 5- day duration to the two wards participating in the study. Of the 71 patients who had completed data on nutritional risk status, 66% were at nutritional risk and 34% were found to not be at nutritional risk. There was no significant difference in age, BMI and gender for patients at risk and not at risk, (see Table 1).

Table 1. Characteristics of study participants by nutritional risk status

Variable	Mean ± SD	Not At risk n=24	At risk n=47	*p*-value
Gender(Female)		12 (50%)	26 (55%)	0.671
(Male)		12 (50%)	21 (45%)	
Age (year)	65.6±13.5	66.4±11.1	62.9±15.2	0.322
BMI (kg/m²)	24.6±5.7	26.1±4.2	23.8±6.4	0.155

4.4.2. MEAL PORTION SERVED, CONSUMED AND WASTED BY PATIENTS OF DIFFERENT NUTRITIONAL RISK STATUS

Table 2 shows the median meal portion served, consumed and wasted by patients of different nutritional risk status. The median meal portion served at lunch session, consumed and wasted by the nutritional risk patients were not significantly different from that of patients not risk. In terms of energy and protein, nutritional risk patients were found to be served and consumed less portions. The portion of energy and protein wasted were not significantly different. At a supper, meal portion size among the two groups was similar. The meal portion consumed was much lower among the patients at nutritional risk. Plate waste was significantly higher in the

nutritional risk patients. Energy and the protein content of the meals served were similar for both at risk and not at risk patients. Nutritional risk patients wasted significantly more energy and protein portions of the meals served compared to the not at risk patients.

Table 2. Median meal portion served, consumed and wasted by patients of different nutritional risk status

Nutritional risk status	Total patient meal count for 5days	Lunch									
		Portion served (g)	Portion consumed (g)	Portion wasted (g)	% Plate waste	Energy served (KJ)	Energy consumed (KJ)	Energy wasted (KJ)	Protein served (g)	Protein consumed (g)	Protein wasted (g)
All patients	142	250 (178-323)	205 (126-294)	29 (3-86)	10 (1-36)	1123 (684-1686)	843 (471-1397)	108 (4-426)	10 (6-17)	8 (3-14)	1 (0-3)
Not at risk	51	271 (197-356)	239 (150-302)	21 (3-58)	6 (1-23)	1201 (807-1709)	990 (517-1567)	72 (0-386)	13 (7-18)	9 (5-15)	1 (0-3)
At risk	91	235 (169-311)	185 (113-292)	32 (3-96)	15 (1-37)	1003 (612-1591)	741 (358-1234)	150 (8-427)	8 (4-15)	6 (2-14)	1 (0-4)
P-vale		0.060	0.061	0.433	0.192	0.047	0.052	0.229	0.020	0.027	0.315
		Supper									
All patients	114	293 (202-396)	225 (127-315)	48 (8-133)	20 (2-44)	1352 (980-2002)	998 (584-1654)	226 (20-691)	16 (10-25)	11 (6-19)	2 (0-7)
Not at risk	47	308 (197-404)	267 (162-330)	23 (0-61)	6 (0-26)	1367 (1005-1922)	1126 (750-1814)	93 (0-311)	16 (10-26)	13 (7-22)	1 (0-3)
At risk	67	284 (203-393)	189 (115-288)	88 (20-146)	31 (9-54)	1223 (949-2430)	809 (482-1454)	472 (112-795)	17 (10-26)	10 (7-19)	3 (1-9)
P- value		0.955	0.032	0.001	0.001	0.825	0.032	0.001	0.579	0.327	0.002

Data are presented as Median (interquartile ranges) *Mann-Whitney U test for P-value*

4.4.3. MEAL PORTION SERVED, CONSUMED AND WASTED AS A PROPORTION OF DAILY RECOMMENDED INTAKE, RELATED TO NUTRITIONAL RISK STATUS

Meal portion size served to the patients at lunch provided 13% and 11% of total daily requirement of energy and protein respectively. The proportion of the total daily recommended energy and protein provided by the meals served to nutritional risk patients at lunch was not significantly less than the not at risk , energy (12% vs 14 %, p = 0.230) and protein (10% vs 13 %, p = 0.136). At the supper meal sessions, the portion size served to the patients contributed 17% of energy and 19% of protein to their total daily requirement. Meals served at supper to both the nutritionally at risk and not at risk patients contributed equal proportions of energy and protein to their respective total daily recommended needs, energy (17% vs 17%, p = 0.564) and protein (21% vs 18%, p = 0.164). However, nutritional risk patients wasted a significant proportion of their energy and protein needed to increase the daily recommended intake than the not at risk patients, energy (6% vs 1%, p = 0.001) and protein (3% vs 1%, p = 0.001).

4.4.4. PREDICTION OF PLATE WASTE FROM MEAL PORTION SIZE SERVED TO PATIENTS OF DIFFERENT NUTRITIONAL RISK STATUS

Table 3 shows the results from a linear mixed model predicting plate waste (squared root transformed) from meal portion size served to patients of different nutritional risk status. A significant positive relationship was found between plate waste and meal portion size served from the food trolley. In relation to nutritional risk status, the mixed model analysis predicts that when nutritional risk patients choose their meal portions at supper they are more likely to generate more plate waste than the not at risk patients.

Table 3. Linear mixed model predicting plate waste (squared root transformed) from meal portion size served to patients of different nutritional risk status

	Plate waste (Both lunch and supper)					
Parameter	Estimate	SE	*t*- value	*p*-value	95 % CI	
Intercept	4.275	0.841	5.071	0.001	2.612	5.939
Meal portion size	0.008	0.003	3.186	0.002	0.003	0.013
Not at risk	-1.451	0.827	-1.752	0.086	-3.114	0.211
At risk	*Referent*					
	Lunch Plate waste					
Parameter	Estimate	SE	*t*- value	*p*-value	95 % CI	
Intercept	5.662	0.996	5.684	0.001	3.688	7.635
Meal portion size	0.000	0.004	-0.101	0.920	-0.007	0.007
Not at risk	-0.466	0.840	-0.554	0.581	-2.148	1.216
At risk	*Referent*					
	Supper plate waste					
Parameter	Estimate	SE	*t*- value	*p*- value	95 % CI	
Intercept	5.689	1.246	4.566	0.001	3.218	8.161
Meal portion size	0.008	0.004	2.341	0.021	0.001	0.015
Not at risk	-3.328	0.960	-3.468	0.001	-5.279	-1.371
At risk	*Referent*					

CHAPTER 5. DISCUSSION

The following discussion will evaluate the methods and results of the different studies and their meaning to the overall aim of the study.

5.1. PAPER I: EXPERIENCES, PERCEIVED BARRIERS AND FOOD WASTE REDUCTION

In paper I, inaccurate forecasting was cited as a barrier to food waste reduction in hospitals due to excess food produced and not consumed. Other studies have reported similar findings which are attributed to difficulties in estimating portion sizes, the unpredictable nature of patient admission and discharges, as well as different nutritional needs (K. Kim et al., 2010; Miller & Shanklin, 1988).

Although forecasting could be improved with data from monitoring, the benefit that foodservice stands to gain from monitoring food waste may include portion control and the identification of food items which generate more waste to enable menu improvement and enhance food waste reduction (Hackes et al., 1997; T. Kim, Shanklin, Su, Hackes, & Ferris, 1997). Food waste monitoring can be accomplished using several means, such as visual estimation in hospital, but previous studies integrating weighing have considered this unrealistic and unsustainable in practice. This is an indication that tools for the purpose of monitoring should be considered in relation to the burden they place on staff, in order to enhance routines for practice.

The potential to reuse unserved food as a strategy to prevent food from being wasted varies with the type of foodservice in question. In this study, we found that all unserved food was returned to the kitchen but could not be reused due to hygiene and safety regulations, which was also observed in a previous study (Goonan, Mirosa, & Spence, 2014).

In relation to food waste awareness, the results indicate that awareness could be gained either externally or internally. The former was attributed to sources outside the foodservice setting and in this case the media was influential. There was an indication that the external sources highlighted environmental, financial, and social impacts of food waste and have increased awareness among staff (Marthinsen et al., 2012). However, this awareness was perceived to be about general food waste issues, rather than awareness about the creation of food waste internally. Internal awareness and the changing of habits should come from within and focus on food waste problems within the participants' particular foodservice setting. They believed that there was much to be done to increase internal awareness by continuously emphasizing various activities contributing to food waste, the direct impact of food waste on the organization, and possible initiatives for reduction.

Food waste reduction requires collaborative team work which thrives with communication among stakeholders. In the hospital, the poor communication identified between kitchen and other staff members from different departments limits collaborative efforts towards reducing food waste. Paper 1 supports findings from a previous study, which found that communication within the hospital foodservice is unstructured between stakeholders on the ward and kitchen, a factor which could be partly blamed for food waste (Edwards, Edwards, & Salmon, 2000; Hartwell, Edwards, & Symonds, 2006).

Furthermore, food waste reduction was identified as a collective responsibility with no specifically assigned responsibility. The participants seemed aware of the view that without assigning a defined task, there is the possibility that some staff may be less committed to take on responsibility and cannot be relied on to achieve food waste reduction (Hartwell et al., 2006).

It was perceived that staff members are more likely to change their attitude towards food waste when the economic benefits of reducing food waste are emphasized, whereas the environmental, ethical and social consequences of food waste are made less of a priority. The environmental, ethical and social values were perceived to have equal potential to motivate staff to take appropriate action on food waste. This concern has also been indicated in another study (Stewart, Shepherd, Bellwood-Howard, & Bowman, 2013).

The priority given to food waste reduction activities seemed to be low across the different stakeholders of foodservice. Food waste usually has to compete with other priorities which may be more strongly linked to the main goal of the foodservice in question. A study by Walton et al., (2006) supports our finding, indicating that nutritional care and foodservice in general are perceived to be a low priority in the hospital setting (Walton, Williams, & Tapsell, 2006).

5.2. PAPER II: PRACTICE AND TROLLEY FOOD WASTE

In paper II, the adopted practice theory perspective provided in depth understanding into how the key themes constituting the three elements (procedures, tools and images) contribute to the practices leading to trolley food waste generation and the opportunities they present for reduction.

Considering how trolley food waste is generated at the ward, the practice theory adopted for the interpretation was found to be appropriate as the three main elements were identified, linking together to form the practice of food waste generation. Monitoring of food waste was perceived as a barrier to food waste reduction such that the data needed by the foodservice management to strategize their operations was hardly recoded. This limits the possibility to target food waste reduction. The fact that the procedure of ordering a meal at the ward requires a

minimum of three days' notice increases the inaccuracy in forecasting meal demands as a patient's condition changes rapidly and may not reflect the same situation at when orders were initially made.

Procedure element: The standard procedure of ordering meals for patients three days prior to serving was reported to coincide with unpredictable changes in patients' circumstances and rendered forecasted meal demands inaccurate. In addition, the three days makes it unrealistic for patients to indicate their preferred option for supper. The study participants recommended shortening the length of time between ordering and serving to minimize the related inaccuracy in forecasting. This has also been reported in other previous studies (Goonan et al., 2014; Kim et al., 2010).

Portion sizes of food items ordered and supplied from the central kitchen were based on standard recommended intakes for patients. Irrespective of patient's preferences, demands and condition, the predetermined portion sizes for food items specifically applies to all patients receiving their meals from the trolley serving. The trolley meal service is designed to encourage patients to decide on their choice of food item and portion size at the point of serving. The patient's choice of portion size can be inconsistent with the predetermined standard portion size such that those with a smaller portion may end up contributing to unserved food on the trolley.

The inadequate communication about patient schedules between the ward and the catering staff deprives the catering staff of vital information required for the timely adjustment of meal orders and meal serving. The findings in paper II further explain the complexity of communication as a barrier affecting practice, a factor also reported in the literature as contributing to food waste (Edwards, Edwards, & Salmon, 2000; Hartwell, Edwards, & Symonds, 2006; Edwards & Hartwell, 2003).

The procedure of monitoring food waste to facilitate food waste reduction initiatives is not pursued effectively, either in the ward or at the kitchen level, No data is collected on food waste from wards, mainly because of a lack of appropriate methods to adopt this as part of the foodservice routine. This could explain why we did not observe any form of food waste monitoring, neither the weighed nor the visual approach, as part of established practice on the ward. This finding seems to be consistent with a previous study which found that the unserved food is improperly monitored by ward staff (Sonnino & McWilliam, 2011).

Material Element: A menu information leaflet provided by the hospital foodservice in wards might offer a good opportunity for patients to plan personalized meal selections prior to serving and consumption (J. Edwards & Hartwell, 2006). In order for this to happen on the ward, the menu information tool should contain all relevant menu information and should be accessible to all patients. Contrary to this, the menu information leaflet displayed on the notice board and menu ordering tools

found in this study contained limited information. Only menu item names, not ingredients, were listed and portions size or nutritional values were not provided. This could hinder the ability of patients to make informed decisions prior to serving(Naithani et al., 2008). In order to ensure that the predetermined portion sizes of all food items are served in a meal, the right serving equipment must be available. The serving equipment found to be used at the ward did not conform to the predetermined portion sizes, and there was a tendency to provide a variation in servings for the same portion requested. Our argument calls for the categorization of standardized portion sizes to cater for variations in what patients need, rather than the single food item-specific standardized portion that is served to all patients. Once this is established, it can be enhanced by the use of standard tools that can serve as dependable measures and methods of portion control (Kim et al., 2010; Sullivan & Atlas, 1998).

In this study, the appropriateness of a method for monitoring food waste remains a challenge for foodservice staff. Without the required tool, the routine monitoring identified as important for hospital settings may not be achieved (Diaz & Garcia 2013). The tight schedules of foodservice professionals would benefit from a tool that is easy to use, less time consuming and that does not interfere or cause delays in the daily routines on the ward. Recent advances in technological innovations in tools such as the computerized weighing scale with scanners and digital cameras provide the potential to facilitate methods of capturing food waste data for routine monitoring (Hammes, 2011; Stewart et al., 2013).

Image Element: The findings reveal that most staff had a positive attitude concerning the potential to use unserved food to benefit patient intakes and as method of saving costs in relation to the hospital food service budget. In their opinions, visiting relatives should be given the option to buy the unserved food and dine with the patient and unserved food should also be given to staff whilst paying close attention to food safety regulation. Contrary to what is currently being done, discarding unserved food as waste gives staff the impression that the unserved cannot be used for any other purpose in the hospital setting. In addition to the hospital food safety regulation, which is also considered as impediment to the reuse of unserved food, this negative sentiment can hinder trolley food waste reduction (Goonan et al., 2014).

5.3. PAPER III: DIMS AND PLATE WASTE ASSESSMENT

The DIMS reported in paper III shows how foodservice and health professionals could initiate an innovation process towards food waste reduction. The DIMS was developed on the basis of a need for an appropriate tool to overcome the barriers to handling food waste reduction mentioned in paper 1, as well as the lack of routine monitoring and related practice perspective found in paper II. According to Omachonu and Einspruch, technology is key to facilitating this process of

innovation (Omachonu and Einspruch, 2010). In other words, for the idea to be transformed into a desirable innovative tool, components of existing tools must be assembled and used to conduct plate assessments. The two main methods were the weighed method and photography, both which have been validated, and the scale and camera are both commonly used tools. With tools readily available, the challenge was how to get these components to work in different ways yet be able to produce accurate data. I developed a manual monitoring prototype tool consisting of a Nikon camera, weighing scale, and trolley. The weighing scale was mounted on the trolley, and the Nikon camera mounted on the tripod stand. The setup was first tested at Aalborg Hospital University and was useful for collecting accurate data but short falls and other development needs were identified.

As to whether this innovation can be met solely in-house determines the extent of the need for external partnership (Omachonu and Einspruch, 2010). At this stage it was obvious that the collaborating researchers at Aalborg University hospital, needed external partnership to develop the desired tool and meet the hospital foodservice and nutritional care needs. The process of finding a potential innovative company or firm to partner in the development of the tool was challenging as it may have slowed the entire innovation process. As indicated in paper III, conducting the research project in partnership with SME made it possible to develop a workable DIMS prototype.

The test confirmed that using the photo and weight data meant that we were able to obtain vital information on how much food is thrown away from plates on the ward, as well as food choice preferences and intakes. The data available from the DIMS indicated that measuring weight can improve the accuracy of estimating portion size from photo images, which are required for a more accurate energy and nutrient intake calculation. This is because the total weight of all food items estimated from a photo can be equated to the actual total weight measured by the DIMS. This was modified and finally adopted for the study to examine the effect of portion serving size on plate waste in paper IV.

5.4. PAPER IV: MEAL PORTIONS, PLATE WASTE AND NUTRITIONAL RISK STATUS

In this study the effect of meal portion serving from the trolley meal delivery on plate waste was examined in relation to patients' nutritional risk status. This has not been investigated in previous studies. Two studies reported median portion served, consumed and wasted from bulk system, similar to the trolley meal system in this study (Hickson, Fearnley, Thomas, & Evans, 2007; A. Wilson et al., 2001). The values reported by Hickson et al., (2007) for patients not at nutritional risk were found to be much higher than this present study. On the other hand, Wilson et al., (2001), reported 7% of energy and 6 % of protein waste at lunch and supper meal times for normal eating patients. This finding seemed to be consistent with our

study. It is well documented that with the trolley meal delivery plate waste is reduced, mainly because patients can choose meal items and portion size at a point of serving to reflect what they want to eat and reduce plate (Edwards & Nash, 1999; Hartwell & Edwards, 2003; Kelly, 1999; Marson et al., 2003).

In this present study, we found that meal portion size served to nutritional risk patients was not significantly different from the not at risk patients, even though both groups made choices from the food trolley. After eating supper meals patients at nutritional risk wasted more in grams, energy and protein. It is acknowledged that nutritional risk patients might have reduced appetite and are likely to eat smaller portions (J. Kondrup et al., 2002). It is possible to suggest that the size of meal portion served to nutritional risk at can be contributing factor to the plate waste at supper. Serving of patient's meal portion choice has been linked to the flexibility of food item sizes on the food trolley (Paper II). For instance, some fixed portioned food items on the trolley, such as cut meat cannot be easily adjusted to patient's specification and when served can contribute to the increase in gram, as well as energy and protein. If the portion served is considered as large, patients may have no option than to consume what they can and leave the rest as waste. The size of meal portions contributing to plate waste can improved, however, any strategy adopted should never compromise the possibilities for providing patients with optimal nutritional intake.

Previous studies have indicated that at least 20-30% of energy and protein of the daily recommend intake should come from each main meal, but the patients' intake was found to be less (Freil et al., 2006; Hickson et al., 2007). This present study confirms the lower energy and protein intake reported in the other studies. With regards to meals served at supper, patients at nutritional risk portion sizes in grams, which should contribute to same energy and protein recommended daily requirement as the not at risk resulted in low coverage and more wasteage. This can be linked to the increased prevalence of undernutrition among hospitalized despite enough food being provided to fully meet requirements (Dupertuis et al., 2003; Thibault et al., 2011). It further raises concern as to a possible lack of focus that leftovers on plates are a risk factor for undernutrition (Dupertuis et al., 2003). Probably a limitation of the current meal service is how to ensure that patients' servings will meet the recommendations of daily energy and protein needs at these two main meals. The lack of an efficient system could, however, explain why routine monitoring of plate waste, and to some extent also food intake, seems to not take place, and may thus be considered as an unrecognized contributor to malnutrition and food waste. Therefore, including effective routine monitoring of patients' food choice, food intake and plate waste as part of a strategy to ensure patients are being served with a portion size that will enhance consumption and increase energy and protein contributions to the total daily recommended intake.

Furthermore, this study showed that plate waste was positively related to portion size. Similar findings have been reported (Lily Zakiah, Saimy, & Maimunah, 2005; P. Williams & Walton, 2011). Interesting, this current study predicts higher plate waste among the patients at nutritional risk as compared to the not at nutritional risk for the meals served at supper. An indication that plate waste is caused by multifaceted factors, including the size of meal portion served. Factors related to patient medical conditions can be more challenging to tackle to achieve reduced plate waste. However, factors related portion size can be improved by the cooperation of portion varieties and may possibly be enhanced by high density protein and energy fortification. Barton et al., (2006) reported the possibility of achieving recommended intake using a combination of small portion sizes and increased energy and protein dense food for the elderly (Barton et al., 2000; Grieger & Nowson, 2006). Therefore, developing an appropriate strategy that focuses on serving patients their own choice of portion size, combined with energy-and protein-dense food items, without necessarily increasing total portion size per meal, could improve total energy and protein intakes and reduce food waste.

CHAPTER 6. CONCLUSIONS AND RECOMMENDATIONS

6.1. CONCLUSIONS

The findings in paper I, have contributed to the understanding of possible barriers stakeholders are likely to encounter in reducing food waste. Reducing food waste in foodservice settings similar to those in this study should consider increasing staff awareness and assigning responsibility with regards to activities that are likely to generate food waste as well as the necessary steps to reduce food waste. Internal awareness creation about financial, environmental and social gains for the organization could enhance attitudinal change towards reducing food waste. The findings indicate that not all staff may take on responsibility if tasks related to food reduction are considered voluntarily. There should be a sense of priority from the management and motivation of staff to appreciate that food waste reduction is all involving.

The embedded elements of procedures (meal ordering, forecasting, monitoring), tools (appropriateness of the food waste monitoring tool) and images of food waste (reusing unserved food waste) appears to power the practice contributing to food waste and direct the activities of the foodservice professional as they engage in their daily routine of providing good nutritional meals to patients.

Focusing on the hospital foodservice setting and related perceived barriers, identified in paper I and complemented with the themes in paper II, revealed how forecasting demand for food is associated with inaccurate estimations, usually contributing to overproduction. The poor communication existing between ward staff and catering staff alters the flow of vital information needed for adjusting patients' meal demands prior to meal distribution. Information including patient discharge or changes in wards or schedules for appointments known to patient handlers, is not sufficiently communicated with enough time for corrective action to be taken. More importantly, the use of predetermined standard portion sizes to estimate patient meal demands does facilitate flexible ordering and serving. This was highlighted in the procedures contributing to trolley food waste but when assessing the effect of the portion size served on plate waste.

The sentiment expressed by foodservice professionals related to the burdens of conducting routine monitoring in practice and appropriate methods or tools to adopt in the hospital provided the insight for the development of DIMS. The piloting and application in a hospital followed as an innovation initiation from healthcare professionals. The application of the DIMS as a case study demonstrates how a developed ICT-enhanced tool can be applied in a specific hospital environment to improve routine food waste monitoring and become part of practice in the hospital foodservice. Using the DIMS demonstrate its capability for collecting relevant data

which was analyzed to reveal that meal portion size serving is positive related to plate waste but differs among patients classified by the NRS- 2002 as nutritional at risk or not at risk. Patients at nutritional risk, regardless of portion size served, produced increased amounts of plate waste when compared to patients not at nutritional risk. However, this factor was not taken into consideration when patients were being served. It is therefore important to identify a patients' nutritional risk status prior meal service. Equipped with this information, foodservice professionals can provide assistance to ensure that the desired choice of food served provides adequate nutrients without necessarily increasing the meal portion size. The need for including high protein and energy density seems to be important, especially if the chosen portion size that should not increase plate waste is to be achieved. This research showed that the DIMS was a feasible method to monitor nutrition intake as well as plate waste, and provided the opportunity to forecast nutrition intakes in nutritionally at risk patients in order to improve communication around serving and thus improve intake.

6.2. RECOMMENDATIONS FOR PRACTICE

Patients at nutritional risk who appreciate smaller portion sizes should be given energy- and protein-dense foods to meet their nutritional requirements.

There is a need for hospital management to reconsider the length of time required between ordering and serving. If possible, it should be reduced to the minimum but realistic length of time that can minimize the effect of changes in patients' appetite level.

A formalized communication structure/guideline needs to be established between the ward and the catering department with regards to patient schedules and appointments that might interfere with serving times, and opportunities for meal cancellation should be provided.

Menu information must be designed to assist patients to make informed decision about the appropriateness of their choice of portion size, nutrient contents and any alternative meals they can obtain.

Routine monitoring of nutrition intake in patients who are nutritional at risk and of food waste should be established in the hospital foodservice using appropriate tools that can provide accurate data without being time consuming and that result in minimal interruption of meal serving routines.

Staff should be trained in serving skills that will enhance their capabilities to combine food items on the trolley to meets patients' nutritional requirements. This should be supported with well-designed equipment that can facilitate flexible portion size serving.

6.3. FUTURE PERSPECTIVES

Nutritional risk screening is required to be performed for patients on admission to determine their nutritional risk status. This can play a vital role in reducing food waste during the serving of meals to patients. The nutritional risk screening perform using the NRS-2002 is standard practice in Danish hospitals, but should be integrated in patient meal servings such that all foodservice or healthcare professionals involved in serving patients' meals are informed about patients at nutritional risk and who may need support to select appropriate meals and portion sizes. For the purpose of ordering meals, nutritional risk should be taken into consideration when choosing the total portion size that will be not only be appreciated by the patient, but that also contains the optimal level of required nutrients, especially protein and energy.

This will further require that hospital nutritional care reconsiders the recommendation of ordering requirements that standardize portion size of food items for all patients, irrespective of nutritional status. There is a need to find innovative ways of minimizing portion size by incorporating changeable nutrient-dense food items into menus, thus maintaining energy and protein content in reduced portions with short notice.

This research has revealed an important aspect regarding the implementation of meal delivery systems as strategies to reduce food waste. Previous literature has found that the implementation of the trolley meal delivery system generated less plate waste when compared to the plated system. The results of our study provide a clear indication that the trolley meal delivery system in practice contributes to levels of food waste that can be reduced. Therefore, implementation should not be based on evaluation comparing a new system to an old, but rather further evaluation should be conducted from the practice perspective to identify how it may contribute to food waste generation, and the possible opportunities it presents for reduction.

Opportunities to develop the DIMS have been identified; automatic nutrient intake analysis of food items on the plate can be performed using digital photographs and the corresponding weight recorded by the scale system. Our current focus is on developing the DIMS application software for automatic/smart picture recognition of food items from the captured image and estimation of the weight in order to produce calorie and nutrient values from food composition databases. This would make the work of dieticians more efficient. We believe that this technology could provide a new methodological approach for collecting data for dietary studies and improve the monitoring of nutritional intake in hospitals.

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APPENDICES

Appendix A: Paper I

Appendix B: Paper II

Appendix C: Paper III

Appendix D: Paper IV

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