Nutritional Screening of Older Adults

Risk Factors for and Consequences of Malnutrition

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Abstract

Aims The overall aim of this thesis was to extend current knowledge about the prevalence of malnutrition, to identify possible risk factors for development of malnutrition, and to describe the consequences of malnutrition in relation to all-cause and cause-specific mortality among older adults admitted to hospital.

Methods The prevalence of malnutrition was estimated in a cohort of 1771 older adults (≥65 years) who were admitted to a Swedish hospital during 2008–2009 (15 months) and screened for malnutrition using the Mini Nutritional Assessment (MNA) instrument. Possible risk factors for malnutrition were recorded during the hospital stay (Study I). Dietary intake 10 years earlier (in 1997) was collected for 725 of these older adults (Study II). All-cause (Study III) and cause-specific (Study IV) mortality were followed up after medians of 3.5 and 5.1 years, respectively, for 1767 of the participants.

Results The prevalence of malnutrition was 9.4% while 55.1% were at risk of malnutrition. Risk factors for malnutrition was an overnight fast >11 hours, <4 eating episodes a day, and not cooking independently. In middle-aged and older adults with a body mass index <25 kg/m² in 1997, the risk of malnutrition increased for each additional percentage point of energy from total, saturated and monounsaturated fat at follow-up after 10 years. Malnourished older adults had almost four times higher risk of death during follow-up, while those at risk of malnutrition had a 56% higher risk, compared to well-nourished. Furthermore, well-nourished older adults had consistently lower risk of death, regardless of the cause of death.

Conclusions Only 35.5% of older adults admitted to hospital were well-nourished. The identified risk factors could be used in interventions aimed at preventing malnutrition. Normal-weight and underweight middle-aged and older adults should consider limiting the intake of total fat and/or improve the quality of the fat in the diet in order to decrease the risk of becoming malnourished later in life. Malnutrition and risk of malnutrition were associated with increased overall and cause-specific mortality. These relationships emphasize the need for nutritional screening to identify individuals who may require nutritional support in order to avoid preterm death.

Keywords: Epidemiology, Malnutrition, Mortality, Older adults, Prevalence, Risk factors


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“When people are too busy to survive they forget to live.”
Stephan Attia

To Tuva, Elsa, Stina and Mathias
List of Papers

This thesis is based on the following papers, which are referred to in the text by their Roman numerals.


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## Abbreviations

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<tr>
<td>BMI</td>
<td>Body Mass Index</td>
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<tr>
<td>CI</td>
<td>Confidence interval</td>
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<td>COSM</td>
<td>Cohort of Swedish Men</td>
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<td>E%</td>
<td>Percentage of energy</td>
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<td>ESPEN</td>
<td>European Society of Clinical Nutrition and Metabolism</td>
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<td>FFM</td>
<td>Fat-free mass</td>
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<td>HR</td>
<td>Hazard ratio</td>
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<td>ICD-10</td>
<td>International Statistical Classification of Diseases and Related Health Problems, 10th Revision</td>
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<tr>
<td>MNA</td>
<td>Mini Nutritional Assessment</td>
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<td>MNA-SF</td>
<td>Mini Nutritional Assessment Short-Form</td>
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<td>MUFA</td>
<td>Monounsaturated fatty acid</td>
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<td>MUST</td>
<td>Malnutrition Universal Screening Tool</td>
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<td>NRS 2002</td>
<td>Nutritional Risk Screening 2002</td>
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<td>OR</td>
<td>Odds ratio</td>
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<td>PUFA</td>
<td>Polyunsaturated fatty acid</td>
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<td>SD</td>
<td>Standard deviation</td>
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<td>SFA</td>
<td>Saturated fatty acid</td>
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<td>SGA</td>
<td>Subjective Global Assessment</td>
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<td>SMC</td>
<td>Swedish Mammography Cohort</td>
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<td>VNAS</td>
<td>Västerås Nutritional Assessment Study</td>
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<td>To estimate the prevalence of malnutrition and to examine the associations between mealtime habits, meal provision, and malnutrition among older adults.</td>
<td>Cross-sectional study of 1771 patients admitted to hospital in 2008–2009 (15 months). Nutritional screening performed with the Mini Nutritional Assessment (MNA) instrument.</td>
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<td>To examine whether a high dietary intake of fat among middle-age and older adults is associated with the risk of malnutrition 10 years later.</td>
<td>Dietary intake was recorded in 1997 in 725 participants from Study I. Nutritional screening was performed with the MNA at follow-up after 10 years when admitted to hospital in 2008–2009.</td>
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<td>To study whether malnutrition is associated with cause-specific mortality in older adults.</td>
<td>Prospective cohort study of 1767 participants from Study I. Cause-specific mortality was analysed after a median of 5.1 years.</td>
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Introduction

This thesis describes the extent of malnutrition among older adults admitted to hospital, possible risk factors for developing malnutrition, and how malnutrition is related to both overall and cause-specific mortality. No previous large-scale Swedish study has examined the prevalence of malnutrition exclusively among older adults admitted to hospital. This may highlight the need for routines in clinical practice for nutritional screening in older adults. There is limited evidence-based research in the field of dietary factors associated with malnutrition, and clarifying the associations may provide useful information for creating interventions to prevent malnutrition. Whether malnourishment identified with a validated screening instrument has any clinical importance in terms of all-cause and cause-specific mortality has not been thoroughly established. Such knowledge may provide support for efforts to screen for malnutrition and to identify individuals who may require nutritional support to avoid preterm death.

Malnutrition

Definitions

There is no internationally accepted definition of the clinical condition malnutrition. The World Health Organization defines malnutrition in adults as underweight or “thinness”, as measured by Body Mass Index (BMI), and graded as mild (BMI 17.0–18.49 kg/m²), moderate (BMI 16.0–16.99 kg/m²), or severe (BMI <16.0 kg/m²) (p. 364) [1].

The European nutritional organization, the European Society of Clinical Nutrition and Metabolism (ESPEN), states that malnutrition due to starvation, disease, or ageing can be defined as “a state resulting from lack of uptake or intake of nutrition leading 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” (p. 335) [2].

In Sweden, the definition by the Swedish National Board of Health and Welfare specifies this type of nutrition deficiency as “a condition where a deficiency of energy, protein, and other nutrients causes measurable adverse
effects on body composition, function or of a person’s clinical outcome” (p. 12) [3].

A deficient intake of protein and energy, termed protein–energy malnutrition, is the most common malnutrition condition seen in Swedish health care [3]. In the present thesis, malnutrition refers to protein–energy malnutrition.

Terminology
The terms malnutrition and undernutrition are used almost equally frequently in clinical practice and in the scientific literature, with a slight preference for the term malnutrition. The ESPEN does not prefer either of these terms [2]. The main difference between these terms is that malnutrition covers both a deficiency and excess (i.e., an imbalance) of nutrition and includes all deviating nutritional states, including overweight and obesity. This contrasts with the term undernutrition, which is used primarily in the context of a nutritional deficiency [2, 4]. The term malnutrition has been chosen for this thesis.

Nutritional disorders
In the present thesis, only the clinical condition of malnutrition is addressed. However, it is important to understand other prevalent nutritional disorders as sarcopenia, frailty, and cachexia, because their symptoms often overlap with those of malnutrition [5]. The unifying feature of these conditions is a loss to some extent of body muscle and fat tissue. Many of these conditions may cause a person to physically look starved, but not all will respond to feeding. Therefore, it is important to be able to distinguish between these conditions [6].

Sarcopenia is defined as “a syndrome characterised by progressive and generalised loss of skeletal muscle mass and strength with a risk of adverse outcomes such as physical disability, poor quality of life and death” (p. 413) [5]. The diagnosis of sarcopenia is based on two criteria: 1. low muscle mass or a percentage of muscle mass ≥2 SD below the mean measured in young adults of the same sex and ethnic background, and 2. slow gait speed (i.e., a walking speed <0.8 m/s in the 4-m walk test) [7]. The condition becomes more common with increasing age; among adults >80 years old, 50% suffer from this medical condition [8].

Frailty is a condition in which the individual is in a vulnerable state and at increased risk of adverse health outcomes and/or dying when exposed to a stressor [9]. Physical frailty is defined as “a medical syndrome with multiple
causes and contributors that is characterized by diminished strength, endurance, and reduced physiologic function that increases an individual’s vulnerability for developing increased dependency and/or death” (p. 393) [9]. The condition is linked to sarcopenia, and most frail older adults also exhibit sarcopenia [5]. Screening tools to detect frailty should incorporate weight loss, exhaustion, weakness, slowness, and reduced physical activity [9]. About 10% of older adults (mean age 75 years) living in the community are classified as frail [10].

Cachexia may be defined as “a multifactorial syndrome characterized by severe body weight, fat and muscle loss and increased protein catabolism due to underlying disease(s)” (p. 156) [7]. Symptoms are often weight loss, reduced food intake and systemic inflammation. Because late-stage cachexia is untreatable, it is important to detect the condition at an early stage. Precachexia is defined as the presence of all of the following criteria: 1. underlying chronic disease, 2. unintentional weight loss, 3. chronic or recurrent systemic inflammatory response, and 4. anorexia or anorexia-related symptoms [7]. Most cachectic individuals are also sarcopenic [5] and malnourished [7]. One difference between malnutrition and cachexia is that the weight loss is large and occurs early in cachexia, whereas muscle loss occurs at a late stage of malnutrition.

Sarcopenia and frailty can be prevented to some extent and treated with an adequate energy and protein intake in combination with strength training exercise (sarcopenia and frailty) [6, 9], aerobic exercise (frailty) [9], vitamin D (frailty), and reduction of polypharmacy (frailty) [9]. On the other hand, treatment of cachexia is difficult because of the inflammatory component. Resistance training may slow or prevent muscle loss [6], and therapeutic approaches, including nutritional and pharmacological treatment options, are under development [11].

Because malnutrition results from inadequate nutrition, the primary goal is to increase the energy and protein intake. Dietary advice and nutritional supplementation may help maintain body weight [12] or cause a modest weight gain and improve body composition and grip strength [13, 14], but it has no effect on survival [13, 14]. The results from a Cochrane review indicate that the effects of nutritional supplementation on mortality apply only to already malnourished older adults and to older adults who receive nutritional supplements of ≥400 kcal a day [15]. According to the latest report from the Swedish Council on Health Technology Assessment, there is no reliable scientific evidence regarding the positive or negative effects of nutritional supplementation to older adults with malnutrition or at risk of malnutrition [14]. Hence, research is needed to identify the most effective interventions in
Nutrition and aging

Energy intake declines with aging and is the primary cause of weight loss in old age [16]. Age-related reduction in energy intake is one of the physiological effects of healthy aging [17], which include declines in sensitivity to taste and smell, diminished sensory-specific satiety, and delayed gastric emptying [16]. Healthy older adults are less hungry and become satiated more rapidly compared with younger adults [16]. The individual differences between older adults become more evident with aging. Healthy aging may be transformed into unhealthy aging if additional risk factors for a reduced energy intake develop, and these can predispose older adults to malnutrition. Non-physiological risk factors [16] that become increasingly frequent with aging include social (isolation and poverty), psychological (depression and dementia) [18, 19], medical (dysphagia), and pharmacological [20, 21] factors. An increased understanding of risk factors that contribute to reduced energy intake and thereby to malnutrition in older adults may prevent an excessive decline in energy intake with increasing age [16, 17]. Research is needed to identify the modifiable risk factors responsible for age-related reduced energy intake so that preventive and treatment strategies can be developed for the maintenance of appropriate energy intake with increasing age. One basic preventive action is screening for malnutrition, which is a prerequisite for detecting nutritional problems before these become manifest.

Nutritional screening tools

Various instruments have been developed to screen for malnutrition [22]. Most screening tools include the following four components: 1. BMI, which reflects the current situation, 2. recent weight loss, which reflects the historical development and indicates whether the condition is stable, 3. eating difficulties, which may indicate the future development course and whether the condition will worsen and, 4. disease, which reflects whether the disease process will cause nutritional deterioration. The ESPEN recommends that the first three components should be included in all screening instruments and that the fourth component about disease is important when screening for malnutrition in hospital [23].
In Sweden, the Swedish National Board of Health and Welfare recommends that a minimum of three components: 1. BMI, 2. weight loss, and 3. eating difficulties, should be registered when screening for malnutrition. According to this screening procedure, any one of these criteria is considered sufficient to state that there is a risk of malnutrition [3].

The choice of an appropriate screening tool depends on the setting and population. Subjective Global Assessment (SGA) is a screening instrument originally developed in 1987 to assess the nutritional risk of hospitalized surgical patients. The questions include the patient’s history of weight loss, changes in food intake, gastrointestinal symptoms, functional capacity, and underlying diseases, and a physical examination to evaluate loss of subcutaneous tissue, muscle wasting, oedema, and ascites is also required. Thereafter, the clinician makes an overall judgment about the patient’s status and classifies patients as follows: A. well-nourished, B. suspected to be malnourished, and C. severely malnourished [24].

The ESPEN has published guidelines for screening instrument for applicable use in different settings. The Malnutrition Universal Screening Tool (MUST) is recommended for use in the community, Nutritional Risk Screening 2002 (NRS 2002) for use in the hospital setting, and Mini Nutritional Assessment (MNA) for older adults (≥65 years) independent of the setting [23].

The MUST was developed by the Malnutrition Advisory Group of the British Association for Parenteral and Enteral Nutrition (BAPEN) in 2000. The instrument identifies adults who are malnourished, at risk of malnutrition or obese (BMI >30 kg/m²). Each parameter is scored as 0, 1, or 2, and patients are classified as 1. low risk (score 0), medium risk (score 1), or high-risk (score ≥2) of malnutrition [25].

The NRS 2002 was developed in 2002 for the hospital setting. The instrument comprises four questions about weight loss, food intake, and BMI (1–3 points), a severity of disease score (1–3 points), and an age adjustment for patients aged >70 years (+1 point). Patients are classified as at no risk (<3 points) or as at nutritional risk (≥3 points). The NRS 2002 was validated against all randomized controlled studies published until 2002 (n = 128) that had evaluated the effects of nutritional support. Patients fulfilling the risk criteria according to the NRS 2002 had a higher likelihood of a positive clinical outcome from nutritional support [23]. It has been suggested that, for older adults to whom the MNA cannot be applied, the NRS 2002 should be recommended [26].
Mini Nutritional Assessment (MNA)

The original MNA (full MNA) was developed in the 1990s and was designed especially for older adults, with the aim of detecting those at risk of malnutrition before the condition becomes manifest. The MNA comprises the following 18 items and relates to the past three months: decline in food intake; weight loss; mobility; psychological stress or acute disease; neuropsychological problems (dementia or depression); BMI; independent living; number of prescription drugs; pressure sores or skin ulcers; meals per day; daily intake of protein; daily intake of fruit and vegetables; daily intake of fluid; autonomy of feeding; self-view of nutritional status; self-view of health; arm circumference; and calf circumference. Each item is weighted, and the threshold values of the instrument categorize individuals into three nutritional screening groups: well-nourished (MNA score 24–30), at risk of malnutrition (MNA score 17–23.5), or malnourished (MNA score <17) [27] (see Appendix. In the latest version of the full MNA, the term normal nutritional status is used which is comparable to the well-nourished used in this thesis).

These threshold values were defined using serum albumin level. The albumin level can be affected by inflammation, which is usually present in people with disease; thus, albumin is an uncertain measure of the degree of malnutrition. However, in these validation studies, people with a low serum albumin level associated with inflammation (defined as a serum C-reactive protein level >20 mg/L) were excluded [28].

The reliability of the MNA has been evaluated in two long-term geriatric units, in which the MNA was applied to 67 older adults by different nurses on two separate occasions. For stratifying the total MNA into the three nutritional screening categories (well-nourished, at risk of malnutrition, and malnourished), the kappa index was 0.78, which demonstrates substantial reproducibility [29].

Although the full MNA can be completed in 15–20 min, the screening procedure may require more time in cognitively impaired older adults. To facilitate its use in clinical practice, a shortened version of the tool, the Mini Nutritional Assessment Short-Form (MNA-SF), was developed in 2001. The MNA-SF includes only the first six questions in the full MNA, which takes up to 5 minutes to complete, and categorize individuals into two nutritional screening groups: well-nourished (MNA score \( \geq 12 \)), or risk of malnutrition (MNA score \( \leq 11 \)) [30].

In 2009, a revised MNA-SF was developed, still including the first six questions in the full MNA, but with the possibility to grade nutritional status in
three categories, as with the full MNA, without increasing the burden of time. The revised MNA-SF (only referred to as the MNA-SF), categorize individuals into three nutritional screening groups: well-nourished (MNA score 12–14), at risk of malnutrition (MNA score 8–11), or malnourished (MNA score 0–7) [31].

In this thesis, the term nutritional status refers not to a diagnosis but only to the three nutritional screening groups according to the MNA instrument (well-nourished, at risk of malnutrition, and malnourished). The term nutritional risk refers to being malnourished or at risk of malnutrition according to a screening instrument.

Validation of the MNA

When developing the MNA, the instrument was validated on healthy and frail older adults in the USA and France. The reference standard for nutritional status was a clinical evaluation conducted by two physicians. This clinical evaluation included an assessment of dietary intake and a functional geriatric assessment, together with biochemical markers and anthropometry. In these validation studies, the specificity and sensitivity of the MNA were 98% and 96%, respectively [27].

One explanation for the high sensitivity and specificity in the study that developed the MNA [27] is that the MNA was validated against a reference standard, which was based on some of the variables included in the MNA. An ideal validation study should compare the MNA with independent parameters that are not correlated with the questions in the MNA (e.g., nitrogen content in the body or fat-free mass [FFM]). In a study of 66 older adults admitted to hospital, the ability to predict malnutrition was compared between a bioelectrical impedance assessment of body composition to assess FFM and the MNA-SF. Use of the FFM index identified 40% of males as malnourished and 21% at risk with 96% categorized by the MNA-SF as either malnourished or at risk [32].

In later studies, the specificity and the sensitivity of the MNA have varied according to the reference standard used [33]. A review from 2006 compared the full MNA with 20 different reference standards and found a mean sensitivity of 80% (range 41–100%) and mean specificity of 59% (range 13–98%) [33]. A study from 2005 used the reference standard of a full nutritional assessment based on BMI, unintended weight loss, triceps skinfold thickness, mid-arm muscle circumference, serum albumin and pre-albumin concentrations, and total lymphocyte count. In that study, the sensitivity of the MNA was 77% and its specificity 36% [34].
The ability of the four nutritional screening tools SGA, MUST, NRS 2002, and MNA to evaluate nutritional risk have been compared in 400 adults aged \( \geq 18 \) years (mean age 67.3 years) treated in three university hospitals. The sensitivity and specificity of the instruments were calculated using the SGA as the reference standard. The MNA classified the highest percentage of participants as being at risk of malnutrition (59%), and the other instruments classified 32–35% of participants as being at risk. These differences are reflected in the sensitivity and specificity of the instruments: the MNA had the highest sensitivity (95%) and the lowest specificity (61%) compared with the NRS-2002 (74% sensitivity and 87% specificity) and MUST (90% sensitivity and 80% specificity) [35].

The high sensitivity of the MNA is still discussed due to the high risk of “overdiagnosis”. Thus, the advantages of a positive screening with the MNA need to be evaluated in terms of outcome [36].

**Diagnostic criteria for malnutrition**

There is no reference standard for diagnosing malnutrition. Therefore, studies have used different criteria to define malnutrition, including body composition (e.g. BMI, muscle mass), biochemical variables (albumin and pre-albumin concentrations), and functional measures (handgrip strength, walking performance) [3].

In clinical practice, the diagnosis of malnutrition is seldom formally assessed and coded as a medical diagnosis according to the International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10), system [3]. In 2013, only 240 older adults (aged \( \geq 65 \) years) in all Swedish hospitals received the diagnosis of malnutrition (ICD-10: E40-E46) [37]. Notably, this was the most malnutrition diagnoses recorded since 1997. In other words, there is a major problem of underreporting of malnutrition as a diagnosis. One reason may be the lack of a reference standard for diagnosing malnutrition.

In 2015, the ESPEN proposed a consensus statement with diagnostic criteria for malnutrition. This stated that the diagnosis of malnutrition should be performed in a two-step process: a screening and a diagnostic process. The first step required fulfilment of the criteria for being “at risk” of malnutrition using any validated risk screening tool [2]. An individual identified as being at risk of malnutrition is then examined further in the diagnostic process, which includes two options for diagnosing malnutrition. The first diagnostic option requires only a BMI \(<18.5 \text{ kg/m}^2\), as recommended by the World
Health Organization for detecting underweight [1]. However, this low cut-off could lead to massive underdiagnosis because the BMI in all populations worldwide is increasing as a result of the obesity epidemic. Therefore, the ESPEN consensus group also decided to use an alternative diagnosis of malnutrition. This option is based on unintentional weight loss in combination with a low BMI or a low FFM. The alternative is as follows:

- Weight loss (unintentional) >10% indefinite of time or >5% over the past 3 months, combined with either
  - BMI <20 kg/m² if <70 years of age, or <22 kg/m² if >70 years of age, or
  - loss of muscle mass, measured as FFM index <15 kg/m² in women or <17 kg/m² in men [2].

The loss of muscle mass gives a more precise measure of malnutrition than BMI. However, the technical devices needed to measure body composition are not available in routine health care. Therefore, the alternative of using a low BMI is necessary for the practical diagnosis of malnutrition in clinics.

At the time of planning and conducting the baseline survey for this thesis (in 2007), these diagnostic criteria for malnutrition did not exist, and the MNA-SF had not been developed. Therefore, the full MNA was used to estimate the prevalence of malnutrition [27, 28] because this instrument was developed specifically to screen for malnutrition in older adults.

Prevalence of malnutrition

The prevalence of malnutrition according to the MNA instrument is well documented internationally: 23–39% of older adults in hospitals are malnourished and 43–49% are at risk of malnutrition [19, 33, 36, 38]. A large number of these are already malnourished when admitted to hospital, and nutritional status often deteriorates further during the hospital stay [39].

A multinational study that included 24 pooled studies (n = 4500) from 12 countries covering five continents showed that the prevalence of malnutrition in individuals aged ≥65 years old (mean age 82 years) was 51% in geriatric rehabilitation units, 39% in hospitals, 14% in nursing homes, and 6% in the community [38]. In a review including 69 observational studies published until 2011 (n = 17 775 older adults), prevalence data on the MNA according to the three nutritional screening categories were provided. The prevalence of malnutrition in acute care (hospitals) were 23% and 49% were at risk of malnutrition [36].
The prevalence of malnutrition in Sweden has been examined in different settings [40-50]. One Swedish study \((n = 83)\) has estimated the prevalence of malnutrition according the MNA in acute geriatric patients (mean age 83 years). Of these, 26% were assessed as malnourished and 56% as being at risk of malnutrition [46]. Two Swedish multicentre studies have estimated the prevalence of malnutrition in hospitals [43, 50]. However, these studies included all adults \(\geq 18\) years of age and did not use the MNA instrument. In one of these studies from 1994, the SGA screening instrument was used to detect malnutrition in 382 patients (mean age 57 years) from four hospitals [43]. The instrument categorized 7% of the patients as severely malnourished, 20% as moderately malnourished, and 73% as well-nourished. In the other multicentre study from 2009, nutritional screening was performed in 2170 patients (mean age 68 years) from nine hospitals. A moderate/high risk of undernutrition was defined as the occurrence of at least two of the following: involuntary weight loss, low BMI, and eating difficulties. According to these criteria, the prevalence of being at risk of malnutrition was 27% [50].

In Sweden, no large-scale study has estimated the prevalence of malnutrition exclusively in older adults in a hospital setting using the MNA screening instrument. Knowledge of the extent of malnutrition is important both for promoting nutritional screening and for evaluating whether the prevalence of malnutrition is increasing or decreasing.

As the risk of developing malnutrition increases with aging [19, 51, 52], it can be anticipated that the number of malnourished older adults will increase in the near future. In Sweden, the population is growing older as the life expectancy is increasing. Half of those born today will live to be 100 years old, and the life expectancy is predicted to rise from 84 to 89 years for women and from 80 to 87 years for men from 2011 to 2060. In 2011, one-fifth of the population was aged 65 years and older, and this fraction will be one-fourth within the next 50 years [53].

Risk factors for malnutrition

Mealtime habits and meal provision

Mealtime habits such as overnight fasting, the number of eating episodes per day, and meal provision (such as receiving meals on wheels) are modifiable factors thought to be related to malnutrition [47, 54, 55]. A long overnight fast has been found mainly among those living in nursing homes, where a mean overnight fast of 14.5 hours is reported. Alarmingly, for a few older adults, the time between the last eating episode in the evening and the first eating episode the following morning may be up to 18 hours [55, 56].
However, even in self-managing older adults, the overnight fast usually exceeds 11 hours (mean 13.0 hours) [55].

At the time of planning and conducting the baseline study for this thesis, the Nordic nutrition recommendations from 2004 stated that the overnight fast should not exceed 11 hours in older adults and that the number of eating episodes should be at least four per day in adults [57]. On a national level, the Swedish National Board of Health and Welfare performs an annual national survey, called “Open Comparisons”, which compares the quality of health care in Swedish municipalities. In this survey, the length of the overnight fast and the daily number of eating episodes are included in the quality indicator “good meal pattern”. To fulfil this quality indicator, meals should be offered at least six times a day at given intervals according to expert recommendations, so that the overnight fast does not exceed 11 hours [58]. Despite these recommendations, no clinical study has been undertaken to clarify whether there is an association between malnutrition and the length of the overnight fast or the number of eating episodes per day.

Dietary fat intake

Another factor that can influence future malnutrition is the dietary intake of fat. Fat is the most energy-dense nutrient, and it can affect the energy density of foods [59]. Individuals with a decreased appetite who are at risk of malnutrition are recommended to eat smaller portions but with a higher fat content, thus helping to maintain the energy density of their food [3]. However, there are no recommendations for the optimum fat intake among older adults [3, 60], and there is a lack of evidence as to whether previous fat intake among middle-aged and older adults is associated with malnutrition in later life.

Consequences of malnutrition

It has been reported that malnutrition is associated with severe consequences, such as increased morbidity [43], poor quality of life [61], and increased health care costs [62]. A systematic review from 2012 provided evidence that malnutrition is associated with increased mortality [63]. However, most of these studies did not perform regression analysis [64-67], and it is uncertain whether this association is independent of confounders. Evaluating the MNA according to the three nutritional screening categories is especially important because this instrument is now being used nationwide in the Swedish health care system. Also, since the high risk of “overdiagnosis” with the MNA is being debated, the advantages of a positive screening with the MNA need to be evaluated in terms of outcome [36].
All-cause mortality

The association between the three nutritional screening groups according to the MNA and all-cause mortality was examined in a study of 2802 independently living older adults (≥65 years old) residing in the community in Taiwan. At the 4-year follow-up, the hazard ratio (HR) for all-cause mortality was 2.4 among those at risk of malnutrition and 6.6 for malnourished older adults [68] compared with the well-nourished. However, the Cox regression did not adjust for concomitant diseases, but only for sex and age, and it remains uncertain whether malnutrition is an independent risk factor for mortality.

A Swedish study of 68 older adults in geriatric hospital wards categorized patients into two groups: malnourished/at risk of malnutrition or well-nourished according to the MNA. At the 3-year follow-up, the combined malnourished/at risk of malnutrition group had a 3.3 times higher risk of death compared with the well-nourished after adjusting for age and cardiovascular diseases (odds ratio [OR] 3.3; 95% confidence interval [CI] 1.1–9.8) [46]. By contrast, no association between malnutrition assessed with the three categories in the MNA and mortality was found in a prospective study of 101 older adults (mean age 71 years) admitted to hospital in Denmark, after adjusting for age, sex, and the cumulative burden of comorbidity according to Charlson comorbidity index [40]. Thus, the results regarding the association between malnutrition according to the MNA and mortality are inconsistent.

Cause-specific mortality

It is unknown whether malnourished older adults are more at risk of death caused by certain diseases compared with those who are well-nourished. Only one previous study has examined the relationship between malnutrition and cause-specific mortality [69]. This study included 358 older adults (mean age 84.6 years) who were screened for malnutrition in long-term care settings. At the 6.5-year follow-up, older adults with malnutrition had a 79% higher risk of cardiovascular mortality compared with those who were well-nourished. However, malnutrition was not associated with other causes of death.
Initiatives to promote nutritional screening

In recent years, there have been several initiatives to improve the nutritional care of older adults. In 2003, a resolution was published by the Council of Europe stating that the nutritional risk of all patients should be routinely assessed at admission to hospital and that those who are at risk of malnutrition or malnourished should have a treatment plan [70]. Sweden and 17 other countries signed this resolution. However, nutritional screening is still not routine in Swedish hospitals [71] even though malnutrition is widespread among older adults, especially in institutions such as geriatric rehabilitation units (51%), hospitals (39%), and nursing homes (14%) [38].

In 2006–2012, the Swedish government decided to invest in improved care, including nutritional care, for older adults with multimorbidity [72]. The Swedish National Board of Health and Welfare was given the assignment to distribute national incentive grants to county councils and municipalities to improve the care. In 2010–2014, the assignment changed to target related compensation and the Swedish Association of Local Authorities and Regions was commissioned to support the county councils and municipalities [73].

One strategy for improving the care of older adults includes the implementation of the national quality register, Senior Alert, in hospitals, primary health care centres, and nursing homes. To promote the implementation of the register, the municipalities and county councils received national incentive grants from the Swedish national government to report data to Senior Alert. The register includes risk screening, investigations of underlying causes, and actions taken to prevent and treat malnutrition, pressure sores, falls, and problems with oral health, all of which are related to malnutrition. To screen for malnutrition among older adults in the Senior Alert, the screening instrument MNA-SF is used. In 2015, 288 out of 290 municipalities and 19 out of 21 county councils are reporting data to the quality register.

The most recent initiative to promote nutritional care for older adults in Sweden is the National Board of Health and Welfare regulations, which were published in 2015; these are binding rules regarding prevention and treatment of malnutrition [74]. In clinical practice, this means that the health care provider must have routines for determining when a patient’s nutritional status should be investigated, how the nutritional status should be assessed, and, for patients identified as being at risk, how malnutrition should be prevented and treated.
Rationale

Given the high prevalence of malnutrition, which is expected to rise as the population grows older in Sweden, and the lack of scientific evidence regarding treatment options for malnutrition, preventive actions to counteract the development of malnutrition are warranted.

Screening for malnutrition is one of the basic preventive actions, because this is a prerequisite for detecting nutritional problems before the condition becomes manifest. In Sweden, the Senior Alert national quality register incorporates the MNA instrument to screen for malnutrition. However, there is a lack of evidence on the prevalence of malnutrition among older adults admitted to hospital before the quality register was introduced. Assessing the prevalence of malnutrition is also important for promoting nutritional screening and to increase the knowledge and awareness of malnutrition.

Since the treatment strategies for malnutrition remain uncertain, it is important to focus on finding ways to prevent malnutrition. Modifiable risk factors thought to be related to malnutrition, such as the length of the overnight fast and the daily number of eating episodes, have not been thoroughly investigated, and there is a need for clinical studies to clarify any possible associations. The association between previous dietary intake from fat and future malnutrition is an unexplored field that also needs further clarification.

The association between malnutrition and mortality has been documented for many years [63]. However, there is a need to investigate whether this association is independent of confounders. In addition, it has not been fully established whether malnourishment identified with the MNA instrument has any clinical importance in terms of all-cause and cause-specific mortality [69]. Such knowledge could support the decision to screen for malnutrition in clinical practice.
Aims

The overall aims of this thesis were to extend the current knowledge about the prevalence of malnutrition, to identify possible risk factors for developing malnutrition, and to describe the consequences of malnutrition in relation to all-cause and cause-specific mortality among older adults admitted to hospital.

The specific aims were as follows.

Study I To estimate the prevalence of malnutrition and to examine the associations between mealtime habits, meal provision, and malnutrition among older adults admitted to a medium-sized Swedish hospital.

Study II To examine whether a high dietary intake of fat among middle-aged and older adults is associated with the risk of malnutrition 10 years later.

Study III To examine whether nutritional status defined according to the three categories in the full MNA instrument is an independent predictor of preterm death among older adults.

Study IV To study whether malnutrition is associated with cause-specific mortality in older adults.
Methods

The present thesis is a compilation thesis that includes four papers and one thesis frame. The thesis is based on my licentiate thesis published in 2013 [75], which includes two of the papers (I and III) described in this compilation thesis [76, 77]. There may be some similarities between the descriptions of the methods, results, and conclusions in the licentiate thesis and this compilation thesis because these two incorporated papers are identical, and thus the conclusions drawn from the results are identical.

This thesis is based on data collected from patients aged ≥65 years who were admitted to hospital and who were screened for malnutrition during their hospital stay. Nutritional screening was performed using the original 18-item MNA instrument, hereafter referred to as the full MNA. An overview of the methods used in the thesis is presented in Table 1.
Table 1. Overview of the methods used in this thesis.

<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Participants</th>
<th>Data collection</th>
<th>Statistical analyses</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Cross-sectional study</td>
<td>1771 patients ≥65 years of age admitted to hospital during 2008–2009 (15 months)</td>
<td>Nutritional screening performed with MNA during hospital stay</td>
<td>Factors associated with malnutrition analysed with multinomial logistic regression models</td>
</tr>
<tr>
<td>II</td>
<td>Prospective cohort study</td>
<td>725 participants from Study I</td>
<td>Nutritional screening performed with MNA</td>
<td>Factors associated with malnutrition analysed with multinomial logistic regression models</td>
</tr>
<tr>
<td>III</td>
<td>Prospective cohort study</td>
<td>1767 participants from Study I</td>
<td>Nutritional screening performed with MNA</td>
<td>Survival data analysed with Kaplan–Meier survival curves, log-rank test, and Cox proportional-hazards regression models</td>
</tr>
<tr>
<td>IV</td>
<td>Prospective cohort study</td>
<td>1767 participants from Study I</td>
<td>Nutritional screening performed with MNA</td>
<td>Survival data analysed with Kaplan–Meier survival curves, log-rank test, and Cox proportional-hazards regression models</td>
</tr>
</tbody>
</table>
Design

Study I was a cross-sectional study conducted over 15 months (from 3 March 2008 to 29 May 2009) at Västmanland County Hospital Västerås in central Sweden. This baseline survey was performed to screen for malnutrition among older adults admitted to hospital. The nutritional screening was performed using the MNA instrument during the hospital stay, and factors potentially associated with malnutrition were recorded. This study is hereafter referred to as the Västerås Nutritional Assessment Study (VNAS).

Study II was a prospective cohort study, utilizing data from the VNAS and two other cohorts: the Swedish Mammography Cohort (SMC) and the Cohort of Swedish Men (COSM). The SMC and COSM are two large population-based prospective cohort studies conducted during the years 1987–1990 (SMC) and 1997 (SMC and COSM). SMC and COSM were designed to collect data on dietary intake and lifestyle as risk factors for chronic diseases among middle-aged and older adults [78, 79]. The study population in the present prospective cohort study comprised participants in the VNAS cohort (2008–2009) who were also included in the SMC or COSM cohorts in 1997. Thus, only data from 1997 is used to analyse dietary intake.

Studies III and IV were prospective cohort studies that examined the relationships between malnutrition measured at baseline in Study I and all-cause mortality (Study III) and cause-specific mortality (Study IV) at follow-up.

Participants

In Study I, a total of 2517 older adults were assessed for inclusion. The baseline sample comprised 1771 participants recruited from two internal medicine wards (n = 706), two surgical wards (n = 681), and one orthopaedic ward (n = 384).

Studies III and IV comprised 1767 participants at follow-up, since older adults with temporary personal identification numbers and those who had emigrated before being registered at baseline were excluded. A flow chart describing the recruitment, reasons for exclusion, and loss to follow-up for Studies I, III, and IV is presented in Figure 1.
In Study II, the VNAS included patients aged ≥65 years who were admitted to the Västmanland county hospital Västerås and screened for malnutrition in 2008–2009.

The SMC included all women born in the period 1914–1949 (aged 48–83 in 1997) and residing in Västmanland or Uppsala county. These women received a mailed self-administrated questionnaire about diet, together with an invitation to participate in a free-of-charge mammography screening program [79]. In 1997, an updated and extended questionnaire containing questions about lifestyle was sent to participants [79].

COSM included all men born in the period 1918–1952 (aged 45–79 in 1997) and residing in Västmanland or Örebro county. These men received the same mailed questionnaire as the participants in the SMC [78]. The analyses in the present study are based only on questions from the 1997 questionnaire.

Figure 1. Flow chart describing participant recruitment in Studies I, III, and IV.
To identify participants who were included in both the VNAS and the SMC or the COSM, the personal identification numbers for the participants in the SMC and COSM were linked with the personal identification numbers from the VNAS. In total, 732 participants (n = 378 women, n = 354 men) were identified. After excluding individuals with extreme values for the macronutrients, 725 participants were included in the present study. A flow chart describing the recruitment of participants is presented in Figure 2.
Figure 2. Flow chart describing participant recruitment in Study II.
Data collection procedure

In Study I, baseline data on risk of malnutrition and clinical characteristics were collected consecutively during the hospital stay. Nutritional screening was performed using the MNA, which was given by registered dieticians, nurses, or assistant nurses (18 personnel in total). Knowledge about nutrition may have differed between personnel because of differences in their education. To increase the interobserver reliability, before the recruitment started, the health care professionals received training on interpreting the questions in the MNA and performing the measurements. The researchers also observed the screenings performed by each of the personnel twice during the study period on average to maintain the internal validity of the process. Further, there were meetings once per month to discuss any queries that arose during the recruitment.

In Study II, a 96-item food-frequency questionnaire was used to assess the diet at baseline in 1997. Participants were asked to report how often, on average, they had consumed various foods and beverages during the past year and answered using eight predefined frequency categories ranging from never to ≥3 times a day. The nutrient intake was calculated by multiplying the frequency of intake for every food item by its nutrient content per portion, which was based on the normal-sized portions defined by the database of the Swedish National Food Administration [80].

In Study III, to analyse the relationship between malnutrition and all-cause mortality, the participants were followed up through the Swedish Population Register [81] until 23 May 2012.

In Study IV, the participants were followed up through the Swedish Cause of Death Register [82] until 31 December 2013 to analyse the relationship between malnutrition and cause-specific mortality. Data were also retrieved through the Swedish Population Register [81] to register censored individuals.

Nutritional screening

Nutritional screening was performed for all participants using the original 18-item MNA [27]. Different points were assigned according to the answers to the 18 questions. In the end, the points were tallied up, and the threshold values of the MNA were used to categorize patients into the three groups: well-nourished (MNA score 24–30), at risk of malnutrition (MNA score 17–23.5), or malnourished (MNA score <17) [27].
BMI was calculated using the standard formula of \((\text{weight in kg})/(\text{height in m})^2\). Weight was measured with a calibrated chair or mobile lift scale \((n = 21)\) to the nearest kg after the patient had emptied the bladder and with the patient wearing a light hospital robe. Height was measured to the nearest centimetre with a stadiometer. Participants unable to stand upright were measured using a sliding calliper \((n = 345)\) or, as a last resort, by calculating their height from half the arm span (demi-span) \((n = 18)\) using the formula 
\[(1.40 \times \text{demi-span in cm}) + 57.8 \text{ for men and } (1.35 \times \text{demi-span in cm}) + 60.1 \text{ for women} \]
[83, 84].

Using the demi-span was considered a last resort because this method has the lowest agreement with standing height [84]. One reason for this is that it can be difficult for older people to stretch out the arms from the rest of the body. When calculating the demi-span, we used the equations developed by Bassey in 1986 [83]. However, these equations were based on a younger population (mean age 34.5 years), when the height is at a maximum and has not begun to decrease [83]. A more recent equation by Weinbrenner [85] was developed in 2001. In this study, the demi-span was measured in a Spanish population of 592 older adults \(\geq 65\) years old (mean age 73.8 years). Because of the slow decrease in height with age, these new equations were developed to correct the estimated height by age. This study analyzed the validity of the equations by Bassey and found that they overestimated height by an average of 1.0 cm in men and 4.5 cm in women compared with standing height [85].

Risk factors for malnutrition

In Study I, the potential risk factors for malnutrition were age, sex, smoking status, medication use, diagnoses, length of overnight fast, number of eating episodes per day, meal provision, and living situation. Age was retrieved from the personal identification number. Smoking status was defined as current or non-smoker. Medication use before admission and the patient’s diagnoses at discharge were retrieved from the patient’s medical records. Primary and secondary medical diagnoses according to the ICD-10 were collected at discharge. These were categorized into the 20 main diagnosis groups of the ICD-10 classification system by registering a “yes” for each patient who had a primary or secondary diagnosis with an ICD-10 code belonging to the diagnosis group in question, and otherwise registering a “no”. The length of the overnight fast was defined as the period between the last eating episode in the evening and the first eating episode the following morning. The number of eating episodes per day was recorded as how often the patient usually ate breakfast, lunch, dinner, and between-meal and evening snacks. Meal provision was recorded as cooking independently and/or with help from a
spouse (cooks independently), meals on wheels, or meals in a nursing home or restaurant. Living situation was defined as living alone, cohabiting, or living in a nursing home. Country of birth was obtained from the Swedish Population Register.

In Study II, potential risk factors for malnutrition were the percentage of energy (E%) from total fat at baseline and its four components, saturated fatty acids (SFAs), monounsaturated fatty acids (MUFAs), polyunsaturated fatty acids (PUFAs), and other fats (glycerol, phospholipids, and sterols). As potential confounding factors, the following variables measured at baseline were included in the study: total energy intake/day (kcal/day); E% from carbohydrates, protein, and alcohol; sex (men/women); age; BMI (<25 or ≥25 kg/m²); sleeping habits (number of hours/day); cigarette smoking (yes/no); alcohol consumption (never, ex-, or current); educational level (high school or more/less than high school); employment (full- or part-time employment, housewife/retired, disability pension, or unemployed); and history of high blood pressure, high cholesterol concentration, vascular spasm, renal calculus, or gallstone.

Mortality

The main focus of Study III was to examine the association between malnutrition and all-cause mortality during the follow-up period. Survival was calculated from the date of the MNA screening to the date of death or date of censoring. Dates of emigration and end of follow-up were used as censoring dates. The participants’ characteristics registered at baseline were considered as potential confounders of the association between malnutrition and all-cause mortality.

The main focus of Study IV was to examine whether malnutrition is associated with cause-specific mortality in older adults. In the analysis of cause-specific mortality, survival was calculated from the date of the MNA assessment to the date of cause-specific mortality or date of censoring. Dates of emigration, end of follow-up, and death from other causes were used as censoring dates. Multiple causes of death were analysed (i.e., all conditions mentioned on a death certificate). Consequently, if an individual had three causes of death registered on the death certificate, the individual could be included as an event in up to three different Cox regression analyses. The models were adjusted for age, sex, BMI, BMI × BMI, current smoking, number of medications, overnight fast >11 hours, and living situation (living alone, cohabiting, or living in a nursing home). Each model was adjusted for the specific diagnoses at baseline; i.e., if the outcome was death from cancer, the model was adjusted for cancer at baseline. The models were also adjust-
ed for the cumulative burden of comorbidity according to the Charlson comorbidity index [86].

Ethical considerations
The study was approved by the Uppsala Ethical Review Board (Dnr: 2007-323). All participants provided their written informed consent before entering the study. If a participant was unable to communicate, a relative was asked if he/she objected to the patient’s participation in the study.

Statistics
For descriptive statistics, categorical data are presented as the frequency and percentage, \( n (\%) \), and ordinal data are presented as the median and interquartile range (q1–q3). Discrete and continuous data are given as the mean and standard deviation (SD).

For all statistical tests, a two-sided \( p \)-value <0.05 was considered significant. Analyses were performed using IBM SPSS Statistics 18/20/22. A summary of the analyses used in the studies is given in Table 2.

Table 2. Statistical analyses used in Studies I–IV in the thesis.

<table>
<thead>
<tr>
<th>Statistical method</th>
<th>Study I</th>
<th>Study II</th>
<th>Study III</th>
<th>Study IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson’s ( \chi^2 )-test</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Kruskal–Wallis test</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>ANOVA</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Fisher’s least significant difference test</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Pearson’s ( r )</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Multinomial logistic regression model</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kaplan–Meier with log-rank test</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Cox proportional-hazards regression model</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
**Pearson’s χ²-test** was used when testing the univariate differences between the three nutritional screening groups (well-nourished, at risk of malnutrition, and malnourished) for categorical data (Studies I–IV), such as sex, smoking (yes/no), overnight fast >11 hours, eating episodes <4, and independent cooking (yes/no).

The **Kruskal–Wallis test** was used when testing the univariate differences between the three nutritional screening groups for ordinal and discrete data (Studies I–IV), such as the number of drugs.

**ANOVA** was used when testing the univariate differences between the three nutritional screening groups for continuous data (Studies I–IV), such as age, BMI, total fat (E%), SFAs (E%), MUFAs (E%), PUFAs (E%), and other fats (E%).

**Fisher’s least-significant difference test (LSD)** was used to test the univariate differences between two nutritional screening groups post hoc for continuous data (Study II).

**Pearson’s r** (Pearson’s correlation coefficient) was used to estimate correlations between the intake of SFAs (E%) and MUFAs (E%), and between the intake of total fat and SFAs (E%), as well as between the intake of total fat and MUFAs (E%) (Study II).

Pearson’s r measures the correlation between two variables. The values can vary between +1 and –1, where 1 represents a maximum positive correlation, 0 is no correlation, and –1 is a maximum negative correlation.

**Multinomial logistic regression** was used to analyse the associations between the three nutritional screening groups and mealtime habits (length of overnight fast, daily number of eating episodes) and meal provision (cooking independently or receiving meals on wheels) (Study I), and the association between the nutritional screening groups and previous dietary fat intake (E%) (Study II). Nutritional risk according to the MNA (well-nourished, at risk of malnutrition, or malnourished) was the dependent variable in the multivariate analyses and was entered as a three-level categorical variable, with well-nourished used as the reference category. The participants’ characteristics at baseline in 2008–2009 (Study I) and in 1997 (Study II) were considered as potential confounders. A multinomial logistic regression model is used when the dependent variable has three or more categories. The measure of the magnitude of the association in a logistic regression is the OR, which is an estimate of the increase or decrease in the odds of an outcome if the independent variable is increased by one unit.
In Study I, the analyses were performed in two steps. In the first step, a base model was constructed by including as independent variables all significant variables in the univariate analysis, except for those that contributed directly or indirectly to the MNA score, together with interaction effects. In the second step, a final model was constructed using a backward stepwise selection procedure with an entry probability of 0.05 and removal probabilities of 0.2 for the main effects and 0.05 for the interaction effects. In a subgroup analysis of the 1685 participants living at home, the variable meal provision was also included.

In Study II, the analyses were conducted in three steps. Firstly, all baseline variables with \( p \)-values <0.20 in the univariate analyses were included as explanatory variables and entered simultaneously into the base model.

Secondly, statistically non-significant variables (\( p > 0.05 \)) were removed from the base model through a manual backward selection procedure, by which the variables with the highest \( p \)-values were removed one at a time and the model was re-estimated until the model included only statistically significant variables (reduced model). Thirdly, all confounding variables included in the reduced model were tested for interaction effects with intake of total fat (E%), SFAs (E%), and MUFAs (E%) by separately adding each interaction effect to the reduced model. Finally, all interaction effects with \( p \)-values <0.05 were added simultaneously to the reduced model. All significant interaction effects were retained in the models and formed the final models. In all steps, if a variable or an interaction between two variables was significant in any of the three models, it was retained in the other models.

**Kaplan–Meier with log-rank tests** were used to analyse survival data (Studies III and IV) and to test the univariate differences in overall survival between the three nutritional screening groups over 50 (Study III) and 69 (Study IV) months from the date of inclusion. Kaplan–Meier survival curves illustrate the cumulative survival from baseline, when the nutritional screening was performed at hospital, to follow-up.

For analysis of all-cause mortality (Study III), survival was calculated from the date of MNA screening to the date of death or censoring. Dates of emigration and end of follow-up were used as censoring dates.

For analysis of cause-specific mortality (Study IV), survival was calculated from the date of MNA screening to the date of cause-specific death or date of censoring. Dates of emigration, end of follow-up and death by other causes were used as censoring dates.
Cox proportional-hazards regression models were used to determine whether malnutrition was an independent predictor of all-cause mortality (Study III) or cause-specific mortality (Study IV). Nutritional risk according to the MNA (well-nourished, at risk of malnutrition, or malnutrition) was the main variable of interest in the multivariate analyses and was entered as a three-level categorical variable, with well-nourished as the reference category. The participants’ characteristics at baseline were considered as potential confounders (Studies III and IV).

In Study III, the analyses were performed in four steps. In the first step, nutritional risk according to the MNA and potential confounders was entered into separate Cox regression models. In the second step, variables that were significant in the first step were entered into a multivariate Cox regression model (base model). In the third step, non-significant variables ($p > 0.05$) were removed from the base model through a backward selection procedure until the model included only significant variables (reduced model). In the fourth step, all confounding variables included in the reduced model were tested for interaction effects with nutritional risk, and significant effects were then added to the reduced model. Finally, non-significant variables were removed through a backward selection procedure until the model included only significant variables (final model). All regression models were hierarchical; i.e., for all higher-order terms of a variable that were included in a model, all lower-order terms of the variable(s) in question were also included. Thus, if an interaction effect between two variables was included in a model, the main effects of the two variables were also included.

In Study IV, all of the multivariate Cox regression models used the same variables for adjustment. The reason for doing this was that the models had to be comparable to each other. Further, each model was adjusted for the specific diagnoses at baseline; i.e., if the outcome was death from cancer, the model was adjusted for cancer at baseline.

Sample size calculation

Studies that have evaluated malnutrition and mortality in older adults in hospitals were used as a basis for a sample size calculation [46, 64, 87, 88]. In these studies, the percentage of well-nourished older adults was 17–59%, and the percentage of malnourished older adults was 16–49%. Thus, the smallest percentages of well-nourished and malnourished people one would expect, in an extreme case, would be 17% well-nourished and 16% malnourished older adults. Based on the aforementioned studies, the expected mortality during the 3 years of follow-up was 24% among well-nourished people and 35% among the malnourished.
To obtain a power \((1 – \beta)\) of 80% at a two-sided significance level of \(\alpha = 0.05\) with a Z-test for differences in percentages with an expected difference in mortality of 11 percentage points, a total study population of 1682 participants would be needed. To take into account expected dropouts, non-responses, and missing values, the aim was to recruit a total of 2080 participants. Because the dropout rate was lower than expected, a decision was made to end recruitment when the nutritional risk of 1795 participants had been assessed in the study.
Results

Study I

At total of 1771 participants were included at baseline in 2008–2009. Out of these, 35.5% \( (n = 629) \) were well-nourished, 55.1% \( (n = 976) \) were at risk of malnutrition, and 9.4% \( (n = 166) \) were malnourished according to the MNA. Figure 3 displays the prevalence of malnutrition according to residence at the time of admission to hospital.

![Figure 3](image_url)

*Figure 3. Prevalence of malnutrition according to residence at time of admission to hospital, according to the Mini Nutritional Assessment, of the 1771 older adults admitted to hospital during 2008–2009.*

A slight majority were women (56%), and the mean age ± SD was 78.1 ± 7.8 years. Among those excluded, the mean age was 4 years older (mean age 82.0 ± 8.2 years; \( p < 0.001 \)). Almost all of the participants were living at home before they were admitted to hospital \( (n = 1685; 95.1\%) \), and the others lived in a nursing home \( (n = 86; 4.9\%) \). Participant characteristics are displayed according to their nutritional screening groups in Table 3.
Table 3. Participant characteristics according to their nutritional screening groups (well-nourished, at risk of malnutrition, or malnourished) derived from the Mini Nutritional Assessment instrument. Data are presented as mean ± SD or n (%).

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Well-nourished (n = 629)</th>
<th>At risk of malnutrition (n = 976)</th>
<th>Malnourished (n = 166)</th>
<th>p-valuea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>76.5 ± 7.2</td>
<td>78.6 ± 7.9</td>
<td>81.1 ± 7.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Women</td>
<td>328 (52.1)</td>
<td>566 (58.0)</td>
<td>99 (59.6)</td>
<td>0.044</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>77.5 ± 13.8</td>
<td>71.4 ± 15.2</td>
<td>58.9 ± 15.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>167.9 ± 9.8</td>
<td>166.4 ± 9.6</td>
<td>166.2 ± 10.6</td>
<td>0.007</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>27.5 ± 4.0</td>
<td>25.7 ± 4.7</td>
<td>21.2 ± 4.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>99.8 ± 12.4</td>
<td>96.5 ± 13.7</td>
<td>86.7 ± 13.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Current smoker</td>
<td>54 (8.6)</td>
<td>113 (11.6)</td>
<td>30 (18.1)</td>
<td>0.002</td>
</tr>
<tr>
<td>Number of medications</td>
<td>5.1 ± 3.6</td>
<td>5.4 ± 4.1</td>
<td>6.2 ± 4.6</td>
<td>0.095</td>
</tr>
<tr>
<td>Number of diagnoses</td>
<td>2.9 ± 1.6</td>
<td>3.1 ± 1.7</td>
<td>3.5 ± 1.9</td>
<td>0.001</td>
</tr>
<tr>
<td>Overnight fast</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>≤11 h</td>
<td>172 (27.4)</td>
<td>182 (18.7)</td>
<td>26 (15.7)</td>
<td></td>
</tr>
<tr>
<td>&gt;11 h</td>
<td>456 (72.6)</td>
<td>793 (81.3)</td>
<td>140 (84.3)</td>
<td></td>
</tr>
<tr>
<td>Eating episodes</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>≥4</td>
<td>392 (62.3)</td>
<td>460 (47.1)</td>
<td>59 (35.5)</td>
<td></td>
</tr>
<tr>
<td>&lt;4</td>
<td>237 (37.7)</td>
<td>516 (52.9)</td>
<td>107 (64.5)</td>
<td></td>
</tr>
<tr>
<td>Meal provisionb</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooks independently (yes)</td>
<td>583 (93.1)</td>
<td>827 (84.9)</td>
<td>109 (65.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Meals on wheels (yes)</td>
<td>34 (5.4)</td>
<td>108 (11.1)</td>
<td>34 (20.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Nursing home (yes)</td>
<td>12 (1.9)</td>
<td>44 (4.5)</td>
<td>23 (13.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Restaurant (yes)</td>
<td>20 (3.2)</td>
<td>50 (5.1)</td>
<td>12 (7.2)</td>
<td>0.050</td>
</tr>
</tbody>
</table>

aANOVA for continuous variables, Kruskal–Wallis test for discrete variables, and χ² test for categorical variables.

bMultiple answers allowed.
In the multinominal logistic regression analysis, older adults with an overnight fast >11 hours had a 46% higher risk of being classified as at risk of malnutrition using the MNA (OR 1.46; 95% CI 1.14–1.87) and a 67% higher risk of manifest malnutrition (OR 1.67; 95% CI 1.04–2.69) compared with those with an overnight fast of ≤11 hours.

Older adults with <4 eating episodes a day had an 88% higher risk of being classified as at risk of malnutrition (OR 1.88; 95% CI 1.52–2.32) and a three times higher risk of having manifest malnutrition (OR 3.10; 95% CI 2.14–4.49) compared with those with ≥4 eating episodes a day.

To analyse the variable meal provision (cooking independently or not), a subgroup analysis was conducted of older adults who were living at home (n = 1685), thus excluding those living in a nursing home (n = 86). Older adults who lived at home and who did not cook independently, but instead received meals on wheels had a 95% higher risk of being classified as at risk of malnutrition (OR 1.95; 95% CI 1.30–2.93) and a five times higher risk of having manifest malnutrition (OR 5.04, 95% CI 2.95–8.61). In this subgroup analysis of older adults living at home, the overnight fast was no longer a risk factor for manifest malnutrition.

### Study II

Of the 725 participants, slightly more than half were women (51.6%). The participants were aged between 53 and 80 years (mean 66.7 years) in 1997. The mean ± SD energy intakes were 1678 ± 572 kcal for women and 2524 ± 768 kcal per day for men. The mean ± SD BMI was 25.5 ± 3.8 kg/m² for women and 26.0 ± 3.3 kg/m² for men.

The follow-up period was between 10 and 12 years (median 10.9 years). At follow-up, the age range of the participants was 65–92 years (mean 77.5 years). At follow-up, 52.8% (n = 383) had risk of malnutrition and 7.2% (n = 52) were malnourished according to the MNA.

The main dietary sources for monounsaturated fat originated from the same food items that also contained a high level of saturated fat, e.g., full-fat cheese and butter/margarine on bread (Table 4).
Table 4. The main food items containing saturated fatty acids (%) and monounsaturated fatty acids (%) consumed by the 725 participants at baseline in 1997 according to the food-frequency questionnaire.

<table>
<thead>
<tr>
<th>Food item</th>
<th>Saturated fatty acids</th>
<th>Monounsaturated fatty acids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-fat cheese</td>
<td>25.6</td>
<td>14.8</td>
</tr>
<tr>
<td>Butter/margarine on bread</td>
<td>14.3</td>
<td>15.9</td>
</tr>
<tr>
<td>Full-fat dairy (milk/yoghurt/cream)</td>
<td>13.4</td>
<td>7.7</td>
</tr>
<tr>
<td>Processed meat (sausages, meatballs, pork, ham)</td>
<td>10.8</td>
<td>15.3</td>
</tr>
<tr>
<td>Sugar-sweetened food (buns/cookies/cake/chocolate/ice cream)</td>
<td>7.5</td>
<td>8.7</td>
</tr>
</tbody>
</table>

In the final multinomial logistic regression models, there were significant interaction effects between dietary fat intake and BMI for participants with a BMI <25 kg/m². Individuals of normal weight or who were underweight at baseline in 1997 and who consumed a diet with a high percentage of dietary fat had the highest risk of developing malnutrition at follow-up after 10 years.

There was a dose–response relationship between energy intake for various fats and the risk of being classified as at risk of malnutrition or being manifestly malnourished. The OR of being at risk of malnutrition or being malnourished increased for each additional percentage point of energy intake of the following types of fats: by 6.5% or 10.6%, respectively, for total fat; by 11.8% or 19.6%, respectively, for SFAs; and by 17.3% or 27.2%, respectively, for MUFAs. However, for participants with a BMI ≥25 kg/m², there were no significant associations between the risk of malnutrition and the intakes of total fat, SFAs, or MUFAs.

Study III

A total of 1767 participants were followed up in Study III. During a median (q1–q3) follow-up of 3.5 (3.3–4.0) years, 655 participants (37%) died. The survival curves for the three nutritional screening groups are shown in Figure 4. At the end of the follow-up, survival was 75.2% (n = 472) for the well-nourished group, 60.0% (n = 584) for those at risk of malnutrition, and 33.7% (n = 56) for the malnourished group (p < 0.001).
Figure 4. Kaplan–Meier survival curves according to the nutritional screening groups defined by the Mini Nutritional Assessment (well-nourished, at risk of malnutrition, or malnourished). Survival differed significantly between the three nutritional screening groups (log-rank test $p < 0.001$).

In the univariate Cox regression analysis, older adults at risk of malnutrition had a 79% higher risk of all-cause mortality (HR 1.79; 95% CI 1.49–2.15) compared with well-nourished older adults ($p < 0.001$). Older adults with manifest malnutrition had a four times higher risk of all-cause mortality (HR 4.00; 95% CI 3.13–5.11) ($p < 0.001$) compared with the well-nourished group.

In the final multivariate adjusted Cox regression model, older adults at risk of malnutrition had a 56% higher risk of all-cause mortality (HR 1.56; 95% CI 1.18–2.07) and older adults with malnutrition had almost four times higher risk of all-cause mortality (HR 3.71; 95% CI 2.28–6.04) compared with well-nourished older adults.
Study IV

A total of 1767 participants were followed up in Study IV. During a median (q1–q3) follow-up of 5.1 (4.9–5.6) years, 839 participants (47.5%) died. The survival rate was significantly related to nutritional screening groups at baseline for all of the registered causes of death (all log-rank tests; $p < 0.05$). Figure 5 shows the Kaplan–Meier curves for the cumulative survival for neoplasms (Figure 5A), diseases of the circulatory system (Figure 5B), diseases of the respiratory system (Figure 5C), and symptoms, signs, and abnormal clinical and laboratory findings not elsewhere classified (Figure 5D) in relation to the nutritional screening groups at baseline.

Figure 5A. Kaplan–Meier survival curves according to the nutritional screening groups defined by the Mini Nutritional Assessment. Survival for participants with neoplasms differed significantly between the nutritional screening groups (log-rank test $p < 0.001$).
Figure 5B. Kaplan–Meier survival curves according to the nutritional screening groups defined by the Mini Nutritional Assessment. Survival for participants with diseases of the circulatory system differed significantly between the nutritional screening groups (log-rank test $p < 0.001$).
Figure 5C. Kaplan–Meier survival curves according to the nutritional screening groups defined by the Mini Nutritional Assessment. Survival for participants with diseases of the respiratory system differed significantly between the nutritional screening groups (log-rank test $p < 0.001$).
Figure 5D. Kaplan–Meier survival curves according to the nutritional screening groups defined by the Mini Nutritional Assessment. Survival for participants with symptoms, signs, and abnormal clinical and laboratory findings not elsewhere classified differed significantly between the nutritional screening groups (log-rank test $p < 0.001$).

In the analysis of cause-specific mortality, 12 main diagnostic groups and eight subcategories according to the ICD-10 system were examined as causes of death. In the univariate Cox regression analysis, a significant association was found between malnutrition and death for all of the 20 examined causes of death. For participants at risk of malnutrition, a significant association was found for 14 of 20 examined causes of death. After adjusting for possible confounding variables in the multivariate Cox regression model, malnutrition or risk of malnutrition was still associated with 17 of 20 examined causes of death (Tables 5 and 6).
Table 5. Adjusted hazard ratios for cause-specific mortality in malnourished older adults\(^c\). Significant associations are presented in bold.

<table>
<thead>
<tr>
<th>Cause of death(^a)</th>
<th>HR (95% CI)(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certain infectious and parasitic diseases</td>
<td>2.15 (0.73–6.29)</td>
</tr>
<tr>
<td>Neoplasms</td>
<td>2.43 (1.54–3.84)</td>
</tr>
<tr>
<td>• Malignant neoplasms of digestive organs</td>
<td>3.26 (1.61–6.60)</td>
</tr>
<tr>
<td>Endocrine, nutritional, and metabolic diseases</td>
<td>2.23 (1.16–4.30)</td>
</tr>
<tr>
<td>• Endocrine, nutritional, and metabolic diseases, excluding diabetes</td>
<td>4.29 (1.35–13.58)</td>
</tr>
<tr>
<td>Mental and behavioural disorders</td>
<td>5.73 (1.90–17.28)</td>
</tr>
<tr>
<td>Diseases of the nervous system</td>
<td>4.39 (1.62–11.88)</td>
</tr>
<tr>
<td>Diseases of the circulatory system</td>
<td>1.95 (1.39–2.74)</td>
</tr>
<tr>
<td>• Ischaemic heart disease</td>
<td>1.95 (1.39–2.75)</td>
</tr>
<tr>
<td>• Heart failure</td>
<td>1.38 (0.83–2.30)</td>
</tr>
<tr>
<td>• Cerebrovascular disease</td>
<td>1.69 (0.84–3.38)</td>
</tr>
<tr>
<td>Diseases of the respiratory system</td>
<td>2.19 (1.30–3.70)</td>
</tr>
<tr>
<td>• Pneumonia</td>
<td>2.55 (1.51–4.31)</td>
</tr>
<tr>
<td>• COPD</td>
<td>1.63 (0.88–3.01)</td>
</tr>
<tr>
<td>• Diseases of the respiratory system, excluding pneumonia and COPD</td>
<td>5.33 (2.38–11.97)</td>
</tr>
<tr>
<td>Diseases of the digestive system</td>
<td>2.11 (0.91–4.94)</td>
</tr>
<tr>
<td>Diseases of the genitourinary system</td>
<td>3.13 (1.53–6.37)</td>
</tr>
<tr>
<td>Symptoms, signs, and abnormal clinical and laboratory findings not elsewhere classified</td>
<td>2.23 (1.38–3.58)</td>
</tr>
<tr>
<td>Injury, poisoning, and certain other consequences of external causes</td>
<td>1.98 (0.82–6.74)</td>
</tr>
<tr>
<td>External causes of morbidity and mortality</td>
<td>1.71 (0.67–4.46)</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; COPD, Chronic obstructive pulmonary disease; HR, hazard ratio.

\(^a\) Main diagnostic groups according to ICD-10. Subcategories are marked with a bullet. Multiple causes of death were analysed.

\(^b\) Adjusted for age, sex, BMI, BMI × BMI, current smoking, number of medications, overnight fast >11 hours, living situation (living alone, cohabiting, or living in a nursing home), diagnoses at baseline, and Charlson comorbidity index.

\(^c\) The reference category is well-nourished (n = 628).
Table 6. Adjusted hazard ratios for cause-specific mortality in older adults at risk of malnutrition. Significant associations are presented in bold.

<table>
<thead>
<tr>
<th>Causes of death(^a)</th>
<th>HR 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certain infectious and parasitic diseases</td>
<td>2.05 (1.05–3.99)</td>
</tr>
<tr>
<td>Neoplasms</td>
<td>1.32 (1.01–1.72)</td>
</tr>
<tr>
<td>- Malignant neoplasms of digestive organs</td>
<td>1.73 (1.15–2.59)</td>
</tr>
<tr>
<td>Endocrine, nutritional, and metabolic diseases</td>
<td>1.36 (0.95–1.95)</td>
</tr>
<tr>
<td>- Endocrine, nutritional, and metabolic diseases, excluding diabetes</td>
<td>1.22 (0.56–2.70)</td>
</tr>
<tr>
<td>Mental and behavioural disorders</td>
<td>5.44 (2.32–12.77)</td>
</tr>
<tr>
<td>Diseases of the nervous system</td>
<td>2.08 (1.07–4.05)</td>
</tr>
<tr>
<td>Diseases of the circulatory system</td>
<td>1.57 (1.27–1.95)</td>
</tr>
<tr>
<td>- Ischaemic heart disease</td>
<td>1.57 (1.27–1.94)</td>
</tr>
<tr>
<td>- Heart failure</td>
<td>1.40 (1.03–1.91)</td>
</tr>
<tr>
<td>- Cerebrovascular disease</td>
<td>1.31 (0.86–2.00)</td>
</tr>
<tr>
<td>Diseases of the respiratory system</td>
<td>1.49 (1.07–2.09)</td>
</tr>
<tr>
<td>- Pneumonia</td>
<td>1.57 (1.12–2.20)</td>
</tr>
<tr>
<td>- COPD</td>
<td>1.50 (0.60–3.80)</td>
</tr>
<tr>
<td>- Diseases of the respiratory system, excluding pneumonia and COPD</td>
<td>1.83 (1.01–3.29)</td>
</tr>
<tr>
<td>Diseases of the digestive system</td>
<td>1.43 (0.83–2.45)</td>
</tr>
<tr>
<td>Diseases of the genitourinary system</td>
<td>1.15 (0.73–1.81)</td>
</tr>
<tr>
<td>Symptoms, signs, and abnormal clinical and laboratory findings not elsewhere classified</td>
<td>1.43 (1.05–1.96)</td>
</tr>
<tr>
<td>Injury, poisoning, and certain other consequences of external causes</td>
<td>2.05 (1.02–4.11)</td>
</tr>
<tr>
<td>External causes of morbidity and mortality</td>
<td>1.85 (1.03–3.32)</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; COPD, Chronic obstructive pulmonary disease; HR, hazard ratio.
\(^a\) Main diagnostic groups according to the ICD-10. Subcategories are marked with a bullet. Multiple causes of death were analysed.
\(^b\) Adjusted for age, sex, BMI, BMI × BMI, current smoking, number of medications, overnight fast >11 hours, living situation (living alone, cohabiting, or living in a nursing home), diagnoses at baseline, and Charlson comorbidity index.
\(^c\) The reference category is well-nourished (n = 628).
Discussion

The present thesis describes the extent of malnutrition among older adults admitted to hospital, with focus on the importance of nutritional screening with a validated instrument. Further, the studies in the thesis examine possible risk factors to be aware of in order to counteract malnutrition, and consequences of malnutrition in terms of all-cause and cause-specific mortality. The two studies regarding mortality also show the clinical usefulness of the MNA screening instrument.

High prevalence of risk of malnutrition

The extent of malnutrition and risk of malnutrition in older adults in acute care hospitals are not known at the national level, as no large Swedish study has estimated the prevalence of malnutrition exclusively in older adults admitted to hospital [46].

Only 35.5% of older adults admitted to hospital were well-nourished. The prevalence of malnutrition was lower than expected: only 9.4% of the patients were assessed as malnourished according to the MNA. Instead, most (55.1%) of the study population was at risk of malnutrition. From the viewpoint of prevention, this result is helpful because malnutrition may be easier to prevent than to treat [43]. This finding emphasizes the need for nutritional screening in adults aged ≥65 years.

Comparison with previous studies

In Study I, almost all participants (95.1%) were living at home before hospital admission, and the rest (4.9%) lived in a nursing home. According to previous Swedish studies, the prevalence of malnutrition in older adults living at home is low (0–1%) [41, 42] compared with those living in nursing homes (30%) [49]. This may also partly explain the lower prevalence of malnutrition found in the present study.

A comparable Swedish study of 83 geriatric patients acutely admitted to hospital estimated that 26% were malnourished according to the MNA. However, the population was 5 years older than that in the cohort in Study I,
which could partly explain the higher prevalence of malnutrition reported. The percentage of older adults at risk of malnutrition in the present study (55.1%) was similar to that in the aforementioned study (56.0%) [46].

The heterogeneity of malnutrition estimates in different studies may be explained partly by the choice of inclusion and exclusion criteria, and the prevalence of dementia. The most frequent reason for not participating in Study I was “unable to communicate and no relative could answer the questions” (n = 356). The excluded patients were also significantly older than the included patients. The included patients were thus relatively healthy compared with those in the previous Swedish study mentioned above, which recruited geriatric patients admitted to hospital [46].

The prevalence of malnutrition in the present study is similar to that found in a previous Swedish study of older adults (mean age 82 years) receiving support at home (n = 353). They found that 8% were malnourished and 41% were at risk of malnutrition [47]. The prevalence of malnutrition in the present study is also comparable to that found in an Italian study of older adults (mean age 82 years) attending family practice (n = 274), which found that 11% were malnourished according to the MNA. However, the risk of malnutrition was lower (25%) than in the present study [89]. In a population-based study of 832 older adults (mean age 90 years) living in the community (n = 473) or in institutional care (n = 359), the prevalence of malnutrition was 13.3%, and 40.3% were at risk of malnutrition [90].

Comparison with prevalence data from Senior Alert

The prevalence of malnutrition (9.4%) and risk of malnutrition (55.1%) in Study I can be compared with recent data from the national quality register Senior Alert. In 2015, of the older adults admitted to Västmanland County Hospital Västerås (where Study I was conducted), 22.5% were malnourished and 45.5% were at risk of malnutrition according to the MNA-SF (personal communication). In other words, only 33.0% were well-nourished, compared with 35.5% in Study I.

This indicates that the prevalence of malnutrition has not changed notably since Study I was performed in 2008–2009. The higher prevalence of malnutrition recorded in Senior Alert in 2015 (22.5%) might be explained by the fact that only older adults >70 years old were screened with the MNA-SF, compared with the inclusion of older adults ≥65 years in Study I. Further, because the MNA-SF was used, more older adults with multi-morbidity may have been included because the MNA-SF has fewer questions; this may have contributed to a higher prevalence of malnutrition in the Senior Alert data.
However, the prevalence of being at risk of malnutrition was higher in Study I than in the Senior Alert data (55.1% and 45.5%, respectively).

National data from Senior Alert show that the mean prevalence of malnutrition in Swedish hospitals is 22% and that 45% are at risk of malnutrition according to the MNA-SF. In primary health care, the prevalence is considerably lower: only 7% are malnourished and 26% at risk. This underlines the importance of detecting nutritional problems as early as possible, preferably in primary health care, before nutritional status deteriorates and hospitalization is required. This is especially relevant considering that most (74%) older adults with multi-morbidity live at home [91]. Frail older adults who seek care are more vulnerable, and minimal stress from, for instance, a disease or medical condition can cause serious functional impairment or death [9]. Therefore, there is a need for simple validated models in primary health care to detect these frail older adults who are at special risk as soon as possible and nutritional screening should be a part of this identification process.

The fact that only 33% of older adults admitted to hospital are well-nourished means that 67% of patients screened for malnutrition with the MNA-SF at hospital need further assessment to identify the underlying causes of malnutrition so that appropriate actions can be taken to prevent or treat malnutrition. Considering the high prevalence of malnutrition, it is even more important that nutritional screening is performed by using validated screening instruments so that actions to prevent and treat malnutrition are targeted to those who are malnourished or at risk. Otherwise, there is a risk that valuable time will be spent on those who do not need the interventions and, consequently, less time spent on those who truly need nutritional support. The importance of using validated screening instruments is also stressed in the resolution from the Council of Europe, which states that “the nutritional risk screening method should be evidence based, in order to secure the identification of patients who may benefit from nutritional support” [70].

Comparison with the diagnostic criteria for malnutrition

The MNA instrument is used extensively to screen for malnutrition both nationally [41, 42, 46-49, 90] and internationally [38]. However, an objective validation of the instrument is lacking mainly because of the lack of a reference standard for the definition of malnutrition [2].

The prevalence of malnutrition according to the ESPEN consensus group’s diagnostic criteria for malnutrition has been evaluated in only one study to date, which included four different populations in the Netherlands. The prevalence of malnutrition in these populations was: 14% \((n = 349)\) in
acutely ill middle-aged patients in hospital (mean age 57.6 years), 6\% (n = 135) in geriatric outpatients (mean age 80.8 years), 0.5\% (n = 306) in healthy older individuals (mean age 74.4 years), and 0\% (n = 179) in healthy younger individuals (mean age 23.4 years) [92]. The prevalence of malnutrition in hospital according to this new definition is lower than that reported in previous studies in hospital using the MNA (23–39\%) [19, 33, 36, 38], which can be partly explained by the younger study population in the Dutch study [92]. One other explanation is that the purpose of the MNA is to identify individuals before malnutrition is manifest, whereas the aim of the diagnostic criteria is to identify individuals who have developed malnutrition.

In this thesis, additional analyses were performed to examine the prevalence of malnutrition when applying the ESPEN consensus group’s diagnostic criteria of malnutrition [2] to those older adults who were assessed as malnourished or at risk of malnutrition according to the MNA (n = 1142) in Study I. According to the first diagnostic alternative (BMI <18.5 kg/m\(^2\)), 77 older adults (4.3\%) were classified as malnourished. According to the second diagnostic alternative (unintentional weight loss in combination with a low BMI), 90 older adults (5.1\%), were classified as malnourished. In total, 7.9\% were classified as malnourished according to the first or the second diagnostic alternative. This compares with the percentage of 9.4\% who were assessed as malnourished using the MNA in Study I.

The prevalence of the diagnosis of malnutrition in Swedish hospital records is generally low. The first criterion for the diagnosis of malnutrition should be based on validated screening instruments according to a consensus statement for diagnostic criteria [2]. As the next step, BMI and weight loss should be evaluated. Using the MNA or another validated screening instrument that includes BMI and weight loss would therefore increase the probability of diagnosing malnutrition or risk of malnutrition, and could be recommended in routine clinical practice.

**Risk factors for malnutrition**

Studies I and II contribute to new knowledge about the inclusion of an overnight fast >11 hours, <4 eating episodes a day, and a high energy intake from dietary fat (E\%) as possible risk factors for malnutrition.

**Overnight fast >11 hours and <4 eating episodes a day**

Older adults with an overnight fast >11 hours had a 46\% higher risk of being classified as at risk of malnutrition and a 67\% higher risk of manifest malnu-
trition compared with those with an overnight fast of ≤11 hours. Further, older adults with <4 eating episodes a day had an 88% higher risk of being classified as at risk of malnutrition and a three times higher risk of having manifest malnutrition compared with those with ≥4 eating episodes a day.

At the time of planning and conducting Study I, the length of the overnight fast and daily number of eating episodes were used as quality indicators in the national “Open Comparisons” survey in Sweden. The Nordic countries had nutrition recommendations regarding the length of the overnight fast and number of eating episodes per day. However, these recommendations were no longer included in the updated version of the Nordic nutrition recommendations from 2012 [93]. The length of overnight fast and daily number of eating episodes were also removed as quality indicators from the current version of “Open Comparisons” from 2013 [94]. The recommendation regarding eating patterns was removed since it was not possible to perform a systematic review because of the lack of scientific evidence on the effects of an overnight fast ≤11 hours and ≥4 eating episodes a day. Study I provides some evidence that information about these mealtime habits should be reintroduced into the Nordic nutritional recommendations and as a quality indicator in the “Open Comparisons”.

In the subgroup analysis of participants living at home, the association between malnutrition and overnight fasting was no longer statistically significant ($p = 0.158$). One possible explanation is the decisive loss of statistical power when those living in nursing homes were excluded from the analysis, because this group included 15.7% ($n = 26$) of the malnourished participants. Another possible explanation is that the overnight fast is only important for people living in a nursing home because these individuals are frailer than those living at home. The findings warrant the inclusion of information about an overnight fast ≤11 hours and ≥4 eating episodes a day in interventions aimed at preventing malnutrition in hospitals as well as in primary health care and in nursing homes.

In older adults living at home, not cooking independently, but instead receiving meals on wheels, was associated with both being at risk of malnutrition and being malnourished. One explanation may be that older adults at risk of malnutrition use meals on wheels more frequently and have a reduced ability to undertake daily life activities compared with well-nourished older adults [47]. This association may be bidirectional; that is, the decline in function, which increases the need for help (e.g., in the form of meals on wheels), may be both a cause and an effect of malnutrition. Regardless of the underlying reason, older adults who do not have the strength or ability to cook independently should be recognized as individuals at risk of malnutrition.
The interaction effects between smoking, length of overnight fast, daily number of eating episodes, and meal provision were analysed because these were presumed to be associated with malnutrition and possibly to be interrelated. However, there were no interaction effects between smoking, length of overnight fast, number of eating episodes, and meal provision.

A high energy intake (E%) from dietary fat

This is the first study to examine the association between dietary fat intake during middle and old age and risk of malnutrition in later life. The finding that underweight and normal-weight (BMI <25 kg/m²) middle-aged and older adults consuming a high fat diet have an increased risk of future malnutrition may appear contradictory. The dietary fats consumed by this population mostly came from foods with a high content of monounsaturated and saturated fat, such as full-fat dairy, solid fats, processed meat, and sugar-sweetened foods, and a lower proportion consisted of polyunsaturated fat (found in olive and rapeseed oils and soft margarines). Although these foods have a high energy density, they also have a low nutrient content, which could partly explain the results. Further, participants with a BMI <25 kg/m² had a higher intake of total fat (E%) and saturated fat (E%) compared with those with a BMI ≥25 kg/m². Another explanation is that being overweight (BMI ≥25 kg/m²) might have a strong protective effect against malnutrition, such that the risk of malnutrition from a high fat content in the diet has no effect in people with a high BMI.

Therefore, normal-weight and underweight middle-aged and older adults might need to limit the intake of total fat in the diet and/or improve the quality of the fat to decrease the risk of future malnutrition. This suggestion is also relevant given that low-carbohydrate, high-fat diets have become popular in recent years as a method for losing weight, but the long-term consequences (>6 months) of these diets are unexplored [95].

Malnutrition as a predictor of all-cause mortality

The prognostic value of the MNA in relation to all-cause mortality was confirmed in our study of 1767 participants aged ≥65 years. Malnourished older adults were almost four times more likely to die during the follow-up, and older adults at risk of malnutrition had a 56% higher risk of death compared with well-nourished individuals. These relationships remained significant after controlling for baseline characteristics such as age, sex, BMI, smoking, number of medications, diseases, and mealtime habits. These data indicate that malnutrition and risk of malnutrition are independent predictors of preterm death.
The results in Study III are consistent with those of previous studies that used the full MNA to examine the association between malnutrition and mortality in older adults in a hospital setting [64-67, 96]. However, most of these studies did not conduct any regression analyses [64-67], which is a limitation when analysing the predictive value of the MNA in an observational study. Only a few studies have measured mortality after discharge from hospital, with follow-up periods ranging from <1 month to 5 years, and 1 year being a common follow-up period [65, 96].

A retrospective study in Australia used data from 476 older adults previously assessed with the MNA at two rehabilitation hospitals to analyse the association with mortality after 18 months. This Australian study adjusted the Cox regression model for diseases at admission—a step that was also included in the analysis for Study III. At follow-up, the HR in the Australian study was 3.41 (95% CI 1.07–10.87) in the malnourished group compared with 3.71 (2.28–6.04) in the present cohort. However, the survival analysis in the Australian study included only those individuals who had survived 1 year [96]. This bias hinders a direct comparison with the cohort in Study III, whose mortality rate was high during the first follow-up year.

A Nordic study of older adults (mean age 90.2 years) living in institutional care or in the community (n = 832) analysed the association between survival and the three nutritional screening groups according to the MNA (well-nourished, at risk of malnutrition, malnutrition). The Cox proportional-hazards regression was adjusted for age and sex. At the 5-year follow-up, an MNA score <17 (malnourished) was associated with lower survival. This suggests that the MNA provides an effective way to identify malnutrition in older adults aged 85 years and older [90].

A large Swedish study (n = 3041) examined the association between malnutrition assessed with the three categories in the MNA-SF in older adults (mean age 73.7 years) and mortality at the 11-year follow-up. After adjusting the logistic regression analysis for age, sex, education, and living arrangement, the mortality rates for older adults with malnutrition and at risk of malnutrition were 3.4-fold and 1.5-fold higher than for those who were well-nourished [97]. However, this study was conducted in older adults living at home or in an institution, in contrast to the present cohort of older adults admitted to hospital.

The results from the survival analyses in the present thesis clearly demonstrate that risk of malnutrition and manifest malnutrition, defined according to the MNA, have clinical importance because of the profound effect on survival. This finding is especially important given that the current regulations in Sweden state that the health care provider should have routines for
investigating nutritional status and preventing and treating malnutrition [74]. The present study demonstrates that the MNA instrument can be used in clinical practice to identify older adults who may require nutritional support to help avoid a preterm death.

Malnutrition as a predictor of mortality, regardless of the cause of death

The prognostic value of the MNA in relation to cause-specific mortality was confirmed in Study IV, which included a cohort of 1767 participants aged ≥65 years. Malnourished older adults and those at risk of malnutrition had a consistently higher risk of death compared with well-nourished older adults regardless of the cause of death. These results remained significant after controlling for baseline characteristics and diagnoses, and show that malnutrition and risk of malnutrition are important prognostic factors for adults aged ≥65 years, regardless of the cause of death.

Previous studies examining the relationship between malnutrition and mortality have analysed all-cause mortality [63]. The one study that examined cause-specific mortality found no association with malnutrition when using the MNA instrument. One reason might be a lack of power, because only 358 older adults (mean age 84.6 years) were examined, which resulted in 297 deceased individuals at the 6.5-year follow-up in comparison with the 839 deceased individuals reported in Study IV. In addition, the present study analysed multiple causes of death, in contrast to the aforementioned study, which analysed only a single underlying cause of death per patient (categorized as cardiovascular, cancer, or respiratory mortality) [69], which resulted in more events in the causes-of-death categories in our study.

The present study is the first to report an association between malnutrition assessed with the MNA and cause-specific mortality among older adults admitted to hospital. The findings demonstrate the clinical usefulness of the screening instrument in all older adults, regardless of the presence of underlying disease.

Ethical considerations

At the time of the study, nutritional screening with the MNA was not performed as a routine at the hospital. There might have been some discomfort for the 21 participants who required use of a mobile lift scale to be weighed. However, weighing should be routine upon admission to the
hospital ward. It may also be ethically indefensible not to weigh older adults. Some of the questions in the MNA might be perceived as affecting the patient’s integrity. This problem has been taken into consideration.

One ethical consideration was whether to include older adults with dementia in the study. It was decided to include these patients because the MNA does not involve great discomfort to patients. To exclude older adults with dementia would have led to a large number of drop-outs, which would have prevented us from obtaining an accurate indication of the prevalence of malnutrition in this population. According to medical records, only 33 patients in the study population had dementia. If a patient was unable to communicate, a relative was asked if he/she objected to the patient’s participation in the study ($n = 23$).

Malnourished participants received only routine interventions at the hospital, and no additional interventions were included in the study. However, the participants received information about their risk of malnutrition, which gave them the opportunity to consider whether they needed or wanted to take further actions, such as consulting a dietician. If the participant was unable to communicate, the relative was informed of the patient’s nutritional risk.

**Methodological considerations**

**Strengths**

The major strengths of Study I were the sample size and the training given to the health care professionals administering the MNA. To increase the interobserver reliability, the health care professionals were trained in how to collect the data, interpret the questions in the MNA, and take the measurements. Detailed instructions were given for the measurements of height, weight, and mid-arm and calf circumferences. The use of a standardized questionnaire (MNA) also contributed to minimizing observer bias.

Study II is the first study to examine the association between dietary fat intake during middle- and old age and malnutrition in later life. The prospective study design allowed for adjustments for important participant characteristics recorded at baseline when the dietary intake was reported.

The strengths of Studies III and IV were the limited number of participants lost to follow-up ($n = 4$) and the length of the follow-up. These studies are the largest studies so far that have examined the relationship between mortality and the three nutritional screening groups defined by the MNA (well-nourished, at risk of malnutrition, and malnourished) among older adults.
admitted to hospital [40, 63, 69, 96]. From a clinical viewpoint, it is more relevant to examine the three nutritional screening groups rather than the overall MNA score (0–30) because these categories are used to screen older adults for malnutrition in the municipalities and county councils in Sweden through the quality register Senior Alert.

The prospective study design in Studies III and IV allowed for adjustment for a number of comorbidities and several other patient characteristics recorded at baseline. This is essential when examining the independent relationship between malnutrition and mortality in an observational study. Other unrecognized, potentially confounding factors may exist and could have affected the HRs. However, the large risk estimates did not change noticeably in the regression models, making it unlikely that the results occurred by chance.

In Study IV, multiple causes of death were analysed; these included all conditions mentioned on a death certificate, which included both the terminal cause of death and the underlying cause of death [98]. By contrast, previous studies have analysed only the underlying cause of death in relation to malnutrition [69] or BMI [99]; i.e., the disease or injury that started the sequence of events leading directly to death or to the circumstances of the accident or violence that produced the fatal injury [98]. However, older adults may have a complex disease history, and multiple diseases may contribute to the cause of death [98]. For this reason, we chose to analyse all conditions specified on a death certificate, and we consider this a strength of the present study.

Limitations

One limitation of the MNA is that it can be difficult to interview older adults who have communication difficulties because of, for example, cognitive impairment. It is likely that these older adults are at high risk of malnutrition [18, 19]. In the present study, 14% of older adults considered for inclusion had communication difficulties and no relatives who could answer the questions in the MNA, and thus they could not be screened. Therefore, these individuals were excluded from the study.

However, it is especially important to screen for malnutrition in this group of older adults because they may have a high risk of malnutrition. One method could be to use the three items recommended by Swedish Association of Local Authorities and Regions [100] and the Swedish National Board of Health and Welfare [3], namely BMI, weight loss, and eating difficulties. If one of these criteria is fulfilled, the individual can be considered at risk of malnutrition.
On the other hand, this can also be considered a strength of the MNA, because it also identifies those who can communicate and might appear to be well-nourished but at the same time have an increased risk of malnutrition; for example, older adults with a high BMI. With aging, most people lose height because of degenerative changes. From ages 60–64 years to 85+ years, the mean measured height decreases by 6.2 cm in men and 7.8 cm in women. This loss of height can increase BMI [101]. Without the MNA screening, these older adults with a high BMI might have been overlooked because they appear healthy. A Nordic study of 832 older adults (mean age 90.2 ± 4.6 years) living in institutional care or in the community found that a substantial portion of those with a low MNA score (MNA <17) still had a high BMI value (BMI ≥22 kg/m²). This suggests that the MNA provides an effective way to identify malnutrition in older adults aged 85 years and older [90], even if the individual has a normal weight according to BMI.

In Study I, one methodological limitation concerns the variable eating episodes. The participants were asked how often they usually ate breakfast, lunch, dinner, and between-meal and evening snacks. This type of closed question could be leading because people usually want to please health care professionals. Optimally, one would use open questions and ask the participants what they ate during the day and then classify the eating habits according to the number of eating episodes.

Because Study I was a cross-sectional study, conclusions about causal relationships cannot be drawn. Factors identified as associated with malnutrition in the cross-sectional study could be risk factors for malnutrition but could also be the result of malnutrition. Nevertheless, older adults who have a long overnight fast and few eating episodes a day and who do not have the strength or ability to cook independently should be recognized as individuals at risk of malnutrition.

Selection bias was a concern in Study II because the study population included a selection of survivors. Only those who had survived until the risk of malnutrition could be screened at hospital could participate. Individuals with a high intake of dietary fat might have had a higher risk of dying [102], meaning that only survivors were selected in the study cohort. Consequently, there is a risk that a high energy intake from fat as a risk factor for future malnutrition might be underestimated in the present study.

In Study II, the dietary intake was measured only at baseline, and malnutrition was screened only at follow-up. Therefore, any changes in dietary fat intake in the years before the nutritional screening of the participants are unknown. The risk of malnutrition for the participants at baseline was not
recorded, but those who were malnourished at follow-up had a lower mean BMI at baseline, compared with the other nutritional screening groups.

One limitation in Studies III and IV was that no information was available about when the malnutrition had occurred. Hence, it is difficult to know whether diseases had led to malnutrition or whether malnutrition preceded the diseases. However, the multivariate Cox regression analyses remained significant even after controlling for the diagnoses at baseline (Studies III and IV), and for the Charlson comorbidity index (Study IV).

In Study IV, one limitation concerned the use of data from the Swedish Cause of Death Register because only a minority of deaths are examined by autopsy [82]. In Study IV, an autopsy was performed on 6.3% of the deceased. An external examination of the corpse, which is considered the least reliable method to examine the cause of death, was performed in only 11.7% of the deceased. The majority (80.3%) had been examined before they died, and the cause-of-death statement was based on this examination. However, in a small percentage of the deceased, the examination for determining cause-of-death was not stated (1.7%).

A limitation of all of the studies is that malnutrition was screened only for older adults admitted to hospital, which limits the generalizability of the results to other older adults. However, most of the participants were living at home (95.1%) and only 4.9% were living in a nursing home before admission to hospital. This indicates that the study population might be healthier than the average population of older adults admitted to hospital and may have more similarities with the general population.

Because of the observational study design in all of the studies, there is always a possibility of residual confounding because of unmeasured or imprecisely measured risk factors for malnutrition.
Conclusions and clinical implications

This thesis describes the extent of malnutrition among older adults admitted to hospital, possible risk factors for developing malnutrition, and the relationships between malnutrition and both overall and cause-specific mortality.

To summarize the results of the studies reported here, malnutrition is a common clinical condition among older adults admitted to hospital, since only 35.5% were well-nourished. This finding demonstrates the need for nutritional screening of older adults. Preventive actions to counteract malnutrition may include decreasing the overnight fast to \(\leq 11\) hours and increasing the number of eating episodes to \(\geq 4\) each day. Normal-weight or underweight middle-aged and older adults should consider limiting the intake of total fat in the diet, and/or improving the quality of fat to decrease the risk of being malnourished in the future. Malnutrition and risk of malnutrition were associated with increased overall and cause-specific mortality. This finding emphasizes the need for nutritional screening to identify older individuals who may require nutritional support to help avoid a preterm death. The MNA screening instrument could identify those with worse survival prospects related to malnutrition and risk of malnutrition, which suggests that this instrument is useful in clinical practice.

The studies presented in this thesis highlight the need for increased knowledge and awareness, as well as routines in clinical practice regarding nutritional screening among older adults and further examinations of those at risk of malnutrition. This should theoretically allow for more older adults to receive the medical diagnosis of malnutrition. Even though nutritional interventions to prevent or treat malnutrition are unclear, it is important that these individuals are diagnosed, which should stimulate the development of effective interventions against malnutrition for older adults.
The latest report from the Swedish Council on Health Technology Assessment concludes that there is no reliable scientific evidence regarding the positive or negative effects of nutritional supplementation to older adults with malnutrition or at risk of malnutrition [14]. Previous studies are of varying quality; some included short interventions and time to follow-up and small study populations, and most were performed during stays at hospital or in nursing homes. However, increasingly more older adults are living in their own home, and the effects of treatment in home-living older adults need further investigation. It is also unknown to whom these interventions should be targeted [13, 15]. The results from a Cochrane review indicate that the effects of nutritional supplementation on mortality apply only to already malnourished older adults and to older adults who receive nutritional supplements of ≥400 kcal a day [15].

There is a need for large-scale, randomized intervention studies evaluating the effects of nutritional interventions in terms of quality of life, functional status, and survival. This was the motivation for a randomized controlled multi-centre study aimed at investigating the effect of nutritional supplements and dietary advice given to older adults admitted to hospital with malnutrition or at risk of malnutrition, which was begun recently, as described below.

A total of 671 individuals aged ≥65 years admitted to Västmanland County Hospital Västerås (n = 300), Målar Hospital in Eskilstuna (n = 87), Nyköpings Hospital (n = 100), Uppsala University Hospital (n = 157), and Falu Hospital (n = 27) were included in the study. Nutritional screening was performed using the MNA instrument during the patients’ stay at hospital. Well-nourished patients were excluded. Malnourished patients and those at risk of malnutrition were randomized to four treatment groups: nutritional supplementation (400 kcal/day), individual dietary advice, a combination of nutritional supplementation and dietary advice, or a control group (usual treatment). The interventions began when the patients were discharged from hospital and continued for 6 months. All-cause mortality and quality of life were followed up at 6 months, 1 year, and 3 years. Inclusion of patients has closed and the analyses will be performed in 2016.
**Sammanfattning**

Denna avhandling beskriver utbredningen av undernäring bland äldre individer som skrivs in på sjukhus, möjliga riskfaktorer för att utveckla undernäring, samt hur undernäring är relaterad till både total- och orsaksspecifik dödlighet. De två studierna gällande dödlighet visar även på den kliniska användbarheten av screeninginstrumentet Mini Nutritional Assessment (MNA).

Undernäring definieras enligt Socialstyrelsen som ”ett tillstånd där brist på energi, protein eller andra näringsämnen har orsakat mätbara och ogynn- samma förändringar i kroppens sammansättning, funktion eller av en persons sjukdomsförlopp” (s. 12) [3].

Det finns ingen referensmetod för hur undernäring ska diagnostiseras. Som en följd av detta har ett flertal screening instrument utvecklats för att identifiera undernäring. Det instrument som oftast används både internationellt och nationellt för att scera äldre individer för undernäring är MNA. Instrumentet består av 18 frågor och varje fråga poängsätts och slutsumman kategoriserar individens nutritionsstatus i tre nivåer; välnärd, risk för undernäring eller undernärd [27, 33].

I Sverige används MNA i så gott som alla kommuner och landsting sedan införandet av det nationella kvalitetsregistret Senior alert under 2010, i vilket screening för undernäring ingår [73]. Ingen storskalig studie i Sverige har dock undersökt prevalensen av undernäring hos äldre individer som skrivs in på sjukhus [46]. Aktuella uppgifter om undernäringens utbredning bland äldre är viktigt för att visa på betydelsen av nutritionsscreening.

Ett högt energiintag från fett (E%) rekommenderas till sjuka äldre individer där risk för undernäring föreligger [3]. Det är dock inte studerat om en hög energiprocent (E%) av fett i kosten kan förebygga undernäring på lång sikt.

Associationen mellan undernäring och död är sedan tidigare beskrivet [63]. Det är dock inte säkerställt om detta samband är oberoende av confounders (störfaktorer) eller om undernäring är associerat med dödlighet, oberoende av underliggande sjukdom. Kunskapen om detta skulle styrka riktigheten i beslut om att screena för undernäring i den kliniska vardagen.

Metod

I studie I screenades 1771 individer ≥65 år för undernäring som skrevs in på ett svensk sjukhus. Screeningen gjordes med instrumentet MNA och möjliga riskfaktorer associerade med undernäring registrerades under vårdtiden på sjukhuset.


I studie III och IV följdes 1767 deltagare upp gällande dödlighet av alla orsaker efter en mediantid av 3,5 år (studie III) och orsaksspecifik död efter en mediantid av 5,1 år (studie IV). Vid analys av orsaksspecifik död, analyserades 12 huvuddiagnosgrupper enligt ICD-10-systemet samt 8 undergrupper från detta.

Studie I

Syftet med studien var att undersöka prevalensen av undernäring hos äldre personer som skrivs in på sjukhus, samt att analysera riskfaktorer för undernäring.

Av de 1771 äldre patienterna som skrevs in på sjukhus var drygt en tredjedel av patienterna välnärda (35,5 %), dock hade mer än hälften risk för undernäring (55,1 %) och nästan en av tio var undernärd (9,4 %) enligt MNA. Med andra ord hade två tredjedelar ett dåligt näringstillstånd.

Äldre som hade en nattfasta >11 timmar hade 67 % ökad risk för undernäring och de som hade <4 åttifällen per dag hade tre gånger ökad risk för undernäring. Ytterligare en riskfaktor för undernäring var att inte laga mat
själv, utan istället få matlådor via hemtjänsten. Äldre som inte lagade mat själv hade en fem gånger ökad risk för undernäring.

Studie II
Syftet med studien var att undersöka om ett högt intag av fett från kosten bland medelålders och äldre individer är associerat med risk för undernäring 10 år senare. Hypotesen var att ett tidigare högt energiintag från totalt fett är associerat med minskad risk för undernäring 10 år senare, oavsett fett-sammansättning.

Totalt 725 äldre individer följdes upp efter en median av 10,9 år. Vid uppföljningen hade 52,8 % risk för undernäring och 7,2 % var undernärda enligt MNA.

Resultatet visade att individer som var normalviktiga och underviktiga 1997 (BMI <25 kg/m²) och vars diet innehöll en hög andel fett (E%), hade högre risk att utveckla undernäring 10 år senare. Det fanns även ett dos-respons förhållande. Sannolikheten att ha risk för undernäring ökade för varje ytterligare energiprocent från totalt fett (med 6,5 %), mättat fett (med 11,8 %) och enkelomättat fett (med 17,3 %). Oddsren för att vara undernärd ökade med 10,6 % för varje ytterligare energiprocent från totalt fett, 19,6 % för mättat fett och 27,2 % för enkelomättat fett. Dock fanns det inget signifikant samband mellan undernäring och intag av totalt fett, mättat fett eller enkelomättat fett för personer med ett BMI ≥25 kg/m².

Studie III
Syftet med studien var att undersöka om undernäring är en oberoende riskfaktor för en för tidig död hos äldre individer.

Totalt 1767 individer följdes upp efter en mediantid av 3,5 år. Under uppföljningstiden avled 655 (37,1 %) av deltagarna. Resultaten från överlevnadsanalyserna visade att vid uppföljning efter 4,2 år levde fortfarande 75,2 % av de välnärda individerna, men endast 60,0 % av de med risk för undernäring och 33,7 % av de undernärda individerna.

Äldre individer som bedömdes ha risk för undernäring enligt MNA hade en 56 % ökad risk för en förtida död, medan undernärda hade en nästan fyra gånger ökad risk för en förtida död jämfört med välnärda individer. Detta indikerar att undernäring och risk för undernäring enligt MNA, är oberoende riskfaktor för en förtida död hos individer som är 65 år och äldre.
Studie IV
Syftet med studien var att undersöka om undernäring är en oberoende riskfaktor för orsaksspecifik död.

Totalt 1767 individer följdes upp efter en median av 5,1 år. Under uppföljningstiden avled 839 äldre individer (47,5 %). Resultaten från överlevnadsanalyserna visade att vid uppföljning efter 5,8 år hade undernärsda äldre och äldre med risk för undernäring konsekvent lägre överlevnad jämfört med välnärsda äldre, oavsett dödsorsak (log-rank test \( p < 0,05 \)).

Undernäring hos äldre var signifikant associerat med död för samtliga undersökta dödsorsaker i de univariata analyserna, medan risk för undernäring var signifikant associerat med 14 av 20 undersökta dödsorsaker. I de multivariata analyserna var fortfarande undernäring och risk för undernäring signifikant associerat med 17 av de 20 undersökta dödsorsakerna. Detta innebär att undernäring och risk för undernäring enligt MNA är signifikant associerat med en ökad dödlighet oavsett dödsorsak.

Slutsats och kliniska implikationer
Prevalensen av undernäring var lägre än förväntat (9 %), medan prevalensen av risk för undernäring var något högre (55 %) än tidigare beskrivet i andra studier som har använt samma instrument (43-49 %) [19, 33, 36, 38]. Detta resultat innebär möjlighet till prevention. Vår studie understryker vikten av att implementera rutiner för nutritionsscreening bland äldre individer som skrivs in på sjukhus.

I Socialstyrelsens riktlinjer gällande undernäring, anges att vårdgivaren måste ha rutiner för hur undernäring ska förebyggas och behandlas [74]. Resultaten från studie I antyder att preventiva åtgärder för att motverka undernäring kan innefatta att nattfastan förkortas till 11 timmar eller mindre, samt en ökning av antalet ättillfällen till fyra måltider per dag eller mer. Dessa rekommendationer har tidigare baserats på expertutlåtanden, men resultaten bekräftar att dessa måltidsvanor är viktiga att uppmärksamma hos äldre individer.

Gällande kopplingen mellan ett tidigare intag av fett i kosten och framtida risk att utveckla undernäring visar resultatet lite överraskande att medelålders samt äldre individer med normalt eller lågt BMI (BMI <25 kg/m\(^2\)), vars diet bestod av en hög andel fett, hade högst risk att drabbas av undernäring 10 år senare. Det fanns också ett dos-respons förhållande, ju högre andel fett i kosten desto högre risk för undernäring senare i livet. Medelålders och
äldre individer som är normalviktiga eller underviktiga bör vara uppmärksam på att mängden fett samt även fettkvaliteten i kosten kan öka risken för framtida undernäring.

Resultaten från studie III och IV gällande dödlighet stödjer de nyligen publicerade riktlinjerna, som anger att vårdgivaren är ansvarig för att ha rutiner gällande när en individs nutritionsstatus ska undersökas och hur denna undersökning ska göras [74]. Fynden understryker behovet av nutritionsscreening för att identifiera äldre individer som kan behöva kostbehandling för att undvika en för tid död. MNA instrumentet kunde identifiera äldre individer med en längre överlevnad som var relaterat till undernäring eller risk för undernäring. Detta talar för att instrumentet är användbart i den kliniska vardagen.

Sammanfattningsvis är undernäring ett vanligt klinisk tillstånd bland äldre individer som skrivs in på sjukhus, eftersom endast 35,5 % var välnärda, och därmed är det angeläget med nutritionsscreening. För detta ändamål är MNA kliniskt användbart. Preventiva åtgärder för att motverka undernäring kan innebära att nattfastan förkortas, att antalet måltider per dag ökas, eller att det totala fetintaget i kosten minskas alternativt att fettkvaliteten ses över. Konsekvenser av att ha risk för undernäring eller att vara undernärd är både en ökad total samt en orsaksspecifik död, vilket understryker behovet av att screena för undernäring för att förhindra en för tid död.

Studierna i avhandlingen belyser betydelsen av att implementera rutiner för nutritionsscreening bland äldre individer som skrivs in på sjukhus, samt ytterligare undersökningar av dem med risk för undernäring. Detta kan möjlig göra att fler äldre individer får den medicinska diagnosen undernäring. Även fast det inte finns någon tillförlitlig vetenskaplig evidens gällande effekter från nutritionsbehandling till äldre undernärda individer är det ändå viktigt att dessa individer diagnostiseras. Om fler undernärda äldre får diagnosen undernäring kan det stimulera utvecklandet av effektiva interventioner.
Acknowledgements

Leif Bergkvist, my principal supervisor. Thank you for valuable advice and guidance through my journey to becoming a medical doctor. Thank you for your endless support and for always believing in me!

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My grandmother, Vera. Thank you for being a constant reminder of why my research is important! Also, thank you for being a model for the cover of the thesis.

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Appendix

Mini Nutritional Assessment (MNA)
Complete the screen by filling in the boxes with the appropriate numbers. Add the numbers for the screen. If score is 11 or less, continue with the assessment to gain a Malnutrition indicator Score.

### Screening

**A. Food intake**: Has food intake declined over the past 3 months due to loss of appetite, digestive problems, chewing or swallowing difficulties?
- 0 = severe decrease in food intake
- 1 = moderate decrease in food intake
- 2 = no decrease in food intake

**B. Weight loss**: Weight loss during the last 3 months
- 0 = no weight loss
- 1 = weight loss of less than 1 kg
- 2 = weight loss between 1 and 3 kg
- 3 = no weight loss

**C. Mobility**: Bed or chair bound
- 0 = able to get out of bed / chair but does not go out
- 2 = goes out

**D. Psychological stress**: Has suffered psychological stress or acute disease in the past 3 months?
- 0 = yes
- 2 = no

**E. Neuropsychological problems**: Severe dementia or depression
- 1 = mild dementia
- 2 = no psychological problems

**F. Body Mass Index (BMI)** = weight in kg / (height in m)^2
- 0 = BMI less than 19
- 1 = BMI 19 to less than 21
- 2 = BMI 21 to less than 23
- 3 = BMI 23 or greater

### Screening score (total max. 16 points)

- 12-14 points: Normal nutritional status
- 0-7 points: At risk of malnutrition
- 8-11 points: Malnourished

For a more in-depth assessment, continue with questions G-R

### Assessment

**G. Lives independently (not in nursing home or hospital)**
- 1 = yes
- 2 = no

**H. Takes more than 3 prescription drugs per day**
- 0 = yes
- 1 = no

**I. Pressure sores or skin ulcers**
- 0 = yes
- 1 = no

### References

For more information, visit: www.mna-for-you.com

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### Malnutrition Indicator Score

- 24 to 30 points: Normal nutritional status
- 17 to 23.5 points: At risk of malnutrition
- Less than 17 points: Malnourished
### Mini Nutritional Assessment (MNA®)

#### Screening, del I

<table>
<thead>
<tr>
<th>Återförrättat menisket under de senaste tre månaderna på grund av försämrad april, maximaläkningproblem, bugg- eller sväljproblem?</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 = ja, minskat intäktsstallning</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hälsa/utveckling under de senaste tre månaderna</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 = ja, mer än 3 kg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rörlighet</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 = ingen rörlighet</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vet inte på sjukdoms expressions eller har avstannat sjukhaus under de senaste tre månaderna?</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 = ja</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Neuropsykiatiska problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 = inga</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Body Mass Index (BMI) = vikt i kg / (vänt i cm)^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 = BMI mindre än 19</td>
</tr>
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#### Screeningresultat

<table>
<thead>
<tr>
<th>Attal</th>
<th>Normalnutritionstatus</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-14 poäng</td>
<td>1-14 poäng</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Risk för undernäring</th>
<th>Undernäring</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-7 poäng</td>
<td>8-11 poäng</td>
</tr>
</tbody>
</table>

#### Screening, del II

<table>
<thead>
<tr>
<th>Här ejt boende? (ej särskilda boendeformer / ej sjukhus)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 = nej</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inte mer än 3 ordinarie läkemedel dagligen?</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 = nej</td>
</tr>
</tbody>
</table>

| Har tryckslag eller annat huvudåsur | 0 = nej | 1 = ja |

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Ref.:


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### MNA resultat

<table>
<thead>
<tr>
<th>Poäng</th>
<th>Resultat</th>
</tr>
</thead>
<tbody>
<tr>
<td>24-30 poäng</td>
<td>Normalnutritionstatus</td>
</tr>
<tr>
<td>17-23,5 poäng</td>
<td>Risk för undersåttande</td>
</tr>
<tr>
<td>Mindre än 17 poäng</td>
<td>Undersåttande</td>
</tr>
</tbody>
</table>

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References


A doctoral dissertation from the Faculty of Medicine, Uppsala University, is usually a summary of a number of papers. A few copies of the complete dissertation are kept at major Swedish research libraries, while the summary alone is distributed internationally through the series Digital Comprehensive Summaries of Uppsala Dissertations from the Faculty of Medicine. (Prior to January, 2005, the series was published under the title “Comprehensive Summaries of Uppsala Dissertations from the Faculty of Medicine”.)