Evaluation of a dietary assessment system in the “MyFood” application for hospitalized patients

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Martina Lovise Lindhart Hagen

Abstract

Background: The prevalence of disease-related malnutrition among hospitalized patients mostly varies from 20% to 50%. There are discrepancies between recommended practice and actual practice in nutritional work, and a lack of routines to calculate patients' dietary intake in relation to their needs is a reported barrier. "MyFood" is an application in development aiming to assess the dietary intake among hospitalized patients at nutritional risk.

Objective: The present study aimed to evaluate MyFood's accuracy in assessing patients' intake of energy, protein and liquid, and foods and beverages, on both group- and individual level. The study also aimed to investigate the patients' experiences from using the application.

Methods: A total of 32 patients hospitalized at two departments at Rikshospitalet, Oslo University Hospital, participated in the present evaluation study. The participants recorded foods and beverages consumed for breakfast, lunch and dinner for one day. The participants' meals were photographed and partly weighed both before and after consumption, as a reference for the actual intake.

Results: There were no differences between the total intakes of energy, protein and liquid estimated by MyFood and the photography method. Underestimations from MyFood were observed for protein intake for breakfast ($p=0.02$) and lunch ($p<0.01$), and liquid intake for breakfast ($p=0.03$). At the individual level, acceptable estimations (±20%) from MyFood was found for 66% of the participants for energy intake, 65% for protein intake, and 69% for liquid intake. The participants omitted 12% of consumed foods and beverages from the recordings. On the group level, the intake of spreads, meat spreads and fruits were underestimated, while bread was overestimated in MyFood. At the individual level, the participants' intake of fruits and meat spreads tended to be underestimated in MyFood, while the actual intake of bread, soups and hospital dinners and desserts, tended to be overestimated. Ninety percent of the participants thought the app was easy to use and navigate in, and 70% reported that MyFood increased their awareness of dietary needs.

Conclusion: The application was considered promising in assessing patients' dietary intake, although some modifications in the MyFood's system are necessary to improve the accuracy of intake estimations. Self-recording of dietary consumption in MyFood was well accepted and it might increase the patients' awareness of dietary needs.

Table of Contents

Tables

Figures

Appendices

Appendix A	Patient background information form
Appendix B	User experience form
Appendix C	Approval from the Regional Committees for Medical and Health Research Ethics (REC)
Appendix D	Written consent form
Appendix E	Plan for data collection procedure
Appendix F	Meal form
Appendix G	Information to staff nurses
Appendix H	Manual for patient registration in MyFood (for nurses)
Appendix I	Manual for dietary recording in MyFood (for patients)
Appendix J	Participant overview form

Abbreviations

24-HDR: 24-hour dietary recall

AE: Acceptable estimations

BAPEN: British Association of Parenteral and Enteral Nutrition

BMI: Body Mass Index

DRM: Disease-Related Malnutrition

ESPEN: European Society for Clinical Nutrition and Metabolism

FFMI: Fat Free Mass Index

ICD-10: International Classification of Diseases, 10th revision

ICT: Information and Communications Technology

LOS: Length of Stay

MNA: Mini Nutrition Assessment

MUST: Malnutrition Universal Screening Tool

NKSU: Norwegian National Advisory Unit for Disease-Related Malnutrition

NRS 2002: Nutrition Risk Screening 2002

OE: Overestimations

OUH: Oslo University Hospital

PDA: Personal Digital Assistant

PGP: Pretty Good Privacy

REC: Regional Committees for Medical and Health Research Ethics

SD: Standard deviation

TEE: Total energy expenditure

UiO: University of Oslo

UE: Underestimations

USIT: University Center for Information Technology

WHO: World Health Organization

1 Introduction

1.1 Disease-related malnutrition (DRM)

There is no universally accepted definition of malnutrition. Malnutrition may be defined as: "*A state of nutrition in which a deficiency, excess (or imbalance) of energy, protein, and other nutrients causes measurable adverse effects on tissue/body form (body shape, size and composition) and function, and clinical outcome.*" (1); a definition which is acknowledged by many, including the European Society for Clinical Nutrition and Metabolism (ESPEN) (2). The term malnutrition thus includes a wide range of conditions, whereof malnutrition in terms of undernutrition is of relevance in this thesis.

Malnutrition may result from starvation, disease or advanced ageing, or a combination of these factors (3). In clinical practice, malnutrition is often substantially influenced by the presence of disease, resulting in disease-related malnutrition (DRM) (4). DRM is the predominant cause of malnutrition in developed countries (4, 5), and may be divided into DRM with and without inflammation, depending on whether inflammation is among the etiological mechanisms for the malnutrition condition (3, 4). An inflammatory response induces anorexia and tissue breakdown, and the basal metabolism may increase as the degree of inflammation increases, resulting in a greater loss of weight and muscle mass compared to other types of malnutrition (3, 6). DRM with inflammation may be further divided into two subgroups, with chronic inflammation (e.g. organ failure and rheumatoid arthritis) or acute inflammation (e.g. burns and trauma), respectively (7). An overview of the discussed subgroups of malnutrition is presented in **figure 1.**

Any disorder, whether acute or chronic, with or without inflammation, has the potential to result in, or aggravate malnutrition. Nutritional factors like the metabolism, appetite, absorption, or assimilation of nutrients may alter as the body responds to the disease (5). Other possible influencing factors in the development of DRM are repeated episodes of fasting due to medical procedures, side-effects of drugs and pain or discomfort after eating due to a disease process or mechanical obstructions (5, 8). Overall, insufficient dietary intake is of central importance in the development and progression of DRM (1).

In addition to the defined types of malnutrition, there are also some nutrition-related conditions caused by disease or ageing; namely, cachexia, sarcopenia, sarcopenic obesity and frailty (figure 1). Common feature is that these conditions are multifactorial and complex, and increased nutritional intake does not necessary leads to improved nutritional status, due to abnormal or changed metabolism (9-11). Cachexia and sarcopenia are both characterized by progressive and generalized loss of skeletal muscle mass (10, 12), while frailty is a geriatric syndrome characterized by increased vulnerability to adverse health outcomes due to age-related declines in multiple physiological systems (3). The nutrition-related conditions complicate the clinical picture in hospitalized patients.

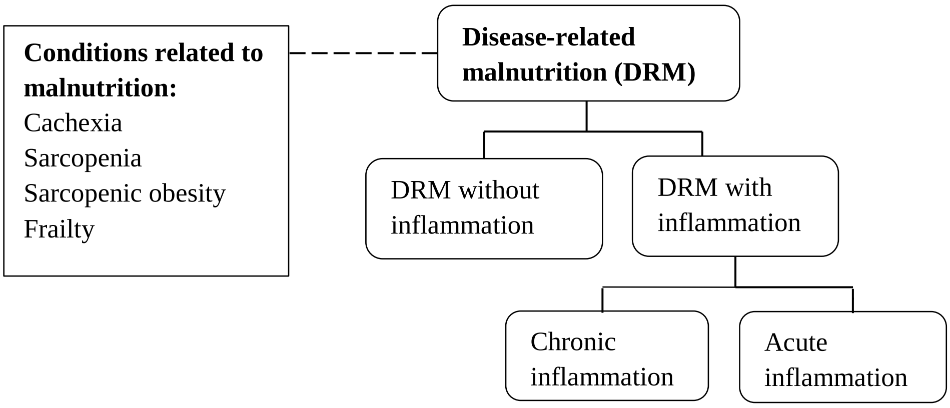

Figure 1. Diagnosis tree of disease-related malnutrition, including nutrition-related conditions.

Discovering patients at nutritional risk is important, and precise classification of malnutrition is crucial for the understanding of the related complexities and consequently of relevance for both treatment and prognosis (3, 4, 6).

1.1.1 Diagnostic criteria

International Classification of Diseases, 10th revision (ICD-10) is a system for reporting occurrence of diseases and health conditions (13). The system is developed by the World Health Organization (WHO), and includes codes for energy- and protein malnutrition of severe (E43), moderate and mild (E44) and unspecified degree (E46) (13). There are descriptions of the codes, but the WHO lists no specific criteria (13). The Norwegian Directorate of Health has developed national guidelines with the purpose of identifying patients at nutritional risk and providing targeted treatment. The guidelines from 2009 propose criteria for each of the diagnoses E43, E44 and E46, based on degree of weight loss, body mass index (BMI) and food intake (14). In 2015, ESPEN suggested two diagnoses for energy-protein malnutrition in the ICD-10 system: "at nutritional risk" and "malnutrition", and the criteria for the diagnoses were based on weight loss, BMI and fat free mass index (FFMI) (15). However, it is of notice that there have been an ongoing controversy and debate concerning the diagnostic criteria for malnutrition over the years, including criticism of the recent criteria from ESPEN (4, 16, 17). In order to improve nutritional practice at hospitals and to increase the homogeneity of studies on DRM, this field should be more readily understood with worldwide definitions and guidelines.

1.1.2 Prevalence

Despite obesity being an increasing global challenge, DRM is highly prevalent in hospitalized patients. This constitutes a large problem in public health care. In the literature, the prevalence of DRM in hospitals is mostly reported to range from 20% to 50-60% (5, 18-22). The prevalence varies greatly depending on study population, patient setting, screening tool and criteria used to diagnose malnutrition (14, 23). There are a large number of studies worldwide demonstrating a high prevalence of malnutrition at hospitals; the following paragraph represents the variety of prevalence of DRM that exists in the literature from Norway.

An assessment of nutritional status in 244 surgical patients at Aker hospital in 1999, using weight loss and BMI as parameters, displayed a prevalence of malnutrition at 39% (24). Tangvik and colleagues performed eight prevalence surveys at Haukeland University Hospital during 2008-2009, in which the patients' nutritional status was categorized according to Nutrition Risk Screening 2002 (NRS 2002) (25). The overall prevalence of nutritional risk among the 3279 patients was 29%. The prevalence was highest in patients with infections (51%), cancer (44%) and pulmonary disease (42%) (25). In another Norwegian survey, which screened just above 500 non-demented elderly patients for nutritional risk, using NRS 2002, the prevalence was estimated to be 46%, ranging from 20% to 65% in different hospital wards (26). A cross-sectional study from Jacobsen and colleagues found that 48% of the 120 acute geriatric patients were at nutritional risk, while 27% were malnourished, using the screening tool Mini Nutritional Assessment (MNA) (27).

1.1.3 Risk groups

DRM may be present in all patients, regardless of age and type of disease (6). However, patients found to be at nutritional risk, or malnourished, are often older (19, 22, 25, 28, 29) and have a low BMI (22, 25, 28). Weight loss in the previous three months and reduced food intake are also reported among the patients at nutritional risk (28). Geriatric patients may be extra vulnerable for malnutrition due to age-related anorexia, dementia, loneliness, immobilization and difficulties with chewing and swallowing (3, 5). Presence of the age-related condition; frailty, may also influence the nutritional status (3). Studies report that the nutritional status often tends to decline during hospital stay (5).

1.2 Consequences of DRM

1.2.1 Health consequences

DRM has several severe health related consequences for the patient. It affects the function and recovery of every organ system, worsening both the physical and mental state (30). Some of the frequently reported consequences of DRM are decreased muscle mass and function, impaired immune function, increased risk of complications and infections, and delayed wound healing and convalescence from illness (5, 30, 31). In addition to enhanced morbidity, malnourished patients consequently have longer length of hospital stay (LOS), increased prevalence of readmissions and a higher mortality rate compared to well-nourished patients (5, 14, 20, 31-34). A review by Norman and colleagues revealed that the average LOS in most studies increased by 40-70% among malnourished patients (5).

Studies have also shown a correlation between recent dietary intake and clinical outcomes. Consumption of 25% or less of the offered hospital food the respective study day, or the previous week, was associated with increased LOS and 30-day mortality risk (33, 34). Patients reporting a reduced dietary intake the prior weeks have also been found to have an increased one-year mortality risk, when compared to those reporting a normal dietary intake (32).

1.2.2 Economic consequences

Many of the health impacts of DRM described in the previous paragraph, consequently results in increased hospital costs. As the following paragraph will demonstrate by the sample of presented literature, DRM constitutes a major resource issue for public expenditure.

A study from Portugal found that the hospital costs of treating the patients categorized to be at nutritional risk (using NRS 2002) was 19% higher than the average costs of treating the well-nourished patients in the respective diagnosis-related group (35). The increased cost represented an estimated increased expenditure of 200-1500 euro per patient (35). The hospital costs of malnourished patients were 61% higher than the costs of well-nourished patients in a Brazilian study (31). A Norwegian study from Tangvik and colleagues estimated the hospital costs to be 60% higher the following year for the patients at nutritional risk compared to patients not at risk; an estimation they described as likely to be too low given that they only included increased hospitalizations in the cost consideration (32). A working group founded by The British Association of Parenteral and Enteral Nutrition (BAPEN) found that the malnourished patients, in addition to longer LOS, had more general practice visits, more hospital readmissions and a greater likelihood of admission to care homes, compared to well-nourished patients (36). The BAPEN working group estimated the yearly cost of DRM to be over £7.3 billion, accounting for up to 10% of the total expenditure on health in the United Kingdom. Further, they described this expenditure as two-fold greater than the expenditure related to obesity (36), a far more acknowledged health problem.

1.3 Effects of nutritional treatment

Given all the described negative consequences of malnutrition, it is reasonable to think that treatment of malnutrition may produce clinical, functional and financial benefits. However, studies regarding the effects of nutritional support are quite dispersed and non-conclusive. Some studies and meta-analysis report no difference in LOS (37, 38), complication risk (37, 38) or mortality (38, 39), while others report decreased LOS (39, 40), lower complication rates (39, 41), and reduced mortality risk (42) in a nutrition intervention group, when compared with a control group. However, the nutrition intervention in the studies varied greatly, e.g. from screening at admission and standardized nutritional follow-up of patients at risk (40), nutritional counseling and protein supplements (42, 43) or a detailed nutrition plan

(37), to mainly enteral (including oral) and parenteral feeding (38, 41, 44) and to additional inclusion of immune nutrition (39). It is frequently reported that patients in nutrition intervention groups increase energy- and protein intake, and reports better quality of life (37, 38, 40, 42, 43), which is revealed to be still maintained after a median follow-up of 6.5 years (42). A large Cochrane Review from May 2017, including 244 trials with nearly 29,000 hospitalized adults, found no effect of nutritional support on the risk of mortality or serious adverse events in short or long term, except for promising results of tube feeding (45). The heterogeneity of the studies in the field is high and the methodological quality is variable, as stated by authors in four meta-analysis and systematic reviews (38, 39, 44, 45).

Stratton and colleagues state that there is little doubt that nutritional support in patients with obvious malnutrition will improve clinical outcome (1). However, due to possible confounding effects of disease and no universally cut-offs to distinguish between health and malnutrition, there exists a grey area with uncertainty about the benefits of nutritional support (1). There is a need for more standardized procedures in nutritional work and high-quality intervention studies to document the improved clinical outcomes when patients identified at nutritional risk are given nutritional support.

1.4 Guidelines on nutritional practice

1.4.1 Nutritional risk screening

Validated tools for nutritional screening are simple techniques to systematic and rapidly identify patients at risk of developing malnutrition (46). The tools embody three main principles which should be considered: current condition (e.g. height and weight), whether the condition is stable (e.g. weight loss history) and whether the patient is likely to get worse (e.g. questioning the appetite) (47). In addition, at hospitals, a fourth variable should be included: whether there is a disease process that will accelerate the nutritional deterioration (e.g. an upcoming surgery) (47). According to the Norwegian guidelines from 2009 (14) and the European guidelines from 2002 (47), all patients should be screened for nutritional risk at admission to hospital and thereafter weekly during hospital stay. The tools which are validated and recommended by the Norwegian guidelines (14) for use in the specialist health care services are: NRS 2002 (48), MNA (49) and MUST (Malnutrition Universal Screening Tool) (50).

1.4.2 Follow-up of patients identified to be at nutritional risk

If a validated screening tool reveals that the patient is at nutritional risk, a nutrition plan should be created (47). Nutrition-related factors should be considered when making a nutrition plan, such as the nutritional status, appetite, eating habits and eating capabilities. The plan should contain the patients' energy- and liquid needs and intakes, as well as the recommended nutrition-related actions (14). The effectiveness of the plan should be monitored by defined measures and observations, like dietary recording and measurements of body weight and function (47). The results of the nutritional screening, assessment and nutrition plans should be communicated in discharge letters to the next level of care (47).

The Norwegian Dietary manual, "Kosthåndboken", from the Norwegian Directorate of Health, is a manual for nutritional work in the public health care services. The aim of the manual is to function as a comprehensive tool to implement the national guidelines and to secure quality in nutritional practice. The manual underlines that intake of foods and beverages (type and amount) should be accurately recorded to compare the intake with the estimated needs (46). This involves specification of time and description of type and quantity of food/beverage consumed in main meals and between the meals (46).

Nutrition was included as a priority area in the Norwegian Patient Safety Program in 2015. As a result, the Norwegian Patient Safety Program "*In Safe Hands 24-7"* presented a package of interventions ready to be spread nationally in March 2017 (51). The package of interventions consists of four measures: risk assessment; individual assessment; individual nutrition plan and transference of information (51). The Patient Safety Program specifies that evaluation of food intake is important, and that the patients should cover at least 75% of energy requirements within four days of hospital stay (51).

1.5 Current nutritional practice in hospitals

The Norwegian (14) and European guidelines (47) for nutritional screening and for providing nutritional support in hospitals are developed in order to identify and give targeted treatment to patients at nutritional risk. Despite this, questionnaire-based surveys among health care professionals and prospective studies at hospitals reveal that nutritional practice at hospitals still seems to be unsatisfying.

Questionnaire-based surveys among health care professionals revealed that nutritional assessment of newly hospitalized patients was a routine procedure among only 16-40% of the respondents, although 77-88% agreed that such nutritional assessment was important (52-54). Half of the participating units reported a screening routine in a cross-sectional survey including 25 countries (28). Another cross-sectional study including just above 6000 patients in Dutch hospitals found, based on reported values, that nutritional screening took place in 40% of the patients and that only half of the hospital wards had a weighing routine at admission (55). Around 40% of asked health care professionals thought it was difficult to set up a plan for nutrition therapy (52, 53), and routinely recording of dietary intake seems to be lacking (52, 54). However, the percent of responders which stated that recording of dietary intake was a routine procedure increased from 22% in 1997 (52) to 45% in 2004 (53) in surveys among Danish doctors and nurses. The surveys that were conducted seven years apart showed overall improvements in both attitudes to nutritional procedures and in nutritional practice (53). Further improvements might have occurred somewhat during the past 14 years.

A prospective cohort study conducted in 2005 at a hospital in the Netherlands found that nutritional assessment was not sufficiently performed by the doctors, medical students nor the nurses; screening 15%, 53% and 30% of their patients, respectively (23). Only a minority of malnourished patients seemed to be recognized (23, 56, 57) and fewer than half of the recognized malnourished patients received nutritional treatment (55, 56). Information about patients' nutritional status is found to be practically absent in discharge letters (23, 56). Documentation of patients' nutritional plan is also insufficient (23, 55). Information about nutritional factors like history of weight loss, current appetite, oral intake and functional status were found to be recorded for fewer than 33% of the patients in a study from 2005 (57).

The report from the National council for nutrition from 2017 points out that the national guidelines and "Kosthåndboken" are little known and adopted in the health care sector to prevent and treat DRM (6).

Summing up, even though the nutritional practice in hospitals might have been improved during the past decades, there is still lack of good, routinely practice on nutritional screening, assessment, treatment and follow-up of the patients at nutritional risk.

1.5.1 Barriers to adequate nutritional practice

The two studies conducted in Denmark, by Rasmussen et al. and Lindorff-Larsen et al., described the same three main barriers for good nutritional work; namely, lack of knowledge, lack of interest and lack of defined responsibilities (52, 53). A recent Norwegian qualitative study also reflects these barriers (58). Based on a focus group of 16 nurses, the following five themes were identified as barriers for adequate nutritional care: *"loneliness in nutritional care; a need for competence in nutritional care; low flexibility in food service practices; system failure in nutritional care and the neglect of nutritional care"* (58). The nurses reported that nutritional care was given little attention at hospitals and that nutritional care, including weight monitoring, was in focus only if it was a necessary part of the medical treatment. Clinical dieticians were considered a useful and necessary resource, but their presence and availability were reported to be insufficient (58). Another barrier for good nutritional work is the lack of an adapted medical record for documentation of nutritional status and practice (6). Nurses have reported that inadequate documentation routines make it difficult to trust the information about nutrition in the medical records (58). It has also been reported that there is a lack of a fixed routine to determine the patients' energy requirements and to monitor whether the patients are achieving their estimated needs (54).

1.6 The need for a nutritional quality care system

The National Health and Care plan (2011-2015) emphasize that the health care services have a responsibility to contribute to good health and prevention of illness in the population (59). The right to receive adequate nutritional care is also regulated by law. According to the Norwegian Patient's Right Act, all patients have the right to receive treatment and care according to their needs (60). This includes the rights to enough, safe and nutritionally adequate food (46). The Norwegian report assessing DRM states that nutritional practice in Norwegian health care seems to develop in a positive direction (6). Among several factors they describe as strengths in nutritional work, are the development of national guidelines and "Kosthåndboken". Also, defined efforts like the Mission Documents from the Norwegian Ministry of Health and Care (2010-2013) with clear guidelines for nutritional work, and the inclusion of nutrition as a priority area in the Norwegian Patient Safety Program in 2015, have been important contributors in the improvement of nutritional work across health regions (6). However, as reflected in the previous paragraphs, many patients at Norwegian hospitals do not reach their dietary needs, and the nutritional work in health care services still needs improvements.

The number of elderly persons above 75 years old will increase with over a two-fold by the year 2030 (61). More people will live longer with good health, but also with chronic diseases and a complicated clinical picture. As the need for health care services increases, there will be a shortage of labor (61). National health- and hospital plan (2016-2019) emphasize that the need for future personnel and competence not only can be resolved by educating more people (62). There is a need for new working forms and for introduction of good electronic tools and new technology to increase the efficiency of the daily work at the hospitals (62).

The National council for nutrition also calls for electronic tools (6). The council states that nutrition should be included in a systematic way as part of the clinical pathway, and that Information and Communications Technology (ICT) is necessary to succeed in nutritional work (6). Some of the ICT-tool-qualities in demand are simple systems for calculation of dietary needs and a user-influenced method for dietary recording. The systems should estimate the patients' intake and estimate in which degree they cover their needs for energy, protein, liquid and other relevant nutrients (6). Further, they ask for ICT-tools to help generate nutrition plans, monitor nutritional variables and measure the effect of nutrition plans. The systems should reflect recommended nutritional procedures and guidelines, ease off the work for health care professionals and secure the quality of nutritional work (6).

The package of interventions formulated by the National Patient Safety Program (described in section 1.4.2) has described that dietary intake should be documented and compared to basic needs (51). Dietary recording also plays an essential part in nutritional monitoring and in evaluation of a nutrition plan (51), as also described in the Norwegian (14) and the European (47) guidelines, and in "Kosthåndboken" (46). However, a lack of a fixed routine to determine energy requirements and monitor nutrient intake have been reported by health care professionals as a barrier to good nutritional follow-up (54, 58).

Together, this describes the need for standardized, electronic systems that assure quality and strengthen the nutritional work at hospitals. For this reason, a decision support system, in form of an application to a tablet, is in development.

1.7 The decision support system in development

The decision support system in development and evaluation is a project financed by South-Eastern Norway Regional Health Authority through a three-year doctor's degree project. The project group principally includes members of the Norwegian National Advisory Unit for Disease-Related Malnutrition (NKSU) and employees at the University of Oslo, UiO. The University Center for Information Technology (USIT) at UiO is in charge of development and design of the application, in cooperation with scientists at NKSU and the department for nutrition science, UiO. Nurses and patients at Rikshospitalet, Oslo University Hospital (OUH), are also involved in the development to assure user influence. When finished, the decision support system will include: 1) a tool for monitoring dietary intake, 2) a tool for evaluation of dietary intake compared with individual requirements, and 3) an output that generates a report, including recommendations for action.

The application, called "MyFood", is aimed to be used by hospitalized patients screened to be at nutritional risk. The patients and/or the nurses should use MyFood to record dietary intake for one whole day, a length which was requested by the National council for nutrition (6). The one-day dietary data from MyFood should form the base for nutritional feedbacks and be used to design a nutrition plan in order to improve the nutritional status. After a set period (described in the nutrition plan), MyFood should be re-used to assess whether there have been any improvements in nutritional intake, and possibly, be used as a fundament for a new nutrition plan.

The main objective of the decision support system is to contribute to a better and more standardized system for evaluation and monitoring of dietary intake and to give nurses assurance through standardized procedures and recommendations based on the reported intake.

1.8 The dietary assessment system to be evaluated

A prototype of MyFood, with a dietary assessment tool and an automatic evaluation of dietary intake compared with individual requirements, is developed in the project so far. In order to proceed the development of the decision support system and to later conduct an intervention study to test the clinical implementation and the clinical effect of the system for prevention and treatment of DRM, the dietary assessment system must be evaluated.

1.8.1 Evaluation of dietary assessment methodology

Evaluation may be defined as the systematic process of determining the merit, value, and worth of some objects (63). When assessing the quality of a method's measurements, it is important to address the validity, in other words; assess whether the method's measurements accurately reflect what it is intended to reflect (64, 65). As there are no methods available to measure dietary intake among individuals or groups of individuals without error (66, 67), the study of validity should demonstrate the magnitude and direction of measurement error, identify potential causes of error and make up the fundament to interpret the results from the dietary assessment method correctly (66, 67). Dietary assessment methods that are especially vulnerable for measurement errors are methods based on self-reported intake, in particular methods that depends on the participants' memory and/or ability to estimate portion sizes (68, 69), as MyFood does.

The ideal procedure would be to determine the absolute validity; however, this is not possible as there is a lack of a gold standard to assess dietary intake (67). Relative validity is determined when comparing a test method with a reference method that is considered more accurate in its measurements than the test method (65). Weighed records are often used as a reference for true intake (66, 70). Biomarkers like doubly labeled water and nitrogen in urine are valid objective measurements for quantitative intake of energy and protein, respectively (37). However, inclusion of such biomarkers is often expensive and not always appropriate (67). Direct observation techniques have been reported to be highly accurate and a close substitute for a gold standard (64, 67, 70).

In order to evaluate the validity of a method satisfyingly, the reference method's validity should have been demonstrated (67). The chosen reference method must retrieve dietary data on the same level of intake (individual intake versus mean intake of a group) and over the same period (a single day versus usual intake) as the test method in order to be suitable as a reference (64). Additionally, the methods' errors should be independent of each other, to avoid correlating errors (66, 67, 71). Factors which also should be considered when validating a method's accuracy in assessment of dietary intake is the design of the study, study population used and type of analyses performed to interpret the results (66).

1.8.2 Evaluation of MyFood

This master thesis presents an evaluation study, in which estimations of energy-, protein- and liquid intake from dietary recording in MyFood was compared with dietary estimations from photograph observations, combined with partial weighing, as a reference method for dietary intake. Studies have found that the digital photography method highly correlates with weighed records (68, 72), which is often regarded as the most accurate method for individual level of dietary assessment (73-75). Weighed records was not considered practicable as the only reference method in the present study, as the method is time-consuming, disruptive for the patients' eating environment and overall a complex operation in real-life settings like hospitals (70, 76). Direct visual observations as a reference method was considered, as the method is easier to organize than weighed records and is proven to be reliable (72, 77). The method is able to differentiate the intake of food items because the observer can mentally separate different items on the plate. However, digital photography, as opposed to direct visual observations, requires a minimum disruption of the patients' eating environment (72), allows unhurried nutrient estimations and gives the opportunity to go back and double check in cases of questions.

The number of innovative technological methods for dietary assessment increases (78). There exists evaluation studies of different types of electronic dietary assessment methods, like web-based dietary assessment systems for children (69, 79), application-based methods for dietary assessment among subjects aiming to lose weight (80) and among young adults (81). However, evaluation of self-administered electronic tools for assessing dietary intake among hospitalized patients has not been revealed in the literature search. An application for elderly people living at home, "Appetitus" has recently been developed and are available in the app stores (82). However, "Appetitus" is not designed to give accurate dietary data from elderly users, but rather to increase inspiration and awareness around meals and dietary habits. A Danish master's thesis from 2012, centered around an electronic dietary recording tool for hospitalized patients, was found in our literature search (83). However, no articles have been published, and no further information about the Danish application was found.

To the best of our knowledge, there are no applications aiming to accurately monitor dietary intake among hospitalized patients in use at Norwegian hospitals, and the evaluation of MyFood is to our knowledge the first evaluation study of that kind, both nationally and internationally.

2 Objectives

This master thesis constitutes an evaluation of the dietary assessment system in the newly developed application, MyFood. The overall aim was to evaluate patients' one day's recording in MyFood by comparing the recorded intake of energy, protein and liquid, and foods and beverages, with estimations from meal photographs as a reference.

More specifically, the main objectives were to:

- Study MyFood's ability to estimate patients' intake of energy, protein and liquid on group level.

- Study the agreement between MyFood and the photography method in estimations of energy-, protein- and liquid intake on individual level.

- Examine the capability of MyFood to estimate consumed amount within food groups, on both group- and individual level.

- Gather information from the study participants regarding the usability of MyFood.

3 Subjects and methods

This master thesis focuses on patients' dietary data collected from one day of dietary recording in the application, MyFood. However, as this master thesis was part of a doctor's degree project, dietary data were collected for two days for each participating subject. The method description, therefore, includes the procedure of collecting dietary data in two days, as this was a central part of our conduction of data collection. A Ph.D. student and a master degree student, further referred to as "the project workers", performed the collection of data.

3.1 Study design

This evaluation study took place from March to May 2017 at Rikshospitalet, OUH. Patients hospitalized at the Department of Gastrointestinal Surgery and at the Department of Hematology were recruited as participants, as the named departments have high prevalence of nutritional risk and therefore are cooperation partners in the project. The first half of the data collection period was conducted at the Department of Gastrointestinal Surgery and the last at the Department of Hematology, consisting of 28 and 30 beds, respectively.

Included subjects were asked to record their intake of foods and beverages in MyFood to the main meals: breakfast, lunch and dinner, for two days. The project workers took photographs of the meals and weighed single meal components before and after intake, as a reference method for the intake recorded by the patient (or nurse) in MyFood. When included in the study, the patients filled out a form with information about degree of education, living conditions and level of experience with use of apps in tablets/smartphones (**appendix A**). When the patients had used the MyFood application for two days, feedbacks were gathered regarding the comprehension, content and perceived value and usability of the tool (**appendix B**).

3.1.1 Calculation of sample size

The primary variable for calculation of sample size was energy intake. Clinical relevant difference between the methods was set to 10%, amounting 50 kcal in a meal of 500 kcal. A minimum of 30 adult patients was found to be necessary to include in this evaluation trial, based on a test power of 0.8, a significance level (α two-sided) of 0.05, and a calculated standardized difference at 1.0 (84).

3.2 Ethics

The evaluation study was approved by the Regional Committees for Medical and Health Research Ethics (REC), region south east (**appendix C**). As the project involved processing of personal data, a dialogue was kept with the Data Protection Official for Research. All study subjects signed an informed written consent form **(appendix D**), and the subjects could withdraw from the study at any time. The patients' Norwegian Patient Register (NPR) number was used as a personal identification number. The NPR-number is accessible in the medical records and was used to register the patients in the MyFood application system (not visible on the screen once the patient was registered and the dietary recording module was ready to use). The data recorded in MyFood were sent to Services for Sensitive Data (TSD, "Tjenester for Sensitive Data"), and the application reset at 3 a.m. every day to avoid any information being stored locally. All subjects received a participant number, which was used to identify the patients in meal photographs, forms, and papers. The form connecting NPR-numbers with participant numbers was locked in when not in use and was only accessible for the project workers.

3.3 Planning and preparation

The MyFood application was frequently tested and examined beforehand of this evaluation study, and the application designers performed user tests among nurses and patients at Rikshospitalet, OUH, followed by subsequent corrections. At the time of study start, a prototype for MyFood was considered ready to test.

The plan for data collection was discussed thoroughly between the project workers. The responsible nurse at the Department of Gastrointestinal Surgery was also included, to make sure the plan was feasible. The final detailed scheme for how to perform the data collection is attached as **appendix E**.

3.3.1 Method practice

In order to use photographs to estimate the nutritional content in the patients' meals, the project workers were required to test the method and produce satisfactory energy consumption estimates from photographs of test meals before the evaluation study. The project workers photographed 13 test meals, including bread meals and warm dishes, prepared by an independent third person. The meals' contents were weighed and described in meal forms developed for the study (**appendix F**) and photographs were taken both before and after the third person removed a specified amount of food to simulate consumption. The project workers used the software program "KostBeregningsSystem" (KBS), at Department of nutrition, UiO, to estimate the energy intake for each of the 13 meals independently. The project workers' estimations of energy intake were then compared with each other and with the true energy intake for all 13 test meals. The total interobserver agreement for energy intake, expressed as the proportion of agreeing observations between the observer pairs, was calculated to be 0.92, and the proportion of estimates matching the actual intake was calculated to be 0.94 for both project workers. Agreement above 0.85 is considered satisfactory in other studies (79, 85) and no further practice was considered necessary.

3.3.2 Information to the ward nurses

Information about the evaluation study was given to all staff nurses at the wards via e-mail. The e-mail also included descriptions of nurses' role in the data collection process (**appendix G**), a manual for registration of patients in MyFood (**appendix H**) and contact information to the project workers. At the Department of Hematology, the nurses on duty the first two days of data collection were also informed about the study in a ten minutes' presentation held by the project workers.

3.3.3 Data collection start-up

During the first two days of data collection, the project workers did the recruitment and photographing of meals in cooperation, to coordinate the routines. Duties for the following weeks of data collection were divided among the two project workers.

3.4 Recruitment of patients

The participants were recruited continuously during the period of data collection. Three tablets (iPad mini) were available for the study, and therefore, a maximum of three patients was followed up each day. When recruiting patients, the responsible nurse went through the list of hospitalized patients and assessed which patients who were suited to participate, based on our inclusion and exclusion criteria. For this reason, there is no overview of the number of patients not suited to participate; however, a flowchart describing the inclusion process of the eligible patients is presented in **figure 2**. The hospitalized patients had to be at least 18 years old and have at least two more days of expected hospital stay after inclusion. Patients were excluded if they were considered to be terminal or critically- or mentally ill. In addition, pregnant women, patients with language difficulties, patients with special infection precautions, and patients scheduled for operations/examinations, including fasting, were excluded. At the Department of Gastrointestinal Surgery, the responsible nurse first shortly informed eligible patients about the ongoing evaluation study. If the patient approved, more detailed information about the study were given by one of the project workers in both verbal and written form (appendix D). At the Department of Gastrointestinal Surgery, the recruitment was done in the mornings before breakfast so the dietary recording could start immediately after inclusion. At the Department of Hematology, the project workers received a list of eligible patients from the responsible nurse, and the project workers recruited the patients without any further involvement from a nurse. At this department, the patients were recruited the day before the first day of dietary recording.

The final sample consisted of 33 patients, 18 from the Department of Gastrointestinal Surgery and 15 from the Department of Hematology (figure 2). However, one participant from the latter department was excluded from the analyses due to loss of data from the application system (figure 2).

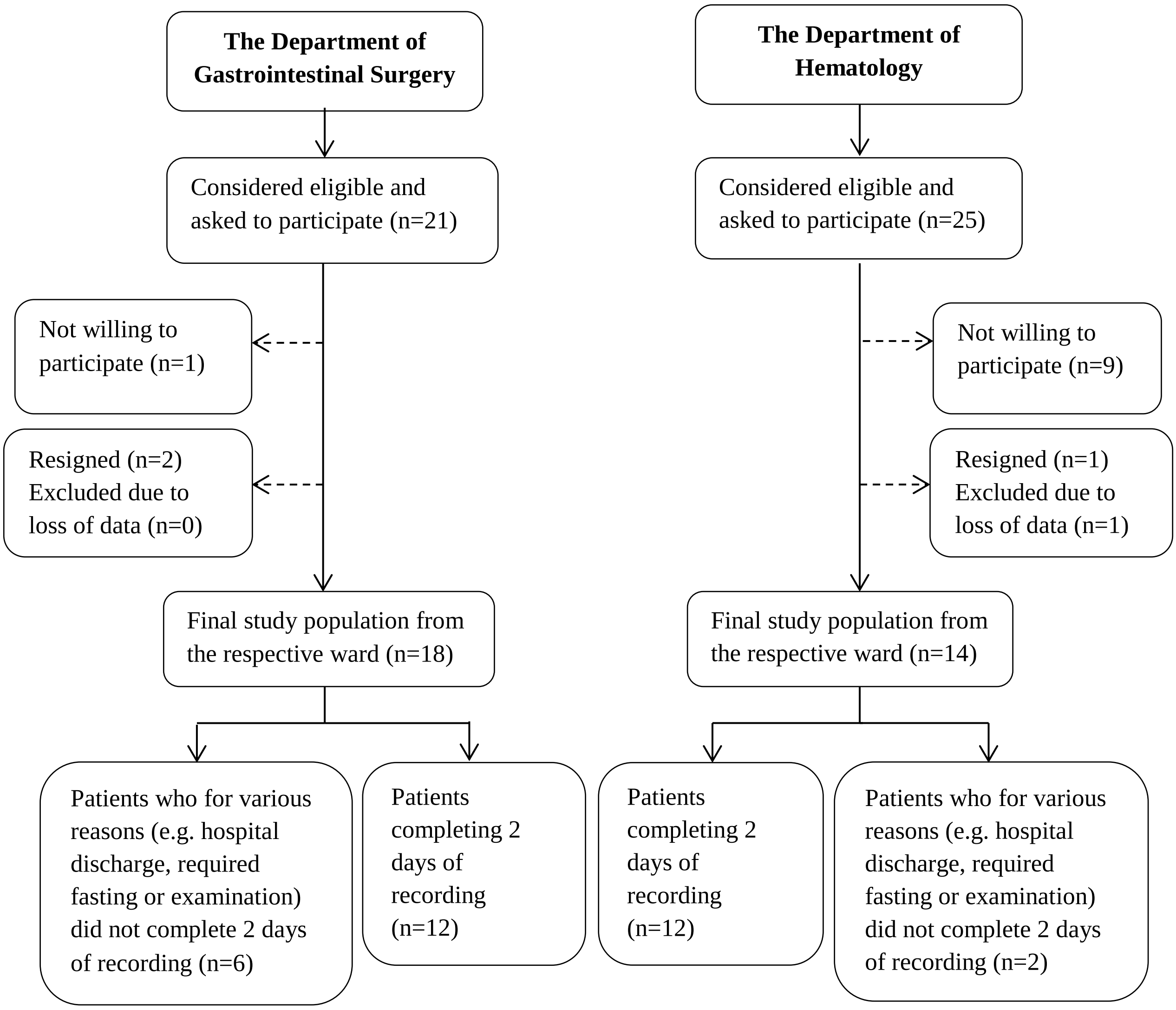

Figure 2. Flowchart of the patient recruitment process

3.5 The dietary assessment system in MyFood

The dietary assessment system to be evaluated in the study consisted of a patient registration part (**figure 3 and 4**), a module for recording of dietary intake (**figure 5a-c**) and a module for automatic evaluation of intake in relation to individually based requirements for energy, protein and liquid (**figure 6**).

3.5.1 Patient registration

Each morning, the study participants received a tablet financed through the project. The tablets were disinfected with surface disinfection on the cover, and with Antibac touchscreen wipes on the screen before given to the patients. For the patients to start their recording of consumed foods and beverages, they had to be registered in the MyFood's system. Patient registration was done either by a nurse (main practice at the Department of Gastrointestinal Surgery) or by one of the project workers (main practice at the Department of Hematology) in the mornings before breakfast. Figure 3 and 4 illustrate the procedure for patient registration, through screenshots from the app. When patients were registered for the first time, an option "Add new user" was selected on the first page in MyFood (figure 3). Required background information for registration of new users is shown in figure 4. The second time the patients were registered (i.e. the second day of dietary recording), the option "Register needs" (figure 3) was chosen, and the following background information were filled in: NPR-number, height, weight, and presence of fever (yes/no). The NPR-number was retrieved from the electronic medical records, while the remaining information (figure 4) were retrieved from the patients themselves or from a blackboard with updated weight- and temperature measurements available at every patient room at the Department of Hematology. After patient registration, the app was ready to use for dietary recording.

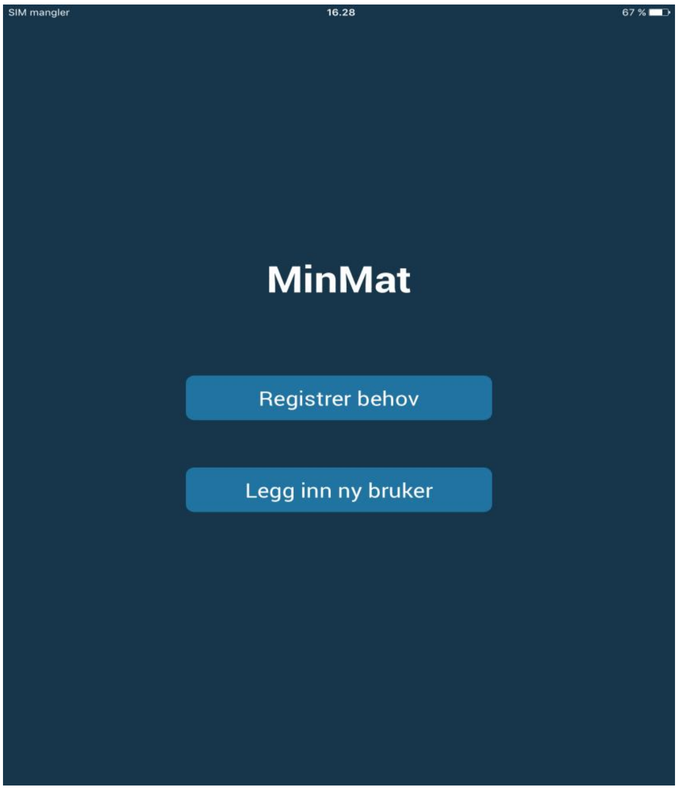

Figure 3. Screenshot of the first page in the application, showing two options for patient registration.

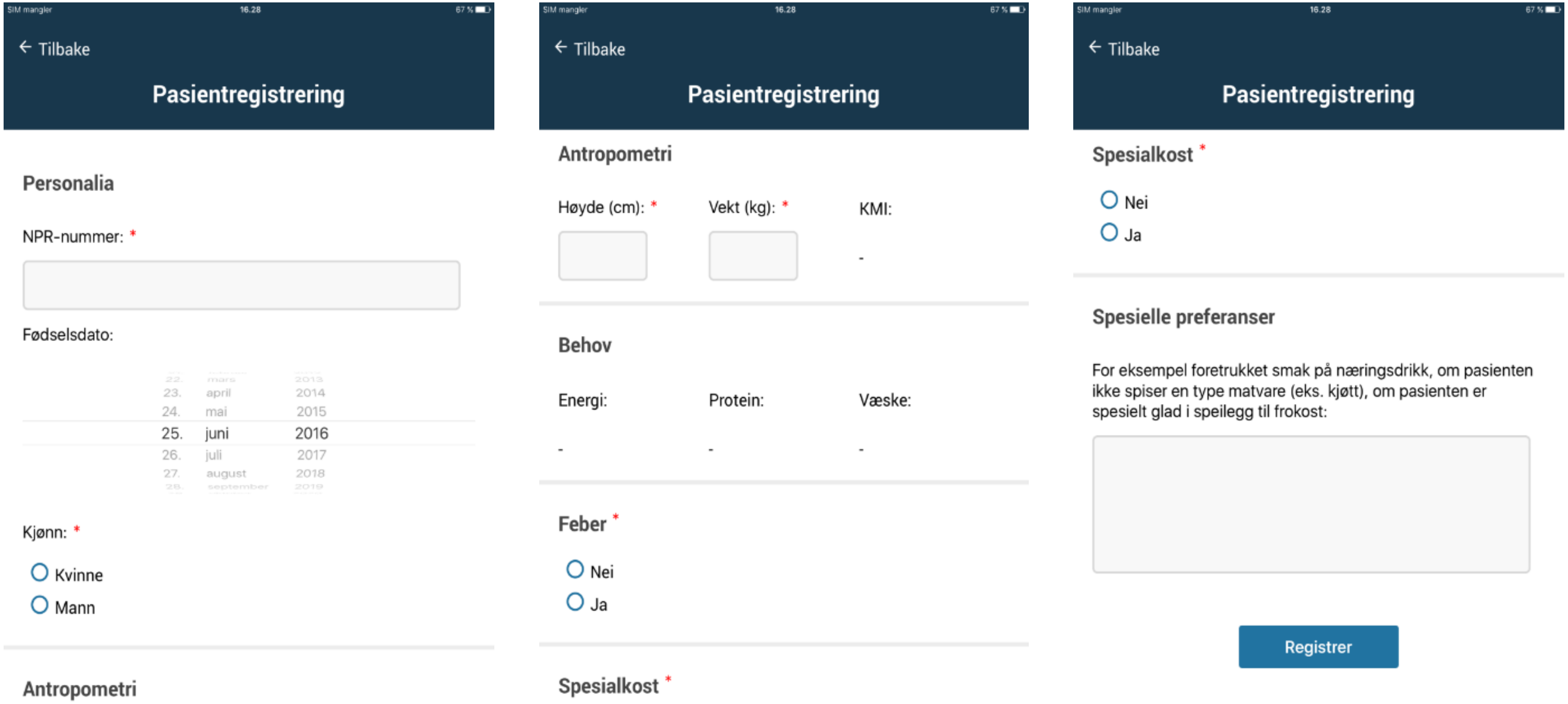

Figure 4. Screenshots of required background information for new users of MyFood.

3.5.2 Dietary recording in MyFood

Written instructions on how to record the dietary intake in MyFood were given to each participant when included in the study (**appendix I**). The patients were instructed to record their dietary intake as soon as possible after meals, to assure the recording to be as precise as possible. They were also informed both verbally and written to only record the intake for breakfast, lunch and dinner.

Figure 5a-c illustrates how MyFood was designed for recording of dietary intake. The patients could touch one category (figure 5a), choose the correct item (figure 5b) and record the amount consumed (figure 5c). The recorded products were shown on an own page called "Today's intake" (figure 5a and figure 6). "Today's intake" did also give an overview of consumed energy, protein and liquid and the percentage reached of individual requirements. Editing of recorded items could also be made from that page (figure 6).

If the participants did not find what they were looking for, they were instructed to record something similar. In cases where the participants did not have the strength to record on their own, either a nurse or the project worker assisted. In the latter case, the project worker recorded what the patient told them to record. Since this was an evaluation study of the dietary assessment system, which is aimed to be used by patients, the project workers were in no position to correct if the patients recorded something wrong or not as precisely as desired if the patient not specifically asked for help.

Figure 5a. Screenshot of the main page for dietary recording.

Figure 5b. Screenshot from the application. The category for breakfast, lunch and supper are chosen and the respective subgroups of foods are displayed.

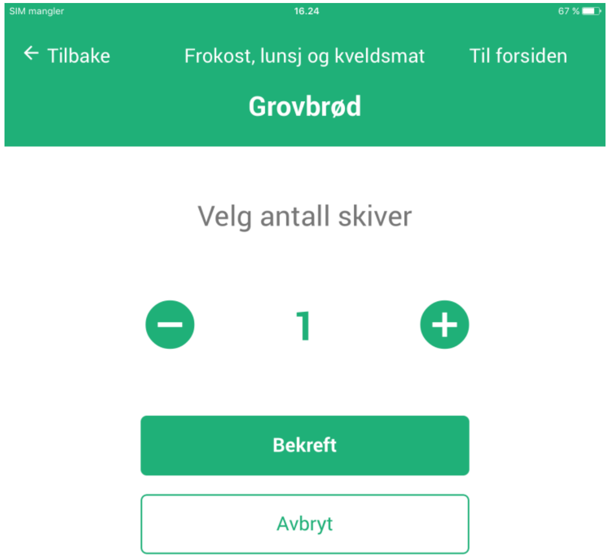

Figure 5c. Screenshot from the application. Bread is chosen and will be recorded when amount is confirmed

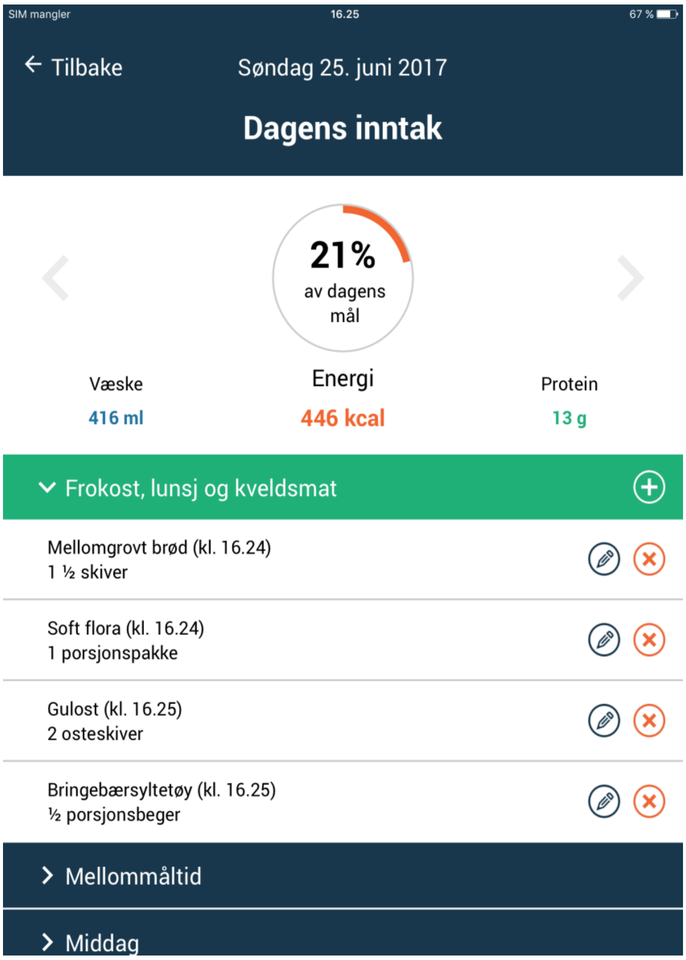

Figure 6. Screenshot from the application, showing "Today's intake".

3.5.3 Retrieving data from the application

All recorded data was encrypted by the program Pretty Good Privacy (PGP) and sent to TSD continuously during the data collection period, see **figure 7** for illustration of the data flow. The registered data were visible in the app until 3 a.m. the following day. The data were later retrieved from TSD, for further sorting and processing (figure 7).

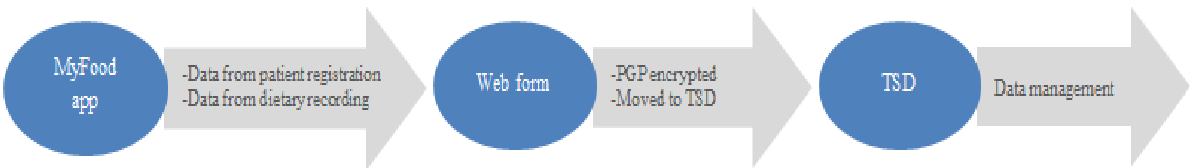

Figure 7. Data flow from the MyFood application.

3.5.4 Nutrient calculation from dietary recording in MyFood

For creating the dietary assessment system in the app, an underlying, comprehensive excel-file was developed by the Ph.D. student. The file includes, among other things, a list of food and beverage products, nutritional values of standard units of the items (energy, protein and liquid) and a list of components in hospital dinners. Intake of energy, protein and liquid was automatically calculated by MyFood based on algorithms, containing information about nutritional content in standard units of the recorded items (e.g. a slice of bread, one glass of milk, a full dinner portion, components of a dinner portion).

3.6 Observations by meal photography

Digital photography of the patients' meals, combined with partial weighing of meal components, was chosen as a reference method to evaluate the accuracy of the electronic dietary assessment system in MyFood.

3.6.1 Photography procedure

The meals were photographed using a digital video camera (Sony Alpha a5000) mounted on a tripod attached to a trolley. The camera lens was approximately 0.6 m above the trolley, and the camera was attached with an angle of approximately 45° looking down at the meals, making it possible to see the depth of the foods (see **figure 8** for an illustration of the photography method). This camera position is found to be common in other studies using digital photography as a reference method (68, 72, 76, 86, 87). Tape was used on the trolley to mark where the tray should be placed in order to take standardized photographs. A post-it note marked with participant number and a 30 cm ruler as an internal reference of size were placed on the tray or within the marked area before each photograph was taken (figure 8). In addition to photographing the trays, dietary products (e.g. beverages, plates, bowels and food products in separate packaging) were weighed separately on an electronic scale (OBH NORDICA, with a precision of ±1g), to increase the precision of portion size estimations.

The surface of the trolley and the electronic scale were disinfected each morning (as a minimum). The trolley was placed in the hallway close to the kitchen, and the project workers brought the camera and all the existing forms and papers back and forth to the trolley.

Figure 8. Illustration of the photography method.

To each meal, the project worker on duty filled out a meal form (appendix F), in which provided information about the dietary items in the photographed meal, including type and weight, both before and after consumption. The participants were instructed to not remove anything from the tray after the meal, like empty packaging or wrapping. If the patients had supplied with additional food and/or beverage during the meal (not captured on the before-photograph), this was noted in the meal form, based on the patients' description of type and amount (see appendix F).

A form including participant number, dates for recording days and the agreed times and meeting points for upcoming meals was filled out for each patient for an overview (**appendix J**).

3.6.2 Dietary calculations from photographs

Each day, the photographs were transferred to a computer, organized in folders and stored in a domain accessible for both project workers. Dietary items and portion size estimations of consumed amount were manually coded in KBS by each of the two projects workers independently from each other, for calculation of energy-, protein- and liquid intake. Some hospital recipes for dishes, sauces, desserts, etc., were added in KBS manually if there were no products with similar nutritional values in the software program.

3.7 Statistical analyses

3.7.1 Preparation of data to be analyzed

Handling of files from TSD (MyFood) and KBS (photography method), and elaboration and processing of the final data files, were done independently by the project workers. This was done to strengthen the procedure and minimize errors, as typing- or calculation errors were detected and corrected when the data files were compared.

Data from TSD (MyFood)

Data from TSD regarding patient characteristics and dietary recordings were presented in several web forms. Manually handling and sorting of the forms were performed, leading to a final data file from the application, which included patients' recordings of foods and beverages to each meal, and summations of total intake of energy, protein and liquid in each meal and total intake each day. Items recorded in MyFood beside the main meals of interest were deleted from the file.

When handling the data from TSD, it was found that one of the participants had been erroneous included, as the participant was only 17 years old. Despite that age <18 was an exclusion criterion, the participant was still included in the data analyses, as removing the participant from the trial was considered more unethical as his work effort would be for nothing. Unfortunately, one participant had to be excluded from the analyses because the data recorded in MyFood were not sent to TSD due to a short-term technical problem, which was later fixed by USIT. In addition, two meals from a patient were excluded from the analysis, as communication problems and misunderstanding resulted in no dietary recordings by the patient in MyFood.

Data from KBS (photography method)

The two project workers' estimations of energy-, protein- and liquid intake from meal photographs were examined. In order to make an average of the values from the two project workers' files, the pairwise observations for each meal had to match each other with a ratio of at least 0.85, as described in other studies (79, 85). If the interobserver ratio for energy, protein and/or liquid was below 0.85 in a meal, the photographs and typing in KBS were re-checked. Obvious typing mistakes were corrected by the respective project worker, while in cases where the project workers had estimated different amounts, the photographs were re-checked and the project workers agreed in where to adjust the estimated amounts (in grams) in KBS. After corrections, the total interobserver agreement for energy, protein and liquid were 0.97, 0.98 and 0.98, respectively, and a final data file from KBS was produced by averaging the projects workers' estimates.

Final data files

In total, three data files were developed:

1) A main SPSS file with data from 32 subjects. The file included participant characteristics, the participants' reported user experiences from dietary recording in MyFood, and the participants' intake of energy, protein and liquid in total and from the three recorded meals, estimated by the two dietary assessment methods (MyFood and photography method).

2) A file with all recordings from the two methods organized within different food groups. All intake estimations within a food group belonging to the same participant were summarized. This file was developed in order to examine the capability of MyFood to estimate consumed amount within food groups.

3) A file with all recordings from the two methods organized within different food groups, with participants' missing- and double recordings in MyFood excluded. This file was developed in retrospect of the initial analyses. It was suspected that missing recordings of consumed foods possibly neutralized a systematic overestimation by MyFood that was caused by too large standard portion sizes in the system. Therefore, a recording from the photography method was deleted in cases where the participant had forgotten to record the consumed item in MyFood. If the participant had recorded an item twice, then one of the two recordings were deleted from the MyFood data. This file was developed in order to investigate portion sizes of foods in the MyFood application, without patients' missing- or double recordings to influence the relationship to the reference method

3.7.2 Processing and presentation of data

Statistical analyses were performed using the statistical software IBM SPSS Statistics 24. All tests were two-sided, and the level of statistical significance was set to $p<0.05$.

Categorical data are presented as frequencies (n) and relative frequencies (%). Most of the non-normally distributed variables could not be corrected by log transformation; therefore, normally distributed continuous variables are presented as mean and standard deviation (SD), while non-normally distributed variables are presented as median and the respective 25^{th}-75^{th} percentiles. To analyze the mean differences in estimations of energy, protein and liquid between the two methods for dietary recording, the parametric paired samples T-Test was performed in cases of normally distributed variables, while the non-parametric two-related Wilcoxon Signed Rank Test was performed for variables with non-normal distribution. Considerations of normality were based on Shapiro-Wilk normality tests, histograms, normal Q-Q Plots and detrended normal Q-Q Plots.

The accuracy of the MyFood application in estimating intake of energy, protein and liquid was calculated by expressing the ratio app:photography (i.e. estimated intake in relation to observed intake), for which a value of 1 would mean complete agreement between the two methods. Cut-off values for the ratio app:photography were used to categorize the recordings in MyFood from the 32 participants as acceptable estimations (AE), underestimations (UE) and overestimations (OE). The range for AE was from 0.80 to 1.20, UE was defined as app:photography < 0.80, and OE as app:photography > 1.20. However, since this thesis aims to evaluate MyFood's accuracy on an individual level, the referred cut-offs for acceptable estimations are considered quite broad, and therefore, the estimations were also categorized with a narrower limit for AE: 0.90 < app:photography < 1.10. These relatively broad and narrow cut-off values were described in an article by Carlsen and colleagues, evaluating energy intake estimated by a food frequency questionnaire in relation to energy expenditure measured by a position-and-movements monitor (73).

To investigate the agreement between estimations of energy-, protein- and liquid intake from the MyFood application and the photography method, Bland-Altman plots and drop-line plots were created. In the Bland-Altman plots, the differences (MyFood application – photograph observations) (y-axis) were plotted against the mean of the two methods' estimations (x-axis). Three vertical lines are presented in each plot, representing the average difference between the two estimations (middle line), and the limits of agreement (mean difference ± 1.96 times the SD). The limits of agreement present the intervals in which 95% of the differences between the methods is likely to lie within if the differences are normally distributed (88). However, a majority of the difference-variables in our data were not normally distributed, which should be verified for use of Bland-Altman plots (88-90). The Bland-Altman plots are valuable to reveal systematic under- or overestimations and to spot trends. The plots were included in this thesis to give a depicted overview of the scattering of differences between the methods, as a supplement to the information retrieved from the drop-line plots. The drop-line plots illustrate the intake (i.e. energy, protein or liquid) for each individual participant, estimated with the MyFood application and the photography method, respectively. For this reason, this plot is considered more informative on individual level.

The app's accuracy in recording different foods and beverages were analyzed using paired sample T-Tests or two-related Wilcoxon Signed Rank Tests, depending on the nature of distribution for the respective variables compared. The agreement between the methods within different food groups was inspected and illustrated by use of drop-line plots. In addition to evaluate the accuracy of MyFood in estimating correct amount of foods and beverages based on the crude dietary data, the investigation was also done on the dietary data after exclusion of the participants' missing- and double recordings (see section 3.7.1).

4 Results

4.1 Subject characteristics

In total, 33 patients participated in the study, whereof analyses were done from 32 patients. The subjects' average age was 51.5 years (±13.9), ranging from 17 to 77 years. From the Department of Gastrointestinal Surgery, there were 15 males and 3 females, while gender was equally distributed among the participants from the Department of Hematology, with 7 males and 7 females. The mean BMI among the participants was 26.6 (±4.9 SD) kg/m^2 at the Department of Gastrointestinal Surgery and 24.0 (±3.0 SD) kg/m^2 at the Department of Hematology. Experiences with use of applications were reported by 91% of the study participants. Subject characteristics are outlined in **table 1.**

Table 1. Subject characteristics (n=32).

Characteristics	Frequency, n (%)
Age, years[a)]	
17-35	5 (16.1)
36-50	8 (25.8)
51-65	14 (45.2)
> 65	4 (12.9)
Sex	
Male	22 (68.8)
Female	10 (31.3)
Department	
Gastrointestinal Surgery	18 (56.3)
Hematology	14 (43.8)
Social Status	
Living alone	5 (15.6)
Living with partner, without kids	11 (34.4)
Living with partner and kids	12 (37.5)
Other	4 (12.5)
Education[b)]	
Low	4 (12.5)
Medium	16 (50.0)
High	12 (37.5)
App experience	
None/little	3 (9.4)
Some	9 (28.1)
A lot	20 (62.5)

a) n=31

b) Low = elementary school (<11 years). Medium = high school to college (11-14+ years). High = university college to university degree (14-18+ years).

4.2 Comparison of the two methods' estimated intakes of energy, protein and liquid

4.2.1 Group level

Table 2 presents an overview of the 32 subjects' mean/median intake of energy, protein and liquid in total and within the respective three main meals, recorded by the subjects in MyFood and estimated by the project workers from photograph observations. The 32 subjects recorded a total of 28 breakfasts, 27 lunches and 26 dinners. No overall difference between the two methods was found when comparing estimations for total intake of energy, protein and liquid (table 2). However, the borderline significant p-value for protein may indicate a trend for underestimation of protein intake on the group level by MyFood (table 2). Looking at the meals separately revealed that the app underestimated the participants' intake of protein for breakfast and lunch (table 2). No difference between the methods was observed regarding the estimation of protein intake for dinner, and of energy intake for breakfast, lunch and dinner (table 2). Regarding recording of liquid, MyFood underestimated the intake for breakfast, while for lunch and dinner, there was correspondence between estimations from MyFood and the reference method (table 2).

Table 2. Subjects' mean/median intake of energy, protein and liquid in total[a)] and subdivided into meals, estimated by MyFood and from photograph observations.

	MyFood application, mean (SD)[b)]/median (25-75p)[c)]	**Photograph observations,** mean (SD)[b)]/median (25-75p)[c)]	**p-value** [d)]
Energy, kcal			
Total[a)] (n=32)	1040 (566-1541)	951 (446-1495)	0.09
Breakfast (n=28)	471 (294)	458 (298)	0.52
Lunch (n=27)	408 (215)	382 (211)	0.12
Dinner (n=26)	473 (285-717)	487 (216-576)	0.34
Protein, g			
Total[a)] (n=32)	35.0 (17.0-45.6)	38.4 (14.0-62.1)	0.05
Breakfast (n=28)	**13.5 (6.4-23.5)**	**14.3 (6.9-27.7)**	**0.02**
Lunch (n=27)	**13.0 (9.3)**	**14.6 (10.2)**	**<0.01**
Dinner (n=26)	14.6 (4.5-20.5)	14.4 (5.9-23.6)	0.28
Liquid, ml			
Total[a)] (n=32)	787 (416)	810 (466)	0.54
Breakfast (n=28)	**292 (153)**	**339 (186)**	**0.03**
Lunch (n=27)	287 (143)	285 (151)	0.89
Dinner (n=26)	356 (210)	334 (166)	0.42

a) Total recorded intake from breakfast, lunch and dinner

b) Normally distributed variables are presented as mean (standard deviation)

c) Non-normally distributed variables are presented as median (25^{th} -75^{th} percentiles)

d) Paired samples T-Test for normally distributed variables, Wilcoxon Signed Rank Test for non-normally distributed variables

Bold numbers represent statistical significant difference between the methods, $p<0.05$

4.2.2 Individual level

The following three sections describe the agreement at the individual level between the MyFood application and the photography method for estimated intake of energy, protein and liquid.

Energy

An overview of the number of participants with energy intake estimations from MyFood categorized as acceptable estimations (AE), underestimations (UE) and overestimations (OE) when compared to the reference method is presented in **figure 9**. For total energy intake, AE were found for 21 participants (66%), UE for three participants (9%), and OE for eight participants (25%). When the range of acceptable estimations was narrowed, the number of participants with OE increased (n=14, 44%) (figure 9). The number of participants with acceptable estimations from MyFood for breakfast, lunch and dinner were 22 (79%), 16 (59%) and 14 (54%), respectively (figure 9).

Drop-line plots and Bland-Altman plots are presented in **figure 10a-d**, representing the energy intake in total and for breakfast, lunch and dinner, respectively. The plots for total energy intake reveal no clear trends for overestimation or underestimation of energy intake by MyFood (figure 10a). The limits of agreement in the Bland-Altman plot for total energy intake estimated an interval of -533 kcal to 648 kcal, which indicates that the MyFood application may estimate as much as 533 kcal below or 648 kcal above the reference, photography method. The differences between the methods for energy intake in total and from breakfast and dinner increased with increasing intake, shown as a fan-shaped distribution of the dots in the Bland-Altman plots (figure 10a, b, d). No such pattern was seen from the recordings of lunch (figure 10c).

The two greatest differences between the methods' estimations of energy intake in total amounted -994 kcal and 747 kcal (MyFood – photography method) (figure 10a). The greatest differences in energy intake for breakfast were 413 kcal and -182 kcal (figure 10b). For lunch, MyFood estimated 231 kcal more than the photography method at the most (figure 10c), while the plots for dinner presents the two largest differences at 710 kcal and -663 kcal (figure 10d).

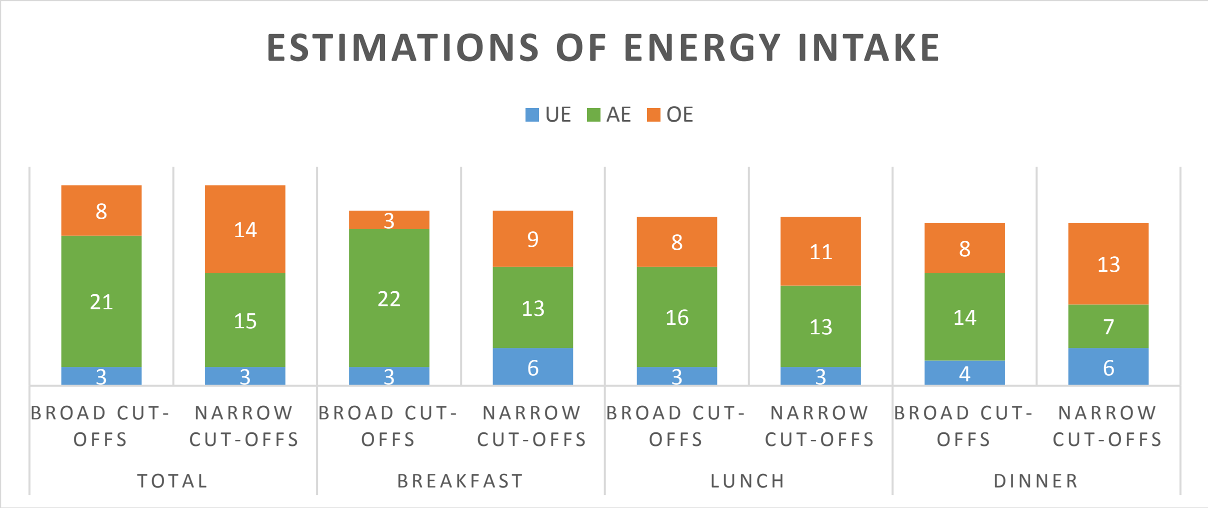

Figure 9. An overview of the number of participants with energy intake estimations from MyFood categorized as acceptable estimations (AE), underestimations (UE) and overestimations (OE), based on two different cut-off values for acceptable ratio of app:photography.
<u>Definitions of broad cut-offs:</u>
UE: app:photography < 0.8. AE: 0.8 < app:photography < 1.2. OE: app:photography > 1.2.
<u>Definitions of narrow cut-offs:</u>
UE: app:photography < 0.9. AE: 0.9 < app:photography < 1.1. OE: app:photography > 1.1.

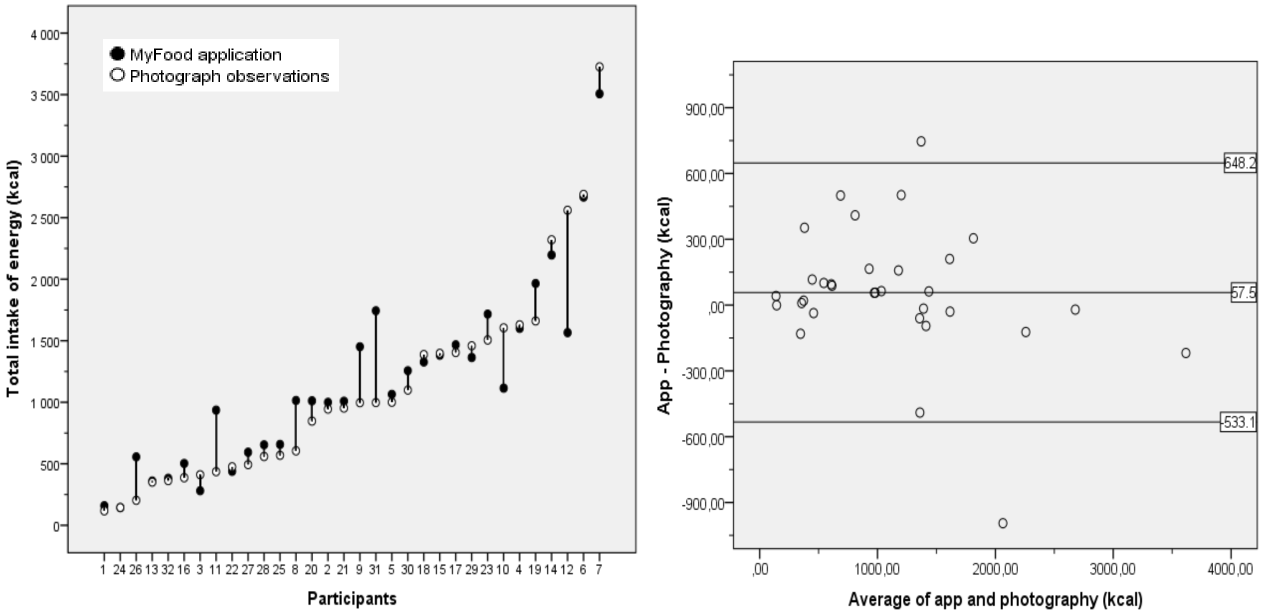

Figure 10a. Total energy intake.
Left: Drop-line plot demonstrating the total energy intake (y-axis) for every participant (x-axis) after one day of dietary recording for breakfast, lunch and dinner, estimated from MyFood and photograph observations. Similar amounts were estimated from both methods in cases where only a white dot is shown.
Right: Bland-Altman plot for estimations of total energy intake. The difference between the two methods (app – photography) (y-axis) is plotted against the mean of the estimations (x-axis). Middle line represents mean difference; upper and lower line represents the limits of agreement, defined as mean difference ± 1.96 times the SD.

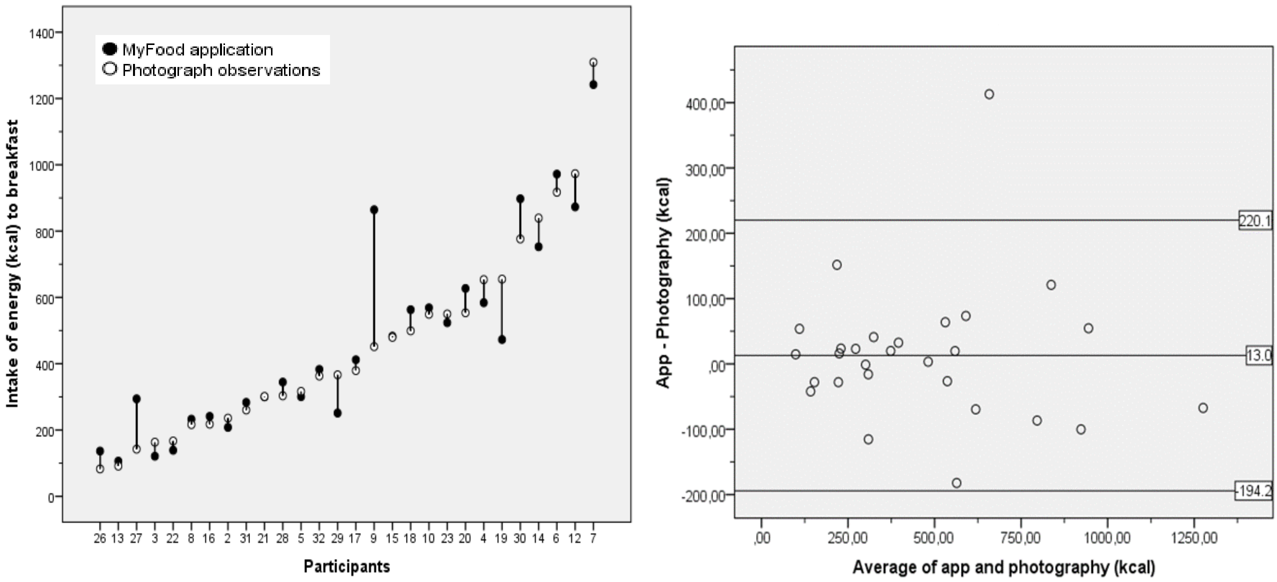

Figure 10b. Energy intake for breakfast.
Left: Drop-line plot demonstrating energy intake for breakfast (y-axis) for every participant (x-axis) estimated from MyFood and photograph observations. Similar amounts were estimated from both methods in cases where only a white dot is shown.
Right: Bland-Altman plot for estimations of energy intake for breakfast. The difference between the two methods (app – photography) (y-axis) is plotted against the mean of the estimations (x-axis). Middle line represents mean difference; upper and lower line represents the limits of agreement, defined as mean difference ± 1.96 times the SD.

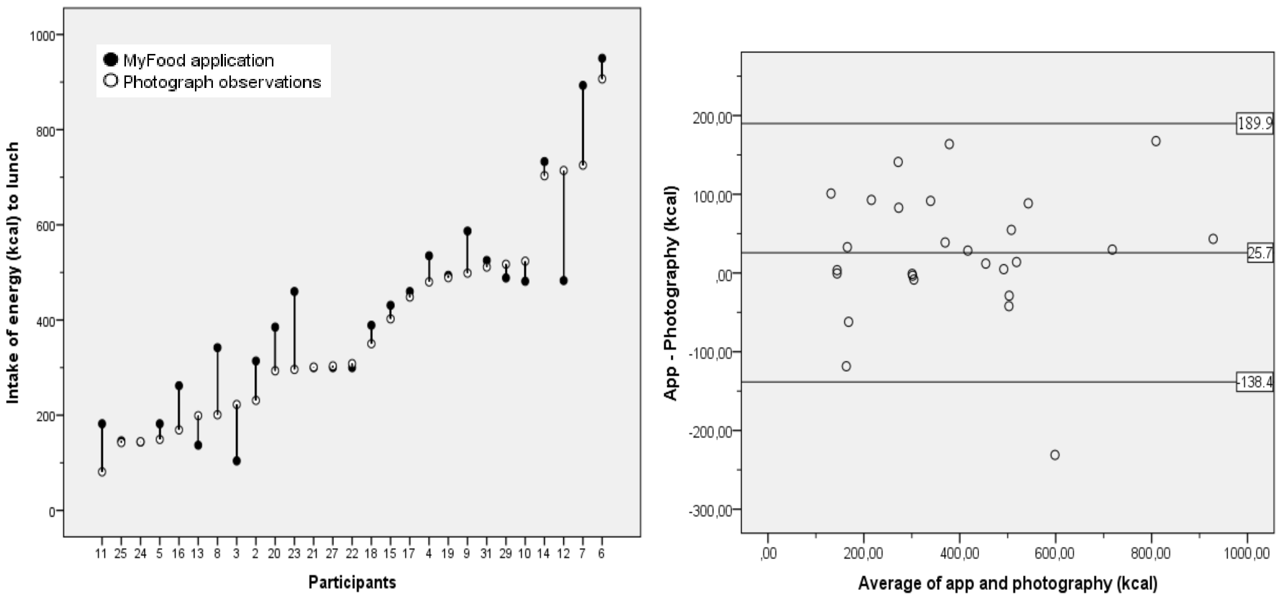

Figure 10c. Energy intake for lunch.
Left: Drop-line plot demonstrating energy intake for lunch (y-axis) for every participant (x-axis) estimated from MyFood and photograph observations. Similar amounts were estimated from both methods in cases where only a white dot is shown.
Right: Bland-Altman plot for estimations of energy intake for lunch. The difference between the two methods (app – photography) (y-axis) is plotted against the mean of the estimations (x-axis). Middle line represents mean difference; upper and lower line represents the limits of agreement, defined as mean difference ± 1.96 times the SD.

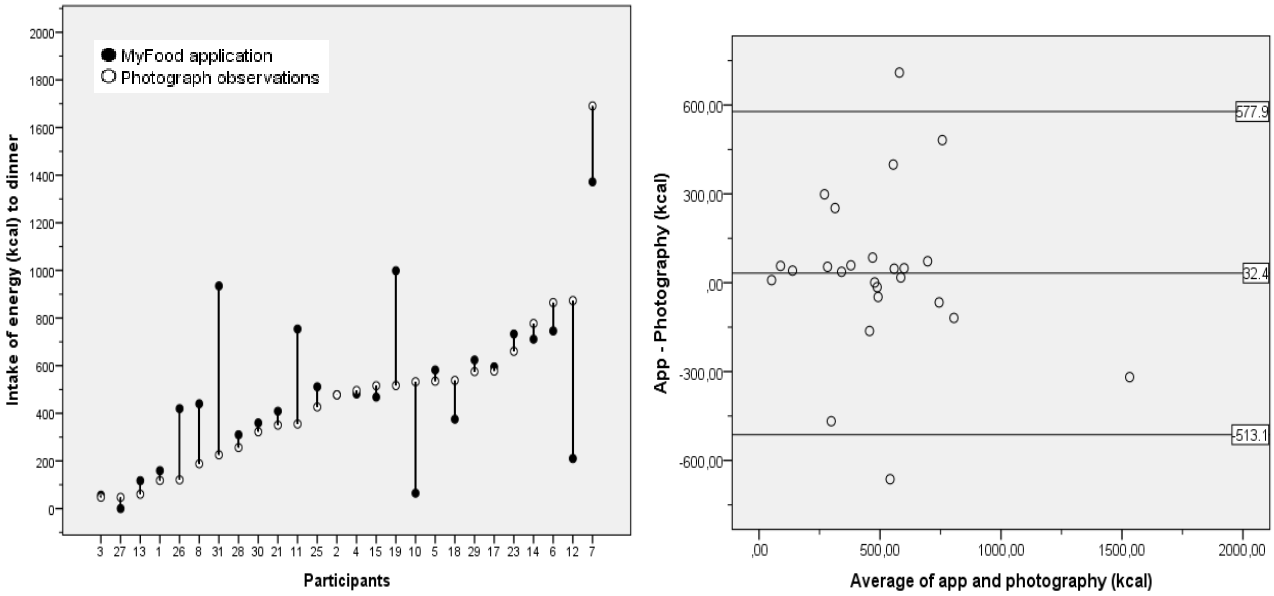

Figure 10d. Energy intake for dinner.
Left: Drop-line plot demonstrating energy intake for dinner (y-axis) for every participant (x-axis) estimated from MyFood and photograph observations. Similar amounts were estimated from both methods in cases where only a white dot is shown.
Right: Bland-Altman plot for estimations of energy intake for dinner. The difference between the two methods (app – photography) (y-axis) is plotted against the mean of the estimations (x-axis). Middle line represents mean difference; upper and lower line represents the limits of agreement, defined as mean difference ± 1.96 times the SD.

Protein

The number of participants with protein intake estimations from MyFood categorized as AE, UE and OE when compared to the reference method is presented in **figure 11**. Regarding total protein intake, AE were found for 21 participants (65%), UE for five participants (16%), OE for six participants (19%) (figure 11). The number of participants with acceptable estimations from MyFood for breakfast, lunch and dinner was 18 (64%), 20 (74%) and 12 (46%), respectively (figure 11). Figure 11 shows that narrowing the cut-offs for acceptable estimations mainly led to increased number of participants with UE of protein intake.

Drop-line plots and Bland-Altman plots are presented in **figure 12a-d**, representing protein intake in total and for breakfast, lunch and dinner, respectively. No systematic trends in the scattering of differences were seen in the Bland-Altman plot for total protein intake, and the limits of agreement ranged from -31 g to 23 g (figure 12a). The plots for protein intake for breakfast and lunch visualizes that MyFood more often underestimated the protein intake compared to the reference method, as a majority of the dots in the Bland-Altman plots lies below the zero-value on the y-axis (figure 12b and c). For breakfast, the degree of underestimations seemed to change in a linear fashion, as greater negative differences were observed with increasing intake (figure 12b). For dinner, the scattering of differences increased in both a negative and a positive manner with increasing intake, meaning that protein intake was both overestimated and underestimated in MyFood (figure 12d).

The two greatest differences between the methods' estimations of total protein intake amounted 51.0 g and 39.3 g (MyFood – photography method) (figure 12a). The greatest differences in protein intake for breakfast were -14.6 g and -10.5 g (figure 12b). For lunch, the greatest differences amounted -9.0 g and -4.9 g (figure 12c), while 34 g less were estimated by MyFood from two participants for dinner (figure 12d).

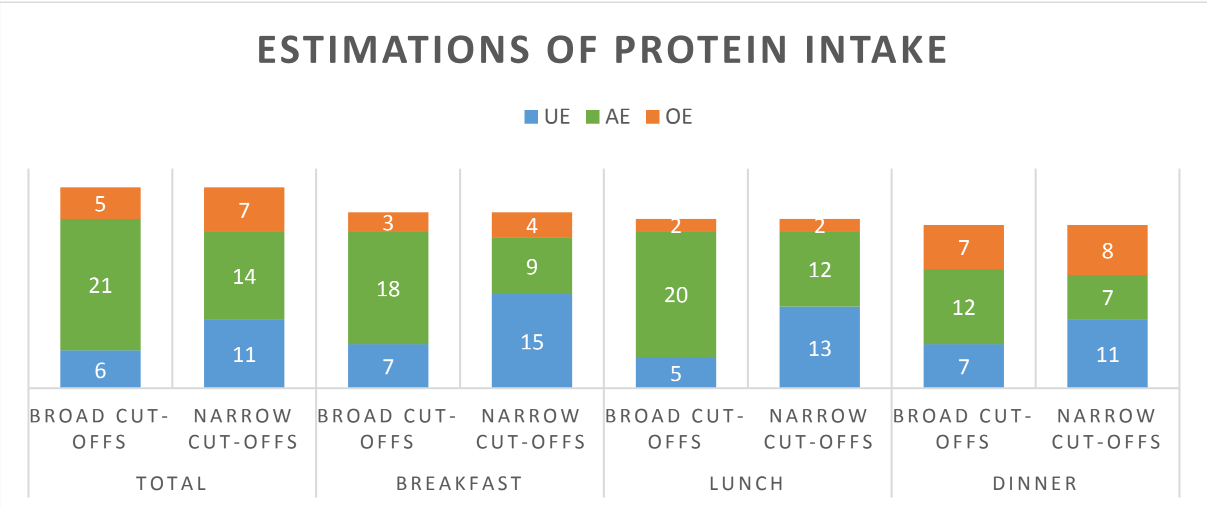

Figure 11. An overview of the number of participants with protein intake estimations from MyFood categorized as acceptable estimations (AE), underestimations (UE) and overestimations (OE), based on two different cut-off values for acceptable ratio of app:photography.
<u>Definitions of broad cut-offs:</u>
UE: app:photography < 0.8. AE: 0.8 < app:photography < 1.2. OE: app:photography > 1.2.
<u>Definitions of narrow cut-offs:</u>
UE: app:photography < 0.9. AE: 0.9 < app:photography < 1.1. OE: app:photography > 1.1.

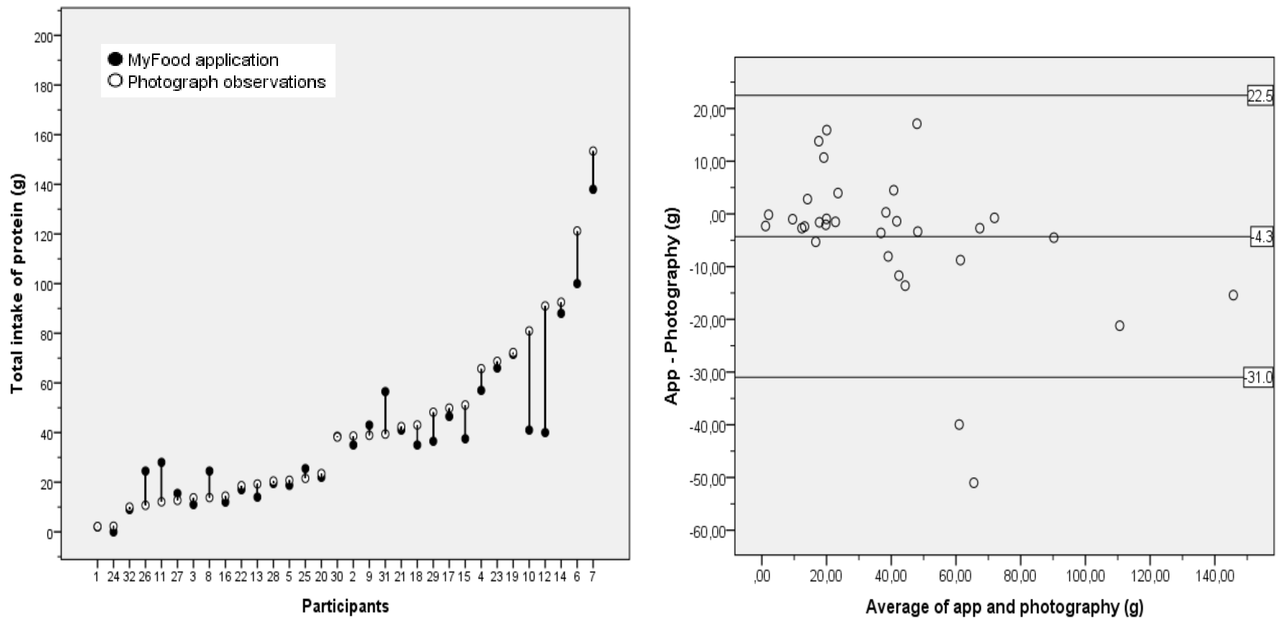

Figure 12a. Total protein intake.
Left: Drop-line plot demonstrating the total protein intake (y-axis) for every participant (x-axis) after one day of dietary recording for breakfast, lunch and dinner, estimated from MyFood and photograph observations. Similar amounts were estimated from both methods in cases where only a white dot is shown.
Right: Bland-Altman plot for estimations of total protein intake. The difference between the two methods (app – photography) (y-axis) is plotted against the mean of the estimations (x-axis). Middle line represents mean difference; upper and lower line represents the limits of agreement, defined as mean difference ± 1.96 times the SD.

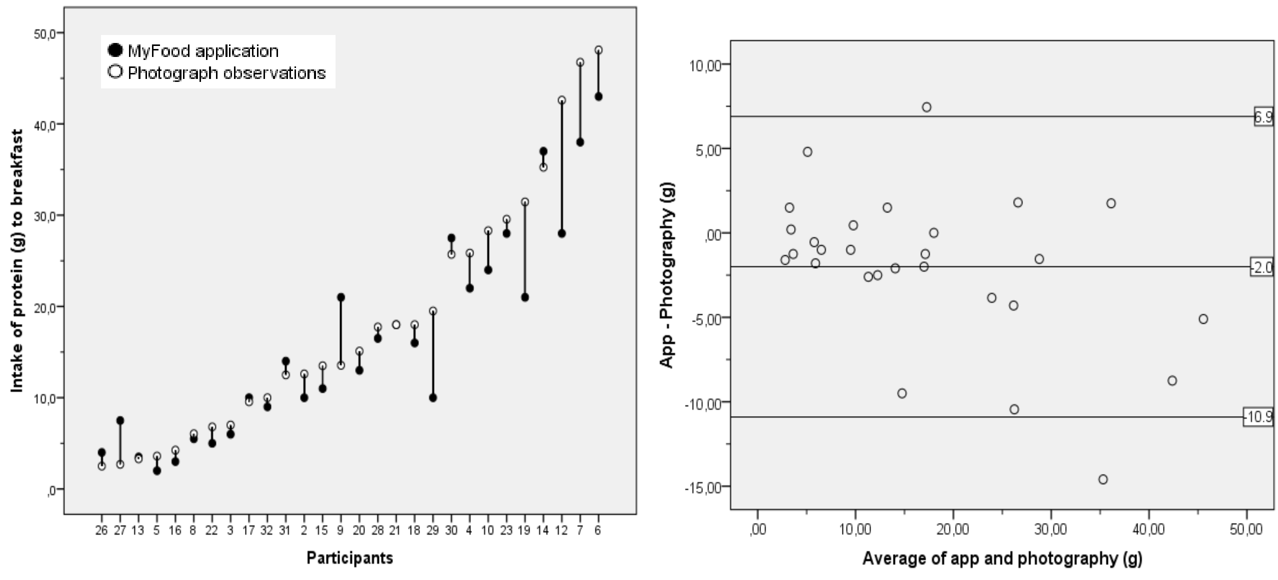

Figure12b. Protein intake for breakfast.
Left: Drop-line plot demonstrating protein intake for breakfast (y-axis) for every participant (x-axis) estimated from MyFood and photograph observations. Similar amounts were estimated from both methods in cases where only a white dot is shown.
Right: Bland-Altman plot for estimations of protein intake for breakfast. The difference between the two methods (app – photography) (y-axis) is plotted against the mean of the estimations (x-axis). Middle line represents mean difference; upper and lower line represents the limits of agreement, defined as mean difference ± 1.96 times the SD.

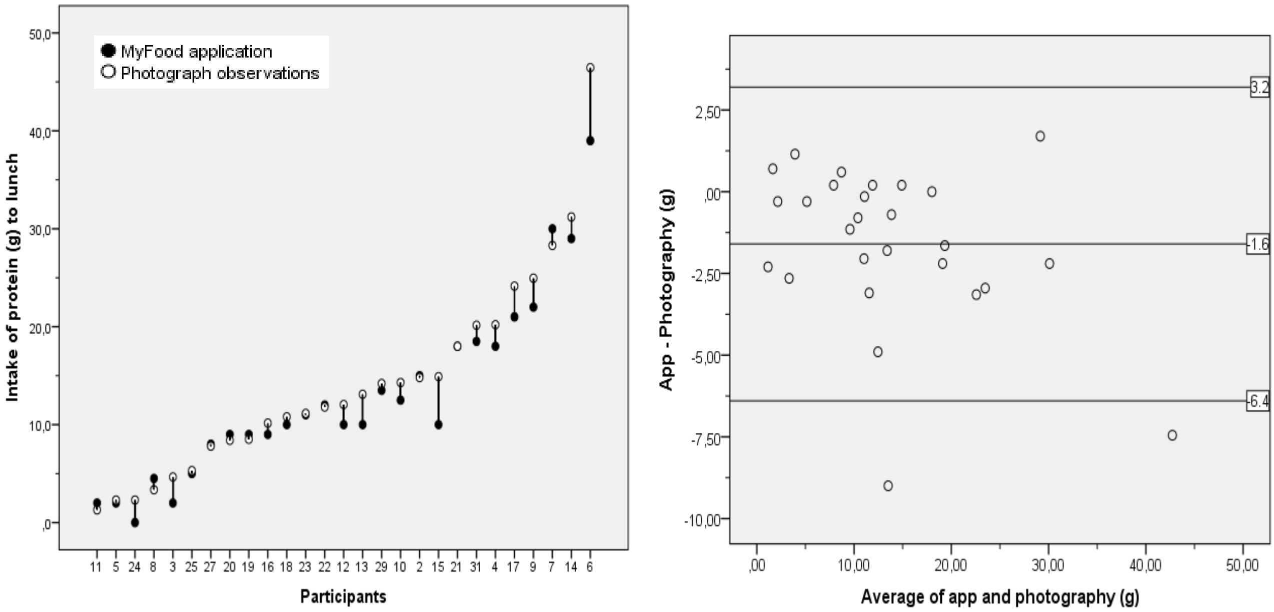

Figure 12c. Protein intake for lunch.
Left: Drop-line plot demonstrating protein intake for lunch (y-axis) for every participant (x-axis) estimated from MyFood and photograph observations. Similar amounts were estimated from both methods in cases where only a white dot is shown.
Right: Bland-Altman plot for estimations of protein intake for lunch. The difference between the two methods (app – photography) (y-axis) is plotted against the mean of the estimations (x-axis). Middle line represents mean difference; upper and lower line represents the limits of agreement, defined as mean difference ± 1.96 times the SD.

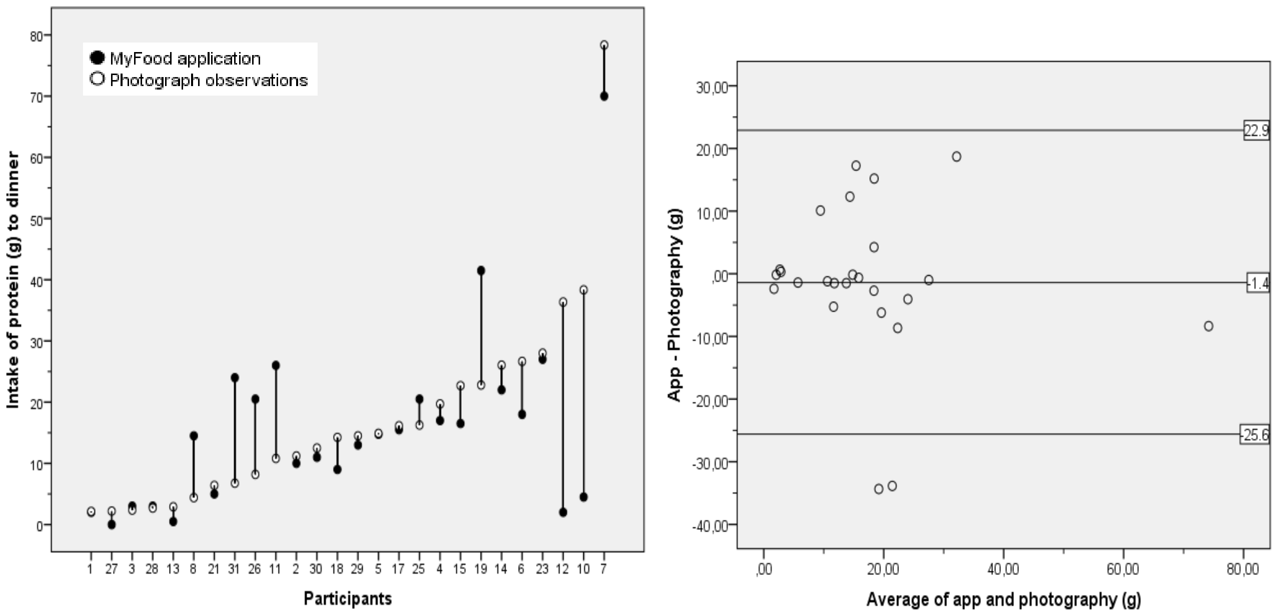

Figure 12d. Protein intake for dinner.
Left: Drop-line plot demonstrating protein intake for dinner (y-axis) for every participant (x-axis) estimated from MyFood and photograph observations. Similar amounts were estimated from both methods in cases where only a white dot is shown.
Right: Bland-Altman plot for estimations of protein intake for dinner. The difference between the two methods (app – photography) (y-axis) is plotted against the mean of the estimations (x-axis). Middle line represents mean difference; upper and lower line represents the limits of agreement, defined as mean difference ± 1.96 times the SD.

Liquid

The number of participants with liquid intake estimations from MyFood categorized as AE, UE and OE when compared to the reference method is presented in **figure 13**. For total liquid intake, AE were found for 22 participants (69%), UE for four participants (13%) and OE for six participants (19%). Within the meals, AE were found for 19 participants (68%) from breakfast, 17 (63%) from lunch and 13 (50%) from dinner (figure 13). Investigation within the meals, revealed that UE were more frequent for breakfast recordings, while OE were more frequent for dinner recordings. Narrowed cut-offs for acceptable estimations mainly resulted in an increased number of participants with UE for breakfast and lunch, while for dinner, the number of OE increased (figure 13).

Drop-line plots and Bland-Altman plots are presented in **figure 14a-d**, representing liquid intake in total and for breakfast, lunch and dinner, respectively. The limits of agreement for total liquid intake ranged from -428 ml to 387 ml (figure 14a). A higher level of both under- and overestimations with increasing intake of liquid was seen for the total intake (figure 14a) and for lunch (figure 14c) and dinner (figure 14d), visible as a fan-shaped distribution of the dots in the Bland-Altman plots. For breakfast, the differences in estimations between the two methods were fairly equal with increased intake of liquid, and the plots show that the liquid intake was especially underestimated in MyFood for three participants (figure 14b).

The two greatest differences between the methods in estimations of total liquid intake were observed to be -822 ml and -415 ml (MyFood – photography method) (figure 14a). The three distinct underestimations of liquid intake for breakfast in MyFood ranged from -211 to -424 ml (figure 14b). For lunch, the two greatest discrepancies between the methods amounted 162 ml and -146 ml (figure 14c), while for dinner, MyFood estimated an intake of 341 ml less and 326 ml more than the photography method at the most (figure 14d).

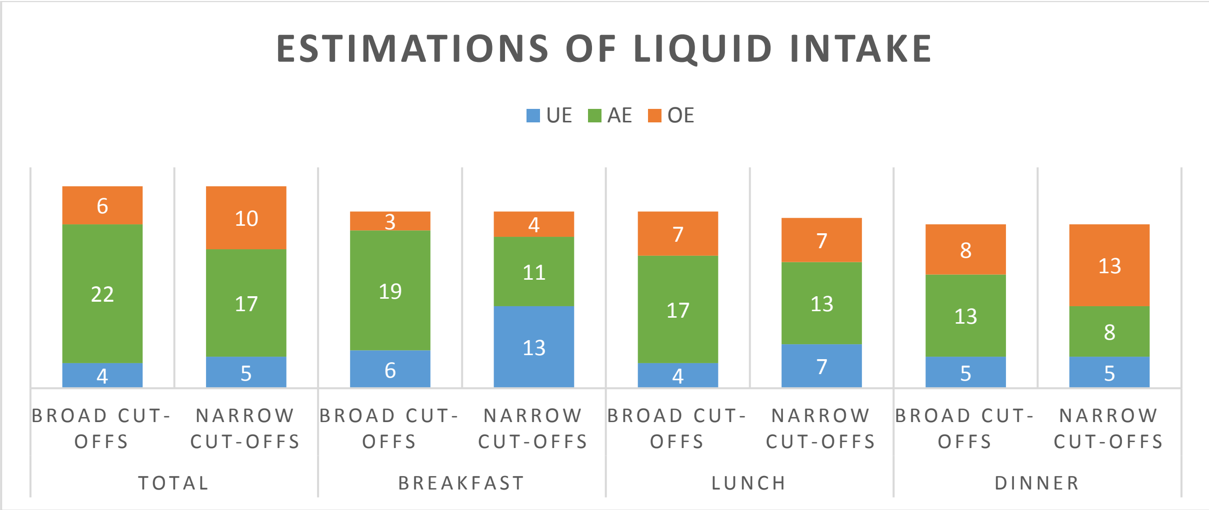

Figure 13. An overview of the number of participants with liquid intake estimations from MyFood categorized as acceptable estimations (AE), underestimations (UE) and overestimations (OE), based on two different cut-off values for acceptable ratio of app:photography.

<u>Definitions of broad cut-offs:</u>

UE: app:photography < 0.8. AE: 0.8 < app:photography < 1.2. OE: app:photography > 1.2.

<u>Definitions of narrow cut-offs:</u>

UE: app:photography < 0.9. AE: 0.9 < app:photography < 1.1. OE: app:photography > 1.1.

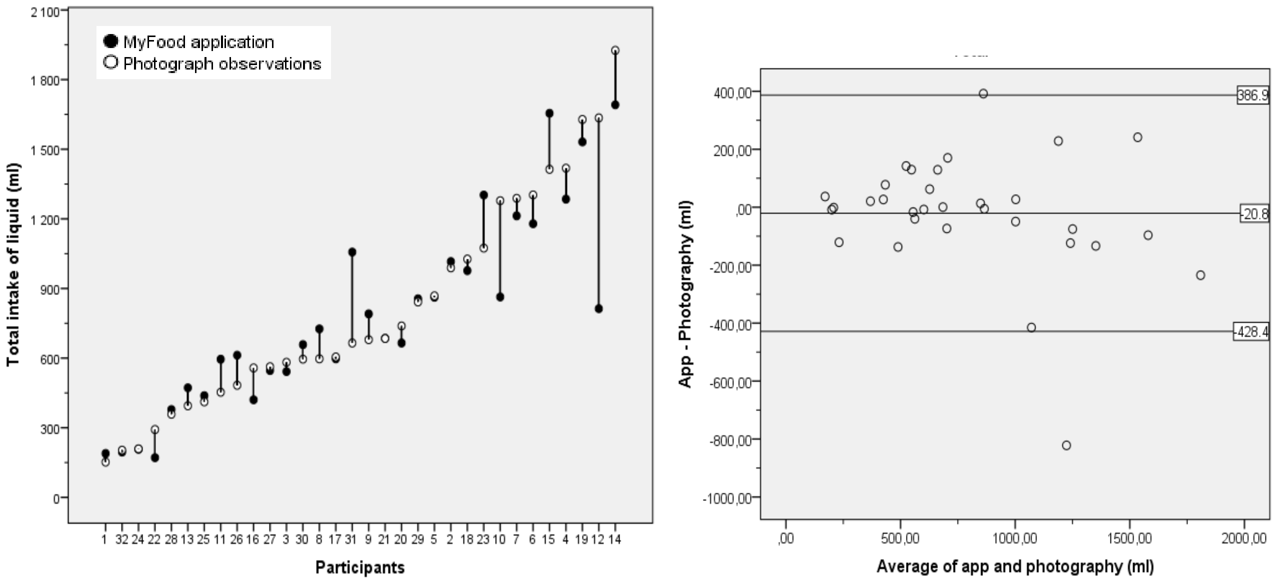

Figure 14a. Total liquid intake.

Left: Drop-line plot demonstrating the total liquid intake (y-axis) for every participant (x-axis) after one day of dietary recording for breakfast, lunch and dinner, estimated from MyFood and photograph observations. Similar amounts were estimated from both methods in cases where only a white dot is shown.

Right: Bland-Altman plot for estimations of total liquid intake. The difference between the two methods (app – photography) (y-axis) is plotted against the mean of the estimations (x-axis). Middle line represents mean difference; upper and lower line represents the limits of agreement, defined as mean difference ± 1.96 times the SD.

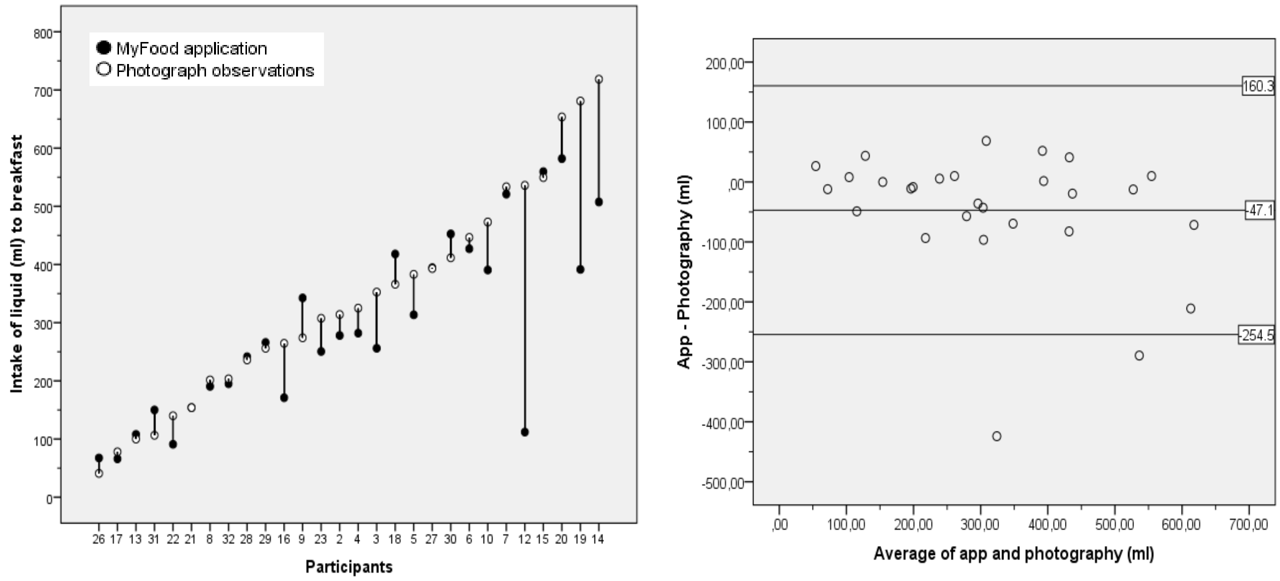

Figure 14b. Liquid intake for breakfast.
Left: Drop-line plot demonstrating liquid intake for breakfast (y-axis) for every participant (x-axis) estimated from MyFood and photograph observations. Similar amounts were estimated from both methods in cases where only a white dot is shown.
Right: Bland-Altman plot for estimations of liquid intake for breakfast. The difference between the two methods (app – photography) (y-axis) is plotted against the mean of the estimations (x-axis). Middle line represents mean difference; upper and lower line represents the limits of agreement, defined as mean difference ± 1.96 times the SD.

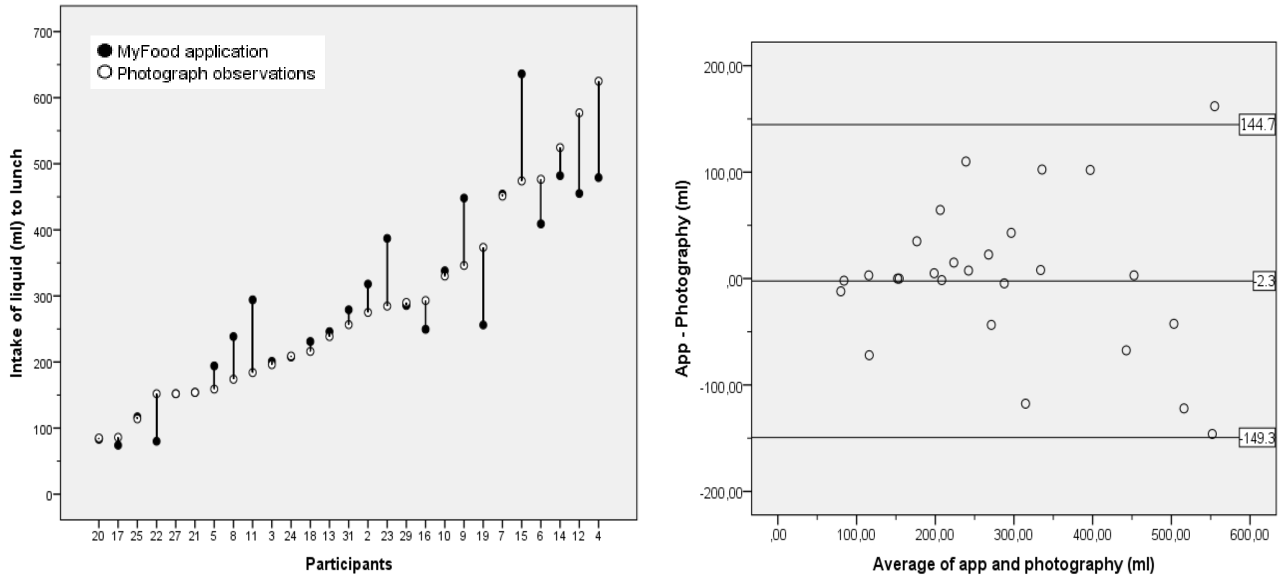

Figure 14c. Liquid intake for lunch.
Left: Drop-line plot demonstrating liquid intake for lunch (y-axis) for every participant (x-axis) estimated from MyFood and photograph observations. Similar amounts were estimated from both methods in cases where only a white dot is shown.
Right: Bland-Altman plot for estimations of liquid intake for lunch. The difference between the two methods (app – photography) (y-axis) is plotted against the mean of the estimations (x-axis). Middle line represents mean difference; upper and lower line represents the limits of agreement, defined as mean difference ± 1.96 times the SD.

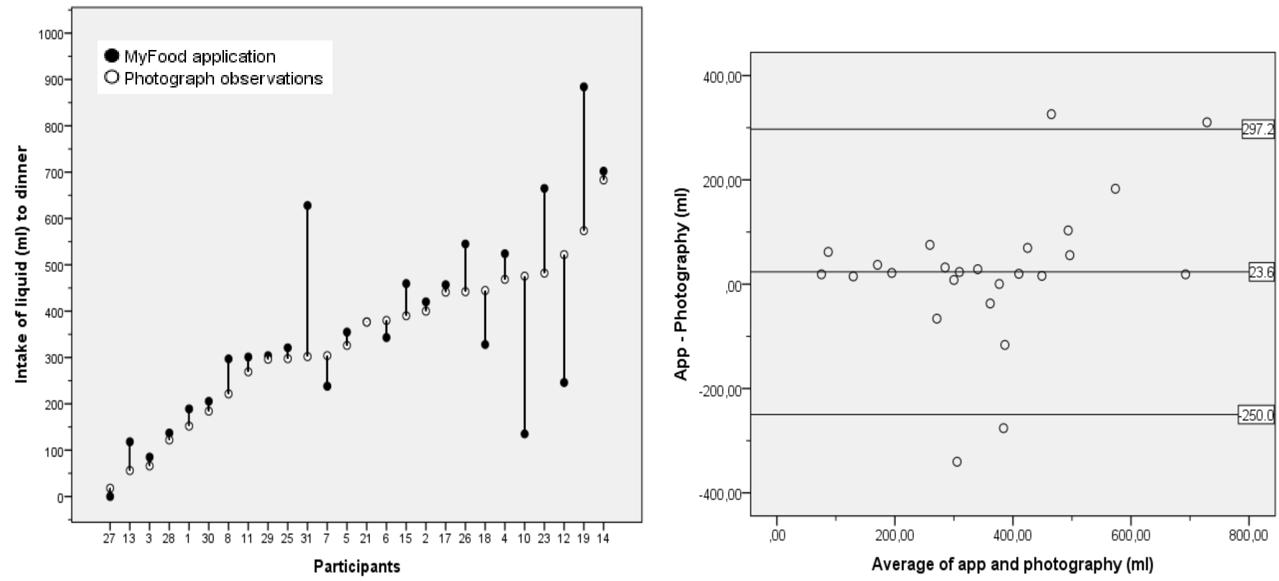

Figure 14d. Liquid intake for dinner.
Left: Drop-line plot demonstrating liquid intake for dinner (y-axis) for every participant (x-axis) estimated from MyFood and photograph observations. Similar amounts were estimated from both methods in cases where only a white dot is shown.
Right: Bland-Altman plot for estimations of liquid intake for dinner. The difference between the two methods (app – photography) (y-axis) is plotted against the mean of the estimations (x-axis). Middle line represents mean difference; upper and lower line represents the limits of agreement, defined as mean difference ± 1.96 times the SD.

4.3 Comparison of the two methods' estimated intakes within food groups

4.3.1 Group level

Table 3 presents the participants mean/median intake within food groups, estimated from MyFood and the photography method. The amount of bread and cereals were significantly overestimated in MyFood, while the amount of spreads, meat spreads and fruits were underestimated, compared to the reference method (table 3).

Table 3. Subjects' mean/median intake of foods and beverages estimated by MyFood and from photograph observations.

Food groups	**Participants (n) with recordings**	**MyFood application (g),** mean (SD) a)/median (25-75p) b)	**Photograph observations (g),** mean (SD)a)/median (25-75p) b)	**p-value**c)
Bread and cereals	23	**110.0 (50.0-190.0)**	**90.0 (44.0-144.0)**	**<0.01**
Spreads	21	**104.3 (67.2)**	**116.9 (79.5)**	**0.04**
Butter and margarine	17	12.0 (6.0-24.0)	12.5 (5.0-30.0)	0.96
Cheese	13	30.0 (30.0-30.0)	30.0 (30.0-58.5)	0.05
Can-basedd)	5	33.0 (22.0-44.0)	27.0 (22.0-41.0)	0.18
Meat	13	**30.0 (22.0-47.0)**	**33.0 (24.5-54.0)**	**<0.01**
Egg	11	56.0 (56.0-72.0)	56.0 (56.0-74.0)	0.29
Jam and sweets	7	20.6 (15.0)	21.0 (10.3)	0.95
Yoghurts	8	158.1 (85.9)	171.4 (89.3)	0.23
Cold beverages	29	395.7 (224.6)	422.6 (198.3)	0.33
Hot beverages	9	288.9 (157.7)	301.7 (154.6)	0.07
Warm hospital dinners	19	251.5 (174.5-418.8)	234.5 (121.8-381.3)	0.21
Soups	11	207.7 (122.3)	179.9 (129.9)	0.25
Hospital desserts	12	60.0 (20.0-80.0)	51.0 (23.5-62.5)	0.40
Meal condimentse)	12	3.5 (0.0-18.8)	18.0 (2.8-24.0)	0.31
Fruits	10	**51.0 (45.0)**	**101.8 (48.3)**	**0.02**
Vegetables	10	36.5 (12.5-78.8)	52.0 (37.3-104.5)	0.86

a) Normally distributed variables are presented as mean (standard deviation)

b) Non-normally distributed variables are presented as median (25th -75th percentiles)

c) Paired samples T-Test for normally distributed variables, Wilcoxon Signed Rank Test for non-normally distributed variables

d) I.e. liver paste and mackerel in tomato sauce

e) For example mayonnaise, sour cream, cowberry jam, sugar, ketchup

Bold numbers represent statistical significant difference between the methods, p<0.05

4.3.2 Individual level

Figure 15a-l presents drop-line plots for the participants’ intake in different food groups, estimated by each of the two methods. The following paragraph describes the results shown in the drop-line plots.

Figure 15a shows that intake of bread and cereals were systematically overestimated in MyFood. The intake was overestimated (in various degrees) for all participants, except for one that forgot to record a slice of bread. The differences between the methods were small with low intake, and increased with increasing intake of bread and cereals (figure 15a); a trend which was also seen for intake of spreads (figure 15b). Intake of butter/margarine was both largely overestimated and underestimated at the individual level (figure 15c). A lower quantity of meat spreads was recorded in MyFood compared to reference method for 85% of the participants (figure 15d). For jam and sweet spreads, the intake was both largely overestimated and underestimated (data not shown). Recording of egg and cheese were quite similar between the methods, except for one participant that forgot to record intake of egg, and two participants which only recorded one of two packages with cheese (data not shown). No trends for overestimation or underestimation by individuals in MyFood were seen for intake of yoghurts (data not shown). The drop-line plot for warm hospital dinners (figure 15e) and soups (figure 15f) shows that the intake was more often overestimated by individuals in MyFood compared to the reference method. Two participants forgot to record their intake of dinner (participant 10 and 12), while two participants recorded the dinner twice (participant 19 and 31) (figure 15e). Figure 15h shows that three participants omitted their intake of desserts from their recordings, while for the ten patients who did record their intake; the intake was overestimated in the application for seven of them. The drop-line plot for fruit intake shows that three participants omitted all consumed fruits from the recordings in MyFood (figure 15i). There is a tendency for underestimation of fruit intake at the individual level in MyFood (figure 15i), while intake of vegetables was both overestimated and underestimated (figure 15j). For recording of beverages, the intake estimations were quite similar from both methods in around half of the participants, and for the remaining participants; both overestimations and underestimations were observed from the recordings in MyFood (figure 15k and l).

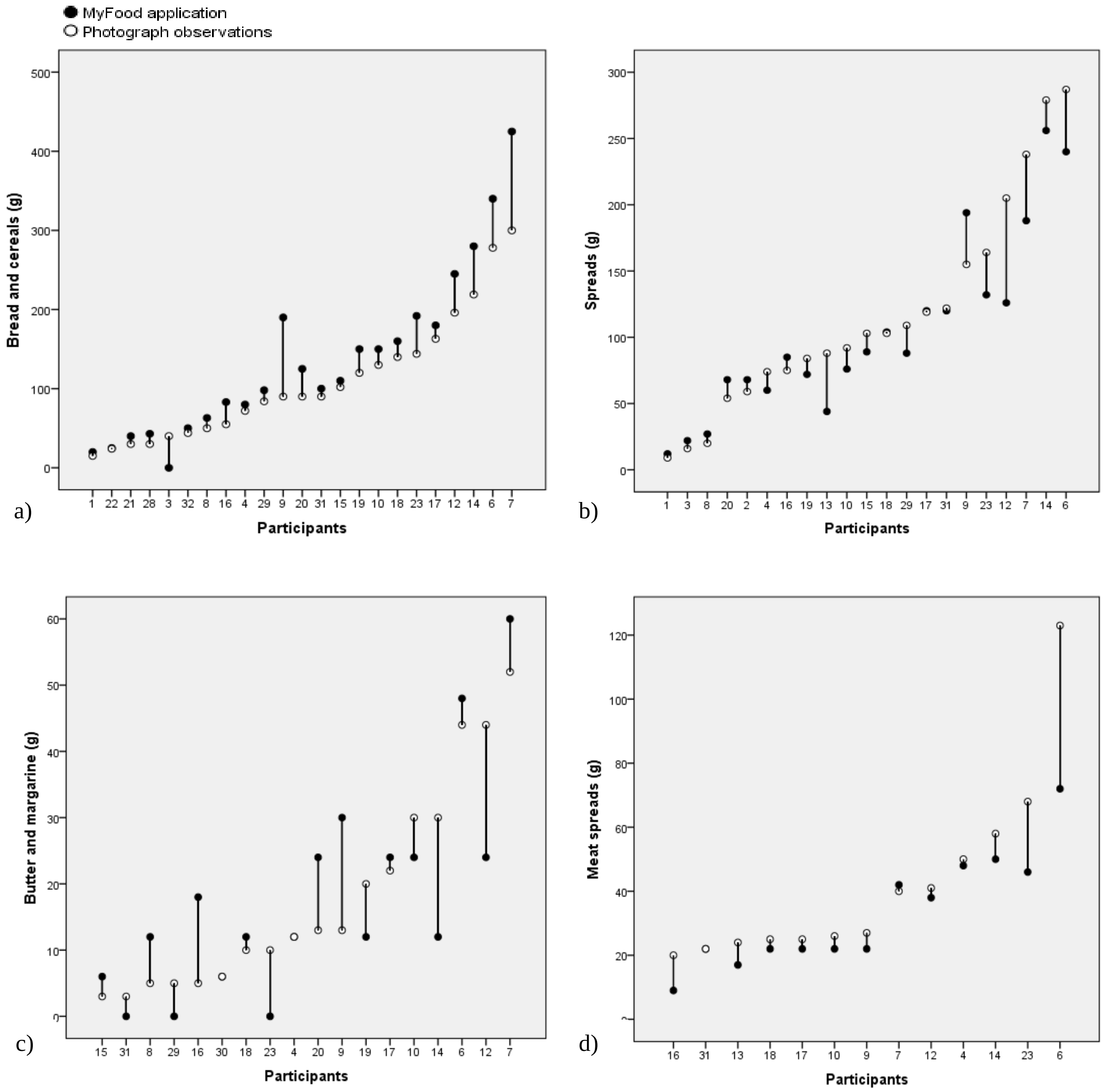

Figure 15a-d. Drop-line plots showing the participants' total intake in different food groups, estimated in the MyFood application and from photograph observations. Similar amounts were estimated from both methods in cases where only a white dot is shown.

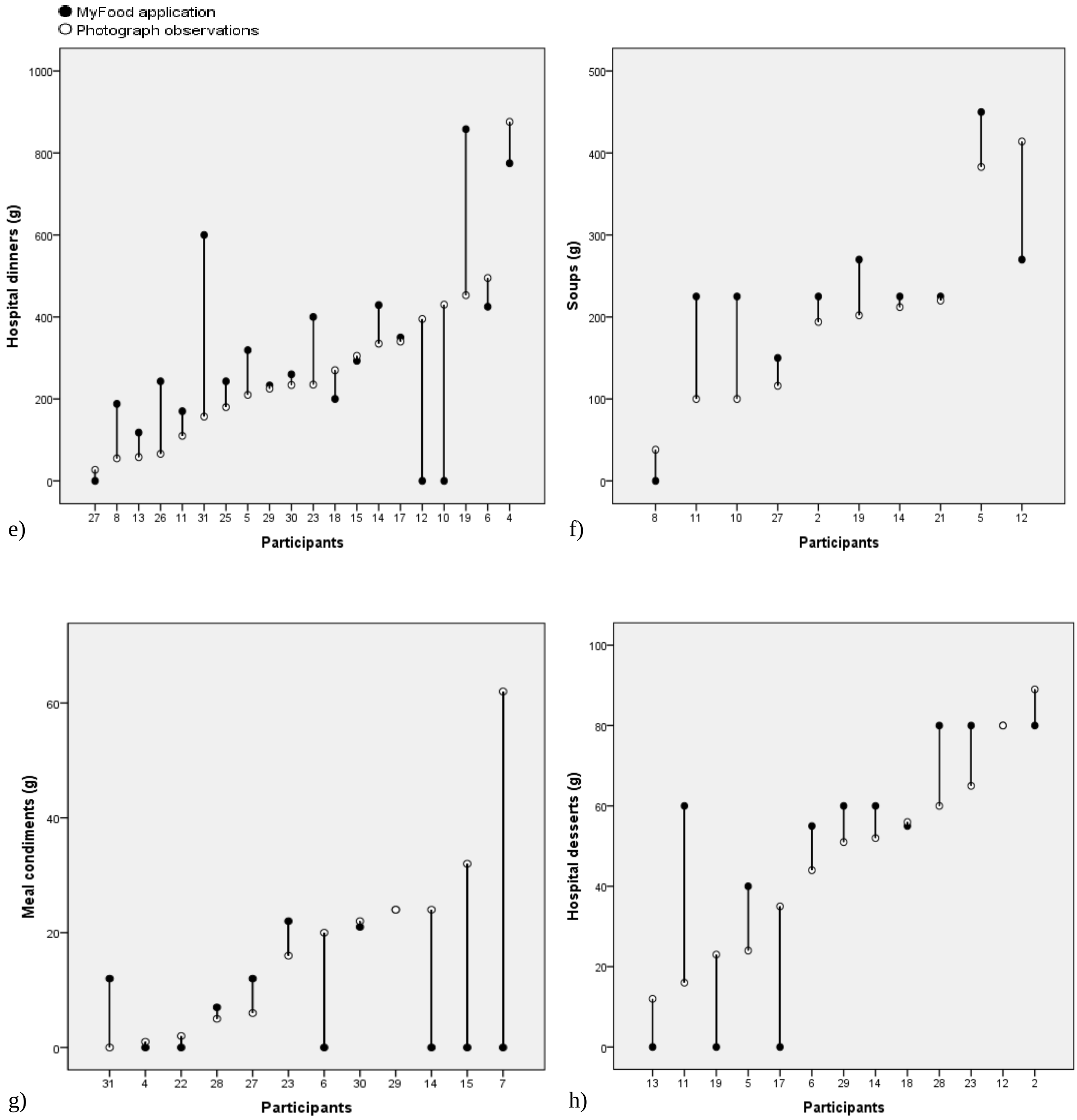

Figure 15e-h. Drop-line plots showing the participants' total intake in different food groups, estimated in the MyFood application and from photograph observations. Similar amounts were estimated from both methods in cases where only a white dot is shown.

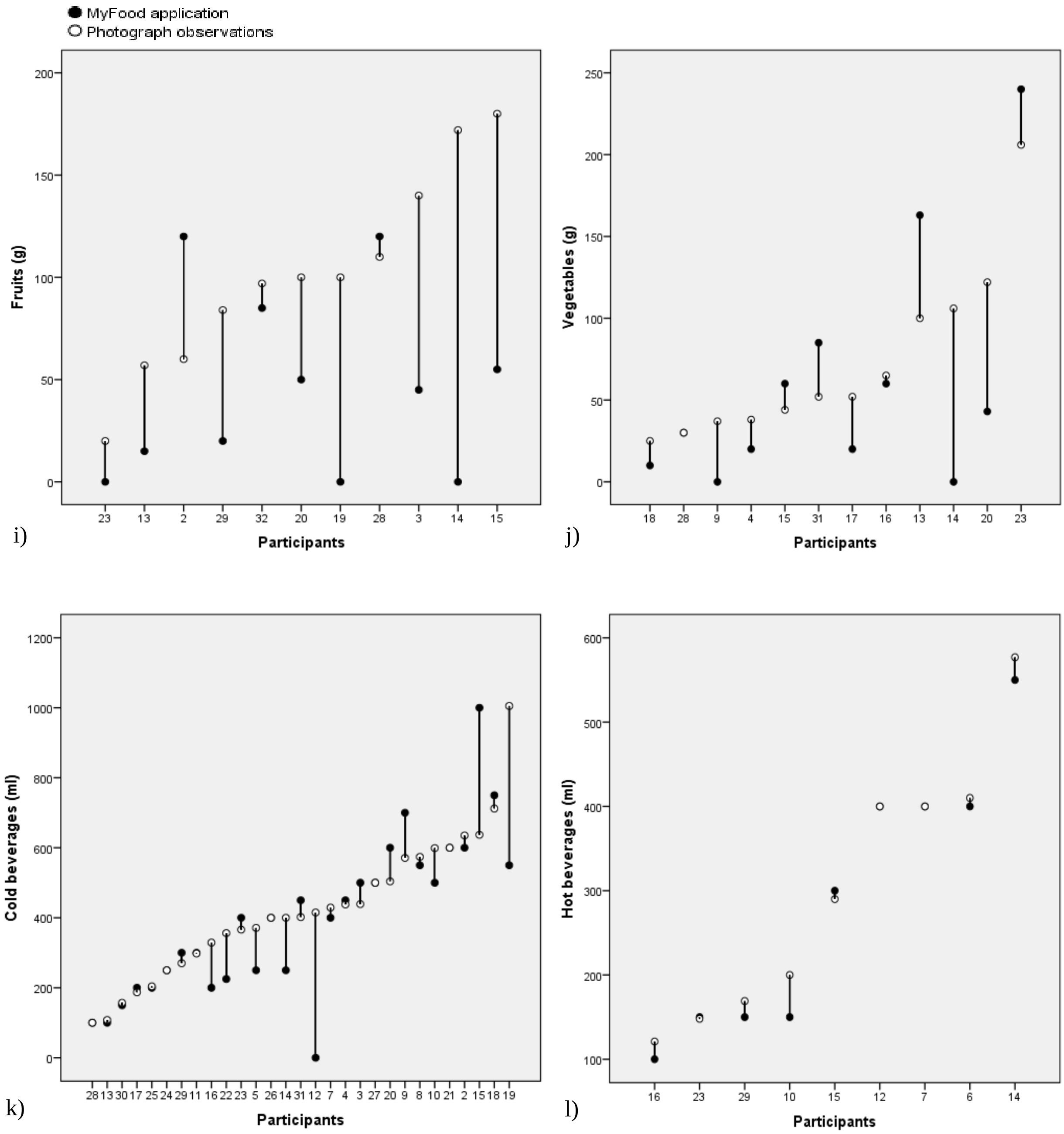

Figure 15i-l. Drop-line plots showing the participants' total intake in different food groups, estimated in the MyFood application and from photograph observations. Similar amounts were estimated from both methods in cases where only a white dot is shown.

4.3.3 Missing- and double recordings by patients in MyFood

A total of 339 items were observed from the photography method, while 309 items were recorded in MyFood after one day of dietary recording for breakfast, lunch and dinner. Corresponding item-recordings in MyFood and the reference method was present in 299 cases. This means that the patients recorded something in MyFood that were not captured on photographs in ten cases, while the patients in total omitted 40 items from their recordings in MyFood that were observed by the photography method. The ten cases where a corresponding recording from the reference method was lacking, were mainly explained by double recording of items in MyFood, except for one participant who recorded consumption of mayonnaise that was not observed from photographs. An overview of the number of items recorded in MyFood and from photograph observations within food groups are presented in **figure 16**. The patients' omitted most items from the recordings within the following food groups: meal condiments (53% of the consumed items were not recorded); vegetables (35%); fruits (31%) and butter and margarine (21%).

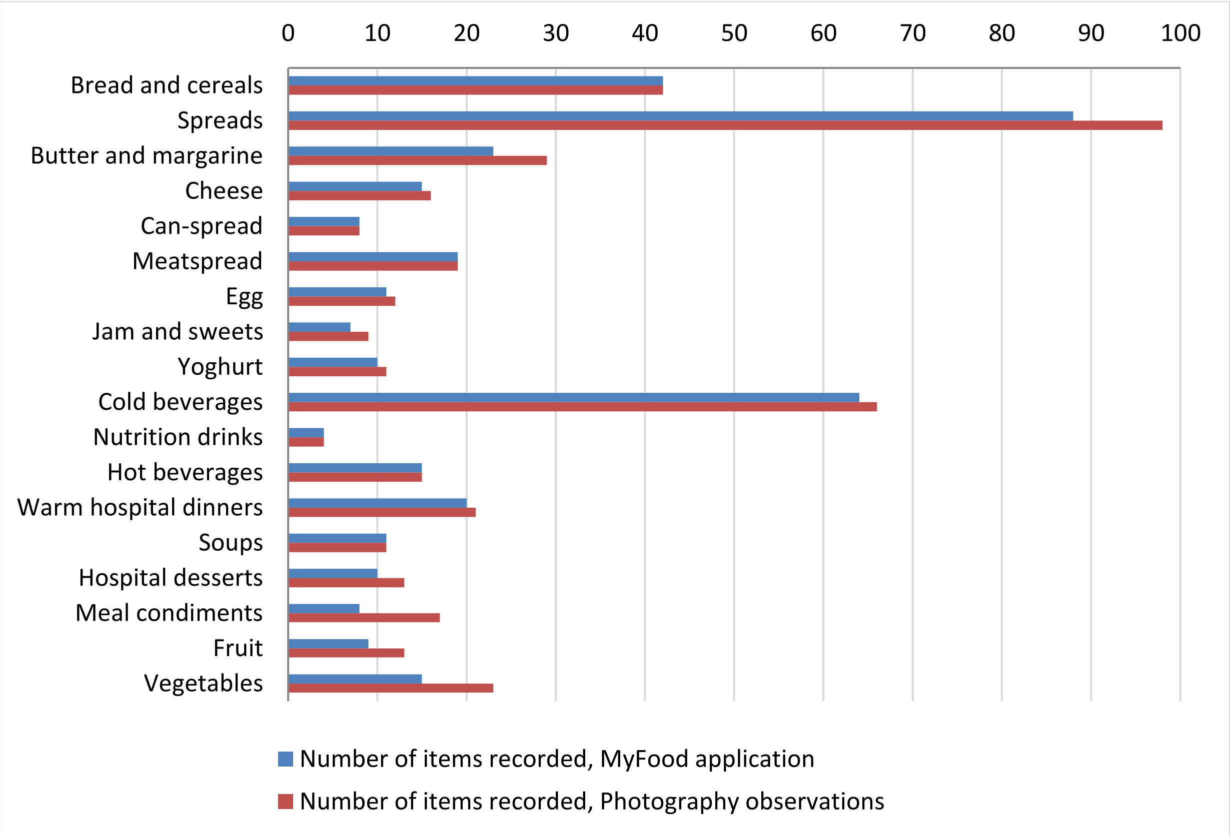

Figure 16. The number of total items recorded in MyFood and from photograph observations within different food groups.

Overall, the patients omitted 12% of consumed items from their recordings, with various nutritional importance (e.g. from a 3 g bag of sugar and cinnamon to a whole hospital dinner), while nine items were recorded twice.

Comparison of the two methods' estimated intakes within food groups when missing- and double recordings were excluded

This section was included to study the portion size estimations of foods by MyFood in relation to the estimations of foods from the reference method.

Group level

When testing the differences between the methods after exclusion of missing- and double recordings, the mean difference between the two methods for intake of spreads (-4 g) and fruits (-33 g) was no longer significant (p=0.25 and p=0.22, respectively). The overestimation of bread and cereals (22.5 g) and underestimation of meat spreads (-5 g) from MyFood still appeared significant (p<0.01 and p=0.04, respectively). In addition, the median difference between the two methods became significant, with an overestimation from MyFood for the following foods: warm hospital dinners (59 g, p=0.04), butter/margarine (6 g, p=0.01) and hospital desserts (6 g, p=0.03) (data not shown).

Individual level

Drop-line plots showing the individual intake estimations of butter/margarine, warm hospital dinners and hospital desserts after exclusions of missing- and double recording of items are presented in **figure 17a-c**. The figures show that the patients' intake within the mentioned food groups was systematically overestimated in MyFood (figure 17a-c). The overestimation of dinner decreased with increasing intake (figure 17b). The relationship between the estimations from MyFood and photograph observations for intake of fruits, vegetables, and meal condiments did change quite markedly, as many patients did not record their intake of these items (figure 16). Error in portion size estimation of meal condiments and vegetables seemed to be random, as both overestimations and underestimations were seen (data not shown). Estimated intakes of fruits are presented in **figure 17d**. Fruit cups were consumed by the three participants where the fruit intake was strongly underestimated by MyFood, while the remainders consumed fruit items (figure 17d).

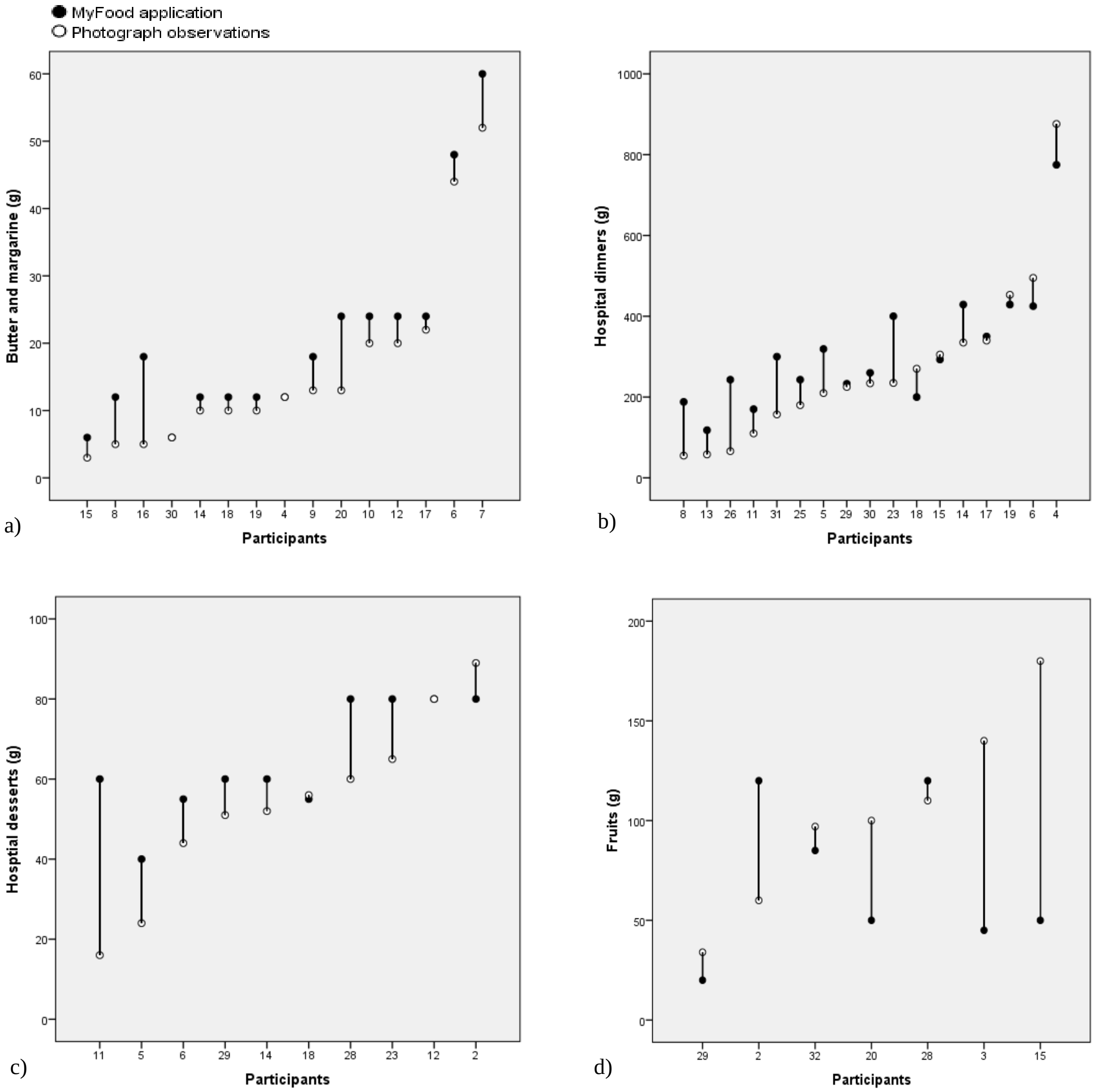

Figure 17a-d. Drop-line plots showing the participants' total intake in different food groups, after exclusion of missing- and double recordings. Similar amounts were estimated from both methods in cases where only a white dot is shown.

4.4 Patients' user experiences from dietary recording in MyFood

In total, 30 participants filled out the experience form (appendix B) after participation in the study. **Figure 18** gives an overview of the results. Overall, 90% of the participants reported that MyFood was easy to use. The patients experienced that they most often found the correct item of food/beverage and that they were able to record the correct amount (figure 18). A minor percentage of the participants (13%) had to learn something new in order to use the app. The opinions were most dispersed regarding the statement that use of MyFood increased their awareness of how much foods and liquids they needed to cover basic needs (figure 18).

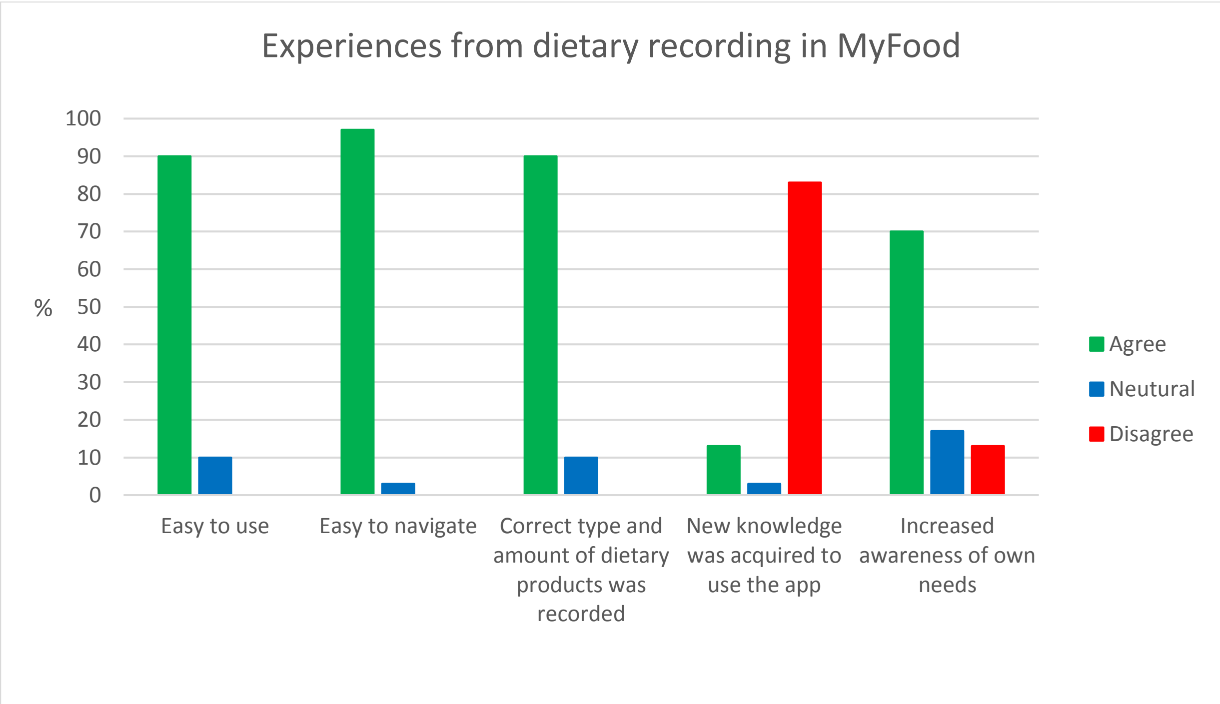

Figure 18. Patients' user experiences from dietary recording in the MyFood application.

5 Discussion

5.1 Subjects and methods

5.1.1 Recruitment and study population

Patients hospitalized at the Department of Gastrointestinal Surgery and the Department of Hematology were asked to participate in the present evaluation study. Even though MyFood is designed to be used by patients at nutritional risk, this was not an inclusion criterion in this study, as we wanted to include patients eating a various amount of foods to evaluate the app as a whole. Seventy-eight percent of those who received a verbal invitation (either from the responsible nurse or from a project worker) agreed to participate (figure 2). More patients declined the invitation from the Department of Hematology (36%) than from the Department of Gastrointestinal Surgery (5%) (figure 2). One reason for this might be that the project workers invited the patients without any involvement from a nurse at the Department of Hematology. The threshold for saying no might have been lower as the project workers were complete unknown in civilian clothes (91, 92). Additionally, patients hospitalized at the Department of Hematology might have been more tired or weaker, as the average length of hospital stay among those patients is longer than for those hospitalized at the Department of Gastrointestinal Surgery (93, 94). Three patients withdrew the consent, giving a drop-out rate of 9% (figure 2).

In studies of validity, it is difficult to include subjects that is representative for the target population, as those willing to participate often are more motivated (66). In the present study, nine patients declined the request to participate. Reasons given were mainly lack of energy and/or interest to get involved, while one older patient declined due to unfamiliarity with iPad use. For this reason, it is possible that the patients who participated in our study were in better shape and had more interest in nutrition than those who declined the invitation. In addition, the initial assessment of eligible patients was done subjectively by the responsible nurse and is likely to have been influenced by selection bias, as the nurse knew the patients and their capacity and energy to get involved in the project. However, we experienced that the participants' health, energy, and commitment to the study were quite dispersed and that the appetite and food intake varied greatly among the subjects.

The average age in the study subjects was 52 years, which might be lower than in other hospital departments, and especially lower than in geriatric departments, which have a high prevalence of nutritional risk (22). Even though it was not a challenge in our study (except for the participant who declined the invitation due to unfamiliarity with smart devices, and one older participant where the nurse recorded the meals instead of the patient), it might be more difficult for older patients to use MyFood (95, 96), and they might need more help from the staff. It is, however, likely that they would need this extra help with paper-based food- and liquid records anyway, which is mainly the current practice at hospitals (78, 97). However, in two pilot studies among older participants with no or little experience with electronic devices, the participants were found to easily learn how to navigate in and use a PDA (98) and a tablet application (82) for dietary monitoring. It is difficult to predict whether the choice of department could have any influence on the results of this evaluation study.

5.1.2 Study design

The present study was an evaluation study with single-center, cross-sectional design. These kinds of studies are often manifested with selection bias and sampling variation (99), which are already discussed in the previous section (5.1.1). Possible confounding variables, such as age; sex; BMI; severity of disease and fatigue; nurses' involvement in the dietary recording and degree of experience with app use among the participants were not controlled for, and statements regarding factors that might influence the accuracy of the dietary recording in MyFood should thus be interpreted with caution.

Two project workers recruited the patients and collected the data from the reference method. When more than one research associate is involved in data collection, there is a risk for inter-individual variance (100); however, the variance in the present study was attempted limited in several ways. First, both project workers practiced in method performance prior to study start, and the interobserver agreement in estimations from photographs of test meals was calculated to be high. Second, standardized protocols for the performance of the reference method (appendix E) were developed and followed. Third, the estimations used as a reference for true intake were based on an average of the project workers' pairwise estimations, after assuring satisfactory interobserver agreement within all meals for energy, protein and liquid. Although these considerations did not exclude the possibility for observer bias to influence the accuracy of intake estimations, the considerations probably reduced the risk for random- and systematic errors from the reference method.

Participation in the study required minimal burden for the patients. Time used for recording a consumed meal was not measured; however, less than eight minutes is considered a reasonable estimate for many patients. Beasley et al. measured that the participants on average used 10.3 minutes to record their meal in a PDA (101). The reference method in the present study was non-invasive, only requiring the project workers' presence before and after meal consumption, for photographing of meals and weighing of main meal components.

5.1.3 Photography as a reference method

Photographing of meals combined with partial weighing of meal components before and after the participants' intake was chosen as a reference method. The photography method is a validated method for dietary recording (68, 72), and weighed records is recognized as one of the most accurate methods for dietary assessment (70). The reference method was presumed to be more precise than MyFood in the assessment of the true dietary intake, although the photography method, to our knowledge, has not been validated in a hospital setting similar to ours, and we did only weigh the main meal components. Still, our reference method is not free for errors, as any other methods for assessing dietary intake (86). It is not possible to reveal MyFood's true validity in capturing the patients' intake of energy, protein and liquid, as there is a lack of a gold standard in dietary assessment methodology (67).

Both the photography method and MyFood estimated the intake to each meal at the individual level. The test method and the reference method both have some degree of inaccuracy and internal estimation errors; however, the methods' errors are mostly independent of each other, a property that is important to avoid correlation error (66, 67, 71). The recordings by patients in MyFood relied on memory, as opposed to the estimations from the photography method. Recording in MyFood relied on users' ability to estimate portion sizes accurately. Dietary data from photograph observations were also dependent on correct portion size estimations; however, two trained nutritionists did the assessment, and the additional weighing of items reduced the risk for errors in portion size estimations from the reference method (102). However, possible common measurement errors between the two methods were present. The project workers estimated consumption from photograph observations by typing food items and weights in the nutrition software program KBS, which then calculated the nutrient intake.

The nutrition composition in some foods and beverages in MyFood is also based on values from KBS. In other words, the methods' nutrition calculations are based on values from the same food composition program for some items. Additionally, if the patients supplied anything to the meal that was not captured by photography, the amount reported by the patient was recorded. This is a weakness, as it will lead to similar recordings in both methods, without necessarily representing the true intake.

5.1.4 Statistics

Handling and sorting of data from TSD required a lot of work, as the data were received in four different webforms that were not systematically built up. Manual entry of data is prone to errors, such as typing a wrong number (103). Therefore, data demanding a greater extent of manual handling could be more prone to errors. However, since both the project workers did this handling independently of each other, the comparison the workers' final data set has been important to increase the strength, as errors were spotted and corrected repeatedly until the data sets were similar.

There is no consensus on the type and number of statistical tests that should be applied to validate a method for dietary intake assessment (67, 104). In the present study, the only statistical tests included were used to compare the intake estimations between the two methods on the group level. A non-parametric test was chosen to compare the methods when the variables of interest were not normally distributed, as log transformation of the data did not lead to normality. Non-parametric techniques are in general less powerful than parametric techniques, making it more possible to miss statistical significant p-values (105). However, they might still be more robust than parametric tests in some situations as they take into consideration outliers in a small data set (105).

On individual level, the calculations of estimations categorized as acceptable, underestimations and overestimations give an insight of the number of estimations from MyFood that was within an acceptable range in relative to the estimations from the reference method (for energy, protein and liquid). However, similar cut-offs in other studies have mostly been used for the ratio of estimated energy intake to total daily energy expenditure (objectively measured or calculated) to identify misreporting of energy intake (73, 106, 107). De Keyzer et al., however, studied portion size estimations by use of photographs and defined correct estimations as estimations within ±10% difference of the measured weight (108).

Analysis of Bland-Altman plots is suggested as a method to compare clinical measurements obtained from two different methods (90), and the method is used in several studies investigating whether a new dietary recording method is valid compared to an already validated method for dietary recording (68, 72, 76, 85, 109-111). However, small sample size challenges the interpretation and conclusions from Bland-Altman plots; the statistic book: "Practical statistics for medical research" specifies that a sample of at least 50 is desirable for use of Bland-Altman plots for method comparison (84). Linear regression analyses in the plots were not performed, as the assumptions for doing linear regression (112) were not met. The limits of agreement should be interpreted with caution reasoning small sample size and non-normally distributed difference-variables used in the plots.

Spotted trends and description of systematic over- or underestimations were solely based on visual inspection of the plots. This could be a limitation as the interpretation might vary depending on the person inspecting the plots. Additionally, as I know the data well, both from data collection experiences and from comprehensive handling of the data, my judgment of the plots might be characterized by my personal opinions and knowledge to the data. On the other hand, this should be considered more as a strength than a limitation, as extensive knowledge to the data may increase the likelihood to spot errors, and it may provide a broader understanding of the results.

In studies of dietary assessment methodology, it is not usual to delete missing recordings, as recall bias is part of measurement error inherited to methods that rely on self-reported dietary data (107). However, during the data collection it was observed that some of the standard portion sizes embedded in MyFood's database were too large compared to the portion sizes most often served. As this was not revealed for all relevant foods in the initial data analyses, further investigation of this was considered useful. A hypothesis was that missing recordings of items by participants possibly neutralized a systematic overestimation error inherited in MyFood, leading to a falsely high agreement between the methods for some food groups. Therefore, exclusion of missing- and double recordings by patients were done in the analyses of food groups in order to investigate the relationship between the portion size estimations from MyFood and the photography method.

5.2 Results

In the present study, the relative validity of MyFood for use among hospitalized patients was examined in relation to the photography method. It is important to keep in mind that poor validity of MyFood may not necessarily be attributable to the dietary system in the application, but may also be related to errors associated with the reference method (67).

5.2.1 MyFood's accuracy in estimating patients' intake of energy, protein and liquid on group- and individual level

MyFood is an innovative technological tool for capturing real-time dietary intake among hospitalized patients with the format of food records. To the best of our knowledge, there are no studies evaluating a patient-administered food record method among hospitalized patients which can be used for comparison of our results, except for one study from 1998 conducted among hospitalized patients at Rikshopitalet, OUH (113). Three studies were found that evaluated a method for dietary assessment among hospitalized patients; however, the tools (a pictorial dietary assessment tool (110), a multi-component method using observation, photography, and a computer program (85) and a plate diagram sheet (114)) were aimed to be used only among health care professionals, and are therefore not comparable to our tool and method. Due to this lack of comparable studies, the results in the present study are also discussed in relation to studies investigating the validity of self-administered food records independently of population type. Eight studies evaluating the validity of a comparable electronic method for food records, like Personal Digital Assists (PDAs) or smart device applications were found. A PDA is defined as a handheld, mobile device (115). Participants using a PDA-tool are instructed to record all foods and beverages consumed by selecting appropriate food items from a drop-down menu integrated in the software (116), and the method is considered comparable to MyFood. However, technology-based methods for food records differ greatly on characteristics, such as the number of selectable foods and beverages in the tool, food database source, use of aids for correct recording and type of target population.

Another feature that complicates comparison between different evaluation studies is the use of different reference methods to reflect the true intake. Additionally, most studies have investigated a self-administered dietary assessment method on group the level, there is considerable less literature available investigating the validity at the individual level.

Group level

Energy

The results in the present thesis revealed that MyFood satisfactory estimated the patients' intake of energy on the group level, as no statistically significant difference between the methods' estimations were found, neither in total nor within any of the recorded meals (table 2). The median difference between the two methods in total estimated energy intake at group level was 89 kcal, accounting for about 10% higher energy intake estimated from MyFood than from the reference method. The study conducted at Rikshospitalet, OUH, in 1998 evaluated a self-administered form for dietary intake among 45 patients hospitalized at five different departments (113). The patients were instructed to record type of food items eaten for breakfast, lunch and dinner, and estimate the amount to the nearest 25% fraction of a full serving size. The reference method was direct observation by two students in clinical nutrition. Hence, the population, dietary recording methodology and the reference method used was quite comparable to our study. The study found a significant underestimation of energy intake in the dietary assessment form, which the authors explained by a significant underreporting of the number of foods served for breakfast, lunch and dinner (113). As our study revealed that the median intake of energy was higher in MyFood (not significantly) despite that 12% of consumed items were missing from the patients' recordings (section 4.3.3), it is possible that the patients' energy intake in general was overestimated in MyFood, but that missing recordings neutralized the overestimation. Possible causes for this might be too large standard portion sizes of foods in MyFood, which is further discussed in **section 5.2.2**.

In general, dietary data that relies on self-reported intake, including food records, are criticized to suffer from energy underreporting (117). Two of the compared studies of technology-based records found an underreporting of energy intake (118, 119). Hutchesson and colleagues compared estimated energy intake from food records completed by young women on computer, smartphone and paper with objectively measured total energy expenditure (TEE) as a reference. The level of underreporting was similar for all three methods (20-22%) (118). Yon et al. also found underreporting of energy intake when comparing food records in a PDA among overweight and obese participants, most of whom were female, with calculated TEE as a reference (119). However, young age, female gender and overweight/obesity are all found to be determinants for underreporting of dietary intake

(107, 120). Both studies concluded that technology-based food records did not seem to influence the bias attached to self-reporting of dietary intake (118, 119). Food records are in general criticized to be subject of measurement reactivity, meaning that the subjects may change their dietary behavior and/or reporting of the dietary behavior as a result of the recording activity (121). However, our population was ill patients hospitalized at two departments with a high prevalence of malnutrition. Patients at risk for malnutrition have often reduced food intake compared to needs (28), and it is possible that reactivity in terms of intentional underreporting of food intake is not that relevant for our target population, as for many other populations in epidemiological research.

Results comparable to ours, i.e. no difference between the test- and reference method, were observed in five studies in the field of innovative technologies for dietary assessment. McClung et al. evaluated dietary recordings from 26 young, normal-weighed participants on paper and in a PDA-tool in relation to measured TEE (122). Three studies evaluated an electronic dietary assessment tool in relation to dietary data obtained from 24-hour dietary recall (24-HDR) (101, 123, 124). The participants in the three studies were heterogeneous, varying from young, normal-weighed participants recruited from a university (123, 124) to middle-age participants with a mean BMI of 26 kg/m^2 (101) and 28 kg/m^2 (123). It is of notice that the reference method used in the three studies included 24-HDR, a self-reported method that is criticized to be even more imprecise than food records as the method is more dependent on memory (120). A crossover-designed clinical trial by Raatz and colleagues investigated paper-based food records, coded and analyzed by a dietitian, in relation to food records in a web-based program and in an application (125). No differences were observed between the mean values for energy intake between the paper-based food records and the two electronic tools (125). The reference method used in the study just presented is quite similar to the practice often performed at hospitals, i.e. paper-based food records analyzed by a health care professional (78, 97).

To sum up, the studies considered most relevant to compare with our study are heterogeneous with varying results. However, it is consistently reported that technology-based food records are just as accurate in estimating energy intake on group level as paper-based recordings (118, 122, 125).

Protein

In the present study, the total estimated intake of protein in MyFood was about 9% lower than the estimated intake from the photography method, a difference that was borderline significant (table 2). Only a few of the validation studies mentioned earlier have investigated the accuracy in estimations of protein intake. Fukuo and colleagues found no difference in estimation of protein intake from dietary recordings in a PDA and from 24-HDR (123), either did Raatz et al. comparing dietary recording on web and in an application with paper-based dietary recording assessed by a nutritionist (125). Prentice et al. evaluated the dietary intake estimated with conventional 4-day food records among 450 women using urinary nitrogen assessment as a biomarker and found that the protein intake was underestimated by 4% (120).

The tendency for underestimation of total protein intake may be partly explained by the significant underestimation of protein for breakfast and lunch (table 2). It is not obvious what caused the application's underestimation of protein intake for breakfast and lunch. The two meal types at the hospital were often quite similar, i.e. often bread meals. A source of protein for breakfast and lunch in Norwegian diet is meat spreads (46). Further investigation of meat spreads in MyFood revealed the application calculated 2 g protein per slice of meat spread; however, a slice of ham, for example, amounts 2.23 g protein in KBS. In other words, the lack of decimals in MyFood consequently led to a slightly underestimation of protein content in each slice, with larger deviation with increasing intake. It was also found that MyFood significantly underestimated the total amount of meat spreads, which is further discussed in section 5.2.2. These systematic errors in MyFood would only lead to a difference in estimated protein intake, but not affect the energy intake, as were the results in the present study.

Liquid

No difference between the methods in estimation of total liquid intake was found. The mean intake of total liquid estimated by MyFood was only 3% less than the mean intake estimated from the reference method (table 2). None of the studies discussed in the sections for energy and protein investigated liquid intake. An article published in 2015 concerning water intake and validity of population assessment specified that there has been little interest in collecting data on water- and beverage intake (126). A recently published validation study of a 7-day fluid record, evaluated in relation to a hydration biomarker, found no bias in estimation of fluid intake on the group level from 96 participants (127). However, it is suggested that a fluid-specific record might be more accurate in measuring fluid intake compared with methods for food- and fluid record combined (126), and that combined records may lead to underestimation of beverage intake (128).

MyFood significantly underestimated liquid intake for breakfast, with a mean difference of 47 ml compared to the photography method (table 2). With regard to recording of liquid, we revealed several weaknesses in the intake estimations in MyFood. First, a glass of milk, juice, water, etc., was described to contain 200 ml liquid, while it often amounted 220 ml in reality. A cup of coffee, on the other hand, was also described to contain 200 ml, while it in reality most often weighed around 180 g. However, coffee was consumed less often than the beverages served in a glass. Fruits contain a high percent of liquid, and a fruit cup served at the hospital often weighed over the double amount than the value described in MyFood. Fruits were only consumed for breakfast and lunch, and 31% of consumed fruits were omitted from the patients' recordings. All the factors described above might have contributed to the mean underestimation of liquid intake from breakfast in MyFood.

Individual level

Energy

Estimations of total energy intake in MyFood were categorized as acceptable for 66% of the participants, while the recordings from 9% of the participants were categorized as underestimations (figure 9). Forli et al. defined patients who grossly misclassified as those who underestimated more than 20% compared to observed intake (similarly to our broad cut-off values), and found that 8% of their subjects grossly misclassified energy intake (113). Twenty-five percent of the participants' estimations in the present study were categorized as overestimations (figure 9), while none were overestimated in the study by Forli et al. (113). However, a limitation with the study by Forli et al. is that standard portions from the hospital's menus were used as the only reference for served amounts, as they did not weigh the foods before consumption. In the present study, we have revealed that the standard portion sizes described in the hospital's menus often are larger than the actual served amount. This might have contributed to the overestimations at the individual level in our study, and it might explain why we observed more overestimations at individual level than Forli and colleagues. Yon et al. categorized 57% as valid reporters based on the ratio of estimated energy intake to TEE, and use of Goldberg cut-offs (119), as described by Goldberg and Black (106, 129, 130). Despite wider cut-offs for valid estimations in the study by Yon et al. (119), the present study found a higher percentage of participants with acceptable estimations of energy intake.

Within the meals, the number of participants with acceptable estimations of energy intake in MyFood were lowest from dinner recordings, with 50% categorized as overestimations with narrow cut-offs (figure 9). One reason for this might be too large dinner portion descriptions in MyFood, discussed more thoroughly in section 5.2.2.

Further investigation on individual level revealed that recall bias and incorrect portion size estimations were the predominantly causes for estimation errors from MyFood among the participants with largest discrepancies between methods' intake estimations (figure 10a-d). Recall bias and difficulties with portion size estimations are stated to be two of the most apparent measurement errors in methods for self-reported intake (117, 131, 132). For example, the largest deviation for breakfast (figure 10b) was mainly due to double recordings of items, while for lunch it was mainly caused by missing recordings of margarine intake and underestimation of soup intake (figure 10c). Regarding dinner, two participants did not record the consumed warm hospital dinner, while two participants recorded it twice (figure 10d).

There were no systematic trends for over- or underestimation of total energy intake seen in the Bland-Altman plot (figure 10a). Similar results were seen in another study plotting the difference between a PDA-tool and 24-HDR against the mean of the estimates (124). Beasley et al. found a tendency towards overestimation at the individual level by a PDA-tool compared with 24-HDR in their plot (101). The limits of agreement in the Bland-Altman plot for total energy intake were wide in the present study (-533 kcal; 648 kcal) (figure 10a), which indicates high dispersion and uncertainty of the estimates at the individual level. However, wide intervals of limits of agreement are observed in all four studies that have examined the accuracy of an electronic tool on individual level (101, 118, 122, 124). The narrowest intervals for daily energy intake ranged from -1200 kcal to 290 kcal in the study by Hutchesson et al. (118), and the widest intervals ranged from below -1500 kcal to above 1500 kcal in the study by Beasley et al. (101). Two studies investigated electronic food records and paper-based food records in relation to measured energy expenditure at an individual level (118, 122). McClung et al. found similar width of the limits of agreement for both paper- and electronic food records (122), while Hutchesson et al. found considerably wider limits of agreement for the paper-based food records than the electronic food records, suggesting that technological-based records were more accurate on individual level (118).

This paragraph discusses some of the factors that might have influenced the variance of the intake estimations at the individual level in the present study. The participants were asked to record their intake for breakfast, lunch and dinner, which is reported by Forli et al. to account for around 85% of the patient's total daily energy intake (113). It is possible that wider limits of agreement would have appeared if intake for a whole day was recorded, as the scattering of estimations tended to increase with increasing intake (figure 10a). The fact that the participants only got to record consumed foods and beverages to the requested meals also caused frustration among some of the participants, as they wanted an overview of their intake in relation to their dietary needs. This might have influenced the accuracy of their recordings negatively. On the other hand, the project workers' planning and cooperation with the participants beforehand of every meal and their presence for photographing meals might have increased both the patients' awareness to record in MyFood and the accuracy of the recordings. The nurses did not follow up the patients' meal recordings, as visualized when designing the present study. It is a possibility that the follow-up by nurses will improve in a real-life hospital setting, and that the patients will record more accurately, as it may feel more important. Follow-up by nurses might increase accuracy, as intake estimations are reported to be improved when a dietitian goes through the dietary records with the participants and clarifies issues and uncertainties (125).

Summing up, the application has the potential to satisfactory estimate energy intake on individual level for many patients. The degree of overestimations of total energy intake might be reduced by correcting portion sizes in MyFood. Errors attached to self-reporting, like memory and imprecisely portion size estimations, may still influence the accuracy on individual level in various degrees.

Protein

The present study found that the estimations for total protein intake were categorized as acceptable for 65% of the participants, which is approximately the same as for total energy (figure 11). Recordings from 19% of the participants were categorized as underestimations in our study, while Forli et al. found that the recordings from the self-administered form were underestimated from 8% of the participants with the same cut-off values (108). Underestimations of protein intake in MyFood were more frequent than overestimations in all three meals in the present study (figure 11). Protein intake for breakfast was underestimated from as much as 54% of the participants with narrow cut-offs. Some possible contributing factors to the underestimation of protein intake for breakfast and lunch were described in the discussion of protein on group level.

Wide limits of agreement were seen in the Bland-Altman plot for total protein intake (-31 g; 23 g) (figure 12a), indicating the uncertainties of the estimates at the individual level. The Bland-Altman plot for protein intake for dinner showed that the intake was both underestimated and overestimated, with no trends in either direction (figure 12d), while the plots for breakfast (figure 12b) and lunch (figure 12c) revealed that an underestimation of protein intake occurred for a majority of the participants. As the standard portion sizes in MyFood for warm hospital dinners were mostly too large (further described in section 5.2.2), this may partly explain why the protein intake for dinner not tended to be underestimated.

The greatest discrepancies between the methods' estimations seen in the drop-line plots for protein intake (figure 12a-d) were predominantly explained by missing recordings of food- and beverage items and meals.

Further investigation of the underestimations of protein intake is crucial to increase the accuracy of MyFood on individual level. It is somehow better that MyFood tended to underestimate the true protein intake than overestimate it, as low protein intake is associated with severe clinical implications (133, 134). An overestimation of protein intake may lead to unrecognized inadequate intake and thereby place the patients at risk for developing deficiencies (110).

Liquid

Estimations of total liquid intake in MyFood were categorized as acceptable for 69% of the participants with broad cut-offs (figure 13). For breakfast, underestimations of intake were more frequent than overestimations, as 46% of the participants' recordings in MyFood were categorized as underestimations with narrow cut-offs (figure 13). It is not certain what caused the underestimations for breakfast. Some possible contributing factors were described under the discussion of liquid on group level. In addition, missing recordings of beverages and consumed fruits, and vegetables for breakfast might have contributed. The three patients seen in figure 14b with distinct underestimations of liquid intake for breakfast did not record consumption of milk, coffee, fruits and vegetables. Common for these omitted items is the possibility to think of them as not as important as other foods when reporting dietary consumption (113, 135). Overestimations were more frequent than underestimations for dinner, with 50% of the recordings being overestimated with narrow cut-offs (figure 13). This may be linked to the large portion sizes for warm hospital dinners in MyFood (see section 5.2.2).

Wide limits of agreement were also observed in the Bland-Altman plot for total liquid intake (figure 14a). The greatest discrepancies between the methods' estimations of liquid intake (figure 14a-d) seemed to be mainly caused by missing recordings, double recordings, and portion size estimation errors.

5.2.2 MyFood's accuracy in estimating patients' intake of different foods on group- and individual level

There are, to our knowledge, limited comparable studies that have assessed the relative validity of a dietary recording tool to estimate intake within food groups. The study by Forli et al. investigated the accuracy of a patient-administered form to estimate intake within different food groups (113). Additionally, a study by Rangan and colleagues from 2016 investigated the relative validity of an electronic dietary assessment tool to measure intake within eight food groups compared to 24-HDR as a reference (136). The following three food groups were comparable to the food groups in the present study: grains/cereals, fruits, and vegetables (136). Studies that have investigated portion size estimations by use of photographs have studied the accuracy of estimations within food groups.

The studies described above may contribute with information on which food groups self-reported intake is challenging, and the studies will be compared with the results in the present study. Although the number of comparable studies is limited, this section is moreover important to discuss the presence of estimation errors from MyFood within different food groups, and possible explanations and solutions.

Bread and cereals

The average intake of bread and cereals were significantly overestimated in MyFood (table 3). This contrasts with the results found by Forli and colleagues, as they found good agreement between the patients' reported intake of "bread/grains" and the observed intake in their study (113). Rangan and colleagues found no difference between the recordings of "grains/cereals" in a PDA and their reference method (136). In the present study, consumption within the respective food group mainly consisted of bread and bread rolls. The overestimation of intake by MyFood was attributed to a systematic error in the food database, as every unit of bread and bread roll that was listed in the system weighed 10-15 g less in reality.

The portion size errors explained above resulted in a systematically higher estimation of intake from MyFood than observed from the reference method for all individuals who consumed bread and bread rolls (figure 15a). The portion size error also explains the increasing difference between the methods with increasing intake as shown in the drop-line plot (figure 15a). For example, the participant who consumed most in this food group recorded five bread rolls in MyFood accounting 425 g, while true intake was five bread rolls weighing 300 g. One participant forgot to record the actual consumption within the bread category and one participant recorded a slice of bread twice. Except for these two cases of misreporting, the participants recorded a correct number of units consumed. The bread rolls served at the hospital are standardized and the bread is commercially sliced and therefore easily quantifiable. Corrections of weights for standard units of bread and bread rolls will probably lead to a satisfactory ability for MyFood to capture patients' actual intake within this food group.

Butter and margarine

Butter and margarine were among the food the patients most often omitted from the recordings (figure 16). When accounting for missing- and double recordings in this food group, the average difference between the two methods went from being non-significant (table 3) to becoming significant with an overestimation of butter and margarine by MyFood (section 4.3.3). A possible explanation is that those patients who forgot to record butter/margarine neutralized an overall systematic overestimation by MyFood. A package of Soft Flora margarine was listed to weigh 12 g in MyFood, while it in reality weighed two grams less due to a change from the producer. Additionally, many patients consumed less than the lowest portion size option in MyFood (i.e. a half package). Forli et al. found moderate agreement between the patients' food records and the observed intake of butter/margarine (113). Portion sizes of butter are found to be significantly overestimated in studies evaluating portion size estimation by use of photographs (108, 137).

At the individual level, the estimation errors in this food group seemed to be random (figure 15c); however, the drop-line plot presented with missing- and double recordings excluded showed that the intake of butter/margarine was systematically overestimated by MyFood when comparing the recordings from the two methods (figure 17a).

The errors on group- and individual level is thought to be limited by reducing the weight of the margarine package by 2 grams and inclusion of a lower portion size option than a half package. However, the challenges with frequent omission of butter and margarine from the recordings will still be present. Forli et al. also experienced margarine as a food the patients often omitted from the recordings (113). After recording a slice of bread in MyFood, the question "Did you have spreads on?" automatically pops up and the patient has to select "yes" or "no" in order to proceed. It may be a solution to change the first question to "Did you have margarine/butter on?" as an aid to improve the patients' recall.

Warm hospital dinners

In the present study, the median intakes of warm hospital dinner from the two methods were not significantly different (table 3). The application includes illustrative photographs of a standard portion size for each dish, with additional text describing the content in a full portion (see **figure 19a**, for a screenshot that exemplifies this). This is a strength, as the size of a normal, full portion would subjectively vary among the application's users. However, whether the patients read the text describing the content of a full portion and examined the photograph is uncertain. The portion size alternatives are based on a plate diagram with portion-size options in quarters (figure 19a). Plate diagrams with estimation of intake in quarters of the offered meal is found to estimate patients' energy- and protein intake with fair accuracy when used by health care professionals (114). Forli and colleagues found good agreement between the patients' estimated intake of warm hospital dinners (estimated in quarters) and the observed intake by the nutritionists (113). However, as stated earlier, Forli et al. did not weigh the actual amount served to the patients. In the present study, when missing- and double recordings were excluded, the median difference between the methods became significant with an overestimation of warm hospital dinners from MyFood. Description of this overestimation is further discussed on individual level in the next paragraph.

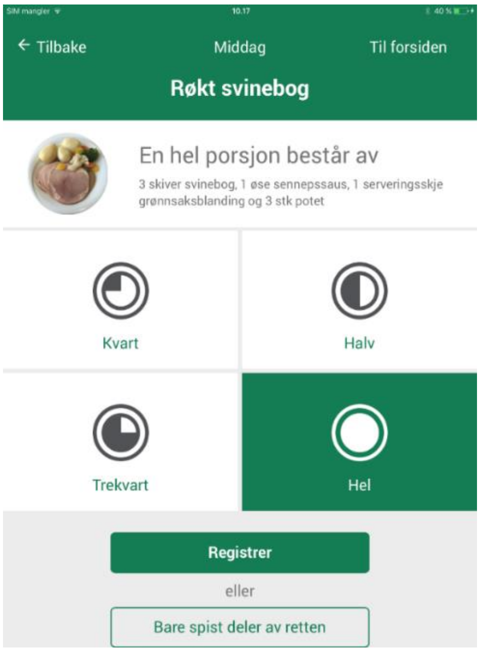

Figure 19a. Screenshot of the recording page for a hospital dinner in MyFood.

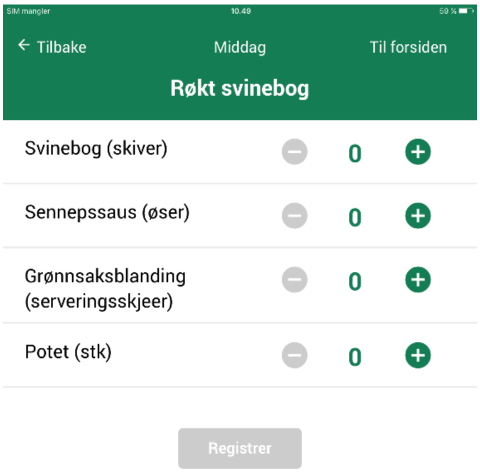

Figure 19b. Screenshot of the recording page for a hospital dinner in MyFood when only parts of the dish were consumed.

At the individual level, an overestimation of intake from MyFood for most participants was seen in the drop-line plot in figure 17b. Moreover, small dinner portions were overestimated more than normal to large dinner portions (figure 17b). Other studies have shown that small portion sizes tend to be overestimated, and large portion sizes to be underestimated; a pattern that is suggested to be caused by a tendency to avoid extreme responses (137, 138). Another type of estimation error pattern is either consistently underreporting or consistently overreporting due to difficulties with visual interpretation of portion size (138). In the present study, both of the mentioned error patterns were observed, as the overestimation in MyFood may be linked to avoidance of the smallest portion size alternative and difficulties with portion size estimations. Of the seventeen patients that remembered to record their warm hospital dinner, only six of them recorded a full portion, in which four of the estimations corresponded with the reference method. Eight patients chose a half- or a three-quarter portion, while three patients recorded "parts of the dish" (see figure 19a and **b**). In other words, the patients moreover intended to record precise intake of the hospital dinner. However, most of the patients received dinner served by a kitchen employee, and the plates were rarely filled up as much as described for a full standard portion. It is possible that choosing "parts of the dish" would increase accuracy and decrease the portion size estimation errors, as the patients there have to record amount consumed of each component in the dish (see figure 19). However, it is also more time consuming and advanced, than just choosing one of the four suggested portion sizes.

Discussion of other food groups

Group level

The significant underestimation of spreads by MyFood disappeared when missing- and double recordings were deleted, which indicates that MyFood was reliable on group level in capturing the correct amount of spreads as long as the patients remembered to record. However, remembering to record all spreads consumed were challenging, as also found in the study by Forli and colleagues where spreads were among the foods most often omitted (113). In a study that investigated portion size estimations by use of photographs, the authors found that estimations of spreads had low accuracy (139).

MyFood significantly underestimated fruit intake on the group level in the main analysis, possibly explained by a high frequency of missing recordings of consumed fruit (i.e. 31%) and too small portion sizes for fruit cups in the MyFood database. Rangan et al. found good correspondence with fruit intake estimated in the electronic dietary assessment tool and 24-HDR on group level (136); however, both the test method and the reference method relies on participants self-reported intake.

Individual level

The errors in intake estimations of meat spreads (figure 15d), hospital desserts (figure 15h) and fruits (figure 15i and figure 17d) seen on individual level are believed to be corrected after adjustment of the unit weights in MyFood. For meat spreads, 1-2 g per slice of meat needs to be added, while the portion sizes for hospital desserts in MyFood need to be decreased. Fruit cups served at the hospital were reported to weigh 50 g. However, the true weight varied from 57 g to 160 g, with an average of 130 g from seven weighed fruit cups. In order to dispose the portion size error in MyFood for hospital desserts and fruit cups, a broad sample of units need to be weighed, and the portion sizes need to be corrected in MyFood.

The intake of soup appeared to be overestimated by MyFood for most participants (figure 15f). The smallest portion size option for the recording of soup was a half bowl, corresponding to 110-135 ml. We experienced that it should be possible to record less than a half portion, as the range from zero to half and from half to a full portion were too large. More options in portion sizes have been found to increase the proportion of correct estimations (140). As it is recommended to include at least three portion size alternatives (138), and the fact that four portion size alternatives are preferred over eight portion size alternatives among participants (139), four portion size alternatives for each selectable food and beverage in MyFood should be considered.

Meal condiments were foods the patients most often forgot to record in the present study (section 4.3.3). However, this recall bias was already tried limited in the MyFood application, as the question “Did you have any meal condiments?” popped up after the recording of a warm hospital dinner or soup. It is a weakness that less than half of consumed meal condiments were recorded, although the meal condiments’ contribution to the daily intake may be of minor importance due to often low weight. The median intake of meal condiments among the eleven participants in the present study was 18 g.

Regarding beverages, the participants most often recorded intake in form of a glass/mug. This may be a challenge as the glasses used at Rikshospitalet, OUH, varies in size and the volume filled in the glasses might vary. This may contribute to both overestimations and underestimations of liquid intake (as also seen in figure 15k and 15l). These challenges in the recording of beverage should be kept in mind by the health care professionals.

5.2.3 Patients' user experiences from dietary recording in MyFood

Overall, the participants in the present study thought the app was easy to use and that they found the items they consumed (figure 18). We got an impression that the innovative form for dietary recording was considered a fun way to record intake, and several patients expressed verbally to the project workers that they had missed such a tool.

Studies consistently report that electronic methods for dietary assessment are well accepted and preferred over conventional methods (80, 118, 141, 142). Two studies conducted among adults over a period of 6 months showed that the participants that were randomized to dietary recording in either a PDA (141) or an application (80) had better adherence to the dietary recording and were more satisfied with their group allocation compared to the patients in the paper diary group (80, 141). MyFood is intended to be used over a shorter period of time. Studies conducted with shorter trial duration also points in favor of innovative technology methods over conventional methods. The study by Hutchesson et al. was conducted over a period of seven days, and the study showed that 45% preferred smartphone- over computer- and paper-based records, and only 6% preferred paper-based diary (118). Dietary recording in a PDA for two days was preferred over 24-HDR in another study including ten pregnant low-income women (142). However, it is of notice that the two studies just referred to, included a small sample of young women, a population group considered technology literate, and therefore not necessarily generalizable to every age groups. As mentioned in the introduction, the proportion of old people is increasing, and the older population itself is ageing (61). Therefore, it is important to develop a tool for dietary assessment that is suitable for this population group. In our study, only four participants were over 65 years old. MyFood should be studied among older hospitalized patients in order to conclude whether MyFood is accepted also among an older generation.

The page "Today's intake" (figure 6) gives an overview of type and amount of recorded items and the total intake of energy, protein and liquid. However, there is no information regarding how much each of the recorded items contributes to the total intake displayed on top of the page (see figure 6). One patient wrote a concrete feedback regarding this topic in the experiences form, and several patients verbally reported to miss this information. Inclusion of this additional information should be considered in further development of the system. However, as it is important to keep the tool informative and useful, it is also important to keep it simple and readily understood by the majority of the patients. Too much information may be overwhelming.

5.3 Strengths and limitations with MyFood as a tool for dietary assessment of patients at nutritional risk

5.3.1 Strengths

The MyFood application includes patients' involvement in dietary recording and the automatic calculation of nutrient intake in relation to basic needs might increase the patients' awareness and potentially lead to improved dietary intake (96). The application is designed to be readily understood and feedbacks from this evaluation study confirm user-friendliness. MyFood includes a picture of every selectable item and dish, which may serve as an aid in estimation of portion sizes (137). Dietary recording close to the time of food consumption might reduce error related to memory (117).

The National council for nutrition emphasized a need for a dietary assessment system with access to the Norwegian Food Composition Table (143) and a database with medical nutrition products (6). This app is based on its own, comprehensive database, where the nutritional values are gathered from KBS, the Norwegian Food Composition Table (143), the hospital's menus and nutrition lists, and from products' own nutrition labeling. MyFood includes foods and beverages typically served at Rikshospitalet, OUH, including medical nutrition products, in addition to typical takeaway foods, and a sample of common foods and snacks that might be brought from outside the hospital. The fact that MyFood's database is especially adapted for hospital foods is considered a strength, as inability to find the correct food consumed might influence the accuracy of dietary estimates (119, 125).

MyFood arranges for a fixed routine to determine the patients' energy-, protein and liquid requirements and to monitor whether the patients are achieving their estimated needs, as identified as one of the barriers for good nutritional practice (54). The automatic nutrient calculations may be more standardized than the calculations done by different health care professionals, and dietary recording by patients in MyFood would potentially be time-saving for the staff (85).

5.3.2 Limitations

MyFood should capture accurate dietary data on individual level. However, dietary recording in MyFood exhibits many of the same limitations as conventional dietary assessment methods (like pen and paper), as it relies on the users' ability to keep accurate records, estimate the portion sizes precisely and recall consumed items (95, 144). Omission of foods and errors in portion size estimation may affect the accuracy of the dietary data at the individual level (113, 140), and the data from MyFood should not be fully trusted as the true intake, but rather be used as a guidance. Although 90% of our study participants thought the app was easy to use, the method may be difficult to apply to certain populations that are not familiar with smart devices (95, 96). The method does also exclude patients with low Norwegian language skills.

If MyFood should be used at hospitals later on, the descriptions of the standard portion sizes of foods in the app's database need to be further investigated and evaluated in relation to the weights of foods and drinks actual served at the hospital. Foods served at a hospital may change based on food availability or season, and such changes need to be monitored and updated, which again require labor and reprogramming. Additionally, as the dietary assessment system in MyFood only is a prototype, the food database is so far based on servings of foods and beverages available at Rikshostpialet, OUH. However, the availability and offer of foods and beverages may differ across institutions. If the app should be spread nationally, the food database needs to be further developed and evaluated in order to match foods and beverages served at other hospitals.

The possibility of occasionally technological problems and loss of data cannot be excluded. Another limitation is that the app automatically resets at 3 a.m. every day, and it is therefore not possible to go back to see previously recorded intake, which might be of interest in order to monitor changes and to evaluate effects of an implemented nutrition plan. Additionally, the algorithms in the application calculate the patients' dietary needs based on their height, weight, and age; however, the actual needs for energy, protein and liquid might vary with type- and severity of disease (14).

Use of MyFood relies on tablets to be available at the hospital departments. Purchase of tablets is expensive. A future perspective in the long term may be to assess the possibility for patients to download the app on their own phones or tablets. However, this consequently leads to new challenges: first, handling and processing of sensitive data; second, Wi-Fi connection at the hospital and third, not every patient have smartphones or tablets.

Ideally, the dietary recording should be collected in a minimum of three days to provide reliable information on usual food consumption (102). Food recording exceeding 3-4 days is associated with a decline in accuracy (65). It is a risk that the patients' one-day recording in MyFood will not reflect the patients' intake and appetite the past days or weeks (145). To address this problem, a solution might be to include question(s) revealing in which degree the respective recording day reflected the previous week's daily intake. Another solution might be to use MyFood for 2-3 days, instead of only one day.

MyFood should be used by patients screened to be at nutritional risk. However, the literature presented in the introduction reveals that nutritional screening in clinical practice is insufficient (14, 47). Risk of malnutrition should be identified at an early stage (6, 40, 146); however, when a systematic screening routine is not present, identification of patients at nutritional risk will mainly occur based on clinical observations, and consequently, only patients with a clear underweight or very low food intake will be identified (58). For the MyFood application to reach its full potential in prevention, monitoring, and treatment of disease-related malnutrition, it is crucial to integrate nutritional risk screening in accordance with the guidelines. However, this has been on the agenda for a while now; the Norwegian guidelines for nutritional screening was developed in 2010, still, the practice is not yet integrated (6). It should also, therefore, be acknowledged that incorporation of MyFood as part of prevention and treatment of malnutrition could be a time demanding process. The barriers for good nutritional work must be seized and reduced, and the strengths must be further developed at the hospital departments. This might involve development of defined responsibilities and a demand for documentation of nutritional screening and follow-up in the medical records (6, 147).

6 Conclusion

Dietary recording in MyFood by hospitalized patients for breakfast, lunch and dinner were compared with dietary data obtained from observations of meal photographs. The conclusions, based on the thesis objectives, are summarized as follows:

- On the group level, MyFood provided valid estimates for intake of energy in total and for breakfast, lunch and dinner. MyFood underestimated protein intake for breakfast and lunch, and tended to underestimate the intake in total. Estimations of liquid intake was acceptable in total and for lunch and dinner, but was underestimated for breakfast.

- At the individual level, acceptable estimations (±20%) from MyFood was found for 66% of the participants for energy intake, 65% for protein intake, and 69% for liquid intake. The total energy intake tended to be overestimated, as MyFood's estimations were >20% above the estimations from the photography method for 25% of the participants, while no trends for over- or underestimation were seen for intake of protein and liquid. Within the meals, the number of participants with acceptable estimations (±20%) of energy-, protein- and liquid intake were lowest from dinner recordings, with acceptable estimations of intake seen for only 46-54% of the participants.

- Twelve percent of consumed foods and beverages were omitted from the recordings. On the group level, the intake of spreads, meat spreads and fruits were significantly underestimated in MyFood, while bread and cereals were overestimated compared to the photography method. At the individual level, the participants' intake of fruits and meat spreads tended to be underestimated in MyFood, while the actual intake of bread, soups and hospital dinners and desserts, tended to be overestimated. Portion size estimations by patients seemed to be especially challenging for warm hospital dinners.

- MyFood was well accepted as a dietary assessment system among the participants.

MyFood was considered promising in assessing patients' dietary intake, although some modifications in the application system are necessary to improve the accuracy of the dietary intake estimations. The electronic tool may be an acceptable alternative to paper-based records, and use of the application may increase the patients' awareness of dietary needs.

7 Future perspectives

Foremost, corrections in the dietary assessment system in MyFood following this evaluation study are necessary. Especially when it comes to:

- Standard portion sizes of bread and bread rolls; butter/margarine; meat spreads; hospital dinners and desserts; yoghurt and fruit cups. For the mentioned foods, the amount constituting a standard unit/portion should be reevaluated and changed in order to reflect the true servings more precisely.

- Four options in the categorical scale for estimation of portion sizes should be considered for foods and beverages, especially for soups and packages of butter/margarine, to decrease the systematic error inherent due to few options for portion sizes.

- The design and procedure in recording hospital dinners and butter/margarine should be assessed, as dinner consumption often was overestimated in MyFood and butter/margarine often was omitted.

- The food database should include decimals for protein content in meat spreads, and other foods and beverages, as an attempt to estimate protein intake more precisely.

The next step in the development of this decision support system is to include an output that generates feedbacks to nurses in case of deviations between the patient's individual basic needs and actual intake, including recommendations for actions. This is a working process, led by the doctor's degree student, and the system is supposed to be tested in an intervention study during spring 2018. The intervention study will test the clinical implementation (through interviews of nurses) and the clinical effect of the system in prevention and treatment of DRM (through quantitative measures, like patients' weight development, body composition and length of hospital stay). Then, further improvements of MyFood will be followed.

If MyFood is considered promising after the three-year doctor's degree project, the relative validation of the dietary assessment system should be reevaluated, involving a greater amount of participants (including elderly) in which all are identified to be at nutritional risk, for a more final and conclusive evaluation of the dietary assessment system in the MyFood application.

For the MyFood application to reach its full potential for use at hospitals in the future, it should preferably be able to connect with the electronic medical records system at the hospital, e.g. DIPS. It should be possible to transfer and store the dietary data from MyFood to the patients' respective medical records; easily available for the health care professionals. Alternately, it should be possible to connect the tablets and the MyFood application with printers at the hospital, so that relevant nutritional data could be printed out upon request.

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Appendices

Appendix A	Patient background information form
Appendix B	User experience form
Appendix C	Approval from the Regional Committees for Medical and Health Research Ethics (REC)
Appendix D	Written consent form
Appendix E	Plan for data collection procedure
Appendix F	Meal form
Appendix G	Information to staff nurses
Appendix H	Manual for patient registration in MyFood (for nurses)
Appendix I	Manual for dietary recording in MyFood (for patients)
Appendix J	Participant overview form

Oslo universitetssykehus

Vedlegg 1. Vennligst besvar begge sider

Deltakernummer:____

Hva er din høyeste gjennomførte utdanning (sett ett kryss)?

- ☐ Ingen
- ☐ Mindre enn 7 år
- ☐ Ungdomsskole (8-10 år)
- ☐ Videregående grunnkurs (11-12 år)
- ☐ Videregående skole (13+ år)
- ☐ Videregående med påbygning (14+ år)
- ☐ Universitet/høyskole (14-17 år)
- ☐ Universitetet/høyskole (18+ år)

Hvem bor du sammen med (hjemme, utenfor sykehuset)?

- ☐ Bor alene
- ☐ Bor sammen med partner, ingen barn
- ☐ Bor sammen med partner og barn
- ☐ Bor alene med barn
- ☐ Bor sammen med foreldre
- ☐ Bor sammen med andre voksne
- ☐ Annet

Hvor tett befolket er området der du bor (hjemme, utenfor sykehuset)?

- ☐ Færre enn 2000 innbyggere
- ☐ Mellom 2000 og 19 999 innbyggere
- ☐ Mellom 20 000 og 99 999 innbyggere
- ☐ 100 000 eller flere innbyggere

SNU ARKET

Appendix A: Patient background information form

Vedlegg 1. Vennligst besvar begge sider

Hva slags erfaring har du fra tidligere med bruk av nettbrett og/eller apper?

☐ Ingen/lite erfaring med bruk av nettbrett/smarttelefoner og apper (bruker aldri eller sjelden)

☐ Noe erfaring med bruk av nettbrett/smarttelefoner og apper (bruker av og til)

☐ Mye erfaring med bruk av nettbrett/smarttelefoner og apper (bruker daglig eller ofte)

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Erfaringer med bruk av MinMat

Kryss av for tallet som samsvarer best med dine erfaringer. Tallet 1 betyr «Helt uenig», mens tallet 5 betyr «Helt enig».

Deltakernummer:____________________

1. Jeg synes appen var enkel å bruke

Helt uenig **Helt enig**

☐	☐	☐	☐	☐
1	2	3	4	5

2. Jeg fant frem til den mat og drikke som jeg skulle registrere

Helt uenig **Helt enig**

☐	☐	☐	☐	☐
1	2	3	4	5

3. Jeg fikk registrert riktig mengde med mat og drikke

Helt uenig **Helt enig**

☐	☐	☐	☐	☐
1	2	3	4	5

4. Jeg trengte å lære meg mye nytt for å kunne bruke appen

Helt uenig **Helt enig**

☐	☐	☐	☐	☐
1	2	3	4	5

Oslo universitetssykehus

5. Jeg ble mer bevisst på hvor mye mat og drikke jeg trenger ved å bruke appen

Helt uenig **Helt enig**

1	2	3	4	5

6. Har du andre kommentarer? Noter dem i ruten under.

Takk for hjelpen!

Appendix C: Approval from the Regional Committees for Medical and Health Research Ethics (REC)

REK
REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

Region:	Saksbehandler:	Telefon:	Vår dato:	Vår referanse:
REK sør-øst	Leena Heinonen	22845529	17.10.2016	2016/1464
				REK sør-øst D
			Deres dato:	Deres referanse:
			11.10.2016	

Vår referanse må oppgis ved alle henvendelser

Lene Frost Andersen
Universitetet i Oslo

2016/1464 Evaluering av et beslutningsverktøy for å forebygge og behandle sykdomsrelatert underernæring

Forskningsansvarlig: Oslo universitetssykehus HF **Prosjektleder:** Lene Frost Andersen

Vi viser til tilbakemelding fra prosjektleder mottatt 11.10.2016 i forbindelse med ovennevnte søknad. Tilbakemeldingen ble behandlet av komiteens leder på delegert fullmakt.

Prosjektomtale

Sykdomsrelatert underernæring er en stor utfordring blant inneliggende pasienter på sykehus. Vi vil utvikle et elektronisk beslutningsverktøy som skal brukes til å forebygge, følge opp og behandle sykdomsrelatert underernæring. Beslutningsverktøyet vil inneholde en funksjon for å registrere mat- og drikkeinntak, en funksjon for å evaluere registrert inntak opp imot behov og til sist en funksjon som genererer en anbefaling av tiltak dersom inntak ikke samsvarer med behov. Prosjektet innebærer i første fase utvikling. Deretter vil verktøyets evne til å kartlegge det faktiske inntaket til pasienten evalueres ved å sammenligne registrert inntak med fotografier. Til sist vil vi teste verktøyets effekt på forekomst av underernæring og andre parametere samt implementering i en intervensjonsstudie med et randomisert parallelgruppedesign. Beslutningsverktøyet vil ha potensiale til å digitalisere og kvalitetssikre dagens rutiner for oppfølging av kostinntak og bidra til økt pasientsikkerhet.

Saksgang

Prosjektet var første gang til behandling i møtet 14.09.2016 hvor vedtaket ble utsatt i påvente av tilbakemelding fra prosjektleder om rekryttering av sykepleiere til prosjektet og presisering om fotografering. Komiteen ba også om revidering av informasjonsskriv til pasientene om fototgrafering av matbrettene.

Komiteen mottok tilbakemelding fra prosjektleder 11.10.2016.

Vurdering

Komiteens spørsmål om sykepleiernes deltakelse i prosjektet er utfyllende besvart. Informasjonskrivet til pasientene er revidert i henhold til komiteens kommentar.

Komiteen har vurdert søknaden og tilbakemeldingen og har ingen innvendinger til at studien gjennomføres som beskrevet i søknad, protokoll og tilbakemelding.

Appendix C: Approval from the Regional Committees for Medical and Health Research Ethics (REC)

Vedtak

Med hjemmel i helseforskningsloven § 9 jf. 33 godkjenner komiteen at prosjektet gjennomføres. Godkjenningen er gitt under forutsetning av at prosjektet gjennomføres slik det er beskrevet i søknad, protokoll og tilbakemelding og de bestemmelser som følger av helseforskningsloven med forskrifter.
Tillatelsen gjelder til 31.08.2019. Av dokumentasjonshensyn skal opplysningene likevel bevares inntil 31.08.2024. Forskningsfilen skal oppbevares atskilt i en nøkkel- og en opplysningsfil. Opplysningene skal deretter slettes eller anonymiseres, senest innen et halvt år fra denne dato.
Forskningsprosjektets data skal oppbevares forsvarlig, se personopplysningsforskriften kapittel 2, og Helsedirektoratets veileder for «Personvern og informasjonssikkerhet i forskningsprosjekter innenfor helse og omsorgssektoren».
Dersom det skal gjøres vesentlige endringer i prosjektet i forhold til de opplysninger som er gitt i søknaden, må prosjektleder sende endringsmelding til REK.
Prosjektet skal sende sluttmelding på eget skjema, senest et halvt år etter prosjektslutt.
Klageadgang
REKs vedtak kan påklages, jf. forvaltningslovens § 28 flg. Klagen sendes til REK sør-øst D. Klagefristen er tre uker fra du mottar dette brevet. Dersom vedtaket opprettholdes av REK sør-øst D, sendes klagen videre til Den nasjonale forskningsetiske komité for medisin og helsefag for endelig vurdering.
Vi ber om at alle henvendelser sendes inn på korrekt skjema via vår saksportal: http://helseforskning.etikkom.no. Dersom det ikke finnes passende skjema kan henvendelsen rettes på e-post til: post@helseforskning.etikkom.no.
Vennligst oppgi vårt referansenummer i korrespondansen.

Med vennlig hilsen
Finn Wisløff
Professor em. dr. med.
Leder

Leena Heinonen
rådgiver

Kopi til: l.f.andersen@medisin.uio.no
Oslo universitetssykehus HF ved øverste administrative ledelse: oushfdlgodkjenning@ous-hf.no

Appendix D: Written consent form

FORESPØRSEL OM DELTAKELSE I FORSKNINGSPROSJEKT

APP FOR Å KARTLEGGE INNTAK AV MAT OG DRIKKE

Dette er et spørsmål til deg om å delta i et forskningsprosjekt der vi skal teste ut en app som kartlegger hvor mye pasienter spiser og drikker.
Du er spurt om å delta i prosjektet fordi du er innlagt på Oslo universitetssykehus (OUS) på en avdeling som er med i dette prosjektet.
Formålet med studien er å vurdere hvor nøyaktig appen klarer å registrere det pasienten spiser og drikker.
Studien gjennomføres av Nasjonal kompetansetjeneste for sykdomsrelatert underernæring ved Oslo Universitetssykehus.

HVA INNEBÆRER PROSJEKTET?

Deltakelse i studien innebærer at du bruker en app til nettbrett for å registrere det du spiser og drikker til frokost, lunsj og middag i to dager. Dette gjøres ved at du eller sykepleier klikker på bilder av måltidene du spiser og angir porsjonsstørrelser. Registreringen går raskt å gjennomføre og du vil bruke ca. 5-15 minutter per dag. Dersom du ikke kan gjøre dette selv, vil sykepleier gjøre det for deg. I de to dagene du bruker appen vil en prosjektmedarbeider fotografere måltidene dine, før og etter måltidets start og slutt, ved frokost, lunsj og middag.
I prosjektet vil vi innhente og registrere følgende opplysninger om deg: Vekt, høyde og om du har spesielle hensyn når det gjelder kosthold, utdanning, sivil status, bosted og tidligere erfaring med apper.

MULIGE FORDELER OG ULEMPER

Deltakelse i prosjektet vil ikke innebære noen risiko eller ubehag for deg.
Prosjektmedarbeideren som skal fotografere måltidene dine vil avtale tidspunkt for dette ut ifra hva som passer for deg. Dersom du trenger hjelp til registreringen i appen, vil en sykepleier hjelpe deg. Hvis du ønsker det kan du få informasjon om næringsinnholdet i det du spiser og drikker under sykehusoppholdet. Du kan også få vite om det du spiser og drikker er nok til å dekke ernæringsbehovet ditt under sykehusoppholdet.

FRIVILLIG DELTAKELSE OG MULIGHET TIL Å TREKKE SITT SAMTYKKE

Det er frivillig å delta i prosjektet. Dersom du ønsker å delta, undertegner du samtykkeerklæringen på siste side. Du kan når som helst og uten å oppgi noen grunn trekke ditt samtykke. Dette vil ikke få konsekvenser for din videre behandling. Dersom du trekker deg fra prosjektet, kan du kreve å få slettet innsamlede prøver og opplysninger, med mindre opplysningene allerede er inngått i analyser eller brukt i vitenskapelige publikasjoner. Dersom du senere ønsker å trekke deg eller har spørsmål til prosjektet, kan du kontakte Professor Lene Frost Andersen, telefon: 22 85 13 74, epost: l.f.andersen@medisin.uio.no.

HVA SKJER MED INFORMASJONEN OM DEG?

Informasjonen som registreres om deg skal kun brukes slik som beskrevet i hensikten med studien. Du har rett til innsyn i hvilke opplysninger som er registrert om deg og rett til å få korrigert eventuelle feil i de opplysningene som er registrert.
All innsamling og behandling av data skjer sikkert og etter personopplysningsloven. Alle nettbrett som brukes i studien installeres og overvåkes av Universitetets senter for informasjonsteknologi (USIT).
Prosjektleder har ansvar for den daglige driften av forskningsprosjektet og at opplysninger om deg blir behandlet på en sikker måte. Informasjon om deg vil bli anonymisert eller slettet etter prosjektslutt.

FORSIKRING

Pasienter som deltar i studien er forsikret gjennom Norsk pasienterstatning.

GODKJENNING

Prosjektet er godkjent av Regional komite for medisinsk og helsefaglig forskningsetikk, 2016/1464.

Appendix D: Written consent form

SAMTYKKE TIL DELTAKELSE I PROSJEKTET

JEG ER VILLIG TIL Å DELTA I PROSJEKTET

Sted og dato

Deltakers signatur

Deltakers navn med trykte bokstaver

Appendix E: Plan for data collection procedure

Detaljert skjema for praktisk gjennomføring av datainnsamling

Rekruttering av deltakere:

- Deltakerne skal rekrutteres fortløpende i datainnsamlingsperioden. Hvilke pasienter vi kan invitere til studien må vurderes av avdelingssykepleieren, basert på studiens inklusjon- og eksklusjonskriterier.
- Eksklusjonskriterier: inneliggende pasienter < 18 år, pasienter som faster på de dagene studien skal gjennomføres, pasienter som skal gjennomgå bariatrisk kirurgi, samt gravide, psykiatriske og terminale pasienter. Inklusjonskriterium: forventet liggetid > 2 dager etter inklusjon.
- Rekrutteringen vil skje dagen før tenkt oppstart av drikke- og kostregistrering i app for pasienten, eller tidlig om morgenen samme dag.
- Selve rekrutteringen skal gjøres av en av prosjektmedarbeiderne, gjerne etter en kort introduksjon fra avdelingssykepleier/pasientens sykepleier.
- Tid pasienten ønsker å spise frokost på, samt hvor vi skal møte pasienten, må avtales før første måltid.

Før igangsettelse av registreringsdag nr. 1:

- Signert samtykkeskjema, inkludert vedlegg, må samles inn.
- Pasientens NPR-nummer må kobles til et deltakernummer.
- Fyll ut et rom-skjema til pasienten.
- Sykepleier må legge inn pasienten som en ny bruker i appen.
- MinMat-brukermanual må utdeles, sammen med en iPad.
- Ytterligere informasjon må gis til pasienten:
  - Ikke rydd bort brettet med maten etter måltid – vi skal ta etterbilder.
  - La kuvertpakninger og emballasjer ligge igjen på brettet.
  - Registrer inntak av mat og drikke i app snarest etter avsluttet måltid.
  - Se brukermanual, eller kontakt sykepleier ved spørsmål/uklarheter.

Samtale med pasient - før måltid:

- Spør pasienten om type drikke og type matvare dersom det ikke klart fremkommer (fylles ut i eget måltidsskjema, sammen med informasjon om observasjonsdag, type måltid og eventuell annen relevant informasjon).
- Avtal hvor brettet skal hentes/leveres etter avsluttet måltid.
- Når aktuelt: spør om pasienten fikk registrert forrige måltid i appen, og om pasienten spiste/drakk noe som ikke finnes i appen (føres i skjema).

Fotografering:

- Kamera skrus på et kulehode som er festet til et påmontert stativ på trallen. Høyden på kamera er ca 60 cm over trallen, og bildet skal tas i en vinkel på ca 45^o.
- På trallen skal sportsteip markere hvor brettet skal plasseres.
- En post-it lapp med deltaker-nummer festes på serveringsbrettet (NB: påse at post-it lappen er der ved etter-bildene også).
- En linjal skal ligge på serveringsbrettet før fotografering.
- Komponentene måltidet består av skal beskrives på et måltidsskjema, som et supplement til før- og etter-bildene.
- Mat og drikke skal i tillegg veies før og etter inntak, vekt skal noteres i måltidsskjemaet.

  - Vei glass/krus med drikke i.
  - Vei tallerken/asjetten med pasientens mat.
  - Noter eventuell vekt på innholdet i kuvertpakninger.
  - Vei dessert/snacks for seg selv.
- Fotografering og veiing etter måltid bør gjøres så likt som mulig som før måltidet.

<u>Samtale med pasient - etter måltid:</u>

- Spør om pasienten forsynte seg flere ganger med mat eller drikke etter at før-bildet ble tatt, samt hva og hvor mye som eventuelt ble spist/drukket (føres i måltidsskjema).
- Avtal tidspunkt for neste hovedmåltid – skriv opp tid på pasientens rom-skjema.

<u>Opplastning av bildene</u>

- Bildene skal lastes opp på fellesområdet med-imb-kosthold.
- Hver pasient skal ha en egen mappe (navngitt med deltaker-nummer), der alle bildene for frokost, lunsj og middag i 2 dager lastes opp.
- Skjema med utfylt tilleggsinformasjon (type mat, drikke, påfyll, vekt og annen relevant informasjon) scannes, navngis og legges inn i mappen til den aktuelle pasienten, sammen med måltidsbildene.
- Hvert bilde lagres med beskrivende navn:
  - Først ID-nummer: 1-30. Deretter dag 1 eller dag 2 av registreringen. Deretter hvilket måltid (F = frokost, L = lunsj, M = middag), til slutt om det er før- (B = before), eller etter-bilde (A = after). F.eks: "1.1.F.B" (1 = ID-nummer 1, 1= dag 1, F = frokost, B = before)
- Bildene bør lastes opp fortløpende gjennom dagen, og skal alltid være lastet opp på slutten av hver dag.

<u>Næringsberegning i KBS</u>

- I KBS:
  - Opprett en ny person for hver deltaker.
  - Nummer = deltakerens nummer.
  - ID = deltakerens nummer.
  - Løpedag 1: måltidene konsumert første dagen. Frokost, lunsj, middag. Legges inn type og mengde av det som er konsumert.
  - Løpedag 2: måltidene konsumert andre dagen. Frokost, lunsj, middag. Legges inn type og mengde av det som er konsumert.
- Næringsberegningen gjøres kontinuerlig i datainnsamlingsperioden.
- Vi skal begge næringsberegne hvert måltid til alle pasientene.
- Ved samsvar over 85 %, blir gjennomsnittet av beregningene brukt i dataanalysene. Ved samsvar under 85 %, går vi sammen og blir enige om type og mengde vi registrerer.

Kamera skrus av kulehodet og låses inn på kontoret til Mari hver kveld. Kamera bør også tas med ved opphold mellom hovedmåltidene. Trallen vil bli stående på et avtalt rom/sted på RH.

Appendix F: Meal form

Deltaker nummer:________ ***Romnummer:________***

Observasjonsdag (sett kryss): 1 ☐ 2 ☐

Type måltid (sett kryss): Frokost ☐ Lunsj ☐ Middag ☐

Før måltid:

NB! Gi pasienten beskjed om at kuvertpakninger må legges igjen på tallerken/brett uavhengig av om alt innholdet er spist eller ikke. Spør dersom det er uklarheter om type mat, drikke (melk, brus o.l) etc.

Avtal sted å møte pasient etter han/hun har spist ferdig. Evt. gi beskjed om hvor du sitter.

Vekt bestanddeler:

Noter vekt på tallerken, glass, kuvertpakninger/emballasje etc. her. Noter evt. også antall eller annet som kan være vanskelig å se av bildet.

FØR	ETTER
________________	________________
________________	________________
________________	________________
________________	________________
________________	________________
________________	________________
________________	________________
________________	________________
________________	________________
________________	________________
________________	________________

Etter måltid:

Spør om pasienten forsynte seg flere ganger med mat eller drikke etter at før-bildet ble tatt. Hvis JA, noter *hva* og *hvor mye* pasienten forsynte seg med:

____

____

____

Annen relevant informasjon, f.eks. dersom pasienten spiste/drakk noe som ikke finnes i appen (mat brakt utenfra sykehuset e.l.), kan noteres her:

____

____

____

____

____

Informasjon om evalueringsstudie av appen MinMat

Tidsperiode
Datainnsamling vil pågå i perioden mars – mai 2017.

Hva innebærer deltakelse i studien for pasienten?
Pasienter som samtykker til å delta skal bruke appen MinMat til å registrere alt de spiser og drikker til frokost, lunsj og middag i 2 dager. De skal ikke registrere det de spiser utenom disse tre hovedmåltidene. To prosjektmedarbeidere vil fotografere måltidene til pasienten før og etter inntak. Dette skal brukes som referansemetode for å sammenligne med det som registreres i appen. Vi avtaler på forhånd med pasientene omtrent når de spiser sine måltider, slik at vi kommer og fotograferer til riktig tidspunkt.

Hva innebærer studien for deg som sykepleier? Vi ønsker at du bidrar med følgende:

- Legger inn informasjon om pasienten i appen MinMat ved oppstart av ny registreringsdag (se brukerveiledning).
- Hjelper pasienten med registrering i appen dersom det er behov for det.
- Minner pasienten på å registrere inntak til frokost, lunsj og middag i appen så fort som mulig etter måltidet.
- Etter at pasienten har fullført måltidet er det viktig at matbrettet ikke ryddes vekk, før vi har tatt bilde av det. Vi klistrer en grønn post-it-lapp på brettet når vi har tatt bildet og brettet kan tas vekk.
- Kuvertpakninger (smør, syltetøy, leverpostei o.l) skal bli liggende igjen på brettet/tallerken uavhengig av om alt innholdet er spist eller ikke. Minn pasienten på dette.

Brukerveiledning
En enkel brukerveiledning for appen er utformet for sykepleier og pasient.

Kontaktinformasjon prosjektmedarbeidere
Ved spørsmål om appen, studien eller ved behov for å gi informasjon om måltidstidspunkter for pasientene eller annet, ta kontakt med:
Mari Mohn Paulsen (prosjektkoordinator), tlf: 95 77 20 48
Martina Lovise Hagen (masterstudent), tlf: 91 38 12 54

MinMat - brukermanual

Registrering av pasienter og behov

1. For en pasient som ikke har brukt appen tidligere må du legge inn informasjon om pasienten under ***Legg inn ny bruker***.

2. Dersom pasienten er på dag 2, fyller du ut informasjonen under ***Registrer behov***.

3. Hvordan finne pasientens ***NPR-nummer***:
   - Logg deg inn i Dips
   - Aktiver pasient
   - Trykk tasten F5
   - Pasientens NPR-ID vises som et 8-sifret nummer i nederste linje

Appendix I: Manual for dietary recording in MyFood (for patients)

MinMat - brukermanual

Registrering av matinntak

Du skal registrere ditt inntak av mat og drikke til hovedmåltidene: frokost, lunsj og middag fortløpende i to påfølgende dager. Det er ønskelig at måltidene registreres snarest etter inntak.

1. Velg ikonet som passer med det du vil registrere.
2. Trykk deg frem til riktig produkt eller søk opp produktet direkte i søkefeltet. Finner du ikke det du leter etter kan du registrere dette manuelt.
3. Angi mengde eller porsjonsstørrelse. Du kan også registrere at du bare har spist deler av retten.
4. Alle registreringer samles opp under ***Dagens inntak.*** Der får du en oversikt over ditt matinntak fordelt på energi, protein og væske.
5. Under Dagens inntak kan du legge til, endre eller slette produkter med ikonene som vist til høyre.

Appendix J: Participant overview form

Deltakelse i studie – app for å kartlegge inntak av mat og drikke

Deltakernummer: _________   **Romnummer: _________**

Datoer for registreringsdager: ____________ og ____________

Avtalt tidspunkt for hovedmåltidene:

DAG 1	DAG 2
Frokost, kl.: __________	Frokost, kl.: __________
Lunsj, kl.: ____________	Lunsj, kl.: ____________
Middag, kl.: __________	Middag, kl.: __________