Nutritional status in a functional perspective

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A study in a cohort of older people in home health care

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Abstract

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High age is a risk factor for most acute and chronic diseases, injuries and function disabilities, and hence, an important risk factor for nutritional problems. A great deal of elderly health care in Sweden are performed in the patient's home environment and home health care has been transformed to more advanced medical care the last decades.

The aim of this thesis was to comprehensively describe the nutritional status and its change over time in a population of older people receiving home health care. The aim includes to propose a framework for investigating and analysing the nutritional status in older people.

Nutritional status was studied at enrolment in home health care and regularly followed up for three years. Patients that were 65 years or older and needed home health care for at least three months between 2012 and 2017 were asked to join the study, resulting in 69 participants (64% women).

Data collection and analysis of the nutritional status was based on the proposed model for assessing the nutritional status in a comprehensive functional perspective (paper 1). The model comprises four domains that affect the nutritional status and functional outcome in a bidirectional way. In paper 2 we concluded that malnutrition, sarcopenia, frailty and dehydration are highly prevalent in the population and the most important indicators were loss of appetite and dehydration. This was confirmed in paper 3, were nutritional status was analysed with a statistical approach. A total of 103 indicators of nutritional status were reduced to 19 that were suggested to be primary investigated. Also, the paper empirically confirmed the relationship within as well as between the domains suggested in paper 1. Finally, we studied meal pattern, being a part of one of the domains (paper 4). We found indications that presence of at least one large meal (high energy intake) per day had more impact on the total daily energy and protein intake than more eating occasions during the day.

Keywords: nutritional status, nutrition, home health care, older people, geriatric, meal pattern, dehydration, appetite.

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Sammanfattning på svenska

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På 1990-talet skedde en förflyttning av ansvaret för service, vård och omsorg om äldre personer och personer med funktionsnedsättningar från dåvarande landstingen till kommunerna i Sverige. Därefter har det skett ett kontinuerligt skifte från vård och omsorg på institutioner och i s.k. särskilt boende till att ske i de äldre personernas egna hem. Därmed har hemsjukvården utvecklats till att omhänderta allt fler personer, men också till en mer avancerad medicinsk vård i hemmet.

Hög ålder är den mest betydelsefulla riskfaktorn för akuta eller kroniska sjukdomar, skador eller funktionsnedsättningar. Därför ökar också hög ålder risken för nutritionsproblem. Sjukdomar och funktionsnedsättningar påverkar en persons nutritionstillstånd, men nutritionstillståndet påverkar även utvecklingen av sjukdomar, läkningsprocesser och rehabilitering efter sjukdom, skador, kirurgi med mera.

För både individuell behandling och för klinisk forskning behöver nutritionstillståndet analyseras och diskuteras ur ett brett perspektiv. Detta gäller särskilt inom vård och omsorg om äldre personer. Mat- och näringsintag är kanske det mest intuitiva när nutritionsproblem ska studeras eller behandlas, men ett otillräckligt intag av mat och näring kan vara en konsekvens av något annat och är sällan den enda orsaken till nutritionsproblem. Därför behövs ett mer holistiskt synsätt på nutritionstillståndet.

Syfte

Syftet med avhandlingen var att på ett holistiskt sätt beskriva nutritionstillståndet och dess förändringar över tid hos en grupp äldre personer som har hemsjukvård.

Metod och material

Huvuddelen i avhandlingen var en klinisk studie där patienter som skrevs in i hemsjukvården, som var 65 år eller äldre och som hade behov av hemsjukvård under minst tre månader erbjöds att delta i studien. Rekrytering av deltagare gjordes kontinuerligt mellan 2012 och 2017 i ett geografiskt avgränsat område och resulterade i 69 deltagare, varav 64 % var kvinnor. Deltagarnas nutritionstillstånd studerades utifrån ett brett perspektiv när personer skrevs in i hemsjukvården och följdes därefter upp regelbundet under tre år.

Datainsamlingen gjordes av dietist/doktorand och personal inom Örebro kommuns hemsjukvård. Sjuksköterska eller undersköterska samlade in blod- och urinprover, blodtryck och puls samt information om aktuella sjukdomar, symptom och läkemedelsbehandling. Arbetsterapeut kartlade deltagarnas förmåga till aktiviteter i det dagliga livet och samlade in information om fysisk aktivitet, sinnesstämning och kognitiv förmåga. Fysioterapeut eller dietist/doktorand samlade in information om fysisk funktion. Dietist/doktorand samlade även in data om mat- och näringsintag, antropometriska mått och kroppssammansättning.

Resultat

I artikel 1 (paper 1) föreslås en modell för hur nutritionstillstånd kan undersökas och bedömas med ett övergripande och funktionellt perspektiv. Modellen är uppbyggd av kugghjul i olika storlekar, som hakar i och driver på varandra. Fyra kugghjul representerar domäner som är kopplade till hälsa: 1) Mat och näring, 2) Hälsa och sjukdom, 3) Fysisk funktion och kapacitet, 4) Kognitiv, känslomässig och sensorisk funktion. Modellen visar hur varje domän har stor påverkan på nutritionstillståndet och olika funktioner och vice versa; nutritionstillståndet och personens funktioner har stor påverkan på varje enskild domän. Datainsamling och analyser av deltagarnas nutritionstillstånd baserades på modellen.

I artikel 2 (paper 2) beskrivs deltagarnas nutritionstillstånd och hur det förändras över tid. Syftet var även att undersöka om och i så fall hur indikatorer inom de fyra domänerna har samband med varandra. I artikeln presenteras att undernäring, sarkopeni, skörhet (frailty) och undervätskning (dehydrering) var vanligt bland deltagarna. Nedsatt aptit och vätskebrist var särskilt viktiga indikatorer på ett nedsatt nutritionstillstånd. Resultaten tydliggör behovet av nutritionskompetens inom den multidisciplinära organisationen i hemsjukvården.

I artikel 3 (paper 3) analyserades nutritionstillståndet statistiskt genom en faktoranalys utifrån den föreslagna modellen. I analysen användes 103 olika indikatorer som kan påverka och påverkas av nutritionstillståndet. Analyserna bekräftade att det fanns samband inom och mellan de fyra domänerna och vi föreslår att de 103 variablerna kan reduceras till 19 som bör inleda en analys av nutritionstillståndet på äldre personer.

I den fjärde och sista artikeln (paper 4) fokuserade vi på måltidernas fördelning över dygnet, inom domänen Mat och näring. Resultaten visade att de flesta deltagarna hade ett måltidsmönster med fyra eller fem ättillfällen per dag, men även att ett måltidsmönster med en måltid med högt energiintag om dagen är viktigast för det totala energi- och proteinintaget.

Slutsats

Avhandlingen föreslår en teoretisk modell för att undersöka nutritionstillstånd, för användning i klinisk verksamhet likväl som i forskning. Modellen kunde bekräftas genom att praktiskt studera den i en population av äldre personer med hemsjukvård. Avhandlingen visar också att nedsatt nutritionstillstånd var vanligt bland deltagarna och att vätskebrist och nedsatt aptit är viktiga indikatorer. Vi kunde också konkludera att minst en stor måltid under dygnet var viktigare för det dagliga totala energi- och proteinintaget än att äta flera måltider under dagen, genom exempelvis flera mellanmål eller en kortare nattfasta.

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List of Papers

1. Engelheart S., Brummer. (2018): Assessment of nutritional status in the elderly: a proposed function-driven model. *Food & Nutrition research, 62, 1366-1371. DOI:* 10.29219/fnr.v62.1366
2. Engelheart S., Bertéus Forslund H., Brummer RJ., Ljungqvist O. (2020): Dehydration and loss of appetite – key nutrition features in older people receiving home health care. *Submitted for publication.*
3. Engelheart S., Andrén D., Repsilber D., Bertéus Forslund H., Brummer RJ. (2021): Nutritional status in older people – an explorative analysis. *Submitted for publication.*
4. Engelheart S., Brummer RJ., Bertéus Forslund H. (2020): Meal patterns in relation to energy and protein intake in older adults in home health care. *Clinical Nutrition ESPEN, 35, 180-187. DOI: 10.1016/j.clnesp.2019.10.003*

Paper 1 and 4 have been reprinted with the kind permisson of the the two respective journals.

Definition of terms

Home health care: Primary health care (i.e. health care services) that is provided in the patients' home. Home help services are not included.

District nurse: A registered nurse, specialised for care in the community. However, in the home health care involved in this study, district nurses and other nurses work together, but are mostly called district nurses in this thesis.

Non-optimal nutritional status: Malnutrition, frailty, sarcopenia and dehydration are different perspectives of a non-optimal nutritional status. To described this generally, the words non-optimal, defeated, deteriorated, impaired and inadequate are used interchangeable.

Preface

It is common knowledge that good nutrition and a good nutritional status are crucial for health in all ages of life; from the cradle to the grave. However, the purpose of a good nutritional status is somewhat different throughout life. First, in the uterus and in childhood period, proper nutrition is important for an adequate growth and development. Later in life, good nutrition contributes to a healthy life strengthening the immune system and lowering the risk of non-communicable disease as cancer, heart disease and obesity. And finally, at old ages, optimal nutrition provides conditions for an active and healthy ageing. And, not mentioned is the impact of social gathering and pleasure of fine meals with family and friends.

Probably, we will all agree on these values of nutrition. But what is good nutrition? And what is a good nutritional status? And how should it be measured or evaluated?

We do know, that in older ages, it is more common with acute and somatic diseases, which increases the risk of nutritional problems in older adults. Nutritional problems, that could lead to a poor nutritional status, do mostly, but not primarily, occur as a cause of ageing *per se*, but are often related to functional decline and secondary to health problems. Disease and disabilities affect the nutritional status, but the nutritional status also affects outcome of disease, healing and rehabilitation following disease, injuries and medical treatments. In other words, the correlation is bidirectional: cognitive, affective, psychological and functional disabilities affect the nutritional status, and the nutritional status affect the disability progress.

As more geriatric care is carried out in primary care and in home health care, so should the prevention of malnutrition and nutritional treatment. This thesis is based on a research project in a synergy of science and practice, carried out closely to the Health and Welfare Administration in the municipality just as it should be in clinical research at its best.

Introduction

This thesis focuses on old adults receiving home health care and their nutritional status. A general introduction to the study population and the home health care organisation are needed but also an introduction in nutrition in terms of nutritional status and its terminology and assessment.

Home health care – organisation and settings

During the last decades, elderly health care in Sweden has transferred to home care, mostly in the patient's own home, but also to nursing homes (1). This trend is also seen across Europe (2). Hence, the home care has developed in order to serve an increasing number of patients, but also to deliver more advanced medical care. This process has been boosted by the demographic changes in Sweden (3) with an increased share of older individuals, typical for most of the western world.

A report of solid facts from The World Health Organisation in 2008 (4) predicted that home care would be more common in the future, as a consequence of changes in demography, epidemiology as well as changes in social and cultural trends. A prediction that seemed to be correct. According to WHO, home health care is the most reasonable transition from unnecessary acute care and long-term institutionalization to an offer for individuals to stay in their home environment if possible. However, this comes with the challenge of "serving the right people at the right time with the right means" to get the economic and functional sustainability that is needed.

The organisation of health care and social care differs between and sometimes within countries. In Sweden, the home care of older people is regulated by two different legislations; the Health Care Act [Hälso- och sjukvårdslagen] (5) and the Social Services Act [Socialtjänstlagen] (6). The county council are responsible for acute and somatic health care (including hospitals and primary care) due to the Health Care Act, for all citizens in the region. The municipalities are responsible for home help services, regulated in the Social Services Act. However, a regional agreement in most councils in Sweden, including Örebro were this study was performed, has transferred the responsibility of home health care (in special forms of housing, ordinary housing and special day-to-day activities) to the municipality. The exception are the physicians, who practice governed by the regional health care system.

According to the National Board of Health and Welfare in Sweden just over 300 000 Swedish citizens above 65 years of age received home help

service and home health care by municipalities in 2019 (7). This corresponds to about 3% of the total population in Sweden, 10 327 589 in December 2020 (8) or about 20% of the populations above 65 years of age (9). A majority (65%) of the population receiving home care, had home health care (7).

Örebro is a middle-sized city, located in the south center of Sweden. With about 155 000 citizens makes it the sixth largest city in Sweden. Home health care in Örebro is available for patients in need of somatic care, rehabilitation or aids, but with difficulties to visit the local health care center. Generally, home health care assignation is to prevent illness, to assess upcoming symptoms or health problems, to act upon these and to follow up and evaluate these actions. Common care actions are administration and evaluation of medical treatment, planning and supporting rehabilitation after surgery or acute disease, but also to prevent, assess and act on wounds, urine or faecal incontinence or nutritional problems.

In Sweden, as well as in other European countries, a shift from institutional living towards care in ordinary homes is promoted (2). This, in combination with the increasing older population has changed home health care to be more focused on a large group of individuals with more severe illness and more complex needs. Hence, a patient group in risk of deteriorating nutritional status (10, 11).

Nutritional regulations and recommendations

The oversight of the care of Swedish citizens is governed by a series of regulations, that also encompass the management of nutrition for individuals receiving care. The overall binding regulations in health care in Sweden are partly stated by the National Board of Health and Welfare. Regulations about the management of systematic quality work [Ledningssystem för systematiskt kvalitetsarbete] states that all caregivers in health och home help services need a management system to ensure high quality (12). The last decade this has been specifically clarified for nutrition by a regulation that points out the need of routines of prevention, assessment and treatment of malnutrition (13). However, one year post this regulation was activated only half of the Swedish municipalities had it implemented (14).

The Nordic Nutrition Recommendations (15) are used as the official Swedish nutrition recommendations. These guidelines states recommended dietary intakes of macro- and micronutrients as well as food-based guidelines for a healthy lifestyle. Based on these, the Swedish Food Agency (16) and the National Board of Health and Welfare in Sweden (17) has published

advise applicable for elderly care and recommendations in malnutrition, respectively.

Prior the 2004 year version of the Nordic Nutrition Recommendations, the recommendations were adapted to a Swedish context, where also meal pattern was included. The recommendations, targeting all age groups, was basically that food intake should be spread over the day.

Guidance of meal pattern is lacking in the current version of Nordic recommendations for a healthy lifestyle (15), but remain in the guidelines for elderly care (16) and in presence of malnutrition (13). The guidelines highlight that the distribution of meals and snacks during the day can affect the patient's possibilities to reach the individual need of energy and nutrients. They also state, that if the overnight fast exceeds 11 hours, it might be hard to reach energy balance, especially in presence of loss of appetite or only managing taking very small meals. However, such a recommendation is primarily based on experience and tradition instead of evidence based research. Research of meal pattern and its effect on health in geriatric care are scarce, both as prevention and treatment of malnutrition, and the present cross-sectional research have contradictory results (18, 19).

Nutritional status in adults and older people

In research related to nutritional status, the definition of the condition is not always theoretically defined, and often determined by the way of measurement rather than by a theoretical framework. A PubMed search in august 2020 with "Nutritional status" in the title resulted in 8 513 articles, while a search with "Malnutrition" in the title resulted in 11 995 articles. However, in a closer reading of the abstract, also the articles with "Nutritional status" in the heading are about malnutrition. It seems that most interest appears to be in identifying an insufficient nutritional status and not in achieving a good nutritional status.

Terminology and definitions

The Food and Agriculture Organization in Europe (FAO) state that *"Nutritional status is the physiological state of an individual, which results from the relationship between nutrient intake and requirements and from the body's ability to digest, absorb and use these nutrients"* (20).

MeSH (the Medical Subject Headings) define the nutritional status as a *"state of the body in relation to the consumption and utilization of nutrients"* (21). MeSH also states that the term Nutritional status is preferred to

Nutrition status. However, the purpose of MeSH is not to define the physiological state, but to organise and index research and information for bibliographic purposes.

In the textbook Krause and Mahan's Food & the nutrition care process (22), Bartok and Mahan describe the nutritional status as a "*physiologic state or condition of an individual based balance between the individual´s intake and unique requirement for nutrients*". Furthermore, the author describes that the "optimal nutritional status" is reached when there is a balance between nutrient requirements and nutritional intake and absorption. In this definition it is also highlighted that the metabolic demands and requirement of nutrients are unique to everyone, affected by the life cycle, stress, medical issues and utilization and body maintenance and wellbeing. Hence, the authors articulate the changing in requirement, not just over the life span, but on life situation and other circumstances.

These definitions relay on the biological need of nutrients in a biochemical approach. In this approach at least two issues are identified. First, current definitions of an optimal nutritional status do not have anything to do with wellbeing or functions in daily life, despite this being the most important outcome in all ages. An optimal nutritional status should, therefore, be defined much broader to include this important outcome. And secondly, it is still unclear how this biochemical optimal nutritional status should or could be measured or evaluated in an individual or in a population. Most of the nutrients are not possible to measure in clinical practice, and for the nutrients that are possible to measure in blood (i.e. vitamin D, B12, calcium and folate) the result of a blood test is hard to interpret because of its complexity.

If the analyses of the optimal nutritional status are initiated from the opposite direction, the term malnutrition might be used, as *mal* indicate wrong or bad, and malnutrition conclusively means wrong or bad nutrition – or non-optimal nutrition. Thus, as such malnutrition theoretically includes both undernutrition and overnutrition. However, in the literature the term malnutrition is commonly used as interchangeable with undernutrition, and a consensus among researchers of what term to use has not yet been reached (23). This is also evident in the Swedish language were the word malnutrition [in Swedish: malnutrition] is rarely used and malnutrition is commonly translated into undernutrition [in Swedish: undernäring].

In order to avoid misunderstanding nationally due to these semantic issues, the National Board of Health and Welfare in Sweden dissuades to use the Swedish term malnutrition, but recommends the more specific Swedish

terms for undernutrition [undernäring], catabolism [katabolism], sarcopenia [sarkopeni] and cachexia [kakexi] (24).

FAO states in a learning note that *the term malnutrition indicates a bad nutritional status* and exemplifies this with undernutrition, overnutrition and deficiencies or excesses of essential nutrients (http://www.fao.org/elearning/course/FN/EN/pdf/trainerresources/learnernotes0280.pdf). Furthermore, they state that malnutrition includes all kinds of deviations from an adequate nutrition status. So, could we read this *vice versa*: An adequate nutritional status is a deviation from malnutrition?

The European Society for Clinical Nutrition and Metabolism (ESPEN) uses the terms Malnutrition and Undernutrition synonymously in their guidelines on definitions and terminology. In the guideline a definition of (adequate) nutritional status is missing, however the expert group agreed on that an assessment of nutritional status should comprehend body mass index, body composition and biochemical indices (23). The same organisation defines malnutrition as "*a state resulting from lack of intake or uptake of nutrition that leads to altered body composition (decreased fat free mass) and body cell mass leading to diminished physical and mental function and impaired clinical outcome from disease"*(25). In this definition the biochemical approach is present, but with a consequential connection to function in a broader sense.

In Sweden, the National Board of Health and Welfare has recently updated the definition malnutrition [In Swedish: undernäring] to *nutritional disorder by nutrient deficiencies* [freely translated, in Swedish: *näringsrubbning i form av brist på näringsämnen*] (24). Furthermore, they define nutritional disorder as *imbalance of nutrients that leads to disease, defective body composition, functional disability or worsened clinical outcome from disease* [freely translated, in Swedish: *obalans av näringsämnen som orsakar sjukdom eller försämring av kroppssammansättning, funktionsförmåga eller sjukdomsförlopp]*. In this definition you get a vague idea of how this state might be evaluated, but the information of how this should be measured or diagnosed remains missing.

Deficiency of some nutrients can lead to documented illness and symptoms, which is also the basis for the Nordic Nutritional Recommendation of nutrition and physical activity (15). For each nutrient, a *lower intake level* (LI) is set that indicates a cut-off level where dietary intake below this cut-off would lead to clinical deficiency symptoms in most individuals. However, *lower intake level* is based on observational studies, for most

micronutrients. In western countries deficiency symptomatic illnesses are uncommon, and therefore nutrient deficiency gets very little attention. But, the biochemical definition of nutritional status and malnutrition, for reasons unclear, still remains.

Malnutrition as deficiency because of low dietary intake of a specific nutrient is easy to treat with supplementation, often in large doses. Although the reason for the deficiency to appears is much more complex. Malnutrition as a general status of undernutrition is complex and difficult to treat with good effects and hence, preventive actions are needed. However, this is a complicated issue. There are numerous of definitions and methods for assessment of malnutrition, which raises the question of what exactly we aim to prevent. The need of screening for malnutrition has been highlighted and recommended (17, 26), as it increases the possibilities to take early actions for prevention (27). There are various methods and instruments to identify risk of malnutrition, but it is often unclear what definition of the (inadequate) nutritional status those instruments are based on. Instead, we have ended up in a situation where the method or instrument became the definition itself. And the question of what we are screening for and what we are preventing remains unclear.

One example of where an instrument to identify malnutrition had become a definition of malnutrition itself is Mini Nutritional Assessment (28). However, this instrument is somewhat different to others as the total score not only define malnutrition and risk of malnutrition but also "normal nutritional status"(29).

Prevalence and outcome of *risk* for malnutrition and *diagnosed* malnutrition must be separated and needs distinction in this communication, as the confusion between the two concepts are regularly present (30), both in research and in practice. A non-distinct discussion makes it hard to interpret and to act upon them appropriately in practice.

The definition, measurement and diagnosis criteria of an inadequate nutritional status has been an ever cause of debate in nutritional research. This disagreement of definitions and methods might be a contributing factor to the fact that nutrition has a relative weak role in both research and practice and makes the field unclear. Also, the overlapping of definitions (see example in Table 1) might contribute to the unclearness.

Below, four separate aspects of non-optimal nutritional status are shortly described; malnutrition, frailty, sarcopenia and dehydration.

Table 1 Description of the included areas in definitions of non-optimal nutritional status presented below.

	Anthropometry[1]	Food intake or absorption[2]	Biochemistry[3]	Disease[4]	Mobility and physical function[5]	Subjective measures[6]
Malnutrition, GLIM (31)	x	x	x	x		
Malnutrition, MNA (28)	x	x		x	x	x
Frailty (32)	x				x	x
Sarcopenia (33)	x				x	
Dehydration (26)			x			

[1] e.g. body weight loss, low body mass index, muscle mass. [2] e.g. lower intake the past days or assimilation. [3] e.g. s-osmolality, inflammation. [4] e.g. number of prescribed medications or morbidity. [5] e.g. chair stand test, mobility, physical weakness, slow walking speed, low physical activity. [6] e.g. self-reported exhaustion,

Malnutrition

The diagnose of malnutrition by GLIM (Global Leadership Initiative on Malnutrition criteria) (31) is based on a combination of phenotypic and etiologic criteria. GLIM criteria is a result of an international collaborative action, from 2019, involving nutrition societies in Europe, America, Asia and Latin America (34), and will hopefully stimulate more researchers and practitioners to use this definition as it will simplify combining and reviewing of research projects.

The Mini Nutritional Assessment (MNA) is an instrument defining risk of malnutrition and malnutrition using a combination of questions and investigations. The instrument were introduced in 1996 (28) and has been widely applied in research of older people (30). The instrument also has been shortened and validated as a screening method, then denoted Mini Nutritional Assessment – Short Form (MNA-SF) (35).

As the GLIM criteria for definition of malnutrition still are new, just a few studies are available using these criteria. GLIM has been compared to other assessment and screening tools and found much higher prevalence of malnutrition according to GLIM than other methods (36, 37). However, both of these studies have included screening tools in their comparisons with GLIM definition criteria. Theoretical, the screening tools should define

more people as in 'risk of malnutrition' than with manifest diagnose of malnutrition. Interestingly this is not the case, as the diagnose criteria defined more participants with malnutrition than in risk for it.

The results indicate that GLIM criteria is a sensitive definition which needs to be validate. However, validation is not an easy task. A review on the validity of malnutrition screening tools (38) studied 119 validations studies including 34 different malnutrition screening tools, concluded that the results differed between tools, but also between studies using the same tool, but in different settings and populations. Notable, is also that different kinds of reference standards, that could be read as definitions of malnutrition, were used in the validations. Also, no specified definition of nutritional status, of malnutrition, besides the instrument itself has been stated.

Frailty

Frailty, by Fried criteria (32) are combinations of weight loss, exhaustion, weakness, slow walking speed, and low physical activity. This is rather a geriatric phenomenon than a nutritional status marker. However, they share a number of similar characteristics (39) and overlaps with malnutrition when it comes to disability, comorbidity and weight loss (32).

In 2001, Fried et al operationalised the definition of frailty (32), and it has been widely applied since. It has been highlighted that all five frailty criteria could be directly or indirectly affected by food intake and quality, but also that frailty might have negative effect on food intake (40), and thus on the nutritional status.

The presence of malnutrition has been found to be associated with the presence of frailty, mostly driven by functional dependence and depression (41). However, malnutrition and frailty are not interchangeable syndromes. A meta-analysis of 10 studies in older adults reported that 68% of the participants with malnutrition (defined by Mini Nutritional Assessment) were frail, but only 8% of the frail participants had malnutrition (42).

Both quantitative (energy intake) and qualitative (nutrient intake) characteristics of the diet seems to be involved in the development of frailty (43). Also, vitamin D deficiency has been proposed to be involved in the pathophysiology of frailty (44).

Sarcopenia

Sarcopenia, by EWGSOP2 criteria (33), is based on a combination of low muscle strength and low muscle quantity or quality.

Weakness, muscle mass reduction and loss of physical function was taken for granted in ageing for a long time. Nowadays loss of muscle mass and muscle function in ageing is called sarcopenia (33). Knowledge on how to prevent, postpone, or interrupt sarcopenia by diet and physical activity and exercise is gradually increasing.

In 2010 the European Working Group on Sarcopenia in Older People (EWGSOP) published a definition of sarcopenia, based on age related loss of muscle mass and function (45). In 2019 the proposed definition was updated to EWGSOP2 (33), including the perspective of that sarcopenia also may occur earlier in life. In the updated version muscle strength is the key of sarcopenia, but muscle quantity and quality define the diagnosis.

The prevalence of sarcopenia has been shown to increase with age (46, 47). However, according to a French population, sarcopenia seems to be present from the age of 45 years (46), but this will probably differ substantially between populations, depending of traditions and living conditions. Physical inactivity is a major risk factor for sarcopenia (46, 48). Its prevalence is also associated with inflammatory and hormonally factors (47), quality of life and protein and micronutrient intake (48). Also, a sustained pattern of a healthy diet seems to be protective (49). However, some cross sectional studies showed equivocal results reporting a lack of association between diet, physical (in)activity and morbidity and sarcopenia (47).

Dehydration

Dehydration might be studied in the sense of dehydration due to low intake or dehydration due to volume depletion due to salt or fluid losses. Dehydration due to low intake (from food and beverages) leads to a loss of both intracellular and extracellular fluid, which raises the osmolality in urine (26). Different methods for define dehydration in older people has been suggested (50), although serum osmolality seems to be the most appropriate and valid method (51).

Symptoms of dehydration could be weakness, fever, nausea, vomiting, headache and apathy (52). The symptoms might be discrete, however, which may be a reason that dehydration is left unattended in older adults. This is possibly also a reason for research on the hydration status in older adults is scares. Although, dehydration in older adults has severe consequences. The presence of dehydration at admission to hospital has been

shown to be associated with a 6-times increased mortality risk during hospital stay, according to a study investigating hospitalised older adults in the United Kingdom (53).

Hydration status and water intake in older has been widely neglected by nutrition research and guidelines, but fortunately this is changing. Geriatric guidelines from the European Society of Clinical Nutrition and Metabolism (ESPEN) published in 2019 included the issue of hydration in clinical nutrition (26). Of the included 82 recommendation, 22 relate to preventing, identifying and treating dehydration. Generally, the guideline states that all older adults should be encouraged to consume fluids regularly and should be handled as being at risk for dehydration.

Hydration status is dependent on various factors leading to a variety of methods for prevention and treatment. However, it is of utmost importance that dehydration is observed as effective therapy is available with very positive health impact (26, 52, 53).

Nutritional status in old adults

The prevalence of good or defeated nutritional status in old adults are highly dependent on the context and the population that are studied. A meta-analysis combining research through 2014 of prevalence of malnutrition (30) showed that malnutrition, defined by the Mini Nutritional Assessment, is very common in older persons. However, the prevalence is highly dependent on individual dependence, living environment and setting of health care. The meta-analysis, combining 258 studies of a total of 113 967 people, found prevalence of malnutrition stretching from 3% (in community) to 29% (in rehabilitation and sub-acute care). The prevalence of malnutrition was 9% in the included studies performed in home care services (n=15 studies). Based on the assumption that not being classified as malnutrition indicate good nutritional status, 91% had an optimal or good nutritional status. Most studies in the meta-analysis were performed in hospital settings (n=66), but the most study participants were participating in studies in the community setting (n=49 631). However international comparisons must be interpreted with caution, because of differences in health care systems are likely to lead to differences of the status of the individuals receiving "home care services".

High age is a risk factor for nutritional problems, but that is not by age *per se*. However, old adults (>85 years) have been shown to have a high risk of malnutrition, due to low intake of macro- and micronutrients, i.e. protein, vitamin D, calcium and magnesium (54), with a variety of reasons.

High age is related to physiological changes that might affect shopping, preparing and eating food, as well as appetite, hunger and absorption of nutrients (55), which all could cause a decreased food intake and a non-optimal nutritional status. However, old adults deterioration of the diet have also been shown to be affected by income, access to a car and the distance to shops, living arrangement and kitchen facilities, appetite, knowledge about food and access to high-quality products, but also access to service providers and support from friends and neighbours – all besides the physical and mental health status (56). But high age is also a major risk factor for most acute and chronic diseases, injuries and disabilities in physical, cognitive, affective and social functions. Morbidity remains as an important risk factor for malnutrition, since it could lead to sedentary life, wounds and impaired immune function (57). Also social aspects such as living alone (58) and eating alone (59) tend to decrease intake of food and are important risk factors of malnutrition.

Hence, high age is an important risk factor for nutritional problems (60-62), and also an important risk factor for non-optimal nutritional status with consequences for daily life.

A broad perspective towards nutritional status and malnutrition will allow a comprehensive picture of the nutritional problem and its related factors in old people, both in individual care and in clinical research (63, 64). While intake of food and nutrients probably is the most intuitive area for studies and treatment of nutritional problems it is rarely the only reason for these problems. Therefore, improving intake alone cannot provide the solution for nutritional problems (60).

However, the non-optimal nutritional status might not be a problem *per se* unless it was for the functional consequences. For instance, body mass index, as a risk factor and nutritional status marker, has been studied in relation to mortality and disability in older people, with a follow up after seven years (65). The study highlighted that the optimal BMI in older people, should not take only mortality as the sole outcome measure. At least one other aspect is needed to complete the discussion; disability. The study concluded that optimal body mass index was 24 in relation to disability, with a steep increased risk for disability in both higher and lower indexes. In relation to mortality, the optimal body mass index was 27, without a steep increased risk in higher indexes.

Presence of malnutrition is associated with decreased quality of life, increased risk of falls, increase morbidity and mortality overall and undergoing surgery or medical treatments resulting in a prolonged length of stay at

hospital (27, 39, 57, 66-68). For instance, a decreased food intake before and after admission to hospital has been shown to be associated with death within 30 days after the hospital stay (69), even after adjusting for type and severeness of disease. Also, the relationship between poor nutritional status and impaired physical function is well-known (57, 70-72). However, the cause-effect relationship between food intake and physical function needs further investigation (30).

Hence, the nutritional status in older adults are important for function and overall health.

Aims of the thesis

The main questions when planning this thesis was: what is a good or optimal nutritional status in older people? And, is it possible to be 85 years old and have a good nutritional status? Or could you have a "normal" or "intermediate" nutritional status, without being malnourished?

The overall aim of this thesis was to study the nutritional status in old people receiving home health care, based on a hypothesis of a model of the nutritional status in old people, in a wide sense.

With the possibility to implement the results in clinical practice in mind, a main purpose was also to test which assessment methods to be most important for clinical practice and at the same time feasible in the patient's home.

Specific aims

- To propose a mindset for analysis of the nutritional status in an ageing and functional perspective, visualized as a schematic model that could be used in research as well as in clinical settings.

- To describe the nutritional status in a population of older people receiving home health care, based on the proposed nutritional status model. Also, to elucidate any interactions between various indicators of nutritional status and to study the changes over time.

- To elucidate patterns and relationships of nutritional status indicators, with a statistical approach, within the four domains in the proposed nutritional status model. But also, to explore if the included variables can be reduced to a few and still be representative to the overall status from the model.

- To describe and explore meal patterns and their relationship to energy and protein intake in a population of older adults in home health care, as the dietary intake are close related to the nutritional status.

Materials and methods

Below, the study population, recruitment procedure and data collection are presented.

Study design and setting

The study for this thesis was designed to study old people when they were enrolled for home health care, and then to follow up the participants for three years.

The overall study design was planned in cooperation between Örebro university and the municipality of Örebro. The choice of including participation of home health care personnel as data collectors, aimed to stimulate the personnel engagement in the research, but at the same time increase nutrition competence and simplify possible implementation of the results.

Study population

The study population comprised men and women, 65 years of age or older, who were enrolled to municipality organised home health care. The reason for receiving home health care could be physical difficulties with transportation, cognitive difficulties in planning and remembering, caring for a relative that is hard to leave alone or other difficulties making it impossible to visit a health care center. Thus, the study population is not homogenous regarding the reason for the need of home health care.

To obtain a study population generalisable to the patients in home health care, as few exclusion criteria as possible was used. Inclusion criteria were age (65+) and need of home health care with an estimated duration of more than three months. Exclusion criterion was palliative care, according to physician's judgement, hospital care leading to that home health care was cancelled or that the patient died before inclusion.

No patient was excluded due to cognitive impairments, dementia, hearing or vision loss or difficulties to read or write Swedish language. No specific actions were taken during the inclusion procedure to stimulate homogenous study population regarding socioeconomic, economy or ethnicity. For patients with cognitive difficulties, hearing loss or that were non-Swedish speaking, the question of participation was asked via a relative, home help service personnel or an interpreter.

Recruitment procedure

Inclusions into the study was continuously from year 2012 to 2017, during which time there were no officially stated changes of strategy or criteria for enrolment in home health care.

Men and women who fulfilled the inclusion criteria were invited to participate in the study. District nurses provided the patient with written information about the study, and within a few days the patient was called and asked for a meeting with the researcher (SE) to receive additional oral information and to obtain written consent.

A defined geographical area in the western part of Örebro city was used, in order to align with the home health care organisation in the municipality and to limit the number of investigators and data collectors. The chosen geographical area included a range in social classes. A participant flowchart is presented in Figure 1.

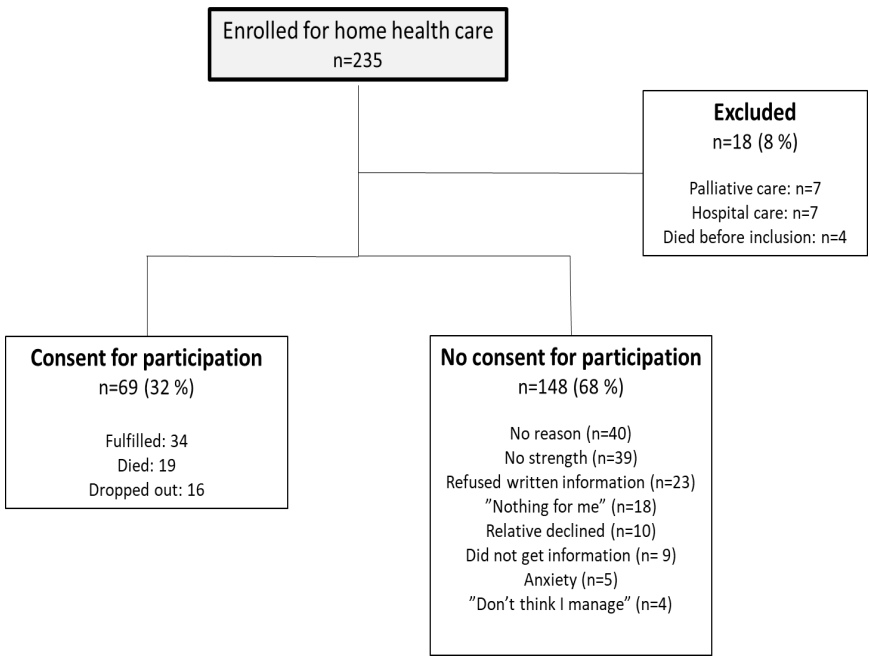

Figure 1 Flowchart of inclusion. Reasons for denying participation are freely interpreted by the researcher (SE) after telephone call. Also, the number of participants that fulfilled, died or dropped out during the 3-year follow up are presented.

Data collection

The nutritional status was studied at baseline (at time for receiving home health care) and regularly for the coming three years; every three month the first year and every six-month year two and three (Figure 2). Follow ups continued also if participants moved to a nursing home or did not use home health care anymore. However, if the participant moved to another city, they were excluded from further follow up, and noted as dropouts.

Figure 2 Study timeline. Baseline (0) and each 1-year follow up (1y, 2y, 3y) comprised a full data collection (FC). The follow up visits at 6, 18 and 30 months from baseline, comprised a limited data collection (LC). At 3- and 9-month follow up were a telephone interview (T).

To avoid unnecessary exclusions, participants were offered to use relatives, interpreter or home help service personnel in the data collection. Also, when participant did not have the skills to or wanted to participate in any part of a follow up, measurement or data collection meeting that was respected and considered as missing data.

The researcher (SE) collected data in cooperation with district nurses or assistant nurses, occupational therapists and physiotherapists at baseline and at the annual follow up. The district nurse or assistant nurse collected blood and urine samples, blood pressure and heart frequency and information about prevalent diseases, symptoms and medication. Occupational therapists collected data related to physical activity and functions of activities of daily living, affection and cognition. Physiotherapists or the dietitian (SE) collected data related to physical function and the dietitian collected data on dietary intake, anthropometry and body composition.

The use of existing personnel for part of the data collection was chosen for two reasons. First, the patients were familiar with the staff and this was thought to make the participant feel comfortable and more likely to participate in the study. Second, it was believed this would be a time effective way of organising the study, since home health care personnel already have other

duties and tasks to perform, during visits at the participant and thus reduce dropout be reducing the number of stressful situations for the participants.

Methods for analysis of the nutritional status, were based on the domains in the proposed nutritional status model (paper 1):

- Food and nutrition
- Health and somatic disorders
- Physical function and capacity
- Cognitive, affective and sensory function.

Based on these domains, methods were not only chosen based on their scientific value, but also with respect to convenience for practical purposes, such as the possibility to transport equipment to be used to the participants' home. Methods was also chosen with respect to the methods used in clinical practice in home health care or those common in research, to facilitate comparisons to other studies.

Below, methods at full data collection are presented and discussed.

Food and nutrition

Dietary intake was estimated by two different, but complementary, methods: a retrospective 24-hour dietary recall and a prospective 3-day food diary. Accuracy in reporting has been shown to be similar in the two methods (73). However, in a prospective diary there is the additionally risk that the participant adjusts the food intake during the period of recording.

At baseline, a ***24-hour recall*** was used for two purposes: first, as a "teaching" tool, to get a practical example of all the details of consumed food and beverage to note in the food diary. Second, for estimating dietary intake, though it is a less of an effort to complete for the participant compared to the food diary.

The 24-hour recall included a detailed description of food and beverages, including vitamin and/or mineral supplements and herbal remedies (74), and a question about if the recall day is representative of an ordinary day. The recall was initiated by the following phrase: "Please describe to me what you ate and drank yesterday. Start from the very first intake in the morning." The recall was ended by asking about any intake during the night or extra snacks during the day, such as small bites of food, drinks, fruit, chocolate or sweets. In addition to the baseline measurement, the 24- hour recall was used at the limited follow up at 6, 18 and 30 months and for the telephone follow up.

The 3-day food diary was used for estimating dietary intake in a limited time. At baseline, a trained dietitian (SE) gave instructions for diary in the participant's home. The participant was informed, with both oral and written instructions to note all food and beverage consumed in detail, the time of consumption, the place of consumption and if the meal or snack was consumed with the participant alone or in the presence of company (29). The amounts of food were estimated using household standards. The diary was completed by the participant or by personnel (when moved to nursing home). After completion, the dietitian made another visit asking complementary questions, in order to improve the accuracy of the dietary data. The 3-day food diary was repeated at each annual follow up.

All dietary data were coded in terms of the household standards and weights in "Dietist Net" (Kost och Näringsdata, Sweden) and the database used was PC-kost (The Swedish Food Agency). A trained dietitian (SE) made all the calculations.

Meal pattern analysis was defined based on eating occasions, defined as each eating or drinking occasion noted to the nearest 30 min [22]. Meal patterns were analysed using the following indicators: the number of eating occasions, the first and the last meal of the day, the length of overnight fast, the timing of energy and protein intake during the day, the time and size of the largest (most energy dense) meal per day. Also, early or late eaters were defined.

Health and somatic disorders

Morbidity was indicated by the number of prescribed medications (both for continuous and occasionally use), categorised by the Anatomic Therapeutic Chemical classification system (75). Also, the nurses noted present diagnosis.

For general health status, a nurse or assistant nurse measured ***blood pressure and heart frequency***, while the participant sat down.

Self-estimated presence of ***symptoms*** was charted by Pharmacotherapeutic Symptom Evaluation in 20 questions (Phase-20). The instrument comprises of following symptoms: dizziness, unsteady or high risk of falls; tiredness or exhaustion; poor sleep pattern or nightmares; abdominal pain or chest pain; headache; low mood; worries or anxiety; irritability; forgetfulness; poor appetite; dry mouth; nausea or vomiting; diarrhoea; constipation; palpitations (rapid or irregular heartbeat); swollen legs or ankles; shortness of breath; frequent urination or being incontinent of urine; itching or rash; and other symptoms. Each symptom is subjectively categorised by

the degree of problem; none, mild, moderate or severe (76). Number of severe symptoms was summed up as it was hypothesised to effect daily life.

Health Related Quality of Life was assessed by EQ-5D, classifying quality of life in five dimensions: mobility; self-care; usual activities; pain or discomfort and anxiety or depression (77). The individual result is weighted, and computer calculated into a summary index (score) from 1 (full degree of health) to -1 ("dead").

Blood samples were collected for biomarkers of malnutrition, inflammation (S-Albumin and P-CRP). Other biomarkers comprised blood count and iron-status (B-Haemoglobin and S-Ferritin), vitamin B-status (S-Cobalamin and S-Folate) and vitamin D-status (S-25-OH-Vitamin-D). Blood samples for the thyroid function (S-TSH and S-FT4), metabolic regulation (P-Glucose and S-Insulin), kidney function (glomerular filtration rate, GFR estimated from S-Creatinine and S-Cystatin C) were analysed as well. Furthermore, biomarkers of hydrations status were analysed in blood samples (S-Sodium, S-Potassium and S-Osmolality) as well as in ***urine samples*** (U-Osmolality and U-Sodium).

All measurements in the domain of health and somatic disorders were included in the full data collection at baseline and at each annual follow up. At the limited data collection time points (at 6, 18 and 30 months follow up) blood pressure, heart frequency as well as blood and urine samples were excluded.

Physical function and capacity

Physical activity was self-estimated using two different questionnaires: In the Frändin-Grimby Scale of physical activity (78), the participant indicate a category, from 1 to 6, that matches their physical activity level at present: 1=hardly any or none at all; 2=mostly sedentary, with occasional light activity; 3=light physical activity 2-4 hours per week; 4=exercise 1-2 hours a week; 5=exercise 3 hours a week; or 6=hard or very hard exercise several times a week.

The International Physical Activity Questionnaire modified for elderly (IPAQ-E), quantify the self-estimated amount of physical activity (79). The participants were asked to estimate how many days and how much time (in hours and minutes per day) in the previous seven days they have been; spending sitting down; walking at least 10 minutes in a row; performed something that has been somewhat strenuous or; performed something that has been very strenuous. The questionnaires were completed by the participant or in assistance by occupational therapist.

Abilities of Activity of Daily Living (ADL) was assessed according to ADL Taxonomy (80), by interview and observation of occupational therapists. The assessment includes 12 activities that are assessed by comprising actions: eating and drinking; mobility; going to the toilet; dressing; personal hygiene; grooming; communication; transportation; cooking; shopping; cleaning; and washing. The ability to perform the activities are rated as "can do and perform" or "cannot, does not perform".

Physical function was assessed by hand grip strength, peak expiratory flow rate, chair stand test and timed up and go test, performed by instructions of a physiotherapist or researcher (SE).

Maximal hand grip strength was measured using a Jamar handheld dynamometer (81, 82), with the participant sitting, with the elbow in 90 degrees angle. The maximal result of three measurements on each hand, regardless of dominant hand, was noted.

Measurements of peak expiratory flow rate was done using Mini-Wright (Clement Clarke International), with the participant in sitting position. The maximum result of three measurements was noted (83).

As a functional test of strength in the lower extremities, chair-stand test (84) was used, where the participant, with folded arms, raised from a chair (with or without armrest), as many times as possible within 30 seconds.

Timed up and go test (85) combine muscle strength, balance and walking ability. The participant raises from a chair (with or without support), walks three meters forward, and then turns back and sits down again. The participant used walking aids if they preferred to do so.

Anthropometric measures were performed, with the participant dressed in underwear or very light clothing, by a dietitian (SE). Body weight was measured on a digital portable scale (MS-4203, Corina Medical) and body height, in a standing position, using a mobile stadiometer for height measurement (Seca 217).

Circumference of waist, hip, mid arm and calf was measured with a non-elastic measuring tape (74). Waist circumference was measured midway iliac crest and the lowest rib, hip circumference crossing the trochanter major, mid arm circumference midway acromion and olecranon and calf circumference at the thickest part of the calf. In measurements of calf circumference, the participant was sitting down, but otherwise the measurement was performed with participants in a raised position.

Body composition was estimated using BCM, Body Composition Monitor (Fresenius Medical Care), a multifrequency bioimpedance spectrometer. Measurement were primarily made on left side of the body, where electrodes

were placed on the wrist and on the upper foot respectively. Participants was asked to, if possible, remove all metal components, as watch, belt, necklace etc. Mean value of two consecutive measures was noted. BCM use multifrequency to measure total body water as well as intracellular and extracellular water. Using integrated models, a three-compartment body composition model of adipose tissue, lean tissue and hydration, are extracted.

All indictors in the domain of physical function and capacity were included in the full data collection at baseline and annual follow up. At the limited data collection (at 6, 18 and 30 months follow up) body height and circumference of waist, hip, mid arm and calf were excluded.

Cognitive, affective and sensory function

Cognitive mental functions were evaluated with Mini Mental State Examination, MMSE (86), by an occupational therapist. A maximum score of 30 indicate no decline in cognitive function, while scores below 20 occur in old adults with dementia, delirium, schizophrenia or affective disorders.

Depressive symptoms were identified using Geriatric Depression Scale (87, 88). The questionnaire was completed by the participant, or by occupational therapist in an interview. With a maximum score of 20, depression is considered to be unlikely below scores of six. However, a score above six indicate that depression could be present, and the symptoms must be further investigated.

Self-estimated sense of ***smell and taste*** were assessed using a Visual analogue scale (VAS). The participant estimated their sense of smell and taste, respectively, on a VAS from 0 to 10, where 0 corresponds to "very much reduced sense of smell/taste" and 10 corresponds to "very good sense of smell/taste".

Appetite was also self-estimated using a Visual analogue scale (VAS) from 0 to 10, where 0 corresponds to "very much reduced appetite" and 10 corresponds to "very good appetite".

All indictors in the domain of cognitive, affective and sensory function were included in the full data collection at baseline and each annual follow up. At the limited data collection (at 6, 18 and 30 months follow up) no indicators were included.

Nutritional status

Generally accepted methods to assess different aspects of non-optimal nutritional status were included, with some commonly used in nutritional studies and occasionally in clinical practice.

Malnutrition were defined using two different methods: the Mini Nutritional Assessment, MNA (28) and by the criteria of Global Leadership Initiative on Malnutrition, GLIM (31).

The MNA questionnaire are summed up to a total score. Of a maximum score of 30, <17 indicate malnutrition and, 17 to 23.5 indicate risk of malnutrition. An included question of body weight loss the previous three months was extracted and used as a binary variable at baseline.

According to GLIM criteria of malnutrition, cut-off values of the phenotypic criteria was as follows (male/female); weight loss >5% past 6 months or >10% beyond; low BMI <22 if more than 70 years otherwise <20; low muscle quantity was defined as fat free mass index <15/<17 kg/m^2. Cut-off values of the etiologic criteria was as follows (male/female); reduced food intake defined by food intake level (energy intake divided by estimated basal metabolic rate) of <0.7 or stated reduction in food intake according to MNA; gastrointestinal condition were defined by ICD (International Statistical Classification of Diseases and Related Health Problems). Inflammation due to disease was based on diagnosis of cancer, heart failure, chronic obstructive pulmonary disease, rheumatic arthritis, renal failure or other renal disease.

Frailty was defined using Fried criteria (32), where the diagnose is set if fulfilling three or more of the criteria: weight loss, exhaustion, weakness, slow walking speed, and low physical activity. Cut-off values was as follows; weight loss of >4.5 kg the past year or >3 kg the past 3 months; moderate or severe tiredness or exhaustion were indicated in Phase-20; physical activity level of 1 or 2 in Frändin-Grimby physical activity scale; a long walking time was defined using timed up and go test of >30 seconds without walking aid and >20 seconds with walking aid. Low grip strength was stratified by gender an BMI; for men ≤29 (if BMI ≤24), ≤30kg (if BMI 24-28) or ≤32 (if BMI >28) and for women ≤17 kg (if BMI ≤26), ≤18 kg (if BMI 26-29) or ≤21 (if BMI >29).

Sarcopenia is defined according to EWGSOP2 criteria (33) using the combination of low muscle strength and low muscle quantity or quality. Cut-off values was as follows (male/female): Low grip strength was <27/<16 kg, low chair stand function was >15 seconds for five rises (converted from maximal chair stand in 30 seconds) and low muscle quantity was fat free mass index <15/<17 kg/m2.

Dehydration by low-intake was defined as U-osmolality >300 mOsm/kg body weight.

Methods for statistical analysis

The following statistical methods have been used in the papers included in the thesis.

Descriptive statistics were used in paper 2, 3 and 4 to describe the study population in different aspects using variables in the four domains. Mean and median values as well as distribution measurements of 95% Confidence Interval were used. Also, boxplots with median and the lower and upper quartile were used for visualising changes over time but also to visualise difference between groups of survivors and non-survivors as well as between dropouts and non-dropouts (paper 2).

Statistical differences were analysed using chi-square test. In paper 2 difference in prevalence of non-optimal nutritional status were compared according to sex (men/women), survival (survivors/non-survivors) and dropout (dropouts/non-dropouts). In paper 2 paired sampled T-test were used to study differences between the two methods of assessment of dietary intake. Mann Whitney U-test were used to analyse differences in nutritional status by individual component scores (paper 3) as well as to analyse differences in dietary intake between early and late eaters (paper 4).

Correlation analysis were made using Spearman rank correlation in paper 2 and 4. In paper 2, correlations were analysed at baseline and at each follow up separately within and between the four domains in the proposed nutritional status model (paper 1). In paper 4, correlations between meal characteristics, pattern indicators, and daily energy and protein intake were analysed. Pearson correlation was used to analyse bivariate correlations between the components from the factor analysis (paper 3).

Regression analysis were used in paper 2, with two separate multiple linear regressions. In the first, four nutritional status variables were dependent; B-Haemoglobin, fat free mass, S-CRP and S-Osmolality. Secondly, four functional status variables were dependent; chair stand test, timed up and go, health related quality of life and number of severe symptoms. Independent variables were variables in the four domains of the proposed nutritional status model, chosen to get variables that represents different areas and perspective in each domain.

Factor analysis was used in paper 3 to identify possible patterns (components) that combine variables within the four domains in the proposed nutritional status model. The analysis was also used to suggest a reduced number of variables that could be recommended in clinical practice.

Statistical analysis was made in IBM SPSS Statistics, and for all analysis statistically significant correlations where considered to be $p < 0.05$.

Missing data strategies

In the statistical analysis of data, handling of missing data is important. One could choose to exclude all participants with missing data, but that also means excluding useful information. Different strategies were used to manage missing data with the main purpose to lose as little information as possible for the analysis.

In some cases, a participant did not participate at follow up but returned to the longitudinal study track at the next follow up occasion, making one set of data for a complete follow up are missing. The main reasons for missing data in the data collection were temporarily illness of the participants that cause incomplete or partial missing data in a follow up or that the participant did not have the physical or cognitive capability to cooperate for some measurements. Missing data also occurred if home health care personnel was not able to do the follow up for any reason and occasionally mistakes in communication made the follow up "fall between chairs". This was probably inevitable but was minimised as much as possible by making all follow ups in the participants home, not demanding the participant to leave home in rainy or snowy weather or with icy sidewalks.

In paper 2 we used data from the annual follow up for analysis and compared with the baseline data. When individual data was missing at an annual follow up, we used individual data from the last observation to fill the space of the missing.

In paper 3, participants with more than 70% missing data of the included variables were excluded. For the remaining participants, missing data was imputed. Imputation consisted of mean values for the variable in question in groups of participants matching for sex, malnutrition and BMI. The imputation was complete and resulted in no missing values.

In paper 4, studying the meal pattern at baseline, nine participants were excluded from the analysis; seven were not able to verbally recall there intake of food and drinks the past day in the in the 24-hour recall that was used for dietary intake analysis, and two could not specify the time for eating and drinking.

Ethical considerations

The research protocol of the study that are the base for this thesis was approved by the research ethics committee in Sweden (Uppsala), Dnr 2013/305. However, throughout the study some more ethical considerations arose.

Firstly, the very broad inclusion criteria could infer the risk that patients who were not fully able to understand the terms of participation were asked to take part and enrolled in the study. Misunderstanding could occur both regarding the extent of the data collection and regarding the follow up in three years from baseline, which is a long time.

The researcher made a home visit to the patient to give information, discuss questions and if willing to take part, also get a signed formal consent to participate. At this point in the recruitment process, it might have been difficult for the patient to deny participation, when the researcher was sitting at the kitchen table.

The written consent included the entire study and including follow up visits and measurements during the following three years. In the written consent it is clearly specified that the participant was free to end their participation at any time, without the need to specify any reasons, and this was also pointed out during the oral information before signing the consent. However, at each follow up, the researcher contacted the participator by telephone in advance in order to obtain consent to further participation.

Theoretically, none of the examinations included in the study protocol should contribute to any physical unpleasantness, with the exception of the blood sampling. However, also questions about cognition or depression symptoms might be upsetting in some situations. Instructions to data collectors were very clear to interrupt data collection if signals of unpleasantness appeared.

The number of measurements for each participant was quite extensive, involving three or four different health care professionals contacting the participants to book visits for follow up over a span of a few days. These visits were intended to be scheduled within a short time period, aiming for a maximum of two weeks to get as little change in health status as possible during the data collection period. This could imply quite a substantial burden to the participant. On the other hand, participants appreciated the visits and the extra social contact. The participants also expressed that they should miss the regularly visits from the researchers when the three year follow up was ended.

When planning this study, we argued that the use of home health care personnel could benefit the inclusion and comfortability as the district nurse and occupational therapist already had a relationship with the patient. Also, another reason was that it would be time effective, since the personnel already had several meetings with the patients and could include the data collection at the same time. In practice, the first argument was only somewhat true since some participants were discharged from home health care. Also, while the study period lasted from 2014 to 2020, some personnel left their jobs and replacements were done during this period. It turned out that, in practice it was also hard for nurses and occupational therapists to coordinate their regular assignments with the study protocol.

All participants were sent a letter, including the participant's results of the various measurements, after baseline and the follow up at 6, 18 and 30 months. Important results were highlighted. Hence, in cases that some results indicated an important functional aberration (e.g. decreased kidney function or extensive weight loss) the participant was noticed about the situation and was referred to their medical contact.

Results and discussions

Below, the main findings of the four included papers are presented and discussed.

Paper 1: Nutritional status model

The aim of the first paper was to propose a theoretical model of nutritional status in a functional perspective, and to articulate the complexity of nutritional status in old people.

The proposed model comprises four domains, all affecting the nutritional status and the optimal function (Figure 3). The four domains are; food and nutrition; health and somatic disorders; physical function and capacity; and cognitive, affective and sensory function, which all should be included in a nutritional examination. Each domain affects the nutritional status in a bi-directional way; each domain affects the nutritional status and the nutritional status affects each domain.

The model is aiming to contribute to fruitful discussions in nutritional assessments and might be a support in finding markers of the nutritional status and planning future care and research. Function is the outcome, instead of the more commonly used morbidity or mortality, as a way to add an important and relevant clinical outcome (89, 90). Hence, function is seen in a broad perspective, as physical, psychological, mental, cognitive, affective, sensory or any other function. Most importantly, the outcome of optimal function must be individually defined to be highly relevant for the individual in mind and adapted to the situation.

The proposed nutritional status model is the main hypothesis of this thesis. The model is multifactorial and suggest associations within as well as between the domains, in a two-way-direction. The model is not focusing on defining a nutritional status but is proposed as a way of thinking in the assessments and discussions of the nutritional status; both in research and in practice, but also both in groups of people and populations as well as in individual cases.

No other models visualising the nutritional status in this wide perspective leading to functional outcome, has been found in the scientific literature. However, there are models describing the processes of mechanisms related to the nutritional status (63, 91). The proposed model is developed with old adults in mind, but future developments could be studies in other groups of people.

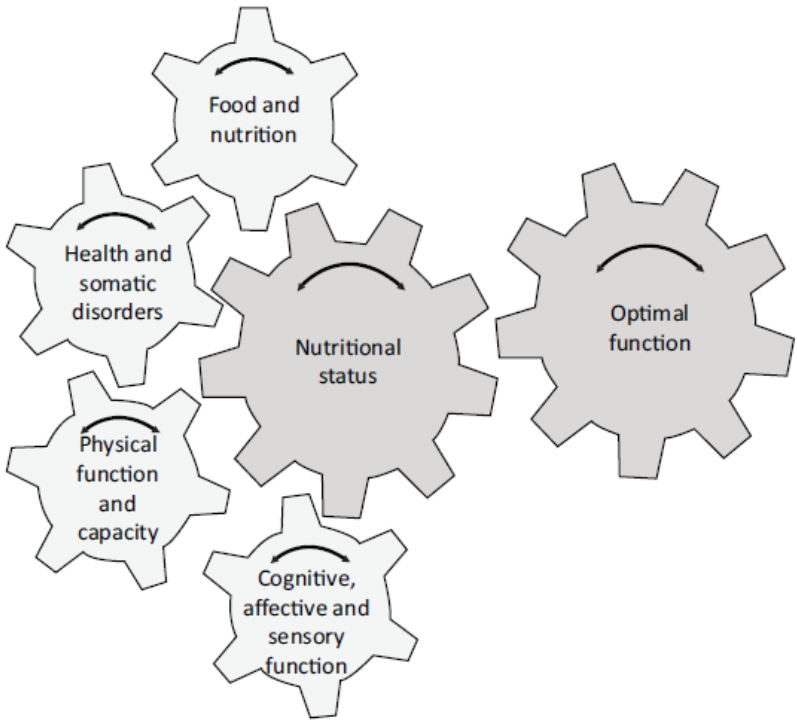

Figure 3 The proposed model of nutrition status assessment, including four domains that all contribute to the nutritional status; food and nutrition; health and somatic disorders; physical function and capacity; and cognitive, affective, and sensory function. Optimal function is defined for each person, and is also the most important factor, and at the same time the overall goal of any act or treatment.

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Ageing is often characterised by the presence of chronic diseases, and more explicitly multimorbidity, increasing the risk of symptoms that affect the nutritional status but also the four domains. A Swedish prevalence study of morbidity in a population of 77-100 years old (92), displayed that 55% of the population had multimorbidity (e.g. two or more chronic diseases), with cardiovascular and mental disease the most common. Additionally, 31% had single-morbidity, leaving the remaining 14% with no morbidity

at all. The multimorbidity is one example of circumstances making the nutritional status in old people unique in its complexity.

This has been shown previously. For instance, the Mini Nutritional Assessment, comprises questions in a wide spectrum, including body structure, questions of lifestyle, medication and morbidity, as well as dietary intake (28). Also, in GLIM criteria of malnutrition (31) body structure components are combined with analyse of food intake, inflammation and disease in the diagnose criteria. In a Model on Determinants of Malnutrition in aged persons (63), the determinants of malnutrition are presented in a triangle form with different closeness to malnutrition, placed in the center, for different variables. Closest to the center is the central etiologic mechanisms affecting malnutrition (low intake, increased requirement and reduced bioavailability of nutrients). The next layer are factors that directly could lead to one of the central etiologic mechanisms (e.g. dysphagia, inflammation and poor appetite), followed by a layer of factors that indirectly could lead to one of the central etiologic mechanisms (e.g. dry mouth, surgery, infections. Finally, the triangle has surroundings factors being age related changes acting even more indirectly or subtle to malnutrition (e.g. frailty, hospitalisation, polypharmacy). The nutrition status indictors in this triangle model of malnutrition ethology are also included in the domains in our proposed nutritional status model. However, we propose a model where the indicators are not sorted by possible effect on nutritional status and with a broader aspect of the nutritional status than malnutrition alone.

Paper 2: The model in use – description of a study population

The aim of the second paper was to describe a population of old people with home health care according to the proposed model of nutritional status assessment, as well as to study interactions between indicators of the nutritional status and its development over a longer period of time.

In total, 69 older men and women with home health care were enrolled and followed up regularly for three years. After three years, 37 men and women remained for the 3-year follow up, while 14 participants (20%) had died and 18 (26%) dropped out or were excluded.

Inadequate nutritional status, such as malnutrition, frailty, sarcopenia and/or dehydration were prevalent in the study population, and especially dehydration and reduced appetite were common and also indicate a deteriorating nutritional status.

The study population was characterised by large intra-individual differences in all the measured variables, a finding shown in similar populations

previously (93). At the same time, almost everyone had medications regularly prescribed, and the prevalence of polypharmacy was 83%. The high prevalence of polypharmacy in older adults and its negative health consequences have been described previously (94). It was also common that participants encountered subjective symptoms classified so *severe* that they substantially affected quality of life. Physical activity, as well as physical strength was generally low, and participants were commonly in need of support to manage complex activities of daily living such as cooking, shopping and house cleaning. However, no clear pattern of changes over time were found. In summary, the study population was fragile, weak and in need of support in daily life, as expected when planning the study.

Energy and protein intake among the participants was generally low. Still, micronutrient intake was generally not critically low compared to the Nordic Nutrition Recommendations (15) and indicated generally a low probability of inadequate intake and that malnutrition due to single micronutrient should be an exception. Nevertheless, malnutrition due to low energy and protein intake could still be present and infer critical consequences.

Low energy and/or protein intake may cause loss of body weight, decrease of muscle mass, muscle strength, functional abilities (95) and bone health (96), but also an increased risk of developing frailty (97-99), making prevention and actions important even in old ages.

The prevalence of overweight or obesity was 44%, while 25% of the participants were underweight, leaving a third of the study population within a BMI span that is optimal for a decreased mortality risk in the coming seven years (65). However, the body fat mass was high, and that represents an increase risk of chronic inflammation, insulin resistance and type II diabetes mellitus, cardiovascular and atherosclerotic disease (100).

Non-optimal nutritional status was also common; prevalence of malnutrition, sarcopenia, frailty and dehydration were 83% (n=35), 44% (n=24), 34% (n=18) and 45% (n=25) respectively and with overlapping syndromes in several individuals. However, as far as we could see, these warning signs were rarely noticed and acted upon by the care givers or medical professionals in touch with the patient. Poor nutritional status in old adults has been reported in several studies from Sweden, Europe and internationally during the last decades (10, 30, 53, 72, 101-106).

We found no clear pattern of indicators or a pattern of change over the 3-year period of follow up. Studying the entire study population, individually changes could be rather large but were counter-balanced by opposite changes in other individuals. This heterogenicity makes these changes

invisible in a group analysis. Therefore presenting results as means or median values of a study populations like this has been called agism (93). The inter-individual differences could be rather large but are concealed in the group presentation.

Analysing correlations and relations of variables within and between domains as well as change over time, dehydration and reduced appetite seemed to be the indicators that were repeatedly identified as important factors of a deteriorating nutritional status. Dehydration was associated with a lower quality of life, depression and loss of physical function, and confirmed previous research (51). Still hydration is rarely studied in nutrition research.

Loss of appetite was more prevalent in the participants that later died during follow up, possibly a consequence of changed dietary habits related to the loss appetite (107). Also, the variables in the domain cognitive, affective and sensory function explained about 30% of the variation in dehydration. However, we did not find correlations between appetite and energy or protein intake.

In day to day practice, loss of appetite and dehydration are symptoms that might be seen as part of normal ageing, and therefore not taken seriously as part of the nutritional assessment and treatment. Since both loss of appetite and dehydration were common in the study population throughout the study, and associated with health problems and even death, these factors should be better emphasized in the training in home health care about nutrition and nutritional assessment.

That participants, for various reasons, would drop out during the three year follow up was forecasted. In analysis of differences between non-survivals and those who completed the 3-year follow up there were some differences between the groups, which might indicate presence of selection bias, as the non-survivors had higher prevalence of malnutrition and worse appetite at baseline. Comparing survivors at baseline with non-survivors at their last follow up prior death, non-survivors had lower quality of life, cognitive and physical function, physical activity and intake of dietary fibre and water. Also, prevalence of frailty and low appetite was more frequent in non-survivors.

Participants who, by various reasons, declined further follow up and those who were excluded during the follow up were compared with participants that completed the 3-year follow up, and no statistically significant differences, in the study variables, were found.

Paper 3: The model with a statistical approach

The aim of the third paper was to explore patterns and relationships of nutritional status indicators, to elucidate how these patterns affects the nutritional status over time and to study if the many observed indictors could be reduced to a few for better manageable implementation into clinical practice.

This study explored the nutritional status with a statistical approach. Study cohort were the same as in paper 2, with 69 older adults. A total of 103 different variables, being nutritional status indictors, were included in the study.

Factor analysis using baseline data, resulted in four to eighteen components within the four domains. The first three components in each of the four domains explained between 31% and 63% of variation in the study population, which was generally stable throughout the three years of follow ups. The three first components, called main components, of each domain were correlated with the main components in the other domains, confirming interrelation between the domains as proposed in the model. There were statistically significant differences in prevalence of malnutrition, frailty, sarcopenia and dehydration between low or high individual component scores in all four domains, indicating that all domains are associated with these syndromes. This was also hypothesised in the theoretical model of nutritional status.

The factor analysis in this study population indicate that the studied 103 variables could be reduced to 19 main indicators of the nutritional status. These were as follows; energy intake, food intake level and E% fat; subjective symptoms of having poor appetite, being short of breath, having swollen legs or ankles or feeling forgetful in combination with s-osmolality and Glomerular Filtration Rate; BMI, hip and waist circumference, body cell mass, intracellular water, fat free mass and timed up and go test; and self-estimated sense of taste, smell and appetite.

To our knowledge, there are only two studies that have used factor analysis to create factors as a description of the nutritional status; one including small children (108) and one including children older than six years, adults and old adults (109). The study including adults included 28 variables in three domains (dietary, biochemical and anthropometric measures). The factor analysis identified eight components and proposed that eight variables should routinely be used in nutritional assessments; vitamin A and iron in the diet; haemoglobin, serum iron, folate, albumin and urinary thiamine or riboflavin; and body weight. Although, none of the recommended variables match

our analysis, but could be explained of us using more variables, in more domains and in less participants.

However factor analysis has been used in other areas of nutritional research, as to component dietary patterns (110, 111), to analyse relations in nutritional status instruments (112) or to compare nutritional status, e.g. defined as malnutrition, to components in an instrument (113).

The results of our study confirmed that the four domains in the proposed nutritional status model (Figure 3) are interrelated to each other. Also, the results confirmed that all domains were associated with (non-optimal) nutritional status. Main determinants in the extracted components are important for health care personnel to assure attendance to. In this analysis, as well as in paper 2, loss of appetite was found to be important variable and could be one of several indicators of malnutrition and dehydration.

Paper 4: Study of meal pattern within domain Food and nutrition

The aim of the fourth paper was to describe meal pattern, as a component in the domain of food and nutrition, but also to study its correlations with intake of energy and protein.

Four or five eating occasions per day were most common, as well as an overnight fast of 13 hours in median. The largest meal of the day was most commonly mid-day, and this meal provided the largest protein intake of the day. The number of eating occasions or a long overnight fast was not correlated with total energy or protein intake. However, a large amount of energy from the largest meal of the day was positively correlated with a larger daily energy and protein intake. This indicates that one large meal a day had more impact on daily energy and protein intake than more eating occasions during the day.

Traditionally Swedish meal pattern comprises three main meals during the day; a cereal-based cold or hot breakfast, a cooked lunch, a cooked dinner and some in-between meals or snacks. Up to 2004, the Nordic Nutritional Recommendations included guidelines of meal pattern (114); energy and nutrients should be spread over the day, and breakfast should contribute to 20-25% of the total daily energy intake and lunch and dinner should contribute to 25-35% each. The remaining (5-30%) should be snacks of good nutritional quality at one to three times a day. Meal pattern guidelines was also differentiated to different age span (children, adolescence and old people) and separated for night and shift workers. In the Nordic Nutrition Recommendations of 2012 meal pattern guidelines are missing (15). However, the Swedish food based guidelines recommend a meal pattern

consisting of three main meals and some snacks if needed (115). In a survey by the International Union of Nutritional Sciences (IUNS) in 1994 (116) revealed that recommendations of meal pattern was uncommon internationally. However, no follow up study in later years have been done, as far as we know.

In elderly care, the Swedish Food Agency guidelines of meal pattern are present (16). These guidelines state that meals should be widespread over the day, for instance with three main meals and at least three snacks. But also, that more snacks and intermediate meals should be offered to people that eats very small amounts in the main meals. The guidelines also stated that the overnight fast should be less than 11 hours in elderly care. We found that most participants exceeded the recommendation of overnight fast, but we found no correlation between the length of the overnight fast and daily energy or protein intake. Thus, in this study population the overnight fast was of minor or even no importance to the daily energy and protein intake.

Several Swedish municipalities measure the duration of overnight fast in elderly care regularly, but no national results have been published. It is important to stress that these measurements can have different purposes. To use it as an indicator of nutritional status or nutrition care our finding suggests it will be too vague. In a group, or organisation, this measurement will rather reflect routines of meal planning or if personnel offer a small snack if patients experience trouble sleeping. However, our data suggest that at an individual level, a long overnight fast might be compensated by increased energy and nutrient intake during the hours awake. At an individual level, it can be argued that a long fasting period will stimulate gluconeogenesis, and therefore cause increased breakdown of protein and muscle mass. Muscle synthesis does not seem do differ between younger and older adults (117), which indicate that the length of overnight fast should not give more negative effects in older than in younger adults. Also, theories suggesting that intermittent fasting used for weight reduction purposes have been raised. For instance, Anton et al (118) concluded in a review that long fasting periods would preserve muscle mass and functions. However, possibly not optimal for older adults, in contrast to young where it may be beneficial. This hypothesis needs to be further explored to clarify if a shortened overnight fast could be an intervention that reduce muscle mass decline and to improve nutritional status in ageing. A shortened overnight fast has also been reported to be used as one of the best known national actions to reduce risk of pressure ulcers wounds in Swedish municipalities (119), despite lack of evidence for its efficacy related to wounds.

We found no association between number of eating occasions and daily energy or protein intake. Instead we found an association between energy intake from the largest meal of the day and total energy and protein intake. Thus, these results suggest that focus should be on eating a proper meal during the day to achieve an adequate energy and protein intake. This strategy should be prior to having a short overnight fast or more eating occasions during the day, that is recommended in the Swedish guidelines for elderly care (115). In practice, this means that the proper meal probably has to be a small, and very energy dense portion so that the person will be able to eat the whole portion.

General discussions and considerations

Experiences of using the nutritional status model

During this study strengths and weaknesses of the nutritional status model proposed and tested has been revealed.

The model displays a multidimensional approach to the nutritional status, but it does not aim to define what a nutritional status is or how it can or should be measured or defined. This approach can be considered to be both a strength and a weakness. A strength because the nutritional status, particularly in old people, needs to be viewed in its complexity for each individual case. The model makes it clear that the nutritional status is not as "simple" as biochemical definition of adequate balance of nutrients, or a body size measurement like body mass index alone. This was also confirmed by paper 2 and 3, as we found interactions between all domains and non-optimal nutritional status. However, the absence of definition of the nutritional status or an optimal function in the proposed model is also a weakness since the complexity makes the nutritional status not concrete and diffuse and therefore hard to understand and to translate into daily practice.

The multidisciplinary context has previously been shown to be important in nutritional interventions (63, 120-122), regardless if the target is to preserve a good nutritional status or to avoid malnutrition, frailty, sarcopenia or dehydration.

Variables related to food intake are of course an important component in the nutritional status but needs to be analysed in a wide context in populations of old individuals. The energy intake is vital, since a larger food intake (i.e. energy intake) is associated with higher intake of nutrients (123). Also, an adequate protein intake, combined with an adequate energy intake, can stop, limit or revert muscle mass decline in older adults, as well as limit the decline in strength and functional ability (95). An adequate total daily intake (of 1.0-1.5 g/kg body weight) (95, 124), but also the distribution during the day seems important for muscle mass (125, 126). Oral nutritional supplements (127), dietary counselling with dietitian (128, 129), vitamin D supplements (130), as well as adjustments of meal situation (131, 132) can be part of an effective strategy to improve nutritional status in older adults. The importance of physical activity and training has been highlighted and gradually integrated in nutritional research and impaired muscle strength may indicate risk for deteriorated nutritional status (81, 83, 133-136).

The nutritional status assessment are, and should be, a self-evident part of the health care of older adults (137), sometimes denoted as a Comprehensive Geriatric Assessment. This serves as a working process to support assessment, diagnosing, treatment and follow up of old adults, comprising assessment of physical, mental, functional, social and environmental conditions. The interaction of nutritional assessment and nutritional aspects in the Comprehensive Geriatric Assessment approach has been clarified (64). This working process are multidimensional, just like the proposed model of nutritional status presented in this thesis. Nutrition and the nutritional status will be involved in all these dimensions, but equally will all dimensions affect the nutritional status (64). This is also confirmed in paper 2 and 3 in this thesis.

With the proposed nutritional status model as a base, one might develop more specific methods or models. For instance, in paper 2, linear regression analysis showed that the variables in the domain cognitive, affective and sensory function explained about one third of the variance of body composition, dehydration, physical function and number of severe symptoms. Also, in paper 3, a total of 19 important variables in the four domains are presented and is a large reduction from the 103 variables included in the analysis. The total results indicate the importance, and use, of self-estimated appetite, smell and taste as well as symptoms of depression and cognitive decline, as its affect health indicators (variables) in the other domains. The triangle of determinants of malnutrition, presented by Volkert et al (63), developed by consensus by experienced researcher included all these 19 nutritional status indicators as determinants of malnutrition, except for self-estimated function of smell and taste.

One could reflect about the construction of the model, comprising four smaller gears of the domains (food and nutrition; health and somatic disorders; physical function and capacity; and cognitive, affective and sensory function), and two larger gears (nutritional status and optimal function). A suggestion of change could be that the gear food and nutrition should be placed in the center; between the large gear of nutritional status and the three smaller gears. Then, food and nutrition could be seen as a transition, a key to nutritional status and optimal functions but as an effect of disease, mood and physical function and activity. Then, the nutritional status always is affected through food and nutrition, but with different entrances from the smaller gears. However, in that case, one could read the model as food and nutrition never could be the domain that alone affect the nutritional status, that it is always affected by the other three smaller domains.

However, this is speculations, and it is not possible to draw any conclusions about these reflections about the construction of the model based on the results of this thesis.

Discussion of study population and methods of choice

A large proportion of the patients declined inclusion in the study, and this was the main reason for the five years it took to include all of the 69 participants. This is a circumstance that may allow the results to be viewed primarily as representing a selected group of patients and not applicable for home health care patients in general. Taking this reservation into account, the results still reflect the situation for a portion of home health care patients. This is reflected by the large spectrum of diagnoses, the wide age span as well as the range and degree of support and care needed by the individuals in the study group. Therefore, we assess that the results reflect the variety in the population receiving home health care, at the time in this area.

The district nurses were instructed to present the study in a neutral and similar way to the patients. However, this was not possible to guarantee, and in the individual situation the district nurses had to answer any questions or comments that came up spontaneously. Also, there were several nurses involved in the recruitment of participants and some nurses recruited more participants than others. This might impact selection for inclusions. However, this was not possible to avoid since nurses covered different geographical areas.

The inclusion procedure might have caused a selection bias towards the healthiest citizens (138). To be asked to participate in the study, the person had to be at least 65 years of age and have the strength and willingness to accept the offer. And once included in the study, they need to cope with the regularly follow ups.

The study population is in a sense both heterogenic and homogenic at the same time. The characteristics of the study group show a heterogenic population, with large inter-individual differences of all characteristics. For instance, the age at enrolment to home health care (baseline of this study) has a range from 65 to 97 years of age – a 32-year difference. But, at the same time the study population is, in other respects, homogenic, consisting of participants with multimorbidity, large numbers of prescribed medications, some decline in cognitive function, normal or just slightly overweight with low physical activity and low energy and protein intake.

The methods of choice for assessing the nutritional status were chosen by their applicability with regards to the location of examinations (in the participants home) and the investigators and personnel (dietitian, district

nurses, occupational therapists and physiotherapists) conduction the study. An example of adaption regarding the location is that the six-minute walk test or gait speed were not chosen, since it was considered not to be doable in the home environment.

Also, for body composition measurements, we used bio-electrical impedance analysis (BIA) since it is transportable and easy to use. The method has been criticised for not being fully reliable in older adults, because the it does not consider the age-related change in hydration status in different body tissues (139). However differences in accuracy of the formulas included in the impedance analysis is probably more dependent on body composition than on age per se (140). Dual energy X-ray Absorptiometry (DXA), where body composition is measured by X-ray technique are considered as a gold standard for body composition measurements. However, the measurement equipment is not portable and was therefore not included.

For most of the methods used, the results showed a wide range in the study population, which could be interpreted as the method caught individual differences. One exception was the method to estimate the physical activity level, the Frändin-Grimby activity scale (78). Also, the other method for estimating physical activity, The International Physical Activity Questionnaire modified for elderly (IPAQ-E), displayed a small range. The results indicate a study population with low physical activity, however the instruments had possibly to low sensitivity for this population, as most had the same result.

Two different methods for defining malnutrition were used in this thesis; the Mini Nutritional Assessment, MNA, (28) and definitions according to GLIM criteria (31). At baseline the prevalence of malnutrition according to MNA was 19% and 83% according to GLIM criteria. Similar differences have been shown between GLIM criteria and other malnutrition criteria (37). This large difference might be a consequence of the absence of definition of a nutritional status and lack of consensus of definitions of malnutrition. However, one would also need to take into account that MNA was first published in 1996, and the GLIM criteria was published about 20 years later (in 2019). During this time our knowledge about malnutrition have increased. MNA is, though, still widely used in geriatric nutritional research yet today.

In this study, a wide range of methods, all nutritional status indicators were used. Reasons was partly to test the usage and feasibility of the methods in the study population and in this way of collecting data; in the participant's homes. All used methods were possible to use, based on these conditions, in this population. However, further exploring of what methods being the most reliable in clinical practice in home health care is needed.

Future challenges and practical implications

The descriptions of the study population (paper 2) revealed that non-optimal nutritional status is common, when it is defined as malnutrition, sarcopenia, frailty and dehydration. This situation was present at baseline as well as at the annual follow ups. More importantly, these nutritional problems were not always noticed, not further assessed and cared for, as far as we could grasp. However, this is not a new situation nor new knowledge, and the results of this thesis articulates important questions and raises some thoughts about this situation. Increased use and applications of the results of this thesis integrated with other knowledge, creates the potential of an increased quality of life in older people as well as an improved possibility for health care to cope with the demographic changes.

Ongoing challenges of implementation of old news about nutritional problems

The high prevalence of nutritional problems presented again in this thesis, and the fact that it is generally not taken seriously, leads to absence of assessment and treatment. This has been pointed out in several research studies in most health care contexts, both in Sweden and internationally during the last decades (30, 69, 127, 137, 141, 142). Guidelines on how to prevent and treat defeated nutritional status are available (16, 26). In the Swedish Medical Journal, a survey about education and competence in clinical nutrition among physicians, nurses and dietitians from 2004 was followed up in 2014 (142). The results indicated some improvements of nutritional care in hospitals, but still insufficient according to the European Council's recommendations of nutritional care of disease-related malnutrition. It is likely that the situation is similar in primary care including home health care.

The longer nutritional problems persist, the greater is its impact a variety of functions (i.e. social, physical, affective, cognitive function) and a more extended rehabilitation period is needed. Therefore it is important to monitor nutritional status regularly, in all meetings with the patients (64), as well as it is important that health care organisations have policies for routines to detect and handle malnutrition, including prevention, treatment and follow up. Last, but not the least, it is important that policies are followed by practice (127). The main question remaining is why the policies that are available are not implemented.

Diseased related malnutrition that is not treated increases the risk for further morbidity and premature death while also decreasing quality of life (10, 127). Malnutrition increases costs for health care organisations and

worsen outcome and suffering for the patients (142). Heismayr et al (69) studied food intake in hospitalised patients and concluded that "partial starvation is accepted as standard care!" Therefore, malnutrition should be treated for ethical and human reasons, if nothing else.

Is the lack of implementation of guidelines unique for nutrition in health care? Is nutritional status less important than other parts of medical care? Is it the knowledge and understanding among health care personnel that is lacking? Is the nutritional status not seen as important by the care giver, when the patient is already ill or old? Is the absence of nutritional care in geriatrics a sign of ageism? Does the prejudice that it is normal for old people to be malnourished, weak and dehydrated still occur? Or could the reason be that the complexity of nutritional status is just too hard to manage, and therefore not prioritised – or even trivialised? In municipality care, availability to nutrition expertise is rare. Hence, is the fact that no profession has specific responsibility for nutrition the major issue? Or that the nurse, leader of the teamwork in the municipality, must prioritise and cannot find room for nutrition care?

Perhaps, the gap between knowledge and practice might be explained by the fact that no attempts of implementation of knowledge have been made. Possibly, some attempts of implementation have been initiated, but not in an effective way. For instance, research of implementation of a Swedish regulation of nutritional routines (13) one year after the introduction, showed that regulation alone, in a top-down perspective, was not enough to a achieve a complete successful implementation (14). Another Swedish study on 18-month implementation of regional nutritional guidelines in nursing homes concluded that an external facilitator was more effective than educational sessions (143). The result was quite modest either way but showed that implementation takes time and engagement to gain effect. A systematic review that studied barriers to screening of nutritional status found that culture, competing priorities, lack of education and training as well as a discrepancy of attitudes and practice were important barriers (144). The studies included were mainly from hospital care, and no studies in home health care were found. However, there is no reason to think that it would differ in home health care.

A large hospital study (69) concluded that, despite decades of discussion about malnutrition in health care, current studies still identify decreased food intake and presence of poor nutritional status as a major problem in European hospitals. And most importantly, very little has been done to

improve the situation, despite all knowledge available. This phenomenon, though, has not been further studied in this thesis.

It has been indicated that the consequences of malnutrition, and the absence of treatment and care, are costly (127). An economic analysis of clinical trials of nutritional interventions after year 2000 concluded that the most expensive consequence of poor nutrition was acute respiratory infections, which cost up to $19 000 per hospitalisation. However, the overall largest cost were found to be institutional long-term care, which cost about $77 000 per patient year (145). So far, no estimation of costs related to malnutrition in the Swedish context have been done, but results indicating high costs would be expected.

In the national context of Sweden, the distinction between health care in the municipality and in the country council should be taken into account. This implies separated budgets although both funded by taxes, which could lead to a money saving paradox; an intervention in the frame of one budget affect the outcome in the other budget, without any feedback mechanism. This could hamper investments or disguise the negative impact of cost saving. Everyone in the health care system should regardless recall the WHOs statement that we need to "serve the right people at the right time with the right means" to get economical sustainability (4). A systematic review of economical effectiveness in nutritional interventions in the European countries showed cost savings of the intervention actions, consisting oral nutritional support, education and micronutrient supplement (127). These savings were mostly achieved by decreasing medical visits in any health care setting, but also by decreasing hospital admission and fewer readmissions. Theoretically, the separation of budget between municipality and county council should not affect nutritional intervention activities – as the main purpose will gain the taxpayers as well as the society as a whole. In reality, however, it is hard to argue within the municipality to spend money in order to decrease hospital care and related costs (not in the municipality budget), in view of its already strained budget.

An interesting observation from this thesis is worth mentioning. It relates to how health care providers respond to the finding of a poor nutritional status compared to that of a low haemoglobin level in blood. In our study, all individual results of the measurements were sent to each participant, with a copy to the nurse involved in the patient. During the study period, feedback, both from the participant as well as from the nurses, to the mailed results were rare. But, in at least one case, a nurse commented on the finding of a low haemoglobin level, and the participant further investigated and

treated. On the contrary, rarely (if not never) did anyone comment or act on findings of decreased body weight, worsened physical performance or insufficient dietary intake. Compared to an inadequate nutritional status, a low haemoglobin level could be regarded as easily treatable (however the cause might be complicated), or it seems more important.

These discussions need to be actualised at all levels of organisation of public health and health care, and relevant efforts towards implementation are needed at local, regional, nationally and internationally level.

Nutritional competence in home health care

Competence and attitudes towards nutritional care among health care personnel might be a part of the solution of the above observed situation.

The shift towards health care in the patients' homes demands from the organisations and the personnel to secure nutritional competence. This must involve all professions, from the management to the personnel working close to the patient. They all need in-depth knowledge of how nutritional status must be screened for, assessed and treated.

In most municipalities in Sweden, nutritional specialist competence in form of dietitians is missing in the health care organisations (146). Consequently, district nurses is responsible for nutrition in home health care and, hence, to detect and treat nutritional problems, in cooperation with other health care professionals (64, 141). However, dietitian expertise is needed for more complex issues or to develop protocols for basic nutritional care routines (64). The above described lack of comprehensive nutritional competence unfortunately leads to insufficient nutritional care.

In a Swedish survey from 2014 among 1221 health care professionals at hospitals, about two thirds of physicians and nurses considered their education in nutrition to be sufficient (142). However, about 20% responded that they sometimes refrained from starting nutritional treatment, because they considered it impossible to continue post-acute care due to lack of competences available in home health care.

This lack of nutrition competence seems to be a universal issue, reported in several countries (57, 129, 147). An Austrian study, focusing on attitudes, reported that 61% of 1152 registered nurses and assistant nurses in nursing homes have a negative or neutral attitude to nutritional care (147).

In conclusion, the nutrition competence in general and availability of dietitians specifically should be regarded as insufficient in home health care. But there is also a need to secure to take advantage of the available competence.

Close-to-practice study design

This study was planned in cooperation with the municipality home health care organisation in order to increase the clinical relevance, but also to stimulate engagement in nutrition, and possible in research, among co-workers. We aimed to perform relevant and fruitful research for clinical practice which needs engagement among the collaborators. However, no evaluation of this matter has been included in this thesis.

The home health care management estimated the number of district nurses that have been involved in data collection to 50-60 during the 6-year period from 2014, when data collection was initiated, until 2020 when the last follow up visit was performed. A lower number of occupational therapists was involved during the study, and the number of collaborating physiotherapists even lower. The large number of data collectors might be considered to be a weakness as it may affect the results and consequently scientific reliability. However, the situation reflects home health care setting. As an example, some assessment methods have a subjective component if the personnel helped the participant to fill in the questionnaire. This may affect the individual results, because completing the questionnaire resembles more a controlled interview, forcing the data collector to interpret an oral answer to tick a specific box. The accuracy of the used measurements in physical performance and strength has been shown to have an adequate intra-rater reliability (148), which is most relevant for this study. The large number of data collectors might have resulted in a lack of introduction to the study, less understanding and less engagement in the study and in understanding the importance of accuracy for research purposes. Though, accuracy is as much important in clinical practice.

This research project had the possibility to increase nutritional knowledge and discussions among the employees in the municipality-organised home health care. More could possibly have been done to engage the collaborators and to increase involvement. The research question was raised by the researcher instead of raised by the practitioners, but they all need a scientific knowledge based attitude. Otherwise, other means to stimulate the knowledge-based attitude are needed in order to create a scientific mindset. However, our translational research, which was close to practice, possibly gained clear value for both research and practice, which hopefully lead to a value chain of knowledge-transfer.

Future 'need-to-know'

Solid evidence behind nutrition guidelines in old adults is still missing, and nutritional recommendations are often not adjusted to high age or equal for all adults (149, 150). One example of this is the meal pattern and its consequence for dietary intake and health. In this thesis we studied meal pattern in different aspects, the number of eating occasions during the day and the length of overnight fast. As mentioned earlier, the Swedish Food Agency advises the overnight fast to be less than 11 hours to increase the hours available for reaching nutritional needs (16). The origin of this recommendations is the observation of meal services in elderly care. Meals are often served within a time span of a few hours, mostly due to practical reasons and adapted to the personnel's working hours. However, the evidence for the 11 hours being the optimal cut-off is missing. The advice of overnight fast is mostly based on practical experiences, which may be fair when scientific base is missing. More research in meal pattern in more aspects than the overnight fast in old adults and in elderly care is needed, since nutrition is multidimensional and all aspects must be safe and adequate. More studies are needed to find out how or if the meal pattern is important, or if the total daily intake of energy and nutrients is most important determinant for achieving a good nutritional status. Furthermore, studies are needed to identify what meal pattern is optimally for old people.

Nutritional interventions seem to improve intake of energy and nutrients, but there is not yet clear evidence that it improves physical or cognitive function or mortality (151), and more knowledge of the effects of interventions in the interactions of the presented four domains is needed. An explanation for this lack of statistical evidence, according to the authors, might be the low number of intervention studies, and also low quality in the randomisation procedure.

A structured review of nutritional intervention trials aiming to increase dietary intake in adults with malnutrition showed an outcome of 26 fewer deaths per 1000 patients in the intervention group (89). Most studies in this review were performed in a hospital setting and solid research in other settings, such as home health care, is missing. However, to improve physical performance, physical exercise seems to be most important (152), and the additional effect of and interrelation with nutrition is still not established (153). A systematic review of interventions in frailty found benefits of multidimensional interventions *versus* unidimensional (154). Our perspective of nutritional status being a multidimensional entity also indicate that multidimensional interventions could be beneficial for nutritional status as well.

Outcome measures in nutritional research have to be carefully selected and also to be relevant for individuals daily life, to facilitate practical implications of the research (89) and facilitate high quality systematic reviews (90). This is important, as health care practice should be based on science.

In this multidimensional approach, qualitative studies with the outcome of nutritional status are highly relevant as well. For sustainable improvements, all aspects within the domain food and nutrition, as well as the other domains, must be included; When do I eat? How and when are the main meal and snacks planned? What affects the food choices when your disabilities impair your independent food shopping? Are the meals a social phenomenon, also in old age? Differs this social impact along life span? What changes in eating occur in old adults related to foods choice, number of meals, the component of meals and the planning of meals?

Conclusions

This thesis, focusing on nutritional status in old people receiving home health care concludes with the following results:

- The proposed theoretical nutritional status model shows a multi-faceted concept which highlights the complexity and the interplay between the four selected domains, the nutritional status and the results measured as various functional outcomes. This interplay between the four domains and the nutritional status is proposed to be of bidirectional character.

- Most participants of our study, comprising old men and women receiving home health care, had inadequate nutritional status. Malnutrition, frailty, sarcopenia and dehydration were common and often, overlapping syndromes. The study identified interactions between variables within but also between four domains of the proposed nutritional status model. An inadequate nutritional status was associated with mortality. Dehydration and loss of appetite were important indicators of a worsening nutritional status.

- The statistical approach on the assessment and description of nutritional status confirmed relationships between within and between the four domains in the proposed nutritional status model. The statistically extracted components in the four domains were associated with the nutritional status, measured as malnutrition, frailty, sarcopenia and dehydration.

- A majority of the study population had four or five eating occasions per day and most had an overnight fast longer than the recommended 11 hours. However, one large meal a day had more impact on daily energy and protein intake than more eating occasions or a short overnight fast.

In summary, this thesis contributes to the understanding of nutritional status in old people that are enrolled in home health care, a group rarely scientifically studied in nutritional research. This thesis introduced a

multidimensional theoretical model of nutritional status that was empirically tested in descriptive analysis as well as in a statistical approach with a factor analysis. In the descriptive analysis we found that particularly loss of appetite and dehydration are important indicators of the nutritional status and are negatively associated with mortality at follow up.

In the statistical analysis, relationships within and between the four domains, as previously proposed in the nutritional status model, were confirmed in this study cohort. Also, the initial high number of variables used as nutritional status indicators could be reduced to 19 indicators that explained most of the variation in the population. Loss of appetite and dehydration were part of the final set of indicators and its importance was confirmed in paper 2. These indicators should comprise the standard in nutritional assessment in home health care.

Meal pattern was studied in this study population as one example of a specific area within one of the four domains. Contrary to national recommendations, the daily energy and protein intake did not seem to be stimulated by a short overnight fast or more eating occasions. Instead a proper meal during the day, with a high content of energy, seems to more important to the total daily energy and protein intake.

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