Determination of the most effective nutritional risk screening tool to predict clinical outcomes in Intensive Care Unit patients

by

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ABSTRACT

Introduction: Malnutrition, as defined by the Malnutrition Universal Screening Tool (MUST), Mini-Nutritional Assessment-Short Form (MNA-SF), Subjective Global Assessment (SGA), Nutritional Risk Screening Tool-2002 (NRS-2002), Short Nutritional Assessment Questionnaire (SNAQ), Nutritional Risk Indicator (NRI) and Malnutrition Screening Tool (MST), has been associated with adverse outcomes in hospitalised patients. Therefore nutritional risk screening is recommended for all hospitalised patients to improve the recognition and treatment of malnutrition. However, little is known about the use of screening tools in an intensive care unit (ICU) setting. The aim of this study was to assess which of these screening tools could best predict clinical outcomes in ICU patients and to comment on their feasibility, in order to make suggestions on their applicability for this patient population.

Methods: Over an eight month study period all patients (>18years) with a surgical ICU stay of >48 hours were included. Patients were screened within 48 hours of admission using each of the seven screening tools. Clinical outcomes (mortality, APACHE II score, length of stay (LOS), length of ventilation (LOV), complications, serum-albumin, white cell count (WCC) and C-reactive protein) were recorded until discharge or death. Feasibility and applicability of the screening tools were also assessed.

Results: A total of 206 patients (62.6% males) were included. The average age was 49.5 ±17.4 years and average LOS was 5.7 ± 5.5 days. Screening was not feasible in 18.3% of patients. The MUST classified 18.9% of patients as at risk of malnutrition and 30.1% as malnourished, but was not predictive of any clinical outcomes. According to the MNA-SF, 52.2% of patients were at risk of malnutrition and 16.5% were malnourished. This was associated with progressively decreasing serum-albumin levels ($p<0.01$) and WCC ($p=0.01$). The SGA classified 30.6% of patients as moderately and 18.4% of patients as severely malnourished and was significantly associated with LOS ($p=0.03$), LOV ($p=0.01$), mild complications ($p=0.04$) and serum-albumin ($p=0.01$). However, except for serum-albumin which progressively declined with a poorer nutritional status, the moderately malnourished patients showed the worst outcomes and the severely malnourished patients the best. According to the NRS-2002, 72.8% of patients were malnourished; and this correlated significantly with LOV ($p=0.02$) and the development of moderate ($p=0.04$) and total ($p=0.01$) complications. A non-significant but consistent trend for worse results in the malnourished group was also seen for the other outcomes studied. The SNAQ classified 35.9% of patients as malnourished or at risk thereof. This was associated with lower serum-albumin levels ($p=0.04$), but

also with decreased LOV ($p<0.01$). The NRI classified 2.3% of patients as mildly malnourished, 21.0% as moderately malnourished and 75.0% as severely malnourished and only effectively predicted serum-albumin ($p<0.01$). The MST classified 78.2% of patients as malnourished and this was predictive of developing more complications ($p<0.01$). Almost all of the other variables also showed worse outcomes for the malnourished group, but this was not significant.

Conclusion: Screening in an ICU seems to have only moderate feasibility and applicability and limited value. Only the NRS-2002 and MST showed potential for predicting clinical outcomes in ICU patients.

ABSTRAK

Inleiding: Wanvoeding, soos gedefinieer deur die "Malnutrition Universal Screening Tool" (MUST), "Mini-Nutritional Assessment-Short Form" (MNA-SF), "Subjective Global Assessment" (SGA), "Nutritional Risk Screening Tool-2002" (NRS-2002), "Short Nutritional Assessment Questionnaire" (SNAQ), "Nutritional Risk Indicator" (NRI) en die "Malnutrition Screening Tool" (MST), is al met nadelige uitkomste in hospitaal pasiënte geassosieer. Daarom word voedings-risiko-sifting vir alle gehospitaliseerde pasiënte aanbeveel om die herkenning en behandeling van wanvoeding te verbeter. Daar is egter min bekend oor die gebruik van siftingshulpmiddele in 'n intensiewe sorg eenheid (ISE) omgewing. Die doel van die studie was om te assesseer watter van hierdie siftingshulpmiddele kliniese uitkomste in ISE pasiënte die beste kon voorspel en om kommentaar te lewer op die uitvoerbaarheid daarvan, om sodoende voorstelle te maak oor die toepaslikheid daarvan vir hierdie pasiënt populasie.

Metodes: Alle pasiënte (>18 jaar) met 'n chirurgiese ISE verblyf van >48 uur gedurende 'n ag maande studieperiode is ingesluit. Pasiënte is binne 48 uur na toelating gesif m.b.v. al sewe siftingshulpmiddele. Kliniese uitkomste (mortaliteit, APACHE II telling, lengte van verblyf (LVVer), lengte van ventilasie (LVVen), komplikasies, serum-albumien, witseltelling (WST) en C-reaktiewe proteïen) is genoteer tot en met ontslag of dood. Uitvoerbaarheid en toepaslikheid van die siftingshulpmiddele is ook geassesseer.

Resultate: 'n Totaal van 206 pasiënte (62.6% manlik) is ingesluit. Die gemiddelde ouderdom was 49.5 ±17.4 jare en die gemiddelde LVVer was 5.7 ± 5.5 dae. Siftings was onuitvoerbaar in 18.3% van die pasiënte. Die MUST het 18.9% van die pasiënte as wanvoeding-risikogevalle geklassifiseer en 30.1% as wangevoed, maar kon nie enige kliniese uitkomste voorspel nie. Volgens die MNA-SF was 52.2% van die pasiënte wanvoeding-risikogevalle en 16.5% was wangevoed. Dit was geassosieer met progressief dalende serum-albumienvlakke ($p<0.01$) sowel as WST ($p=0.01$). Die SGA het 30.6% van pasiënte as matig en 18.4% as erg wangevoed geklassifiseer en het 'n beduidende assosiasie met LVVer ($p=0.03$), LVVen ($p=0.01$), ligte komplikasies ($p=0.04$) en serum-albumien ($p=0.01$) getoon. Behalwe vir serum-albumien wat progressief verlaag het met 'n swakker voedingstatus, het die matig wangevoede pasiënte egter die swakste uitkomste getoon en die erg wangevoede pasiënte die beste. Volgens die NRS-2002 was 72.8% van die pasiënte wangevoed en dit het 'n beduidende korrelasie met LVVen ($p=0.02$) en die ontwikkeling van matige ($p=0.04$) en totale ($p=0.01$) komplikasies gehad. 'n Nie-beduidende, maar konsekwente neiging vir swakker resultate in die wangevoede groep is ook vir die ander studie-uitkomste gesien. Die SNAQ het 35.9% van pasiënte as

wangevoed of as risikogevalle daarvoor geklassifiseer. Dit was geassosieer met laer serum-albumienvlakke ($p=0.04$), maar ook met ‘n korter LVVen ($p<0.01$). Die NRI het 2.3% van pasiënte as lig, 21.0% as matig en 75.0% as erg wangevoed geklassifiseer en het slegs serum-albumien effektief voorspel ($p<0.01$). Die MST het 78.2% van pasiënte as wangevoed geklassifiseer en dit het die ontwikkeling van meer komplikasies ($p<0.01$) voorspel. Amper al die ander veranderlikes het ook swakker uitkomste getoon in die wangevoede groep, maar dit was nie-beduidend.

Gevolgtrekking: Dit blyk of sifting in ‘n ISE slegs matige uitvoerbaarheid en toepaslikheid en beperkte waarde het. Slegs die NRS-2002 en die MST het potensiaal gewys om kliniese uitkomste in ISE pasiënte te voorspel.

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CONTRIBUTIONS BY PRINCIPAL RESEARCHER AND FELLOW RESEARCHERS

The principal researcher, Christa Blanckenberg, developed the idea and the protocol for the research project. The principal researcher planned the study, undertook all data collection and captured the data for analyses. The data was analysed with the assistance of a statistician, Prof. DG Nel. The principal researcher interpreted the data and drafted the thesis. The study leaders, Prof. R Blaauw and Mrs JM Kruger, provided input at all stages of the project and revised the protocol and thesis.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
APACHE II	Acute Physiology, Age and Chronic Health Evaluation II
ASPEN	American Society for Parenteral and Enteral Nutrition
BAPEN	British Association for Parenteral and Enteral Nutrition
BMI	Body Mass Index
CM	Centimeters
CRP	C-Reactive Protein
DEXA	Dual-Energy X-Ray Absorptionmetry
ESPEN	European Society for Parenteral and Enteral Nutrition
GI	Gastrointestinal
ICU	Intensive Care Unit
KG	Kilograms
KH	Knee Height
LOS	Length of stay
LOV	Length of ventilation
MNA	Mini-Nutritional Assessment
MNA-SF	Mini-Nutritional Assessment – Short Form
MST	Malnutrition Screening Tool
MUAC	Mid-Upper Arm Circumference
MUST	Malnutrition Universal Screening Tool
NPO	Nil per os
NRI	Nutritional Risk Indicator
NRS-2002	Nutritional Risk Score-2002
NRSTs	Nutritional Risk Screening Tools
PG-SGA	Patient-Generated Subjective Global Assessment

RCT	Randomized Controlled Trial
S-albumin	Serum-albumin
SGA	Subjective Global Assessment
SICU	Surgical Intensive Care Unit
SNAQ	Short Nutritional Assessment Questionnaire
SNAQ65^{+}	SNAQ for community-dwelling elderly
SNAQRC	SNAQ-Residential Care
TAH	Tygerberg Academic Hospital
TLC	Total Lymphocyte Count
WCC	White cell count

CHAPTER 1: REVIEW OF THE LITERATURE

1.1 INTRODUCTION

This study aimed at shedding light on the use of nutritional risk screening tools (NRSTs) in an intensive care unit (ICU) setting – a topic that has not received much attention thus far. In the review of the literature on this topic, the researcher starts by reviewing the scope of hospital and specifically ICU malnutrition. The definition, prevalence, consequences and current recognition of hospital malnutrition is presented, to illustrate the critical need for nutritional risk screening. The second part of the review focuses on nutritional risk screening and the different screening tools used in this study. A brief description of each NRST is provided as well as an overview of its use in clinical practice. The goal was to discuss all the information available on the use of NRSTs in critically ill patients, but since not much is known on this topic, the review also encompasses the clinical utility of NRSTs in the broader hospital environment. Specific reference is made to the link between NRSTs and clinical outcomes as well the general feasibility of NRSTs. The review concludes by giving a summary of the key arguments that motivated the choice of study topic.

1.2 HOSPITAL MALNUTRITION

1.2.1 Definition and etiology

Many organisations and individuals have over many years proposed various definitions for malnutrition; nevertheless a universally accepted, gold standard definition is still lacking.[1,2] Broadly, malnutrition can be described as a nutritional state where there is an imbalance (lack or excess) of macro- and/or micronutrients that may cause significant unfavourable effects on body size, composition and function as well as clinical outcomes.[3] The term malnutrition therefore encompasses both under- and overnutrition; in this study it will refer to undernutrition only.

A variety of causes may give rise to a malnourished nutritional state. In simple terms either a decreased intake of nutrients or the complications of disease (or a combination of both) lead to malnutrition.[4] Hospital malnutrition may therefore occur due to a decreased intake, or poor provision of nutrients, and also to the role of disease.[3] The link between malnutrition and disease has been described as a vicious circle in which the one feeds into the other.[5] Disease conditions may lead to increased nutritional requirements, malabsorption, decreased utilization of nutrients, increased losses through wounds, vomiting or diarrhoea and decreased dietary intake all of which may result in mild to severe cases of malnutrition.[3,6-8] Malnutrition on the other hand is known to weaken the body's defense mechanisms against disease leading to an aggravated state of disease, which in turn can again aggravate the presence of malnutrition.[5]

Disease conditions are also associated with a heightened inflammatory response that may lead to the rapid development of malnutrition. In the inflammatory state a change in stress metabolism and body composition is brought on by the presence of pro-inflammatory cytokines. These cytokines are potent catalysts of increased energy expenditure, hypercatabolism of lean body mass, gluconeogenesis, fluid shifts and alterations in acute phase protein synthesis including decreased protein synthesis. Furthermore, the inflammatory cytokines suppress appetite which may lead to anorexia and a decreased intake of nutrients. The net effect of these changes is a decrease in the body's protein stores, especially a loss of muscle protein.[9]

To provide scope for the role that the inflammatory response plays in disease-related malnutrition, Soeters et al[5] has proposed the following definition for malnutrition: "A subacute or chronic state of nutrition in which a combination of varying degrees of over- or undernutrition and inflammatory activity have led to a change in body composition and diminished function." This definition may be more accurate for hospital (and especially ICU-related) malnutrition, where inflammation in varying degrees is common.

An international Consensus Guideline Committee put together by the American Society for Parenteral and Enteral Nutrition (ASPEN) together with the European Society for Parenteral and Enteral Nutrition (ESPEN), has recently proposed that the etiology of malnutrition should be integrated into its diagnosis. It recommends that starvation-related malnutrition resulting from pure chronic starvation only, should be distinguished from malnutrition related to either injury or disease (chronic or acute) since the latter two include the role of inflammation (either mild to moderate sustained inflammation or severe acute inflammation) in their diagnosis.[6] Given the general confusion regarding the exact definition or diagnosis of malnutrition and the current acceptance of the role of inflammation in the etiology of disease-related malnutrition, this proposal might be the first step towards a universally accepted and standardised approach to defining malnutrition.

1.2.2 Prevalence

The prevalence of hospital malnutrition has been documented since the 1970s when Dr. Charles E. Butterworth published the landmark paper on this topic titled the "Skeleton in the hospital closet".[10] Butterworth recognized that hospital malnutrition was a large-scale problem that needed urgent attention from the medical community. Twenty years later, in 1994, McWhirter et al. undertook a study to reassess the prevalence of hospital malnutrition. They found that at least 40% of patients suffered a degree of malnutrition, of whom nearly half were moderate to severely malnourished. Also documented was the fact that patients continued to experience weight loss during hospital

stay, especially those who were already malnourished upon admission. Sixty-four percent of malnourished patients experienced further nutritional deterioration.[10]

Today, a large body of literature supports the fact that hospital malnutrition remains a significant problem. The prevalence of malnutrition differs according to the specific hospital patient population studied and the method used to assess malnutrition.[3] As already stated, a gold standard definition for malnutrition is still lacking as is a universally accepted assessment method. Therefore, determining the exact scope of the problem, without these mechanisms in place, is challenging.[11] Still, even though different definitions and methods are used, there is overwhelming evidence that hospital malnutrition is widespread and a serious problem.[12]

In general, hospital malnutrition since 1994 has been reported at 20-59%.[13-22,22-25] Some hospital settings show higher rates of malnutrition than others. For instance, patients undergoing surgical procedures have been shown to have high rates of malnutrition.[17] Gastrointestinal surgical patients especially are at risk with a reported malnutrition prevalence of 57-82%[11,23] and a high risk of further deterioration.[11]

Not a great deal is known about the prevalence of malnutrition in South African hospitals. Studies from the 1980s and 1990s indicate that many hospitalised patients present with a body weight below 80% of their ideal body weight and low body fat stores, indicated by a triceps skinfold thickness of less than 60% of the reference standard. Indexes of muscle stores such as arm-muscle circumference or arm-muscle area are have also been reported to be less than ideal in many hospitalised patients.[26,26-29] One previous study was conducted among medical patients in Tygerberg Academic Hospital (TAH)[26], the same hospital where the present study was conducted. In the previous study, the researcher assessed BMI and other anthropometrical and biochemical indices and found that 17% of patients were malnourished, while 77% presented with subclinical manifestations of malnutrition. More recently, malnutrition prevalence was reported to affect 40-60% of patients in another South African hospital, when measured with one of the screening tools included in this study.[30] It is therefore clear that malnutrition also affects South African hospitalised patients.

The ICU setting is also known as a danger zone for malnutrition. Many patients are already nutritionally depleted before admission and this is aggravated by poor oral intake, metabolic stress and inflammation.[11] Not being able to eat (i.e. requiring enteral or parenteral nutrition) compromises immediate nutritional intake and may lead to the development of large energy and protein deficits. This is often exacerbated by interrupted feeding periods to allow for various medical

or surgical procedures.[6,7] Furthermore, critically ill patients are known to experience hypermetabolism, hypercatabolism and a heightened inflammatory response, which all play a significant part in the development of malnutrition.[6,7]

Very few studies have documented the exact prevalence of ICU malnutrition, mostly because it is difficult to measure.[11] Stratton et al. report on two small-scale studies using anthropometry and biochemistry to detect malnutrition that reported respectively a 43% and 100% prevalence of malnutrition.[11] Three more studies used the subjective global assessment (SGA) method to identify malnutrition in ICU patients. In the first of these, 22% of patients were found to be moderately malnourished and 7% severely malnourished.[31] The second study was conducted in mechanically ventilated patients and found that 54% of patients were moderately malnourished and 5% severely malnourished.[32] Both these studies were relatively small (n=55 and n=57 respectively). The third study (n=124) found 26% of medical and surgical ICU patients to be moderately malnourished and 11% severely malnourished.[33] In summary it seems that at least 29% of ICU patients and most likely more may be nutritionally at risk.

1.2.3 **Consequences**

Malnutrition, especially malnutrition associated with underlying disease, can affect every system of the body and lead to detrimental changes in metabolic, physiologic and psychological function.[4] In their book on disease related malnutrition, Stratton et al.[34] describe in detail the consequences of malnutrition as shown in the literature. The following is a summary of the most important and life threatening outcomes.

On a cellular level, it is known that even in the early stages, malnutrition delays wound healing and increases the risk of developing pressure ulcers and wound infections. It also leads to diminished immunological function which renders the body unable to effectively respond to local or systemic infections. Gut-barrier function may also be compromised which increases the risk of bacterial translocation, systemic inflammation and sepsis. Malnutrition may also impair thermoregulation and can result in hypothermia.[34]

On a physiological level, malnutrition leads to depletion of body stores, most detrimental of which is diminished muscle mass and function. This affects skeletal, cardiac and respiratory muscles. When cardiac muscle mass is diminished it can lead to decreased cardiac output, hypotension, renal impairment and eventually circulatory failure. Decreased respiratory muscle mass and function may lead to decreased voluntary ventilation and cough pressure which in turn can result in increased ventilator dependency and occurrence of chest infections.[34]

Malnutrition even impacts the body on a psychological level, by bringing about higher levels of anxiety, depression and cognitive impairment and decreasing the overall quality of life. Malnourished patients are often fatigued, apathetic and lack the will to recover.[34]

The consequences of malnutrition as described here have serious implications for clinical outcomes such as morbidity and mortality. For example it has been shown that the malnourished patient is at risk of developing more complications and infections than well-nourished patients.[1,4,8,13,24,34] They also have a longer length of stay (LOS) in hospital[4,8,13,17,19,22,24,34] and greater mortality.[8,19,24,34] This also holds true for ICU patients in whom malnutrition may be even more common. Malnutrition in the ICU has been linked to increased ventilator dependence, deterioration of the gut-barrier function, longer LOS, higher Acute Physiological, Age and Chronic Health Evaluation II (APACHE II) scores, lower serum-albumin (s-albumin) levels and higher morbidity and mortality.[11,33,34]

It is thus clear that the consequences of malnutrition in hospitalised patients can be devastating. Importantly, not only patient outcomes are affected: adverse patient outcomes increase the pressure on hospital resources such as nursing care and medication, resulting in ballooning health care costs associated with treating the malnourished patient.[4,8,13,20,21,35] A few studies have looked at the financial implications of malnutrition in hospital patients. The British Association for Parenteral and Enteral Nutrition (BAPEN) found that in 2003 roughly 10% of its total health care expenditures were for the treatment of disease-related malnutrition.[36] Other studies also found that health care costs were much higher for malnourished patients or those with declining nutritional status than for those not at risk of malnutrition.[8,37,38]

1.2.4 Recognition and treatment

Even though the scope and magnitude of hospital malnutrition is known it seems to be a problem that is not often recognised or treated. A number of studies have reported low rates of documentation of patients' nutritional status (8, 19, 23 and 60% respectively).[17,19,23,25] In 2009, the United States Department of Health and Human Services reported that only 3% of hospital admissions receive a formal diagnosis of malnutrition.[2] That is far off from the estimated prevalence malnutrition of 20-59%.

Likewise, implementation of a nutritional care plan may be carried out for as few as one in every ten patients on average.[17,23,25] Kondrup et al. also report that less than a third of nutritionally at risk patients are monitored during their hospital stay and only a quarter receive sufficient amounts of calories and protein.[19] Referral of nutritionally at risk patients to a health care worker specialised in

nutrition also seems to be poor. A 2011 review found that only 7-36% of at risk patients were referred to a dietician.[4]

Further proof that malnutrition is not effectively managed is found when looking at the deterioration of nutritional status during hospital stay. In one study (n=135), 42% of hospitalised patients lost more than 5% of their body weight and 39% of the patients had a decreased dietary intake.[18] A bigger study (n=750) reported that 31% of nutritionally at risk patients showed additional weight loss of which more than half of the patients had weight loss greater than 5% of body weight.[19]. Kyle et al. also found that when measuring nutritional status at admission and during the period of hospitalisation, malnutrition grew more prominent during hospital stay.[39]

Many reasons are proposed for why malnutrition is not adequately treated; one of these is poor awareness of nutritional risk.[10,19,23] It is clear that the treatment of malnutrition is ultimately dependent on the recognition thereof.[4]

If malnutrition is recognised and appropriately treated it may go a long way to improving clinical outcomes and reducing health care costs. Elia et al. found that most cases of malnutrition that are currently not recognised are in fact treatable and that nutritional support could improve outcomes such as LOS, mortality and morbidity.[12] Also in the critically ill, randomized controlled trials (RCTs) have shown that treatment of malnutrition can improve clinical outcomes.[12]

1.3 SCREENING FOR NUTRITIONAL RISK

1.3.1 What is screening for nutritional risk?

In simple terms, screening is a process that identifies a certain, sometimes not immediately visible, condition that may respond to treatment.[12] According to ESPEN the purpose of nutritional screening is "to predict the probability of a better or worse outcome due to nutritional factors, and whether nutritional treatment is likely to influence this".[40] It can therefore be used to identify malnutrition or the risk of developing malnutrition and more importantly, identify patients who are likely to benefit from treatment.

Nutritional screening should not be confused with nutritional assessment. Where screening can be described as a quick and simple method that can be used by all health care workers and applied to all patients,[40] assessment is a more comprehensive and time-consuming approach that seeks to define nutritional status using a wide range of measures and which requires the skill of a nutrition professional to complete.[4,40] The American Dietetic Association defines nutritional screening as "the process of identifying patients with characteristics commonly associated with nutritional problems

who may require comprehensive nutrition assessment."[4] This implies that screening is the first step in the nutritional care of a patient and that a positive screen would then identify the need for further assessment and treatment. ASPEN supports this stating that screening aims to detect malnutrition or risk thereof which would then indicate the need for nutritional assessment.[41,42]

1.3.2 Why screen?

As previously mentioned, malnutrition is a common and serious problem that may affect 20-59% of hospitalised patients[13-22,22-25] including ICU patients.[11,31-33] The problem is worsened by the fact that it is often not recognised and therefore not treated.[17,19,23] In most cases, however, malnutrition can be treated inexpensively, yielding improved patient outcomes.[12]

It is therefore suggested that special effort be made to identify hospital malnutrition;[12] this is where nutritional risk screening plays a crucial role. Nutritional risk screening procedures are designed to identify malnutrition or risk of malnutrition, currently or in the patient's future.[40] Routine use of a screening procedure may therefore increase the recognition of malnutrition and enable better treatment thereof. The evidence also points towards this. A review of intervention studies found that nutritional risk screening markedly helped increase the identification of malnutrition, and improved clinical outcomes such as LOS and complications when appropriate treatment was used.[12]

Thus there is no doubt that screening for nutritional risk is a fundamental step in the management of hospital malnutrition. Instead of asking "Why screen?" the question should rather be "How to screen for hospital malnutrition?"

1.3.3 How to screen for nutritional risk

A universally accepted malnutrition screening method for hospitalised patients does not exist; this is most likely due to the lack of a gold standard definition or diagnosis for malnutrition. The literature reveals a large variety of different methods with varying degrees of acceptability, feasibility and accuracy. A number of guidelines directing nutritional screening have been published by international bodies such as ASPEN and ESPEN. Although these guidelines do not indicate a specific method, they provide a gauge with which to evaluate the different aspects of screening methods. The next section discusses the general agreement on how screening should be conducted and which elements could be included in the screening.

1.3.3.1 The screening procedure

The screening procedure includes both the actual screening of patients and the effective treatment and monitoring of malnourished patients.[12] According to ESPEN's guidelines published in 2003, all patients should be screened upon hospital admission. The screening procedure should be simple

enough so that any health care worker or admission staff member would be able to complete it and rapid enough in order to be practical. Importantly the screening procedure should also be linked to a nutritional care plan depending on the outcome of the screening. In cases where a standard nutritional care plan is insufficient or where malnutrition is severe, a referral to a dietician for a detailed assessment and follow-up may be implied.[40] More recently, ASPEN also published clinical guidelines on nutrition screening, assessment and intervention. These guidelines are similar to those set out by ESPEN, highlighting that all hospitalised patients should be screened and that those with nutritional risk be subjected to more detailed assessment and appropriate treatment.[2,42]

1.3.3.2 Screening components

The screening components include the various criteria that are used to diagnose an individual as well-nourished or malnourished. Because a universally accepted standardised set of criteria with specified cut-off points does not exist, the various screening tools available include different sets of criteria and differ with the regards to the specific cut-off points used.

As part of its screening guidelines, ESPEN has proposed the different categories of criteria that screening tools should cover. First the screening tool should assess the current nutritional situation. In this instance anthropometrical measurements can be used, of which the simplest may be weight and height in order to calculate the body mass index (BMI).[40] However, many different BMI cut-offs for malnutrition exist (ranging between 17-23.5) which makes the interpretation of malnutrition challenging. Most often a BMI of <18.5-20 is used to identify malnutrition.[3] ESPEN recommends using a BMI of 18.5-20 as an indication of borderline malnutrition and <18.5 as malnutrition. Alternatively, the mid-upper arm circumference (MUAC) may be used as an index of current nutritional status.[40] Although not mentioned by ESPEN, some screening procedures include a physical examination which is also a measure of current nutritional status.[43] Biochemical measures have also been recommended, especially the measurement of inflammatory activity which may be associated with decreased fat free mass.[1,5] There is however a large amount of controversy regarding biochemical measures and nutritional status.[44] There is evidence that inflammatory markers such as acute phase proteins neither reflect nutritional status accurately nor respond to nutritional intervention, or at least in ways that can be accurately measured. However, although their relevance in terms of nutritional status may be low, inflammatory markers may still indicate the presence of inflammation and risk of poor clinical outcomes.[9] Common markers of inflammation include s-albumin, pre-albumin, C-reactive protein (CRP), white blood cells and hyperglycaemia.[6,8] Low s-albumin levels for example, have been linked to adverse outcomes such as longer LOS, readmissions, more complications and higher mortality. CRP, a positive acute phase protein, may be

useful in determining the presence of active disease and predicting poor clinical outcomes.[9] However, other factors such as cost-effectiveness and practicality should also be considered when deciding to include inflammatory markers in nutritional screening.[44]

The second component of screening should be to assess whether the current condition is stable.[40] Weight-loss history is a good measure of the stability of nutritional status and may reveal malnutrition in individuals whose current status stills seems good i.e. obese patients.[40] The general consensus is that unintentional weight loss of more than 5% over 3-6 months indicates a risk for malnutrition and more than 10% over the same period indicates significant malnutrition.[3] ESPEN recommends using a cut-off of more than 5% over 3 months as an indication of malnutrition.[40]

Third, screening should assess if the current condition of a patient is likely to change in the near future.[40] Assessment of dietary intake can be used to measure this component. If dietary intake is below nutritional requirements, then further nutritional depletion is likely.[40] Gastrointestinal symptoms such as anorexia, nausea, vomiting and diarrhoea may also play a role in decreasing intake or depleting the body of nutrients.[3,43]

Lastly, screening should take into consideration any disease condition that might progressively worsen nutritional status.[40] Acute and chronic diseases may increase nutritional requirements as well as deplete fat free mass through inflammation and catabolic stress metabolism.[1,2] Disease-related factors play a large role in the development of malnutrition, especially in a hospital setting.[40]

In 2012, ASPEN proposed a set of criteria of which at least two should be included to make an adequate diagnosis of malnutrition. The criteria include 1) assessing energy intake, 2) assessing weight loss, 3) assessing loss of muscle mass, 4) assessing loss of fat mass, 5) assessing fluid accumulation that may mask weight loss and 6) assessing grip strength as a measure of functional status. They also proposed some cut-off points for these criteria which allow standardisation, as well as differentiation between moderate and severe malnutrition. The cut-offs differ between acute disease- or injury-related malnutrition and chronic disease-related malnutrition contexts. ASPEN discourages the inclusion of a marker of inflammatory status due to its limited ability to reflect nutritional status.[2] Although these propositions are paving the way to a standardised diagnosis of malnutrition, ASPEN is still unclear how these criteria can be incorporated into a screening tool.

The guidelines presented by ESPEN and ASPEN provide a framework for nutritional screening. However there is no consensus on exactly which components to include in a screening procedure or which cut-offs to use.[12] In a recent Delphi study[1] the experts nominated BMI, weight loss history and a measure of nutritional intake as most vital in indentifying malnutrition. They were not conclusive

however on the cut-off values that should be used. They also believed that disease severity should be included in the definition of malnutrition, but could not decide on how it should be measured.

It is further likely that different clinical settings could demand different screening methods according to the patient population and practical or economic issues.[41] A screening procedure that works for the general hospitalised patient may not be suitable for use in an ICU setting. ASPEN highlights that critically ill patients pose a complex and unique risk for malnutrition and that certain criteria such as inability to eat, long periods of nil per os (NPO), interruption of feeding and unintentional weight loss should take precedence in diagnosing malnutrition.[2]

1.3.4 Screening in an ICU

There are currently no specific guidelines for nutritional screening in an ICU setting. Recommendations for nutritional screening in hospitals rarely distinguish between different clinical settings. It is however clear that nutritional screening is recommended for all hospitalised patients, which would automatically include critically ill patients.[40,42]

Using the currently recommended screening procedures in an ICU setting may present many obstacles. ICU patients are mostly bedridden and often comatose or sedated, which can render anthropometry and questioning either very difficult or even impossible. Traditional methods for measuring nutritional status might thus be inadequate. ICU patients may also present a unique risk for disease-related malnutrition due to high levels of metabolic stress and inflammation. Both of these clinical conditions are potent aggravators of nutritional depletion[2] and some screening procedures may not be sensitive enough to detect them.

Very few studies have focused specifically on the nutritional screening of the critically ill. Whether current screening practices are indeed feasible or accurate is still largely unknown. It is however known that ICU patients are at high risk of malnutrition and that this may have deleterious effects on patient outcomes.[11]

Evidently, there is a lack of information on screening for nutritional risk in an ICU setting. This can be seen as a critical preventative factor to optimal patient care as malnutrition may remain largely unrecognized and therefore undertreated in this patient population.

1.4 NUTRITIONAL RISK SCREENING TOOLS

For the purpose of nutritional screening many nutritional risk screening tools (NRSTs) have been developed over the years. These are usually in the form of a questionnaire which differ in the procedure followed and the components of screening that they include, but all aim to identify patients who are either malnourished or at risk thereof.[45] Screening and NRSTs have been a topic of extensive study in the last decade. The numerous NRSTs have been studied in different clinical settings and in different patient populations. They have been evaluated for validity and reliability as well as for practical and economic factors. They have been assessed for their ability to predict patient outcomes or even influence patient outcomes by intervening with appropriate treatment. However, there is still no consensus on the optimal NRST for hospitalised patients, a fact that is ascribed to the lack of a universally accepted definition for malnutrition.[5,12,40]

No specific NRST exists or is recommended for use in ICU patients. A few NRST studies have included ICU patients in their study samples[11,31-33] but on the whole very little information is available about using NRSTs in this patient population.

When studying NRSTs a number of aspects merit attention. First, screening tools have to be valid and reliable i.e., be able to accurately detect the presence or absence of malnutrition and be reproducible with reasonable agreement between different raters.[40,41,45] Of particular interest with regard to validity, is a screening tool's ability to predict clinical outcomes. The screening tool has to be able to identify malnourished patients who will benefit from treatment or, if not treated, might show worse outcomes than patients who were not classified as malnourished.[40] This measure of validity might be particularly helpful when a gold standard measure for nutritional status is lacking.

Screening tools also have to be practical; they should be simple to master, quick to perform and not require unnecessary equipment or skill. Cost-effectiveness is also important so that large-scale implementation will be possible. Lastly a clear screening methodology has to be specified which outlines the target patient population; when, how and by whom screening should be conducted; and how the outcome of the screening should be managed.[40,41,45]

The following seven NRSTs are most widely recommended for screening hospitalised patients for nutritional risk and have proven most valuable in recognizing malnutrition.

1.4.1 Malnutrition Universal Screening Tool

1.4.1.1 *Development and validation*

The Malnutrition Universal Screening Tool (MUST) was developed and published by the Malnutrition Advisory Group of BAPEN in 2003. The grouped aimed to create a NRST that would assess current

weight as well as recent or likely weight changes which would reflect upon dietary intake and disease conditions. Scientific criteria with evidence-based cut-off points were chosen to form part of this screening tool. These components are independently related to clinical outcomes, but together they showed the greatest strength for predicting outcomes. The tool also had to be practical to implement, valid and reliable, linked to a plan for nutritional care and be applicable to use across all health care settings.[46]

The content validity of the MUST was assured by including professionals from different health care disciplines in the development phase. Face validity was also ensured by including components that are relevant to the identification of malnutrition risk.[46,47] Concurrent validity with another measure of nutritional risk (dietician's assessment) was excellent.[48]

1.4.1.2 *Components of the MUST*

The MUST (Figure 1.1) consists of five steps that include guidelines for rescreening and nutritional management as a fifth step. The criteria used to screen the patient are: BMI, percentage of weight loss in the past 3-6 months and the presence of acute disease with no nutritional intake for longer than five days.[46] These three criteria are all objective and proven to be effective measures of malnutrition.[40] The patient will be classified as either low risk, medium risk or high risk for malnutrition.[46,47]

The MUST also describes alternative measurements that can be used if any of the above three screening criteria cannot be performed. If weight and height cannot be measured, clinical judgment can be used to determine BMI by assessing whether the patient is wasted or of normal weight for height. BMI can also be estimated using MUAC, where a MUAC of <23.5cm will be indicative of a BMI <20. Self-reported weight and height may also be used. Other alternative measurements include using ulna length, knee height or demi-span length to determine height. If the patient is unsure about recent weight changes they may be asked whether their clothes are looser or if their dietary intake has been reduced. The patient can also be asked about underlying disease states, dysphagia or other disabilities that may have lead to a reduced food intake and weight loss.[46]

For critically ill patients it is assumed that most will be at risk of malnutrition and should therefore receive an acute disease effect score of 2, which will classify them as at high risk of malnutrition.[46] However it has been reported that classifying patients with acute disease as high risk of malnutrition leads to an overestimation of high nutritional risk, whereas moderate nutritional risk is underestimated.[22,49] Not all ICU patients will have a similar risk of malnutrition and classifying them

all as high risk will be a gross overestimation. The MUST also does not provide an option for the grading of chronic disease conditions.[49]

The MUST provides a nutritional care plan depending on the outcome of the screening. Patients at low risk of malnutrition should be rescreened weekly, whereas those with a medium risk should be closely monitored for three days to assess dietary intake and, if necessary, action should be taken according to protocol. Patients at high risk of malnutrition should be referred for specialised nutrition support and monitoring. A detailed plan for nutritional care is stipulated in the MUST explanatory booklet.[46]

Figure 1.1 (next page) graphically illustrates the MUST process.

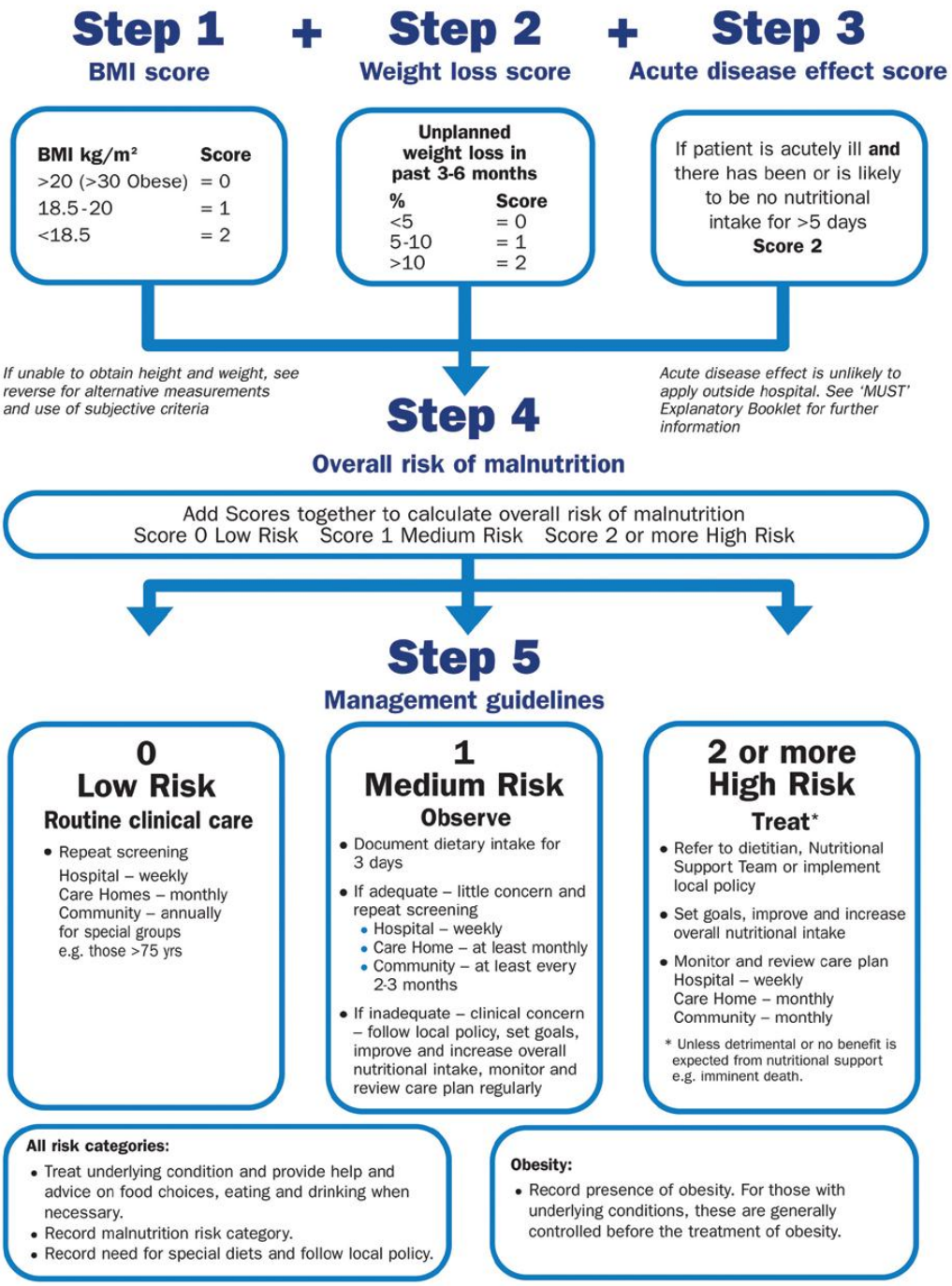


Figure 1.1 The Malnutrition Universal Screening Tool (MUST)[46]

1.4.1.3 *Clinical studies*

A few studies have proven the MUST's ability to predict clinical outcomes. In elderly[50] as well as surgical and medical[48] hospitalised patients the MUST significantly predicts mortality. It also predicts LOS in these patient populations[16,22,48,50] and specifically in oncology patients.[51] Velasco et al. found

that the MUST can predict the number of complications in surgical and internal medicine patients[16] and Stratton et al. found that the MUST predicts a trend towards discharge to a care facility versus discharge to home.[48] On the other hand, a 2010 study in a mixed hospital patient population (n=705) could not find any predictive validity of the MUST with regard to LOS, mortality and rate of complications.[49]

The criterion validity of the MUST in comparison to the Subjective Global Assessment (SGA) has been explored. The MUST has shown sensitivities of 61–96% which indicates insufficient to excellent sensitivity.[16,22,52] The worst sensitivity was found in a group of mixed hospitalised patients[22] and the best sensitivity in oncology patients.[52] When Velasco et al. stratified their patient population the sensitivity of the MUST was better in internal medicine versus surgical patients and in elderly patients versus those younger than 65 years.[16] In these studies, the specificity of the MUST ranged from fair (76%) to excellent (90%).[16,22,52] Compared to the Nutritional Risk Score-2002 (NRS-2002) the MUST has shown excellent (97%) sensitivity and fair (77%) specificity. A possible explanation for these positive results is that the MUST and NRS-2002 use similar criteria to screen patients i.e. BMI, weight loss, severity of disease and food intake.[46,53]

The criterion validity of the MUST has also been studied compared to a definition of malnutrition based on BMI (<18.5) and percentage of weight loss (>5% in 1 month or >10% in 6 months) in a group of mixed hospital patients. Compared to this definition, the MUST showed fair sensitivity (73%) and good specificity (82%) when only “high risk of malnutrition” was used as an indication of malnutrition. When both “moderate and high risk of malnutrition” was used as an indicator, sensitivity improved dramatically to 97% and the specificity fell slightly to 80%.[54]

With regard to convergent validity the MUST has been compared to various other screening tools. In surgical and medical inpatients the MUST showed moderate to good agreement (κ=0.55-0.61) with the Mini Nutritional Assessment - Short Form (MNA-SF) and good agreement (κ=0.70) with the Malnutrition Screening Tool (MST).[48] It also showed good agreement (κ=0.64-0.78) with the NRS-2002 in medical and surgical[48] and oncology patients[51] and moderate agreement (κ=0.52) in mixed hospital patients.[49] Convergence with the SGA ranged from fair to excellent (κ=0.28-0.8) in various patient populations.[22,48,49,52] From these studies it can be concluded that the MUST has acceptable convergent validity with other NRSTs.

The reliability of the MUST has been tested among a rage of health care professionals and in different patient settings. An excellent reproducibility of κ=0.81-1.00 has generally been found.[48,55]

The prevalence of malnutrition in hospitals, as assessed by the MUST, ranges from 10-25% at moderate risk of malnutrition and 18-41% at high risk of malnutrition.[16,22,46,48,50,54,56-59] Some studies have only reported the combined prevalence of moderate and high risk of malnutrition ranging from 28-78%.[48,49,51,52] Only one study specifically reports the prevalence of malnutrition defined by the MUST in critical care patients. In this study 77% of patients were classified as at "high risk of malnutrition".[58]

Only one study has been conducted using the MUST in a South African population. This study did not report the prevalence of malnutrition found nor the specific patients included in the study. Poor agreement was found between the MUST and the NRS-2002; sensitivity was 59% and specificity 90% using the NRS-2002 as a gold standard measure. It is important to note that this study was conducted retrospectively and used data collected by final year dietetic students.[30]

To the researcher's best knowledge the MUST has not been studied in an ICU setting specifically. Many of the studies implementing the MUST have excluded bedridden, unconscious or oedematous patients as well as patients who couldn't give consent.[49,51,52,54] These patient characteristics are abundant in an ICU setting and therefore most studies would have excluded the majority of ICU patients. This makes it difficult to extrapolate the results for the ICU patient population.

1.4.1.4 *Feasibility and applicability*

According to the developers of the MUST, the tool is applicable for use in all adult patients across all health care settings. This would then include all hospitalized adults, even those who are bedridden and/or unconscious. They have also reported it as a simple NRST that is user-friendly for a wide spectrum of health care workers.[47]

Interestingly, ESPEN only recommends the use of the MUST in the community setting.[40] According to the literature however, the MUST seems to be a valid and reliable NRST to use in most hospital patients.[16,48,51,52,56,58,59]

The feasibility of using the MUST in all hospital patients can be questioned even though the tool was developed to offer alternative measurements when patients cannot be weighed or measured. Although one study in elderly patients (where only 56% of patients could be weighed) obtained a 100% screening rate by successfully using the alternative/surrogate measurements,[48] another study, also on elderly patients, reported only an 80% successful screening rate.[59] The main problem was that there was no information available regarding recent weight loss.[59] Another study in general hospitalised patients reported only 61% of patients were successfully screened using the MUST. In

this case the staff responsible for completing the screen struggled to ascertain disease severity. Interestingly this study already excluded bedridden, unconscious and demented patients.[54]

Hypothetically, similar problems would be experienced in an ICU setting where patients are often bedridden and unable to provide the necessary information. Even though surrogate measurements can be used to obtain information about current weight,[46] determining weight loss history might be problematic. As mentioned previously, deciding on disease severity in the ICU setting is also controversial. The MUST tool recommends that all ICU patients be assigned a score of two which will routinely classify them as "at high risk of malnutrition",[46] whereas it can be argued that not all ICU patients are equally critically ill and therefore shouldn't receive similar MUST classifications.

The MUST is user-friendly in the sense that it offers a very comprehensive implementation guide (The MUST explanatory booklet) to ensure the careful and accurate use of the screening tool.[46] This booklet serves as a training manual for health care workers and explains in detail each step of the screening process. The booklet also provides information on which alternative measurements to use in bedridden patients or those who are unsure about recent weight loss.[46] Although this booklet provides the means for in-depth training it also points toward the fact that this NRST is more complex than some of the other quick-and-easy screening tools. It indicates that thorough training is needed to ensure that[58] health care workers are able to perform the necessary measurements, calculations and assessment of disease severity.[58] The MUST should therefore be considered a more complex screening tool requiring skilled assessors.[54]

Two hospitals in Australia have implemented the MUST choosing this specific tool based on its "validity, reliability, precision, minimal time commitment, expense, quantitative scoring system and ease of use with adult patients". However, a study exploring the use of the MUST in these hospitals found low levels of compliance with the screening protocol. Some of the reasons stated were "not enough time" and "not being able to handle the anthropometric measurements".[60] The MUST includes the measurement of weight and height or other surrogate measurements should the patient be bedridden.[46] These measurements take time and add to the complexity of the MUST.[54] Nonetheless, Stratton et al., Velasco et al. and Raslan et al. have all employed the MUST in their studies with ease and found that it could be completed in a few minutes.[16,48,49]

In a large multinational audit of hospitalized patients (n=21,007) across Europe, it was found that the MUST is used least often compared to the NRS-2002 and other national or local tools to screen for nutritional risk. The authors however did not explore possible reasons for this finding.[14]

1.4.2 Mini Nutritional Assessment – Short Form

1.4.2.1 *The original Mini Nutritional Assessment*

The original Mini Nutritional Assessment (MNA) is a valid and reliable assessment tool for determining the nutritional status of elderly patients (>65 years). It was first published in 1994 and has since been extensively studied and validated for clinical use and even called the gold standard for geriatric nutritional risk screening.[61-63] It has been shown to correlate well with other measures of nutritional status and clinical outcomes.[64] The MNA is the NRST used most often to assess the nutritional status of elderly patients[61] and is also recommended by ESPEN for the elderly.[40] The MNA consists of 18 questions and takes approximately 10-15minutes to complete; it is therefore too comprehensive and time-consuming to use for screening purposes. For that reason a shortened version of the MNA was also developed;[64] this will be discussed in Section 1.4.2.2 below.

A 2006 literature review[62] found that the MNA showed fair to excellent sensitivity in 11 previous studies, with only two studies showing sensitivity below 70%. However specificity ranged from 13-98% with the majority of studies indicating an insufficient specificity below 70%.[62] A recent study[16] among internal medicine and surgical hospitalised patients compared the MNA to the SGA. The MNA showed excellent sensitivity, but specificity was low at 61%. When the patients were stratified according to age and admission department the MNA showed the best sensitivity in elderly (>65 years) and internal medicine patients.[16] The MNA is thus considered to have good criterion validity, although it seems to overestimate nutritional risk.

The literature review also reports that the MNA is associated with adverse hospitalisation outcomes such as longer LOS, mortality and discharge to nursing homes.[62] Beck et al. however also looked at previous studies to assess the efficacy of the MNA to predict adverse outcomes and found that very few of the associations reported in the literature have good sensitivity, specificity and predictive validity. The associations also did not always reach statistical significance. According to their review, mortality is the adverse outcome with the highest sensitivity, but it still lacks specificity.[67] More recently the MNA has been reported to predict mortality[68-71], development of complications[16] and LOS[15,16,49,69,70,72,73] by some authors. On the other hand Cereda et al. reported one study were the MNA did not predict mortality[74] and another study where only the malnourished MNA category was predictive and not the “at risk” category.[71] Vischer et al. also found that the MNA was unable to predict hospital mortality and LOS as well as discharge to long-term care facility and 4-year mortality.[75] The authors concluded that the MNA is not sensitive enough to disease-related malnutrition and that it struggles to predict outcomes in a hospital setting where acute disease and

comorbidities are abundant.[75] It therefore seems that the MNA may lack predictive validity and that clinicians are still unsure exactly what a positive screen for malnutrition means in clinical terms.[67]

The MNA has been studied using intervention protocols such as supplementation for patients classified as malnourished or at risk of malnutrition. Intervention in these cases has resulted in improved nutritional status and shortened hospital stay.[62] This may provide some evidence of clinical benefit when using the MNA to direct nutritional intervention.

According to the MNA 3-57% of elderly patients in all health care settings are malnourished, and 29–65% are at risk of being malnourished.[15,16,64,68,71,73,74,76-81] Malnutrition in the hospital setting looks similar to this.[15,16,64,68,71,73,74,76-81] Only one study has looked at the prevalence of malnutrition, using the MNA, in Africans. In this study, which only included community-dwelling and institutionalized elderly, 5% of the population was malnourished and 50% at risk of malnutrition.[82]

The MNA is by far the most widely studied and documented NRST for elderly patients. It can be considered the gold standard screening tool for elderly patients[63] and its use is recommended by ESPEN.[40] It should however be noted that the MNA tends to overestimated risk[67,83,84] and its predictive validity in the hospital setting may be limited.[67,71,74,75]

1.4.2.2 *Development and validation of the MNA-SF*

The Mini Nutritional Assessment – Short Form was developed using the same patient population used to develop the MNA. The study sample consisted of 105 hospitalised elderly patients and 50 community-dwelling elderly. The questions from the original MNA that 1) best correlated with the MNA score, 2) had good sensitivity and specificity compared to physician clinical assessment of nutritional status and 3) were internally consistent, were chosen for inclusion. This resulted in a 6-question version of the MNA. For validation, this version was then further studied in two additional patient populations against the full MNA. Each of the 6 questions selected for the Mini Nutritional Assessment – Short Form correlated well with the full MNA score and had diagnostic accuracies above 72%. It its totality, the Mini Nutritional Assessment – Short Form had 97% sensitivity and a perfect specificity for predicting malnutrition as defined by the MNA. It was therefore considered a valid screening tool for assessing nutritional status in elderly patients.[64] However, the Mini Nutritional Assessment – Short Form was only able to determine patients who were “normal” and those who were “at risk of malnutrition”; for patients to be identified as “malnourished” the full MNA still had to be administered.[61,64] This led to a final revision and revalidation of the Mini Nutritional Assessment – Short Form by Kaiser et al. in 2009.[65]

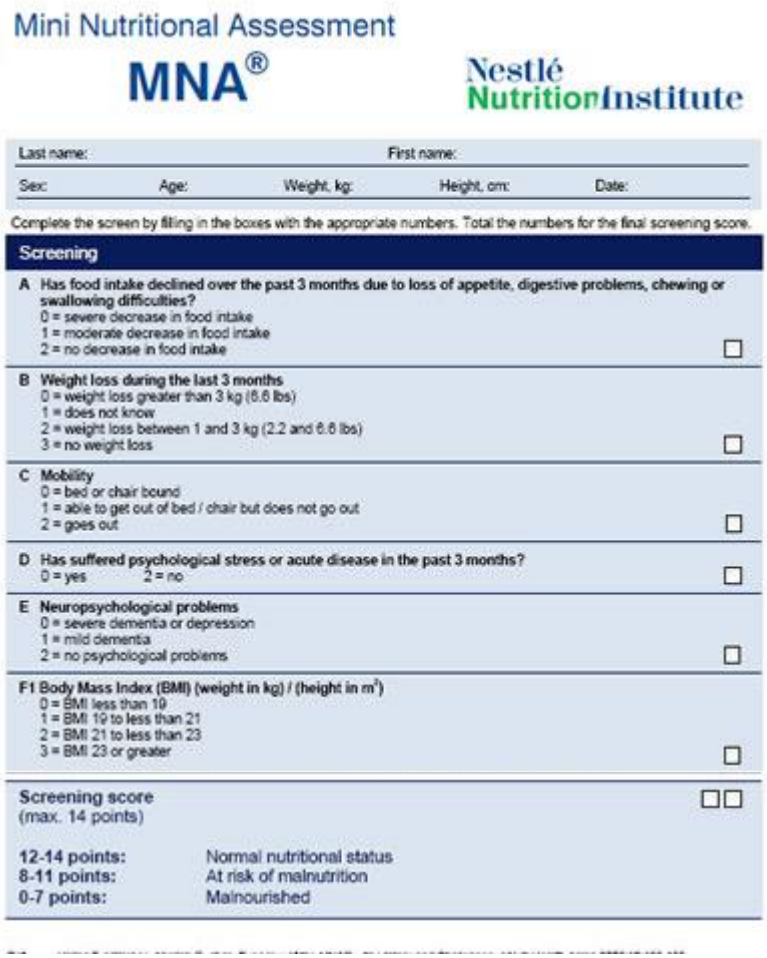
The modified version of the Mini Nutritional Assessment – Short Form (hereon referred to as the MNA-SF) was developed using the same methodology described above, but included data from 12 previous studies. Again, six questions emerged as most accurate and predictive with only one of them different from the original Mini Nutritional Assessment – Short Form. The increase in sensitivity was however marginal (which proves the validity of the original Mini Nutritional Assessment – Short Form) and therefore no changes were made in the questions included in the new MNA-SF. The researchers explored the use of three cut-off points similar to those used in the full MNA that would classify patients as "normal", "at risk of malnutrition" or "malnourished". This scoring system showed good accuracy (sensitivity and specificity above 80%) compared to the MNA and eliminated the need to complete the full questionnaire. Lastly, the researchers investigated the use of MUAC and calf circumference as alternative measurements for when weight and height cannot be measured. Only calf circumference showed good congruence with BMI and was included as an alternative measure.[65]

The MNA-SF is thus a stand-alone screening tool to identify the nutritional status of elderly patients. It has good criterion validity and accuracy compared to the full MNA.[62]

1.4.2.3 *Components of the MNA-SF*

The MNA-SF (Figure 1.2) consists of six questions that cover aspects of dietary intake, weight loss (in kg), mobility, psychological stress/acute disease, neuropsychological problems and current nutritional status (BMI). The fact that it includes indices of functionality makes it more applicable for use in elderly patients than most of the other NRSTs.[62,63] According to the final screening score the patient will be classified as "well nourished", "at risk of malnutrition" or "malnourished". The MNA-SF's screening score is different from the other NRSTs in that a higher score is associated with a better nutritional status and a lower score with a worse nutritional status.[65]

With regard to weight loss history, the MNA-SF provides an option for when patients are unsure about whether or how much weight they have lost. In these cases the option "does not know" can be used and the patient will receive a score of 1 (no weight loss scores 3, 1-3kg weight loss scores 2 and >3kg weight loss scores 0). The MNA-SF and the MST are the only two screening tools that make provision for patients not familiar with their weight history.[65,66] The MNA-SF still requires weight and height measurements for calculating BMI, which will be problematic in bedridden patients. However, calf circumference can be used as an alternative to BMI, as it is much easier to measure in bedridden patients and has been shown to be a reliable measure of nutritional status in elderly patients.[65] The above mentioned characteristics make the MNA-SF a more feasible NRST to complete in hospitalised and specifically ICU patients.



Mini Nutritional Assessment

MNA®

Nestlé NutritionInstitute

Last name: First name:

Sex: Age: Weight, kg: Height, cm: Date:

Complete the screen by filling in the boxes with the appropriate numbers. Total the numbers for the final screening score.

Screening

A 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 during the last 3 months
0 = weight loss greater than 3 kg (6.6 lbs)
1 = does not know
2 = weight loss between 1 and 3 kg (2.2 and 6.6 lbs)
3 = no weight loss ☐

C Mobility
0 = bed or chair bound
1 = able to get out of bed / chair but does not go out
2 = goes out ☐

D Has suffered psychological stress or acute disease in the past 3 months?
0 = yes 2 = no ☐

E Neuropsychological problems
0 = severe dementia or depression
1 = mild dementia
2 = no psychological problems ☐

F1 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 (max. 14 points) ☐☐

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

Figure 1.2 The Mini-Nutritional Assessment Short Form (MNA-SF)

Source: http://www.mna-elderly.com/mna_forms.html

1.4.2.4 *Clinical studies of the MNA-SF*

Apart from the original validation studies, a few other studies have looked at the validity of the MNA-SF compared to the full MNA. They have generally found good to excellent sensitivity and specificity (>80%) in a variety of health care settings.[77,78,82,85] High agreement between the two tools has also been reported.[77,83] One study found that both the MNA-SF using BMI and the MNA-SF using calf circumference could classify 85% and 81% patients respectively into the correct MNA category.[83] A very recent study among hospitalised elderly also found a strong association between the classification of patients according to the MNA-SF and the full MNA: 80% to 85% of patients were correctly classified as “at risk of malnutrition” or as “malnourished”.[75] One study has used the MNA and MNA-SF in elderly Africans residing in the community or long-term care institutions. Although excellent sensitivity was found the positive predictive value was only 16% with almost 50% of patients wrongly classified as “normal”. The authors concluded that the MNA-SF is useful to identify

patients who are clearly malnourished, but that it struggles to identify the patients who are at risk.[82] Others have however reported good and even excellent positive predictive values when the MNA-SF is used.[77,78] The MNA-SF is considered to be a sufficient and stand-alone NRST to use in elderly patients.[78]

Compared to other screening methods the MNA-SF has also shown good sensitivity but poorer specificity. In elderly hospitalised patients the MNA could identify all patients malnourished according to BMI and weight loss criteria, but it also overestimated the malnourished group by 60%.[54] A similar trend was found when the MNA was compared to a comprehensive nutritional assessment including anthropometric, clinical, dietary and biochemical evaluation in hospitalised elderly[86] and to biochemical, anthropometric and gastrointestinal assessment of elderly in a sub acute facility.[87] The MNA-SF, similar to the MNA, seems to overestimate nutritional risk. Although high sensitivity is the preferred goal for a NRST, a low specificity has clinical implications in terms of time and cost effectiveness.[86] It has been suggested that the MNA-SF may not be suitable for the hospital setting due to the high rate of false-positive screens.[49,54]

The MNA-SF has shown reasonable convergence with other NRSTs such as the MST, NRS-2002, MUST and SGA. In elderly hospitalised patients good agreement was found with the MUST (κ=0.75).[73] In a similar patient group a kappa of 0.23 was found with the NRS-2002 indicating only fair agreement.[49] In a sample of adult internal medicine and surgical patients, the MNA-SF demonstrated fair agreement with the MUST and NRS-2002 and moderate agreement with the SGA.[16] Better convergence may have been found if only elderly patients were included in the study. Reasonable agreement was also found in a study using the NRS-2002 and MST.[88]

With regard to predictive validity, the MNA-SF has been associated with post operative infectious- and wound complications in surgical patients.[88] Interestingly this study was conducted on adult patients of all ages and not only elderly patients. In elderly hospitalised patients, Raslan et al. showed that the MNA-SF could predict rate of complications, LOS and mortality.[49] Two other studies also demonstrated associations with adverse outcomes such as readmission to acute care or discharge to a long term care facility.[70,87] However Vischer et al. found that neither the MNA-SF nor the MNA could predict hospital or long-term mortality in elderly patients.[75]

The MNA-SF seems to be a reliable NRST. Good to very good agreement has been found when nursing staff perform the screening.[89] It seems that there is good agreement for the different screening questions except for the question on loss of apetite.[89]

In studies using the older version of the MNA-SF 28-73% of patients were classified as a risk of malnutrition.[49,76-78,84,86,88] This version of the MNA-SF only identified patients as normal or at risk of malnutrition. However Vischer et al. used the modified version of the MNA-SF in elderly hospitalised patients and found 51% were at risk of malnutrition and 26% were already malnourished.[75] In a non-acute setting Kaiser et al. found that 14% of elderly patients were malnourished and 30% at risk of becoming malnourished.[83]

Neither the MNA nor the MNA-SF has specifically been studied in ICU patients.

1.4.2.5 *Feasibility and applicability*

The MNA-SF was developed for use by non-specialised staff.[62] It seems that nurses are best suited to perform the screening as they have shown very good inter-rater reliability.[68]

The MNA-SF is applicable to use in elderly patients as the tool was developed and validated specifically for patients over 65 years of age.[64,65] The tool may possibly also be used in adults of all ages.[88] The MNA-SF development and validation studies included hospitalised elderly patients and therefore it can be considered applicable to use in a hospital setting.[64,65] There is however evidence that the MNA-SF may overestimate malnutrition by too large a degree which impedes on its clinical usefulness in a hospital setting.[49,54]

The MNA is easy to use and screening can be done in less than 5 minutes.[49,64,78,90] It does however require some anthropometrical measurements (height and weight, or calf circumference) and calculations which make it slightly more complex than some of the rapid screening tools that only entail questions.[64,91] To improve the accuracy of screening and increase the ease of use, a training guide was developed that provides information on the practical implementation of the MNA and MNA-SF. Although training may be more extensive and time consuming, this guide makes the MNA more user-friendly and standardised.[62]

The feasibility of implementing the MNA-SF in hospitalised elderly can be questioned. Height and weight measurements may be difficult in bedridden patients although in these cases it is suggested using calf circumference.[64] Cognitive impairments such as dementia and delirium are also common problems among the hospitalised elderly which may hinder the completion of the MNA-SF questions.[83] In the literature it is reported that the MNA-SF could be completed in 59-96% of the hospital-based study populations.[15,54,75] The reasons for the failed screens were not reported but it can be surmised that there were difficulties obtaining all the relevant information.

It is not known how feasible and applicable the MNA-SF is for critically ill patients. As with the other NRSTs it is assumed that a high number of bedridden and unconscious or cognitively impaired

patients will make it difficult to complete the MNA-SF. Even though surrogate measures such as calf circumference may be used, this may not always be feasible due to lower limb oedema.

1.4.3 Nutritional Risk Screening–2002

1.4.3.1 *Development and validation*

The Nutritional Risk Screening-2002 (NRS-2002) was developed by an ESPEN working group in 2001 and 2002. Their purpose was to create a screening tool which would measure current nutritional status as well as severity of disease state. They argued that disease state and its associated increase in requirements could play an important role in the development of malnutrition and therefore including this is the screening tool would not only help to recognize malnourished patients but also those at risk of becoming malnourished. The authors retrospectively studied controlled trials to ascertain which nutritional criteria or attributes are associated with specific outcomes. They felt a strong need to develop a tool which was valid in the sense that it could predict clinical outcomes, unlike some of the existing NRSTs.[53]

Malnutrition was measured using the following variables: BMI, recent weight loss (as percentage of body weight) and changes in food intake. These variables are commonly used in NRSTs and have shown association with functional and clinical outcomes. Disease states were classified as absent, mild, moderate or severe depending on the effect nutritional support had on outcomes in previous trials.[53]

A comprehensive validation study was also undertaken involving 128 controlled trials where the effect of nutritional support on clinical outcomes was measured. Patient groups from the RCTs were classified according to the NRS-2002 and then clinical outcomes were studied to see whether the screening tool could effectively predict them. After analysis they added an adjustment score for elderly patients (≥ 70 years) to their screening tool. Content validity was ensured by involving the ESPEN working group in the validation.[53]

The reliability of the NRS-2002 has been reported good with a kappa value of 0.67 between a nurse, dietician and doctor[40] and 0.76 between 28 doctors[24].

1.4.3.2 *Components of the NRS-2002*

The NRS-2002 entails two screening phases (Figure 1.3). The initial screening phase consists of four simple questions covering BMI, reduced intake, recent weight loss and severity of illness. If the answer is “yes” to any of the questions e.g. “Yes, the patient has recently lost weight”, then the second phase screening should be done. Patients who answered no to all four questions should be rescreened on a weekly basis.[53]

The second phase screening entails scoring the patient on two aspects, namely nutritional status and disease state. For nutritional status a score is allocated looking at the variable (BMI, dietary intake or recent weight loss) that is the worst off. For example, a BMI <18.5 will take precedence over a weight loss of >5% in 2 months (see Figure 1.3 below). For disease state the patient is scored according to their illness. If the specific illness is not in the table (see figure), then clinical judgment must be used to score the patient. Generally, patients with chronic diseases with one or more complications fall into the "mild" category. They are sick, but still able to walk around and their nutritional requirements can be met with oral supplementation. Patients who are bedridden due to their illness and whose protein requirements are considerably increased so that artificial feeding may be necessary, fall into the "moderate" category. Lastly, patients requiring intensive care, ventilation, inotropic support and whose protein requirements are increased to a level that is difficult to provide, should fall into the "severe" category. For patients 70 years or older, an age adjustment score of 1 is also added.[53]

A score of equal to or more than 3 is seen as "at risk of malnutrition" with a need for immediate nutritional support. The specific nutritional support to be followed is not specified. Patients with scores between 0-2 should be rescreened on a weekly basis.[53]

Initial screening

	Yes	*No*
Is BMI < 20.5?		
Has the patient lost weight within the last 3 months?		
Has the patient had a reduced dietary intake in the last week?		
Is the patient severely ill? (e.g. in intensive therapy)		

Yes: If the answer is 'Yes' to any question, the screening in table II is performed.
No: If the answer is 'No' to all questions, the patient is re-screened at weekly intervals. If the patient e.g. is scheduled for a major operation, a preventive nutritional care plan is considered to avoid the associated risk status.

Final screening

	Impaired nutritional status		*Severity of disease (E increase in requirements)*
Absent Score 0	Normal nutritional status	Absent Score 0	Normal nutritional requirements
Mild Score 1	Wt loss >5% in 3 mths or Food intake below 50–75% of normal requirement in preceding week	Mild Score 1	Hip fracture* Chronic patients, in particular with acute complications: cirrhosis*, COPD*. Chronic hemodialysis, diabetes, oncology
Moderate Score 2	Wt loss > 5% in 2 mths or BMI 18.5-20.5 + impaired general condition or Food intake 25-60% of normal requirement in preceding week	Moderate Score 2	Major abdominal surgery* Stroke* Severe pneumonia, hematologic Malignancy
Severe Score 3	Wt loss >5% in 1 mth (>15% in 3 mths) or BMI >18.5 + impaired general condition or Food intake 0-25% of normal requirement in preceding week in preceding week.	Severe Score 3	Head injury* Bone marrow transplantation* Intensive care patients (APACHE410)
Score		Score	**Total score:**

Score ≥ 3: the patient is nutritionally at-risk and a nutritional care plan is initiated.
Score < 3: weekly rescreening of the patient. If the patient e.g. is scheduled for a major operation, a preventive nutritional care plan is considered to avoid the associated risk status.
*indicates that a trial directly supports the categorization of patients with that diagnosis.

Figure 1.3 The Nutritional Risk Screening–2002 (NRS-2002) form[53]

1.4.3.3 *Clinical studies*

One of the strengths of the NRS-2002 is that it was developed and validated for predictive ability.[53] It's ability to predict clinical and other outcomes have also been studied further, generally with good results.[19,92-97] The NRS-2002 has been shown to predict LOS,[19,94,96,98] development of moderate and severe complications,[93] development of post-operative complications,[96-99] mortality,[93] decreased handgrip strength[94] and increased hospital costs.[95] A large, international, multicenter study of 5,051 patients also found that patients at risk of malnutrition, as defined by the NRS-2002, developed significantly more complications and those with complications had significantly longer LOS in hospital. Mortality was also higher in the "at risk" group.[24] This study included a small proportion (6.1%) of ICU patients. In another ICU patient population, risk of malnutrition as defined by NRS-2002 was significantly associated with risk of pressure ulcers.[100]

A RCT (n=212) used the NRS-2002 to identify patients at risk of malnutrition who were then assigned to an intervention or control group. The control group received standard nutritional support, whereas the intervention group received more intensive dietary treatment. Patients were followed

up for outcomes such as LOS, development of complications and quality of life. This study found that LOS was significantly reduced in patients with complications in the intervention group.[92] Another very recent RCT had similar findings: patients with a NRS-2002 score of ≥ 3 and who received nutritional intervention had significantly better clinical outcomes than the control group patients.[101] The NRS-2002 is thus unique in the sense that it has to some degree been validated by two RCTs.[92,101] A similar prospective study, though not a controlled trial, also found reduced rates of complications, especially infectious complications, in NRS-2002 "at risk" patients who received nutritional support.[102] The value of these findings lies in the fact that it proves the clinical benefit of giving nutritional support to malnourished patients – patients that have been classified as "malnourished" according to the NRS-2002.

In comparison to other measures of nutritional risk the NRS-2002 has shown moderate agreement with the SGA[93] and good to excellent criterion validity compared malnutrition defined by BMI and unintentional weight loss cut-offs.[54] In general there is a lack of data on the convergent validity of the NRS-2002.

The NRS-2002 has been used in many studies to determine nutritional status. In these studies risk of malnutrition ranged from 6% to 42%.[24,54,93-99,101-107] Important to note however, is that a substantial amount of heterogeneity exists between different hospital departments and different diagnostic groups. Specifically for ICU patients, risk of malnutrition measured by the NRS-2002 has been reported between 52-100%.[24,105]

Only one study has been conducted using the NRS 2002 in a South African population. This study was however retrospective and the research investigators were final year dietetic students. The authors aimed to establish the agreement between the MUST and the NRS 2002 in hospitalised patients. The specific patients included in the study were not reported. Malnutrition prevalence was measured by the NRS 2002 at 40-60% of patients and poor agreement was found between the NRS 2002 and the MUST.[30]

1.4.3.4 *Feasibility and applicability*

Even though the NRS-2002 is considered a more complicated and comprehensive NRST,[54] it is still rated by many as feasible and simple to use in clinical practice.[96,98,104] It has been reported that the NRS-2002 is more time-consuming than other quick-and-easy screening tools such as the Short Nutritional Assessment Questionnaire (SNAQ) and MST [54] and although this might be true, the NRS-2002 screening can still be done in 5-10minutes.[96,98] Guidelines for implementing the NRS-2002 are

available.[53] One drawback however is that the measurements and calculations involved in the screening process requires a more skilled person to complete it.[54]

A few studies have described the rate of successful screenings in their patient populations. Failed screening due to missing data (anthropometrical measurements that could not be taken or no information regarding dietary intake or weight loss history) was reported between 1-7%.[19,23,24,98,104] In most cases, however, these patient populations were general hospital patients and excluded patients who were not able to communicate effectively, ICU patients and patients who were not orientated with regard to place and time.[19,23,98,104] If these patients were included it could be expected to lead to an increased rate of failed screens.

In developing and validating the NRS-2002 the authors also reported that in some cases it was difficult to obtain accurate measurements of height and weight and obtain information about weight loss or dietary intake. They investigated the use of MUAC instead of weight, but could not find cut-off points for all the different BMI categories in the literature. Their recommendation is that the patient should be classified as at risk whenever there is any doubt and until sufficient dietary intake can be confirmed.[53]

The NRS-2002 has been studied in many different groups of adult patients. It is considered applicable to use in general hospitalized patients[24,40,53,54,101,105] as well as, specifically, oncology,[98,99,107] surgical[96,102,104,106] and urology patients.[97] It has also been validated for the Chinese population.[102,104] Very few studies have used the NRS-2002 in an ICU setting and they did not specifically comment on the ease of use or applicability of the NRS-2002 in this setting.[24,100,105]

1.4.4 Nutritional Risk Indicator

1.4.4.1 *Development and validation*

The Nutritional Risk Indicator (NRI) was developed by Buzby et al. in 1988[108] for use in the Veterans administration cooperative group study of peri-operative parenteral nutrition in surgical patients.[108,109] The NRI was thus specifically aimed at identifying nutritional risk in surgical patients. In the development phase Buzby et al. established various measures that could be used to identify nutritional risk: current body weight, percentage of usual body weight, percentage of ideal body weight, triceps skinfold, mid-arm muscle circumference, s-albumin and serum pre-albumin. These measures were thought to be relatively inexpensive, simple and quick (<8 hours) to use in a screening test. They then studied the association between different combinations of these measures to determine which combination could best predict risk of post-operative complications is surgical patients. When the combination of s-albumin and percentage of usual weight was used, patients

identified as at risk of malnutrition (abnormal) had significantly higher rates of complications and mortality.[108] The NRI was thus developed and validated for its ability to predict clinical outcomes.

1.4.4.2 *Components of the NRI*

The NRI uses two variables to screen individuals: s-albumin and percentage of usual weight. An accurate measure of current weight and an indication of usual weight are necessary to determine percentage of usual weight, and s-albumin should be measured in grams per litre. The two variables are then used in a formula to calculate an NRI score.[109]

According to the NRI score a patient can be classified as "not malnourished", "mildly malnourished", "moderately malnourished" or "severely malnourished".[109] Figure 1.4 below shows the NRI formula and the cut-offs used for the four categories of nutritional status.

NRI score = (1.519 x serum-albumin) + 0.417 x (current weight/usual weight x 100)

Score	Classification
>100	Not malnourished
97.6 - 100	Mild malnutrition
83.6 – 97.5	Moderate malnutrition
$\leq$ 83.5	Severe malnutrition

Figure 1.4 The Nutritional Risk Indicator (NRI)[109]

An s-albumin level of 27.8g/l is necessary to classify a patient as severely malnourished if the patient has not experienced any weight loss. In the presence of substantial weight loss however, only slightly decreased s-albumin levels are necessary to classify a patient as severe malnourished.[108,109]

The NRI is the only NRST included in this study that has a biochemical variable and as such also an inflammatory marker, s-albumin, in its screening method. There are different opinions regarding the use of s-albumin as an indicator of nutritional risk; some authors suggest that is a good predictor of malnutrition whereas others report that it overestimates the prevalence of malnutrition.[110,111] S-albumin levels are influenced by more than just nutritional status. The acute phase reaction, sepsis, liver disease, cancer, nephrotic syndrome etc. may all lead to increased capillary leakage of s-albumin, increased catabolism or decreased synthesis by the liver.[9,112] It can therefore be argued that s-albumin levels are a good indicator of risk in general, but not such a sensitive indicator of nutritional risk per se.[9,113] A few studies have found an association between hypoalbuminaenia and clinical outcomes such as mortality, nosocomial infections, complications, readmissions and

LOS,[9,111,114] while others have not.[110,115] Although it is currently accepted that inflammation plays an important role in the development of malnutrition and that is warrants attention during nutritional assessment, there is no consensus regarding how to measure the degree of inflammation. S-albumin has been proposed as a marker of inflammatory status, but as mentioned, it also has certain limitations regarding its relation to nutritional status.[9] At the moment, ASPEN recommends against the use of inflammatory markers for diagnosing nutritional status, mainly due to the lack of an accurate and nutritionally related inflammatory marker.[2]

The NRI does not provide any guidelines for implementation or treatment of patients according to nutritional risk classification.

1.4.4.3 *Clinical studies*

The NRI has mostly been studied in surgical patient populations for its ability to predict clinical outcomes. In gastroenterology,[110] obstructive jaundice[116] and general hospital patients including surgical and medical patient groups[117-119] the NRI has been shown to predict LOS. It has also demonstrated good predictive ability for post-operative mortality in gastric cancer[111] and obstructive jaundice[116] patients. Furthermore it is able to predict post-operative morbidity such as the development of nosocomial infections,[118] cellular immunosupression[111] and pancreatic fistula after distal pancreatectomy.[120] In a study of patients admitted for elective, major surgeries (n=480), the NRI also showed good predictive validity for post-operative mortality, morbidity (infectious and non-infections severe complications) and LOS.[121]

Kyle et al. used the NRI in a multicenter population based study of hospitalized patients (n=1,273). Apart from finding the NRI a good predictor of clinical outcomes, they also found that a severely malnourished classification by the NRI led to three times higher hospital costs than a well-nourished classification. They also proved that the NRI is better in categorizing nutritional risk than its counterparts, weight loss and s-albumin, on their own.[119]

One study has found the NRI unable to predict clinical outcomes: in patients with oesophageal malignancies admitted for surgery the NRI could not predict LOS or the development of postoperative infections.[122]

A few studies have compared the NRI to the SGA as a gold standard for defining malnutrition.[110,115,117] In gastroenterology patients the NRI demonstrated fair agreement (κ=0.37) with the SGA[110] and in a general hospitalized patient group it showed moderate agreement (κ=0.57).[117] In the last mentioned study the authors also reported the NRI to have fair sensitivity (79%) and good specificity (82%).[117] A study in gastric cancer patients however demonstrated poor

agreement between the NRI and the SGA with a kappa of 0.18. In this study the sensitivity was still fairly good (74%), but a poor specificity (40%) was found.[115]

The NRI has also shown good correlation with other objective measures of malnutrition such as more detailed anthropometry, biochemistry (s-albumin and total cholesterol) and weight loss.[117]

Reports of the prevalence of moderate to severe hospital malnutrition, as defined by the NRI, range from 24-68%.[39,115,116,118-120]

The NRI has not been studied in an ICU patient setting specifically.

1.4.4.4 *Feasibility and applicability*

Not much is known about the ease of use of the NRI. It is safe to assume that including a biochemistry variable in a NRST could present some complexities. First, it is more time-consuming to draw blood and wait for laboratory analysis than to complete a quick questionnaire. Second, the variable may not be routinely screened in all hospital patients. Third, the cost involved in measuring biochemistry variables cannot be ignored; if it is not routinely screened it will result in a much higher cost of screening. Last, the biochemical test is much more invasive than the other parameters normally used in NRSTs.

On the other hand, the advantage of a biochemistry variable is the fact that it is completely objective.[39] It is also feasible to implement even in patients that are bedridden and/or comatose. However, even though the s-albumin test can be implemented, completion of the NRI also requires an accurate current and usual weight. It might therefore be difficult to screen bedridden patients as well as those unable to provide information on their usual weight.

A number of studies have reported the rate of failed screens that were found when the NRI was implemented. This number ranged from 1%,[121] 10%,[116] 16%,[122] 19% and 32%[39] to 62%.[118] The reasons given to explain the failed screens were incomplete data on current weight,[39,118] lack of information on usual or premorbid weight,[39,116,118,122] no s-albumin values available[39,118] and patients unable to be interviewed.[121] The study with a 62% rate of failed screens was a national study including all hospitalized patients from participating hospitals in France.[118] Although they didn't report the rate of failed screenings specifically for ICU patients, it can be expected that it would have been high. Other studies with lower rates of failed screenings often excluded comatose and unconscious patients[121] or were conducted in patient populations that were generally conscious and mobile e.g. pre-operative elective surgery patients.[116,122]

Clugston et al. reported that the NRI is easy to calculate if you have all the necessary data.[116] Nonetheless, a person trained in weight measurement would be needed to obtain an accurate weight.

From the literature available it can be concluded that the NRI is applicable for use as a NRST in surgical patients,[109,111,117,121] with the possible exceptions of gastric and oesophageal cancer patients.[115,122] It also seems possible to apply it to general hospital patients.[39,119]

The applicability of the NRI in ICU patients is unknown. In most cases, especially in a surgical ICU, it can be expected that most patient conditions will entail an inflammatory or infectious component which will lead to decreased s-albumin levels. It may thus be that the NRI will overestimate nutritional risk based on the high prevalence of decreased s-albumin levels.

1.4.5 Malnutrition Screening Tool

1.4.5.1 *Development and validation*

The Malnutrition Screening Tool (MST) was developed by Ferguson et al. in 1999 and was one of the first of a number of quick- and-easy NRSTs that have been developed over the years. Ferguson et al. were frustrated with the lack of simple as well as valid and reliable NRSTs in the literature and therefore aimed to develop such a tool for the acutely ill hospitalised adult population.[123] Their objectives were to create a tool that would be applicable for the general hospital patient, make use of data that is readily available, be quick and easy to complete, be cost-effective and non-invasive and lastly, would be accurate and reliable.[123]

For the development of the MST, hospital patients (n=408) from various wards (general medical, cardiology, gynaecology, orthopedic, oncology, plastic surgery, gastrointestinal and general surgery) were conveniently sampled. All maternity, psychiatric, patients younger than 18 years and patients that could not communicate were excluded. The SGA was used as the gold standard to identify malnourished patients. A list of questions that could possibly identify malnutrition was analysed against the SGA results. In the end, two questions were identified as most predictive of malnutrition.[123]

To validate the questionnaire, the researchers studied criterion and convergent validity. The sensitivity, specificity and positive predictive value were all excellent (>90%). The negative predictive value rated fair with 27% of malnourished patients being wrongly classified as not at risk of malnutrition. Compared with other measures of nutritional status (biochemical and in-depth anthropometrical measures), the MST also appeared to be accurate. Furthermore, the MST was able

to predict a clinical outcome i.e. LOS in hospital. Reliability also appeared to be excellent as measured between dieticians as well as between nutritional assistants and dieticians.[123]

1.4.5.2 *Components of the MST*

The MST (Figure 1.5) consists of two questions: one dealing with recent unintentional weight loss (in kg) and the other with loss of appetite. The MST is unique in the fact that it provides an "unsure" option for when patients are not sure about whether they have lost weight or how much weight they have lost. Patients are classified as either not at risk of malnutrition (score of 0-1) or at risk of malnutrition (score of ≥ 2). The MST also includes implementation guidelines: patients at risk of malnutrition should be subjected to a more thorough nutritional assessment whereas patients not at risk of malnutrition should be rescreened on a weekly basis.[123]

MALNUTRITION SCREENING TOOL (MST)	
Have you lost weight recently without trying?	
No	0
Unsure	2
If yes, how much weight (kilograms) have you lost?	
1–5	1
6–10	2
11–15	3
>15	4
Unsure	2
Have you been eating poorly because of a decreased appetite?	
No	0
Yes	1
Total	

Figure 1.5 The Malnutrition Screening Tool (MST)[66]

1.4.5.3 *Clinical studies*

After initial validation in the acute adult hospital population, the validity of the MST was further studied in different groups of hospital in- and outpatients using the SGA as a gold standard measure of malnutrition.[88,124-126] Among oncology outpatients receiving radiology the MST showed good to excellent criterion validity[124] and excellent to perfect criterion validity compared to a version of the SGA in patients receiving chemotherapy.[126] Inter-rater reliability was also measured in the chemotherapy population; there was good agreement between MST scores when completed by nursing or administration staff or patients themselves. This can be expected as the MST only entails

two questions which decrease the chances of disagreement.[126] The MST has also been compared to the SGA in a large adult inpatient sample (n=2,211) in Turkey. In this study the MST showed only fair sensitivity and specificity. Although still acceptable, other screening methods such as assessing loss of subcutaneous fat proved far more accurate.[125]

The MST has been studied in relation to NRSTs other than the SGA. Compared to the MUST in a group of medical inpatients, the MST showed fair-good agreement and a similar prevalence of malnutrition. However, even though the proportions of malnutrition were comparable, the individuals classified as "at risk of malnutrition" differed.[48] The MST was also compared to the NRS-2002 in oncology inpatients and in this study the MST showed very poor sensitivity (49%), while specificity was excellent.[51]

Among elderly patients, the MST has also been shown to have poor sensitivity of 59%, but good specificity of 85% when compared with the NRS-2002.[127] On the other hand, in a 2009 study among elderly patients admitted to an emergency medicine department, the MST showed good sensitivity and specificity of 84% and 85% respectively. In this study, however, the SGA was used as the standard definition for malnutrition.[128] Furthermore, the MST also showed good sensitivity in elderly patients in a residential care setting, when compared to the SGA.[129]

The above discrepancies and poorer relative validity found when the MST is compared to NRSTs other than the SGA can possibly be explained by the fact the MST was developed to predict malnutrition as defined by the SGA and not by other NRSTs[66]. Due to the absence of a gold standard measure for malnutrition it is difficult to identify which tool should be considered as the more accurate. A very recent study on NRSTs in hospital inpatients found the MST to be a sufficiently valid screening tool that could identify malnourished patients just as well as other assessments. In this study a BMI <18.5 and unintentional weight loss of >5% in 1 month or >10 % in 6 months was used as the definition for malnutrition. The MST was also able to identify older patients at risk of malnutrition.[54]

A few studies have looked at the MST's ability to predict clinical outcomes. In pre-operative surgical inpatients the MST, along with three other screening tools, was studied for its ability to predict post-operative infectious and wound complications. Although the MST could predict post-operative outcomes to some degree, it scored the worst out of the four NRSTs and did not add any useful information above that provided by known risk factors for post-operative infectious and wound complications such as s-albumin.[88] Moreover the MST was not able to predict LOS in oncology

inpatients[51] or elderly orthopaedic trauma patients.[127] It therefore seems as if the MST is not particularly good at predicting clinical outcomes and this can be considered one of its limitations.

The prevalence of malnutrition as identified by the MST ranged from 18-55% among hospitalised patients.[48,51,54,125,127]

The MST has not specifically been studied in an ICU patient setting.

1.4.5.4 *Feasibility and applicability*

The MST is one of the few NRSTs that is really quick and easy to complete. The two questions that comprise the MST are simple to answer and no calculations are necessary.[123] It has been reported that the screening tool takes 1-3minutes to complete.[48] Screening can be done by nursing staff, administration staff or the patients or friends or family of the patient themselves; no trained personnel are required.[48,123,124] This ensures better use of specialised personnel such as doctors and dieticians. The MST is also non-invasive, uses data that is routinely available (when assuming that the patient is able to communicate) and it includes implementation guidelines which further increase its ease of use.[123]

Another advantage of the MST is its scoring system. All patients with a score of equal to or higher than two are classified as at risk of malnutrition, with a maximum score of five. Patients can be prioritized based on their score in terms of urgency of treatment needed.[123,124]. Furthermore, for patients who do not know their current or previous weights, the MST provides an "unsure" option the question about recent weight loss. This will however immediately categorize the patient as at risk of malnutrition as the patient scores 2 when choosing the "unsure" option.[123] Although this ensures that malnourished patients are classified as such, it may also lead to a large number of patients being misclassified as at risk of malnutrition, especially in a patient population who often do not know their weight history.

A limitation of the MST is the fact that only subjective criteria are used.[48] Although this simplifies the tool to a great extent, it does necessitate clinical judgment and may open the doorway to bias.

The MST is applicable for use in a large adult patient population: from general hospital inpatients to the oncology outpatient setting.[54,123-126] It is also applicable for use in elderly patients.[128,129] It is currently unknown whether it is applicable for use in the ICU setting. It is estimated that the MST might be difficult to implement in the sample of ICU patients that are not able to communicate, especially if the necessary information is not readily attainable from other sources e.g. patient files, relatives or friends.

1.4.6 Short Nutritional Assessment Questionnaire

1.4.6.1 *Development and validation*

The Short Nutritional Assessment Questionnaire (SNAQ) was developed by Kruizenga et al. after a national nutritional risk screening study in hospitals in the Netherlands revealed current practices were impractical.[130] This large-scale screening study found that when BMI or percentage of unintentional weight loss is used to identify malnutrition, nutritional risk was often not identified. The main reason was lack of time for nurses and clinicians to do the necessary measurements and calculations.[131] Kruizenga et al. therefore wanted to develop a short questionnaire to identify malnutrition that could be incorporated into nursing staffs' admission procedures and would take no longer than 5 minutes.[130]

The questionnaire was developed in 2002 using adult patients (n=291) from internal medicine and surgical wards. The researchers determined three questions that were predictive of malnutrition, as defined by a BMI <18.5 and unintentional weight loss in the past 6 months of >5 to 10% of body weight. After the development phase a cross-validation study was performed in 2003 using 297 patients from the same wards. The results from this study indicated that the SNAQ has a sensitivity of >76% and a specificity of 83% which is considered fairly good. Furthermore the SNAQ also showed good negative predictive values. The positive predictive value however scored only 62% and 70% for the severely malnourished and moderate and severely malnourished patient groups respectively which indicates that the SNAQ may overestimate the number of patients that are truly malnourished. Nonetheless, when dieticians were asked to rate the referrals they received based on the SNAQ score, 89% of the referrals were rated as very necessary. The reproducibility of the SNAQ was also assessed. A kappa score of 0.61 indicated moderate nurse-nurse reproducibility and a kappa score of 0.91 indicated good nurse-dietician reproducibility. It was suggested that these scores could further be improved with in-depth training of staff.[130]

1.4.6.2 *Components of the SNAQ*

The SNAQ (Figure 1.6) consists of three questions dealing with unintentional weight loss (in kg), appetite changes and enteral nutrition support received in the previous month. Each question is scored and then added together to obtain the total score. Depending on the outcome the patient will be classified as well-nourished, moderately malnourished or severely malnourished.[130] The SNAQ also provides a dietary treatment plan based on the classification of nutritional status. Patients classified as moderately malnourished should receive nutritional intervention in the form of high energy and protein meals with two snacks, whereas patients classified as severely malnourished should also be referred to a dietician for additional support.[132]

Figure 1.6 The Short Nutritional Assessment Questionnaire (SNAQ)[132]

1.4.6.3 *Clinical studies*

Kruizenga et al. also tested whether the use of the SNAQ and its dietary intervention component, opposed to the usual protocol for identifying and treating malnutrition, could affect clinical outcomes. This was a controlled trial using the same patient population as for the SNAQ validation study and with the patient population from the SNAQ development study acting as a control group. With regard to clinical outcomes they measured LOS, weight changes during hospital stay, use of enteral or parenteral nutrition support and number of visits by a dietician. In short, they found that LOS was shorter in frail, malnourished patients when the SNAQ was used. The SNAQ did not significantly impact on weight changes although this was ascribed to the fact that weight is often an unreliable variable and hospitalisation is generally too short a period to expect noteworthy weight gain. The SNAQ did however impact nutritional support by increasing the number of meals patients received and the administration of normal food opposed to parenteral feeding, tube-feeding or supplemental drinks. The use of the SNAQ also led to greater efficiency with regard to number of visits by the dietician. A cost-effectiveness analysis demonstrated that although the use of the SNAQ was associated with additional costs, it still resulted in considerable savings by decreasing LOS in frail, malnourished patients and the use of unnecessary specialised nutrition support.[132] This is a particularly important finding as it indicates the SNAQ's ability to impact clinical outcomes, even if just in a subgroup of patients.

The SNAQ has also been used to identify patient characteristics associated with malnutrition, specifically general health status and complexity of medical care. In this study, adult patients from internal medicine and surgical wards were assessed with the SNAQ at admission. The authors found

that patients classified as severely malnourished had reduced quality of life, handgrip strength and fat free mass indices indicating inferior physical functioning. They also had increased health care needs.[133] This study underscored the fact that malnourished patients are often complex patients with more complex health care needs and that the SNAQ can be used as a NRST to identify these patients.

In a recent comparison of five screening tools in one sample of hospital inpatients, the SNAQ along with the MST showed fair to excellent criterion validity when measured against malnutrition defined by BMI and weight loss parameters. The authors also found that it was a practical tool to implement. The MUST and NRS-2002 demonstrated acceptable criterion validity but were not as quick and easy to complete and had high rates of missing data. In this study, patients classified as moderately and severely malnourished in the SNAQ were grouped together and compared with the well nourished patients. This was done to make comparison between the different NRSTs possible since some of them only have two outcome categories. When the well-nourished and moderately malnourished patients were grouped together and compared with the severely malnourished patients, the sensitivity fell to an insufficient level (<70%). However, this can probably be explained by the fact that the SNAQ was not intended to be used in this manner and that if used correctly the criterion validity would be higher.[54]

In a recent systematic review of NRSTs for hospital patients, the SNAQ along with the MST outperformed other NRSTs. The SNAQ and MST were both found to have good diagnostic accuracy (underlimit of 95% confidence interval for criterion validity >65%) and was the most practical and applicable NRSTs.[134]

Since its initial validation in hospital inpatients, the SNAQ has also been validated and in some cases modified for other patient populations. In pre-operative and general hospital outpatients the SNAQ was found to have a sensitivity of 53-67% and specificity of 94-97% (measured against BMI and weight loss parameters).[135] Considering the fact that detection and treatment of nutritional risk in the outpatient setting has previously been reported at 15% the SNAQ will drastically increase these numbers and can therefore be used with acceptable accuracy.[135] A systematic literature review also found the SNAQ to be a valid and reliable NRST for elderly living in the community.[136] Two modified versions of the SNAQ have also been developed and validated for use: one in the residential care setting (SNAQ-Residential Care or SNAQRC)[91] and one for community-dwelling elderly (SNAQ65^{+}).[137]

Looking at the studies in which the SNAQ was used to assess nutritional risk, the number of patients classified as moderately malnourished ranged from 5-14% and the number of patients classified as severely malnourished ranged from 7-29%.[54,130,132,133,135]

The diagnostic accuracy and applicability of the SNAQ has not been studied in an ICU patient population. Also, limited data is available on the ability of the SNAQ to predict clinical outcomes in hospitalised patients.

1.4.6.4 *Feasibility and applicability*

One of the aims in the development of the SNAQ was to ensure that it could be completed in just a few minutes.[130] It is an extremely practical and feasible NRST, because the questions are simple, require no calculations and can easily be performed by nursing staff during patient admissions.[54,130,134] Completing the SNAQ has been reported to take less than three minutes and only upon scoring equal to or more than 3 will a patient be referred to the dietician, which helps to decrease workload among specialised hospital staff.[134]

The SNAQ was developed using a mixed hospital patient population which included oncology, surgical, internal medicine, gastroenterology, dermatology and nephrology patients.[130] This NRST is thus applicable for use in the majority of hospital inpatients. When considering the ICU patient population however, the feasibility and applicability of the SNAQ can be questioned. First, the SNAQ has not been validated among ICU patients and therefore it is not known whether it is valid and applicable to use in such a population. Second, the questionnaire completely relies on the patient's ability to answer the questions. If the patient is unable to answer the questions (due to sedation, coma, oral conditions etc.) and the correct information is not available it would be impossible to implement the SNAQ. The fact that no anthropometrical measurements are required does however count in the SNAQ's favour and might make it more feasible for use in ICU patients than some of the other NRSTs.

1.4.7 Subjective Global Assessment

The Subjective Global Assessment (SGA) is considered more a nutritional assessment tool and not as much a nutritional screening tool.[42] Nevertheless it is often used for screening purposes and it has been implemented in ICU settings. It is therefore included in this study as one of the NRSTs to be examined.

1.4.7.1 *Development and validation*

The SGA was developed in the 1980s in an effort to change the way nutritional status was assessed. The developers wanted to use a more subjective approach rather than the extensive

anthropometrical and biochemical assessments that were the current practice at the time. A sample of gastrointestinal surgery patients was used to develop the SGA questionnaire. The subjective criteria employed in the questionnaire seemed to correlate well with objective measurements of nutritional status indicating convergent validity. The SGA was also able to predict the development of post-operative infections.[43] A later study further confirmed the predictive validity of the SGA for a wider scope of post-operative outcomes such as mortality, wound healing and infectious complications. This study also tested the reproducibility of the SGA and found that it has good inter-rater reliability (κ=0.78).[138]

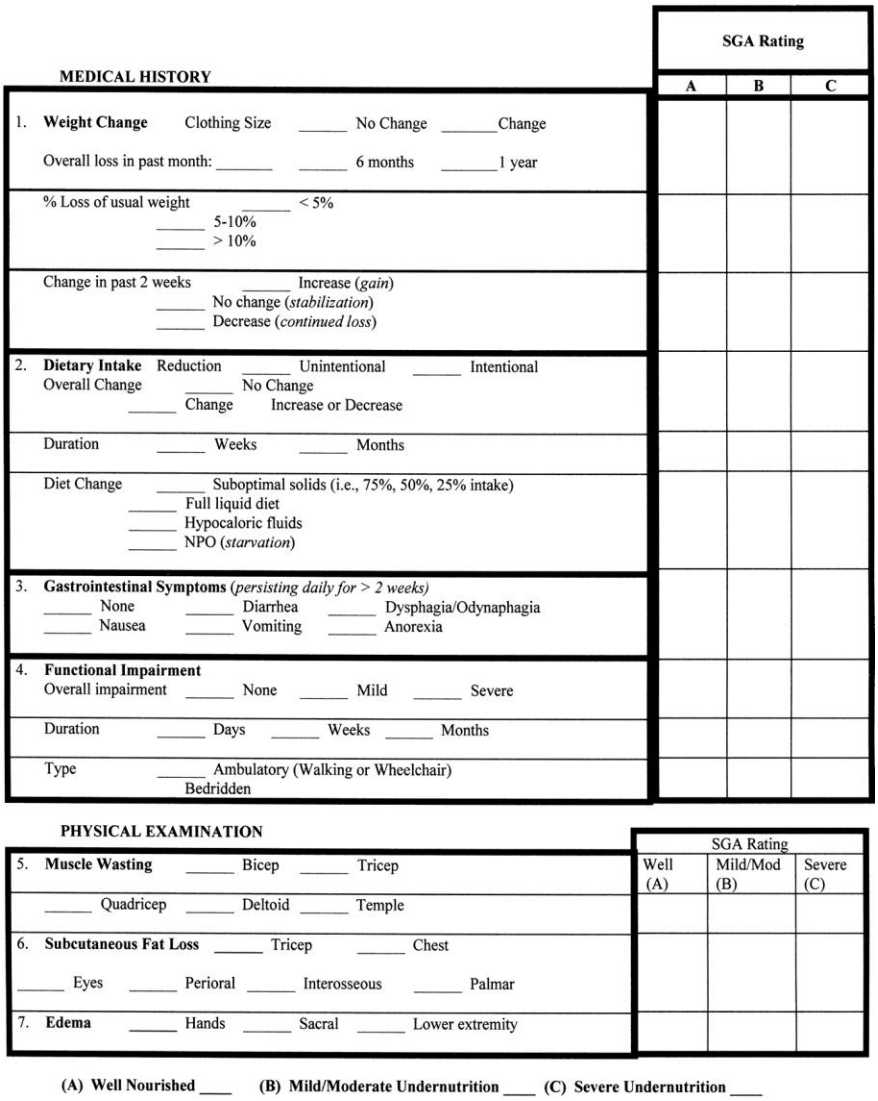
1.4.7.2 *Components of the SGA*

The SGA involves five areas of nutritional assessment (Figure 1.7). The first four areas cover aspects of patient history such as recent weight changes, dietary intake, GI symptoms and functional capacity. The SGA is unique in the sense that it looks at these aspects in much more detail than the other NRSTs. For instance it includes questions on weight changes in the past six months and also about weight changes experienced in the last two weeks. The SGA thus includes historical information as well as current symptoms and tries to establish the pattern of abnormalities. Change in dietary intake is assessed by not only asking about whether it occurs, but for how long it has been occurring and also the severity of the changes i.e. suboptimal diet versus liquid diet versus starvation. The last area of nutritional assessment entails a physical examination to look for evidence of muscle wasting, fat loss or oedema.[43]

It is worth noting that originally the SGA included a question pertaining to the degree of metabolic stress that was experienced by the patient due to the presence of underlying disease. The authors however recommended that this question be excluded from the SGA in the future since clinicians found it difficult to rate this question and importantly, it did not seem to influence overall SGA ratings.[43]

Using the SGA, patients can be classified as well nourished, moderately malnourished (or at risk of malnutrition) or severely malnourished. The scoring of patients into these categories is however not based on definite numerical scorings, but rather on a subjective basis of using clinical judgment to arrive at a classification. It has been reported that SGA classifications are most influenced by weight loss patterns and physical evidence of muscle or fat wasting.[43]

The SGA is not linked to a specific nutritional care plan bases on the outcome of the assessment.[43]



MEDICAL HISTORY	SGA Rating A	B	C
1. **Weight Change** Clothing Size _____ No Change _____Change Overall loss in past month: _____ _____ 6 months _____1 year			
% Loss of usual weight _____ < 5% _____ 5-10% _____ > 10%			
Change in past 2 weeks _____ Increase (*gain*) _____ No change (*stabilization*) _____ Decrease (*continued loss*)			
2. **Dietary Intake** Reduction _____ Unintentional _____ Intentional Overall Change _____ No Change _____ Change Increase or Decrease			
Duration _____ Weeks _____ Months			
Diet Change _____ Suboptimal solids (i.e., 75%, 50%, 25% intake) _____ Full liquid diet _____ Hypocaloric fluids _____ NPO (*starvation*)			
3. **Gastrointestinal Symptoms** (*persisting daily for > 2 weeks)* _____ None _____ Diarrhea _____ Dysphagia/Odynaphagia _____ Nausea _____ Vomiting _____ Anorexia			
4. **Functional Impairment** Overall impairment _____ None _____ Mild _____ Severe			
Duration _____ Days _____ Weeks _____ Months			
Type _____ Ambulatory (Walking or Wheelchair) Bedridden			

PHYSICAL EXAMINATION	SGA Rating Well (A)	Mild/Mod (B)	Severe (C)
5. **Muscle Wasting** _____ Bicep _____ Tricep			
_____ Quadricep _____ Deltoid _____ Temple			
6. **Subcutaneous Fat Loss** _____ Tricep _____ Chest			
_____ Eyes _____ Perioral _____ Interosseous _____ Palmar			
7. **Edema** _____ Hands _____ Sacral _____ Lower extremity			

(A) Well Nourished ____ (B) Mild/Moderate Undernutrition ____ (C) Severe Undernutrition ____

Figure 1.7 The Subjective Global Assessment (SGA) form[139]

1.4.7.3 *Clinical studies*

The SGA has been most widely studied of all the NRSTs. Due to its comprehensive nature it is often used as a gold standard of nutritional assessment against which other NRSTs are validated.[140,141] Its use as an assessment tool is recommended by international bodies such as ASPEN, especially when initial screening has indicated risk of malnutrition.[42]

Mostly the SGA's validity has been studied using objective measurements of nutritional status as reference standards. The SGA has been shown to correlate well with anthropometrical measurements such as BMI, percentage of weight loss, MUAC, arm muscle circumference and triceps skin fold, and biochemical variables such as s-albumin, pre-albumin and total lymphocyte count (TLC).[125,142-151] These correlations illustrate the SGA's convergent validity for a wide variety of patient groups: surgical patients,[144,152] general hospitalised patients,[125,148] elderly patients,[147] patients

with digestive diseases[149] or renal failure,[143,145,150] oncology patients[142,146] and cardiac patients.[151] However, some studies have failed to show significant correlations before or after controlling for confounding factors. A study in Chinese patients only found a strong agreement with percentage of weight loss and not with BMI, s-albumin, pre-albumin or TLC.[153] Another study in GI surgery patients did not find a significant correlation with s-albumin or pre-albumin.[152] In elderly as well as surgical patients the SGA has been correlated with BMI, but not with biochemical measures[154] or other anthropometrical indices.[155,156] A lack of correlation does however not disprove the SGA's validity, but may rather be an indication of the SGA's superiority to these single or combined objective measurements in identifying malnutrition.[155,156]

In one study the SGA was also compared to Dual-Energy X-Ray Absorptionmetry (DEXA) measurements of fat free mass. Here the SGA fared poorly scoring only 46% for sensitivity. The authors argued that it is difficult to pick up loss of fat free mass in overweight or obese patients and that this limits the SGA's sensitivity.[157]

Only a few studies have looked at the criterion validity of the SGA. Against a detailed nutritional assessment including measures of anthropometry, biochemistry, dietary intake and risk factors for malnutrition, the SGA scored fair-to-good: 77% for sensitivity and 84% for specificity. A kappa value of 0.4 indicated a moderate agreement between the two questionnaires.[158] The SGA also showed good agreement (κ=0.79) with a similar full nutritional assessment.[148] Compared to body fat percentage, biochemistry variables and a prognostic nutritional index, the SGA showed good sensitivity (82%) and fair specificity (72%).[159] Pablo et al. found that when combining the SGA with measures of s-albumin and TLC for a nutritional assessment and comparing it with just the SGA, the SGA alone still has 100% sensitivity, but specificity is only 59%.[160] SGA is thus an excellent tool for identifying malnourished patients but it also tends to overestimate and misclassify well nourished patients as malnourished.

Moderate to good agreement with other NRSTs such as the NRS-2002, MUST and MNA have been found.[16,140,154]

The SGA has mostly demonstrated good predictive validity with regard to patient outcomes, although there is also some opposing evidence. The SGA seems to be predictive of LOS in oncology patients,[146,153,161] renal failure patients,[162] general hospitalised patients,[17,21,37,163,164] patients with digestive diseases[149] and trauma patients.[165] It is also linked to the development of complications in internal medicine and patients with GI diseases[149,166] as well as acute renal failure,[150] elderly,[139]

trauma,[165] surgery,[138,144,167,168] oncology[142] and general hospitalised patients.[37] It is also predictive of mortality in most of these patients groups.[37,147,150,154,162,165,167]

In stroke patients, however, Davis et al. found that after adjusting for confounding factors such as age and stroke severity the SGA was unable to predict poor patients' outcomes.[159] Often, authors find that although univariate analysis may reveal associations between malnutrition and poor patient outcomes, adjusting for confounders through multivariate analysis or stratification dismiss these.[169-171] Sungurtekin et al. also could not find any significant association with SGA category and LOS.[167] In Chinese patients with GI cancer there was a trend for increased LOS in malnourished subjects, but this was not significant.[153] In another similar sample the SGA could predict complications but not mortality or LOS. Alvares da Silva et al also found no significant associations between malnourished subjects with liver cirrhosis and morbidity and mortality.[172,173]

In spite of its subjective nature the SGA seems to be a reliable tool. The initial papers on the development, validation and use of the SGA already reported good agreement between examiners.[43,138] Today, many other research papers support these findings.[174] The level of agreement between examiners ranges from 54-95% with kappa values from 0.48–0.9.[32,141,143,147]

The prevalence of hospital malnutrition across various patient groups ranges from 10-59% for risk or moderate malnutrition and 0-42% for severe malnutrition.[16,17,21,37,43,125,142,144,146,148-150,152,153,157,160,161,163,165,167,169,175-179]

Three small studies have looked at the use of the SGA in ICU patient populations. The first employed only a small portion of ICU patients (n=55) in its sample of elderly hospitalised patients. The ICU patients (also elderly only) had a 22% prevalence of moderate malnutrition and a 7% prevalence of severe malnutrition. This was similar to what was found in the total sample i.e. 28% moderate malnutrition and 6% severe malnutrition. The SGA categories for the whole sample was not predictive of LOS or mortality, although in the ICU patients there was a trend towards higher APACHE II scores in the malnourished patients; however, this was not significant.[31] Sungurtekin et al. studied the SGA in medical and surgical ICU patients (n=124) and found that 26% of patients were moderately malnourished and 11% were severely malnourished. In this study the moderate and severely malnourished patients had significantly higher APACHE II scores than the well nourished subjects. The SGA also correlated significantly with percentage weight loss, body weight, s-albumin and mortality, but not with LOS. The authors concluded that the SGA is a simple and feasible tool with predictive validity that can be used in ICU patients. However they did not describe how they collected data from unconscious or ventilated patients, or whether they excluded these patients.[33]

The third study was designed to measure the reproducibility of the SGA in a mechanically ventilated patient population (n=57). The authors collected data by using alternative methods such as reviewing doctor or nursing files, asking family members for information and using their nutrition management software programme that is used to store patient information. Fifty-four percent of patients were found to be moderately malnourished and 5% severely malnourished. There were no associations with malnutrition categories and APACHE II scores. Associations with mortality or patient outcomes were not reported. The authors found 95% concordance between the two dieticians conducting the SGAs. They concluded that the SGA is reliable and reproducible in an ICU or mechanically ventilated patient sample, but that the validity of the tool should still be ascertained.[32]

One of the negative qualities of the SGA that has been highlighted in the literature is the fact that it is subjective in nature which may lead to bias.[63,159,169,180] Some have even questioned its applicability for research purposes because of its high level of subjectivity.[63] However, as mentioned before the SGA demonstrates moderate to excellent inter-rater reliability which indicates that bias may not be as prevalent as expected. The importance of examiner training and experience should be emphasized as this will help to decrease bias and improve reliability.[16,169] Ozkalkani et al. have also pointed out that the SGA does not provide for a categorization of mild malnutrition and that it is not sensitive to pick up short-term changes in nutritional status.[168]

There are a few other versions of the SGA that are worth mentioning. The Patient-Generated Subjective Global Assessment (PG-SGA) is similar to the SGA but includes additional questions regarding patient symptoms that could influence nutritional status.[141,161] It is supposed to be more sensitive to short-term changes in nutritional status than the original SGA.[174] The questionnaire part is completed by patient themselves whereafter the health care worker completes the physical examination.[161] This tool was specifically developed and also validated for oncology patients.[161,174] The scored PG-SGA is exactly similar to the PG-SGA except that numerical scores are used and added up to classify a patient as well nourished or malnourished.[161] Due to the fact that patient participation is crucial in the use of this tool it is unrealistic to study its use in an ICU setting.

From the literature it is clear the SGA has been widely studied, even in ICU patients. Although there is contradicting evidence it seems that the SGA is valid in terms of concurrent measures of nutritional status and its ability to predict clinical outcomes in different patients groups. The SGA has also been shown to be reliable. There is also evidence of reliability and reproducibility in ICU patients, but this, as well as the validity of the SGA in this population, needs to be studied further.

1.4.7.4 *Feasibility and applicability*

Most studies making use of the SGA have described it as simple and easy to use.[152,176] Still, it is reported to take between 5-15 minutes, with the average assessment lasting 9 minutes.[17,163,176] A few studies have indicated that the SGA is too time-consuming and comprehensive to use for all hospitalised patients.[66,123,124] The tool is however inexpensive and non-invasive as no measurements are taken and no specialised equipment or biochemical tests are necessary.[17,176]

No studies commenting on the rate of successful completion of assessments in hospitalised patients could be found.

The SGA is meant to be implemented by health care workers.[141] In the literature it has mostly been utilised by physicians, registered dieticians, nurses and students in the medical or nursing professions.[32,43,138,141,143,147,153,174,181] It seems that the most important issues are training of the examiner[16,43,168] and proper experience[169] before using the tool in clinical practice. Training can be done with relative ease[17] and produce good results in a maximum of three hours.[181] The technique involved in using the SGA is described in sufficient detail so that it can be implemented by even an inexperienced examiner.[141]

The SGA seems to be applicable for a wide variety of hospitalised patients. It was initially developed and validated for use in pre-operative surgical patients[43], but since then it has been applied with acceptable validity in most hospitalised adult patients.[141,174]

As with the other NRSTs there are possible hurdles that the SGA will face in the ICU setting. One of them is unconscious, intubated or demented patients who will be unable to answer the necessary questions and thus hamper the completion of the questionnaire.[174] Yet, one study has successfully made use of alternative methods, as discussed previously, to collect the necessary information in mechanically ventilated patients. The study however does not report the rate of completion of assessments. It is realistic to expect that some information may not be obtained from sources other than the patient. Also, it is possible that the sources of information used in the study were more elaborate than those available in TAH i.e. the nutrition management software programme which is routinely used to capture patient care data.[32] This study also points out that the physical examination of patients in the ICU may be inaccurate as loss of lean body mass may easily be masked by fluid disturbances and obesity, two common phenomena among the critically ill.[32] One advantage of the SGA which will be of benefit in the ICU setting is that no anthropometrical measurements need to be taken. The tool is thus feasible in bedridden patients. It seems that

although the SGA has previously been used in the critically ill with relative success there are still doubts regarding its feasibility and applicability.

1.5 CONCLUSION AND MOTIVATION OF STUDY

The literature clearly indicates that hospital malnutrition is a serious and wide-spread problem. Likewise, the ICU setting poses a large risk for malnutrition and its debilitating consequences.[11] The evidence suggests that ICU malnutrition is linked to increased ventilator dependence, deterioration of the gut-barrier function, longer LOS and higher morbidity and mortality.[11,34] This in turn drives up health care costs dramatically and burdens hospital resources.[4,20]

To counteract this problem, international nutrition bodies recommend nutritional risk screening of all hospitalised patients, followed by proper nutritional care.[40,42] This recommendation aims to increase the recognition and treatment of hospital malnutrition, an area that merits attention as treatment of malnutrition has been shown to improve patient outcomes.[12] Various NRSTs exist for screening purposes and have been a topic of extensive study, but there is still no consensus on the optimal screening tool for detecting hospital malnutrition.

Screening all hospital patients would include screening ICU patients. However, very little information is available on the feasibility and accuracy of using existing screening tools in this patient population. Most studies on NRSTs exclude critically ill patients from their patient populations and as such, no single NRST has been recommended for use specifically in the critically ill. This can be seen as a major obstacle in the fight against hospital malnutrition as it prevents a group of patients at high risk for malnutrition from being screened and from being identified for nutritional intervention.

This study therefore aimed to shed light on the possible use of existing NRSTs in an ICU setting. The purpose was to identify NRSTs that could effectively predict clinical outcomes in critically ill patients and that were feasible, in order to make some suggestions on their adequacy for this patient population.

CHAPTER 2: METHODS

2.1 AIM AND OBJECTIVES

The primary aim of this study was to determine which nutritional risk screening tool (MUST, MNA-SF, SGA, NRI, NRS-2002, SNAQ or MST) most effectively predicts clinical outcomes in adult patients admitted to the Surgical Intensive Care Unit (SICU) of Tygerberg Academic Hospital (TAH), Cape Town, South Africa. The secondary aim was to comment on the feasibility and applicability of these NRSTs in a SICU setting.

Research objectives:

- To determine which NRST most effectively predicts clinical outcomes in adult SICU patients;
- To determine the relationship between nutritional status classification at admission and the clinical outcomes of SICU stay;
- To reflect on the applicability of NRSTs for this population;
- To comment on the feasibility of using NRSTs in this population and
- To identify elements of NRSTs that are applicable for screening adult SICU patients.

2.2 HYPOTHESIS

All NRSTs (MUST, MNA-SF, SGA, NRI, NRS 2002, SNAQ and MST) effectively predict clinical outcomes in adult patients admitted to the SICU of TAH, but some are likely to be more effective than others.

2.3 STUDY PLAN

2.3.1 Study type

A descriptive, prospective study design with an analytical component was followed. The data collected was quantitative.

2.3.2 Study population

2.3.2.1 Overall study population

Census sampling was used to select study participants. All eligible patients admitted to the SICU of TAH from November 2010 to June 2011 were included in the study after obtaining a waiver of consent – see Section 2.6 Ethical and legal considerations.

The only inclusion criterion was that patients had to be admitted to ward A1 West (SICU) of TAH. Exclusion criteria were patients younger than 18 years, patients who were included in the pilot study and patients with an SICU stay of less than 48 hours.

2.3.2.2 Sample size and subgroups

For statistical purposes, the sample size needed was calculated at 48 patients per subgroup if comparing the different NRST classifications of each screening tool to each other. Delta/Root Mean Square Standardized Effect equal to 0.25 and a statistical power of 90% were used by the statistician to arrive at this sample size. These parameters would allow the researcher to detect small differences with a good confidence level. The majority of the NRSTs have three nutritional risk classifications and therefore at least 142 patients (3 x 48 patients) would be needed if the patients were equally distributed among the three classifications. That was however highly unlikely and therefore a total sample size of 200-250 patients was estimated by the researcher to be sufficient to allow for adequate comparison.

About 60 new patients are admitted to TAH's SICU per month. Of these, roughly 30 have a SICU stay of at least 48 hours, which was necessary for data analysis. Over an eight month period it was thus estimated that 240 patients would be included in the study.

2.3.3 Methods of data collection

This study formed part of a bigger study entitled "Determination of the nutritional status of patients admitted to the surgical ICU of TAH and identification of correlations thereof with clinical outcomes". Data for both the main and the sub-study was collected simultaneously from November 2010 to June 2011 in the SICU of TAH. All the data was collected by the same researcher; thus there was no need for standardization of fieldworkers. The researcher is a registered dietician.

This was a non-invasive study only using data that is routinely collected in the SICU. Data collection for the study therefore depended on the availability of information.

2.3.3.1 General information

Data was gathered for every patient on each of the following:

- Age
- Gender
- ICU admission and discharge date
- Relevant medical history prior to admission
- Reason for ICU admission
- Diagnosis at ICU admission
- Surgical procedures/investigations (continuously).

Age and gender was obtained to describe the patient demographics while ICU admission and discharge dates were used to calculate LOS. The reason for admission, diagnosis at admission and ongoing surgical procedures were obtained to identify the primary diagnostic groups found in the study. The groups were not defined before the onset of the study, but were selected based on the most prevalent diagnostic categories among the patients once the data was collected.

2.3.3.2 Nutritional risk screening information

All patients were screened within 48 hours after admission. All information needed to complete all seven screening tools was summarised; the collection of the data is discussed below.

Note: In some cases where biochemical data (s-albumin) only became available at a later stage, the screening was completed as soon as possible. If a patient's s-albumin was not tested during the duration of their ICU stay then the NRI screening tool was not completed. This study was non-invasive and thus tests could not be ordered for research purposes only.

When patients were unable to converse effectively with the researcher (i.e. comatose, sedated, demented) alternative methods were used to collect the necessary data. First, the medical file was studied for information on weight loss, dietary intake, gastrointestinal symptoms, disease severity etc. Second, close friends or family members were asked to provide the relevant information. If these were not present within the first 48 hours after admission and a contact number was specified in the patients' file, the contact person was phoned. Only one call was made even if the call was unsuccessful. It was decided that since screening tools are meant to be simple, quick-and-easy to complete, more than one phone call would require too much time and effort for screening purposes.

If no or insufficient screening information could be gathered, the patient was noted as a failed screening patient. In these cases none of the different screening tools were completed; however the patients were still followed up until discharge. This was done to be able to compare information about the development of clinical outcomes in patients who could not be screened versus patients who could be screened.

a) <u>Anthropometrical data</u>

<u>Height</u>

Height was determined using lower arm length. This method has shown good correlation (r=0.98) with standing height and has a five percent error rate. Its use is recommended in patients who are unable to stand or where arm-span measurements are not possible, which is often the case in the ICU patient due to intravenous lines etc.[182]

Method: The patient's arm was held relaxed at his/her side with the elbow bent to form a 90 degree angle, wrist in a neutral position and fingers extended. The lower arm length was measured (in cm) from the olecranon to the tip of the third finger. The measurement was taken twice and the average used as lower arm length. The recommended conversion table was used to determine height from lower arm length (Figure 2.1).[182]

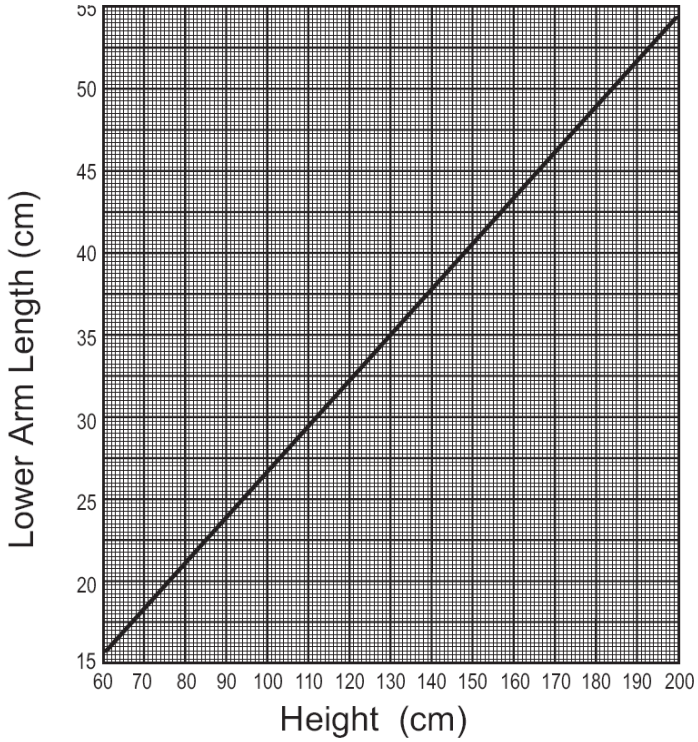


Figure 2.1 Conversion table for determining height from lower arm length[182]

In a few cases it was impossible to measure lower arm length, for example where both arms were in casts. In these cases the bed length method was used to determine height.

Method: The patient was positioned so that the body (head, shoulder, trunk and extremities) was aligned and then a mark was made at the base of the patient's heels as well as the top of their crown. A measuring tape was used to measure the distance between the two marks (in cm) which was then subtracted from the length of the bed.[183]

Body weight

Body weight is extremely difficult to measure in ICU patients as they are mostly bedridden and often also sedated. Furthermore, the use of bed scales is not a common practice in South African hospitals due to a lack of resources. The current practice among dieticians in the SICU of TAH is to estimate body weight in order to calculate nutritional requirements. It was thus decided that for the purpose of this study weight would be estimated.

Care was taken to increase the accuracy of estimations and an objective method was also implemented to verify the estimations (see Section 2.3.5 Reliability and validity). It was decided that two investigators would independently estimate the weight (in kg) of each patient: the researcher as well as the SICU dietician. The average of the two observer's estimations was used as body weight.

When estimating body weight of ICU patients it is important to take into consideration that they are often fluid overloaded. Therefore, if fluid retention was prevalent the fluid-weight was subtracted from estimated body weight to arrive at an oedema-free body weight. To assess fluid status a clinical examination was performed and the patient's fluid balance records were studied. In the case of uncertainty the attending physician was asked to assist with the evaluation of fluid status.

The following guideline was used to compensate for edema/ascites:[184]

Table 2.1 Guideline for deducting weight for oedema and ascites[184]

	Oedema	Ascites
Mild	1 kg	2.2 kg
Moderate	5 kg	6 kg
Severe	10 kg	14 kg

In the case of a patient with an amputation, the weight of the amputated limb(s) was subtracted from total body weight.[183] Therefore, when estimating body weight, the observer did not have to compensate for the amputation. Body weight was estimated as if the amputated limb was present. The following table indicates the percentage of total body weight that each limb represents.[183]

Table 2.2 Guideline for deducting weight for amputated limbs[183]

Body part	% of total body weight
Entire arm	6.5
Upper arm	3.5
Forearm	2.3
Hand	0.8
Entire leg	18.5
Upper leg	11.6
Lower leg	5.3
Foot	1.8

Body mass index

BMI was calculated by dividing weight (after subtracting for fluid overload or amputation if necessary) with height in meters squared.[183]

b) Weight changes

Each patient was asked about recent changes in weight. Patients were asked to be as specific as possible and provide weight loss in kilograms as well as the time frame of the weight loss. To accommodate the different screening tools, patients were asked about weight loss in the previous two weeks, three months and six months. Patients were also asked about their usual weight before weight loss occurred. From this the researcher was able to calculate percentage of weight loss using the formula below:

Percentage of weight loss = (usual weight – amount of weight lost) / usual weight x 100[183]

Of the seven NRSTs, only the MST and the MNA-SF provide options for when patients or health care providers are unsure about changes in weight. For the other screening tools a definite answer is necessary and the following methods were used: where patients could not quantify the amount of weight lost, they were asked to classify it as mild, moderate or severe. If patients were unsure about weight loss, they were asked about symptoms such as anorexia or decreased food intake that could have led to weight loss. They were also asked whether their clothes fit as normal or if they have dropped in dress size. From this the researcher then estimated the amount of weight lost.

c) Dietary intake

The patient was asked about recent changes in appetite or dietary intake. If there had been a decrease in appetite or intake, the patient had to specify the degree (mild, moderate or severe), the time frame and the specific type of restriction (suboptimal intake, liquids only, starvation). Patients were also asked about use of supplemental drinks or tube feed in the previous month as well as their functional ability to eat.

d) Biochemistry

The NRI tool required s-albumin values for screening and therefore the first s-albumin value available for each patient was noted. No additional bloods were drawn for this study.

e) Clinical examination

Only the SGA tool required a physical examination of each patient. Therefore the methods described by Detsky et al.[43] for completion of the SGA physical examination were used. All patients were

examined for evidence of loss of subcutaneous fat, muscle wasting, and oedema which was then graded as normal, mild moderate or severe.

- To assess loss of subcutaneous fat the shoulders, triceps, chest and hands was examined for loss of fullness.
- To assess the presence of muscle wasting the deltoid muscles and quadriceps femoris muscles was examined. The deltoid muscles are the muscles at the sides of the shoulders and the quadriceps femoris muscles are the muscles of the anterior thigh.
- To assess the presence of oedema, the ankles and sacrum were examined. The area was tested for pitting oedema by pressing down with a finger for two seconds and then observing for a persistent indentation.[43]

f) <u>Gastrointestinal symptoms</u>

Patients were asked about any symptoms of nausea, vomiting, diarrhoea or anorexia in the past two weeks.

g) <u>Medical data</u>

The patient was asked about the severity of their disease, their history of acute disease, any neuropsychological problems and their mobility. The medical file was also studied and the attending doctor consulted to verify the answers.

2.3.3.3 Observation of clinical outcomes

Patients were followed up daily for the duration of their SICU stay. The following clinical outcomes were documented for each patient:

a) Length of stay: The number of days from admission to discharge or death of the patient was noted.

b) Length of ventilation: The number of days that a patient required ventilation (full or partial ventilation) was recorded.

c) Mortality: If death occurred during SICU stay this was recorded. Only in-SICU mortality was studied.

d) APACHE II: The Acute Physiology, Age and Chronic Health Evaluation II (APACHE II) score was used as the scoring system for severity of disease as this is the current practice in TAH. The

APACHE II scoring system is an ICU scoring system that measures disease severity and risk of death. A number of physiological variables (age, white cell count, hematocrit, mean arterial pressure, rectal temperature, heart rate, respiratory rate, Glasgow coma scoring, serum sodium, serum potassium, serum creatinine, arterial pH, history of severe organ insufficiency or immunosuppression and oxygenation) are measured, scored and added together to arrive at a total score. A higher total score is indicative of higher risk of death.[185] The attending doctor calculated each patient's APACHE II score before discharge.

e) **Complications:** The occurrence of any complications during SICU stay was noted daily. The modified criteria of Buzby et al. were used to classify complications according to their severity.[186]

Table 2.3 Classification of complications according to severity[186]

Grade	List of complications
Mild	Cutaneous, catheter and urinary infections, cellulites, oral and oesophageal candidiasis, lobar atelectasis and infectious diarrhea
Moderate	Pulmonary infection, extra- and intra-abdominal abscesses, spontaneous bacterial peritonitis, venous thrombosis, liver dysfunction, cardiac arrhythmia, pancreatic or biliary gastrointestinal fistula, renal and congestive heart failure, wound dehiscence, gastrointestinal bleeding, decubitis ulcers, post-operative bleeding and empyema
Severe	Sepsis or bacteremia, septic shock, coagulopathy or septic coagulopathy, cholangitis, cardiac arrest, rejection of transplanted organ, respiratory failure, myocardial infarction, pancreatitis, osteomyelitis and pulmonary embolism

The medical file and bed chart were used to obtain information about the development of complications and the attending doctor was asked to assist if the classification of complications was unclear.

f) **Biochemistry:** The following biochemical values were noted on a daily basis or as they became available: s-albumin, C-reactive protein (CRP) and white cell count (WCC). Total protein is not routinely tested in the SICU of TAH and therefore it could not be included in the outcomes studied. Only routinely collected laboratory data was noted – no additional bloods were drawn. For s-albumin the lowest value observed during SICU stay was noted as

minimum s-albumin. For CRP and WCC the highest value observed during SICU stay was noted as maximum CRP and maximum WCC.

2.3.4 Measuring feasibility and applicability

The applicability and feasibility of using NRSTs in the SICU was assessed by noting the availability of the necessary data within the first 48 hours of SICU stay. The method of obtaining data was recorded e.g. could data be obtained from the patient, medical folder, family member or friend or was no data available. It was also noted on which day the patient was first able to communicate effectively with the researcher. This enabled the researcher to identify which NRSTs and, more specifically, which elements of NRSTs, are applicable for use in this population.

2.3.5 Reliability and validity

2.3.5.1 General reliability and validity

The validity and reliability of the various NRSTs have been discussed in the literature overview. The researcher familiarized herself with the screening methodology for each of the screening tools to ensure valid screening results. Inter-observer variation was eliminated by having only one researcher collect all the relevant data (except for body weight – see above).

Standardised methods, in which the researcher was trained, were used for all anthropometrical measurements. A non-stretchable tape measure was used for MUAC, lower arm length and bed length.

If any uncertainty existed the attending medical doctor was asked to assist with the determination of the degree of fluid overload and the physical assessment of muscle and fat wastage.

Data was entered into Excel spreadsheets by the same researcher and was spot-checked before analysis to minimize the prevalence of data-capturing errors. A qualified statistician performed all data-analyses.

2.3.5.2 Reliability and validity of body weight estimations

To increase the accuracy of body weight estimations, a second observer (the SICU dietician) was asked to also provide a weight estimation for each patient. The average of the two estimations was used as estimated body weight.

To test the reliability and validity of the body weight estimations two tests were conducted. First, the agreement between the two observer's weight estimations was measured to provide information about inter-observer reliability.

Second, the estimated body weight was also compared to an objective measurement of body weight as determined by knee height (KH) and MUAC. This method is recommended for use in bedridden patients and uses KH and MUAC in a formula to calculate an estimated body weight.[183] However the method is labour intensive and specialised equipment is necessary, which makes it impractical for screening purposes. It also has a wide accuracy range which may imply it is not necessarily more accurate that visual body weight estimations. Nonetheless it was decided to use this method as an objective measure of body weight with which to compare the dieticians' estimations.

Measuring MUAC

The patient rested in the supine position and the left or right arm was used. The upper arm was held parallel to the body, with the elbow bent to form a 90 degree angle and the forearm resting on the upper body with the palm facing downwards. The midpoint of the arm was marked halfway between the tip of the acromion process and the olecranon process. The arm was then stretched out parallel to the body with the palm facing upwards. The arm was elevated by placing a pillow under the elbow. A tape measure was used to measure the arm circumference in a vertical plane in line with the midpoint of the arm. The soft tissue was not compressed and the measurement was taken to the nearest millimeter.[183]

Measuring KH

Knee height was measured using a length-measuring rod with one fixed and one moveable blade. The patient rested in the supine position with the left leg positioned so that the knee and ankle were at a right angle. The fixed blade of the measuring instrument was then placed under the heel of the foot while the adjustable blade was positioned on the anterior surface of the thigh. The shaft of the measuring instrument was positioned parallel to the fibula, posterior to the head of the fibula and over the lateral malleolus. Soft tissue was compressed as the purpose was to measure the bone only. The measurement was taken to the nearest millimeter.[183]

Table 2.4 lists the formulae used to calculate body weight from MUAC and KH.[183]

Table 2.4 Formulae for calculating body weight from MUAC[a] and KH[b] [183]

Age	Race	Equation	Accuracy
Female			
6 - 18	Black	Wt = (KH x 0.71) + (MUAC x 2.59) – 50.43	± 7.65 kg
	White	Wt = (KH x 0.77) + (MUAC x 2.47) – 50.16	± 7.20 kg
19 - 59	Black	Wt = (KH x 1.24) + (MUAC x 2.97) – 82.48	± 11.98 kg
	White	Wt = (KH x 1.01) + (MUAC x 2.81) – 66.04	± 10.60 kg
60 - 80	Black	Wt = (KH x 1.50) + (MUAC x 2.58) – 84.22	± 14.52 kg
	White	Wt = (KH x 1.09) + (MUAC x 2.68) – 65.51	± 11.42 kg
Male			
6 - 18	Black	Wt = (KH x 0.59) + (MUAC x 2.73) – 48.32	± 7.50 kg
	White	Wt = (KH x 0.68) + (MUAC x 2.64) – 50.08	± 7.82 kg
19 - 59	Black	Wt = (KH x 1.09) + (MUAC x 3.14) – 83.72	± 11.30 kg
	White	Wt = (KH x 1.19) + (MUAC x 3.21) – 86.82	± 11.42 kg
60 - 80	Black	Wt = (KH x 0.44) + (MUAC x 2.86) – 39.21	± 7.04 kg
	White	Wt = (KH x 1.10) + (MUAC x 3.07) – 75.81	± 11.46 kg

[a] Mid-Upper Arm Circumference, [b] Knee Height

Note: If a patient's fluid status influenced MUAC measurements (e.g. in the case of upper body oedema) the same methods as described previously were used to correct for the extra fluid weight. This was done so that oedema-free estimated body weight could be compared with oedema-free calculated body weight. Limb amputations were also corrected for as described previously.

2.3.6 Data extraction

A summary was made of all the information necessary to complete all seven screening tools. The researcher designed a single extraction form to gather all the relevant information since there were many overlaps between the screening tools and to improve use of time. The information was then used to complete the different screening tools upon data capturing.

The data extraction sheet was pilot tested during October 2010 on 4 SICU patients. The extraction sheet was found to be sufficient to collect all the necessary data. An example of the data extraction sheet can be seen in Addendum 1.

2.4 DATA ANALYSIS

2.4.1 NRSTs

Table 2.5 (following pages) indicates how the various screening tools were used to classify each patient's nutritional status. Each NRST was used according to the guidelines set out by the various developers and as described in the literature overview. The only exception was measuring disease severity for the MUST. In practice, when screening hospitalized patients, it is recommended that

critically ill patients should be scored two, which would automatically classify them as malnourished. However as this would have classified 100% of our study population as malnourished it seemed pointless and it was decided to follow the usual protocol for scoring disease severity.

Table 2.5 Nutritional Risk Screening Tool scoring and classification[43,46,53,65,66,109,130]

NRST	SCORING		CLASSIFICATION
MUST	**a) BMI**		Add up a, b and c for total score 0 = Well-nourished 1 = Risk of malnutrition >2 = Malnourished
	>20	0	
	18.5-20	1	
	<18.5	2	
	b) Unintentional weight loss in past 3-6months		
	<5%	0	
	5-10%	1	
	>10%	2	
	c) If patients is acutely ill AND there has been or is likely to be no or very little nutritional intake >5 days:	2	
MNA-SF	**a) Declined food intake**		Add up a, b, c, d, e and f for total score 12-14 Well-nourished 8-11 Risk of malnutrition 0-7 Malnourished
	Severe	0	
	Moderate	1	
	None	2	
	b) Weight loss in last 3 months		
	>3kg	0	
	Unsure	1	
	1-3kg	2	
	none	3	
	c) Mobility		
	Bed/chair bound	0	
	Mobile but sedentary	1	
	Active	2	
	d) Psychological stress/acute disease in past 3 months		
	Yes	0	
	No	2	
	e) Neuropsychological problems		
	Severe dementia/depression	0	
	Mild dementia	1	
	None	2	
	f) BMI		
	<19	0	
	19-21	1	
	21-23	2	
	≥ 23	3	

NRS-2002	**a) Nutritional screening** Normal 0 Weight loss >5% in 3 months OR food intake <50-75% of normal in preceding week 1 Weight loss >5% in 2 months OR BMI 18.5-20.5 OR food intake 25-60% of normal in preceding week 2 Weight loss >5% in 1 month OR BMI <18.5 OR food intake 0-25% of normal in preceding week 3 **b) Severity of disease screening** Normal nutritional requirements 0 Hip fracture/Chronic patients with acute complications: cirrhosis, COPD, hemodialysis, diabetes, oncology (nutritional requirements met with oral supplementation) 1 Major abdominal surgery, stroke, severe pneumonia, hematologic malignancy (increased requirements, need artificial feeding) 2 Head injury, bone marrow transplant, ICU (APACHE >10)(ventilation, inotropic support, protein requirements very high, difficult to provide) 3	Add up a and b for total score: 0 Well-nourished 1-2 Risk of malnutrition ≥ 3 Malnourished
NRI	NRI score = (1.519 x s-albumin) + 0.417 x (current weight/usual weight x 100)	**>100** Well-nourished **97.6-100** Mild malnutrition **83.6-97.5** Moderate malnutrition **≤ 83.5** Severe malnutrition
MST	**a) Recent unintentional weight loss** No 0 Unsure 2 1-5kg 1 6-10kg 2 11-15kg 3 >15kg 4 **b) Poor intake due to decreased appetite?** No 0 Yes 1	Add up a and b for total score: 0-1 Well-nourished ≥ 2 Malnourished
SNAQ	**a) Unintentional weight loss** None / little 0 ≥ 6kg in past 6 months 3 ≥ 3kg in past months 2	Add up a, b and c for total score: 0-1 Well-nourished

	b) Decreased appetite over past month	2 Risk of malnutrition
	No 0	≥3 Malnourished
	Yes 1	
	c) Supplemental drinks /tube feed in past month	
	No 0	
	Yes 1	
SGA	**a) Recent weight change (0-12 months)**	Count number of A, B and C's for question numbers a-i:
	<5% A	
	5-10% B	
	>10% C	
	b) Weight change last two weeks	Mostly A's
	Kept losing C	Well-nourished
	No change B	
	Gained A	Mostly B's
	c)Dietary intake – amount	Moderately malnourished
	No change A	
	Moderate decrease B	Mostly C's
	Severe decrease C	Severely malnourished
	d) Dietary intake – type	
	Normal A	**NB:** A, B and C allocations is only a guideline - subjective clinical judgment should be used to classify the patient in the end.
	Suboptimal solids/full liquid B	
	Little fluids / NPO C	
	e) Gastrointestinal symptoms >2weeks (Nausea, vomiting, diarrhoea, dysphagia/ odinophagia, anorexia)	
	None A	
	One symptom B	
	Two or more symptoms C	
	f) Functional impairment	
	None A	
	Mild B	
	Severe C	
	g) Muscle wasting	
	None A	
	Mild-moderate B	
	Severe C	
	h) Fat wasting	
	None A	
	Mild-moderate B	
	Severe C	
	i) Oedema	
	None A	
	Mild-moderate B	
	Severe C	

2.4.2 Statistical analysis

MS Excel was used to capture the data and STATISTICA version 9 (StatSoft Inc. (2009) STATISTICA (data analysis software system, www.statsoft.com) was used to analyse the data.

Summary statistics were used to describe variables such as patient demographics, NRST classifications and clinical outcomes. Distributions of variables are presented with frequency tables. Medians or means were used as the measures of central location for ordinal and continuous responses and standard deviations and quartiles as indicators of spread.

The relationships between continuous response variables such as LOS, length of ventilation (LOV), APACHE II score, complications, and biochemistry values, and nominal input variables such as the different NRST classifications were analysed using appropriate analysis of variance (ANOVA). For completely randomized designs the Mann-Whitney test or the Kruskal-Wallis test was used.

The relation between two nominal variables such as NRST classification and mortality was investigated with contingency tables and likelihood ratio chi-square tests.

Relationships between two continuous variables such as comparing body weight estimations between investigators and comparing estimated body weight with calculated body weight was analysed with regression analysis and the strength of the relationship measured with the Pearson correlation, or Spearman correlation if the continuous variables were not normally distributed.

A p-value of $p < 0.05$ represented statistical significance in hypothesis testing and 95% confidence intervals were used to describe the estimation of unknown parameters.

The adequacy of NRSTs to predict clinical outcomes was judged based on overall performance. In other words, all clinical outcomes carried equal weight. NRSTs that were significantly and positively associated with more clinical outcomes than other tools were considered to have better predictive ability. If a tool could not significantly predict any clinical outcomes then it was considered to have poor predictive ability.

2.5 BUDGET

The following table depicts the research expenses. The umbrella study was granted R50,000 by Sub-Committee C of the Research Committee of the Faculty of Health Sciences and this was applied to cover all research costs.

Table 2.6 Research project budget

Item	Quantity	Cost per item	Total
Data extraction sheets	2016	R0.25 / page	R504
Telephone calls	40 calls	R5.00 / call average	R200
		Total	**R704**

Expenses related to the researcher's thesis (language editing and printing) were covered by the researcher.

2.6 ETHICAL AND LEGAL CONSIDERATIONS

Ethical approval was granted for the umbrella study in August 2010 (Project number: N10/07/243). There was no need for further ethical approval as this study formed part of the aims, objectives and methodology outlined in the umbrella study.

The protocol for the umbrella study was also reviewed by the Medical Superintendent of Research in TAH and permission was obtained to proceed with the study.

A waiver of informed consent was requested by the umbrella study, due to the fact that ICU patients are often sedated and family members are not always present. The study was also non-invasive and only made use of routinely collected data. The waiver was granted and permission from the Head of the SICU was considered as consent on behalf of the patients.

Privacy and confidentiality was at all times respected. Identifying information was and will be kept confidential. The data gathered was and will be used only for the purpose of this study as well as the umbrella study.

2.7 TIME SCHEDULE

The pilot study for the data extraction sheet was conducted during October 2011. The research project then began in November 2011 and data collection continued until June 2012. Data was thus collected for a total of eight months.

CHAPTER 3: RESULTS

3.1 STUDY POPULATION

During the eight month study period a total of 252 SICU patients met the inclusion criteria and were included in the study. Of these patients, 46 patients (18.25%) failed nutritional risk screens due to the unavailability of data. These patients were not able to effectively communicate with the researcher and their data could not be gathered from other sources such as the medical file or friends or family. Therefore these patients were excluded from the data analysis on the relationship between NRST classification and clinical outcomes. The final study population thus consisted of 206 SICU patients.

3.1.1 Demographic data

The demographics of the SICU patients included in the study are summarized in Table 3.1. Of the 206 patients, 62.62% were males and 37.38% were females. The mean age of study participants was 49.52 (SD 17.39) years, with 78.16% younger than 65 years and 21.84% older than or equal to 65 years of age. More than half (57.78%) of the patients were emergency admissions; the rest (42.23%) being elective surgery patients.

Table 3.1 Demographic characteristics of patient population (n=206)

Patient demographics	n (%)	n (%)
Gender	Male 129 (62.62%)	Female 77 (37.38%)
Age Mean: 49.52 (SD 17.39) years	<65 years 161 (78.16%)	≥ 65 years 45 (21.84%)
Admission status	Emergency 119 (57.77%)	Elective 87 (42.23%)

The majority (43.69%) of the study participants fell into the gastrointestinal surgery diagnostic group. Vascular surgery (15.53%) and polytrauma (12.62%) were the second and third largest diagnostic groups. Seven patients did not fit into any of the diagnostic groups and were grouped together in the category "other" (Table 3.2). Their diagnoses were as follows: GIST tumor, ankle fracture, spinal injury, Fournier's gangrene, necrotic penis, Gilberts' syndrome and typhosis.

Table 3.2 Primary diagnosis of patient population (n=206)

Diagnostic group	n (%)
Gastrointestinal surgery	90 (43.69%)
Vascular surgery	32 (15.53%)
Polytrauma	26 (12.62%)
Gynaecological surgery	13 (6.31%)
Urogenital surgery	13 (6.31%)
Other	7 (3.40%)
Assault	6 (2.91%)
Respiratory	6 (2.91%)
Infectious	5 (2.43%)
Trauma	4 (1.94%)
Metabolic	3 (1.46%)
Renal	1 (0.49%)

The majority of study patients (n=166; 80.58%) had a BMI of more than 20.00, while 21 (10.19%) had a BMI between 18.50 and 19.99 and 19 (9.22%) had a BMI of less than 18.50. The average BMI of the group was 24.78 (SD 5.86). Figure 3.1 depicts the spread of patients according to BMI category.

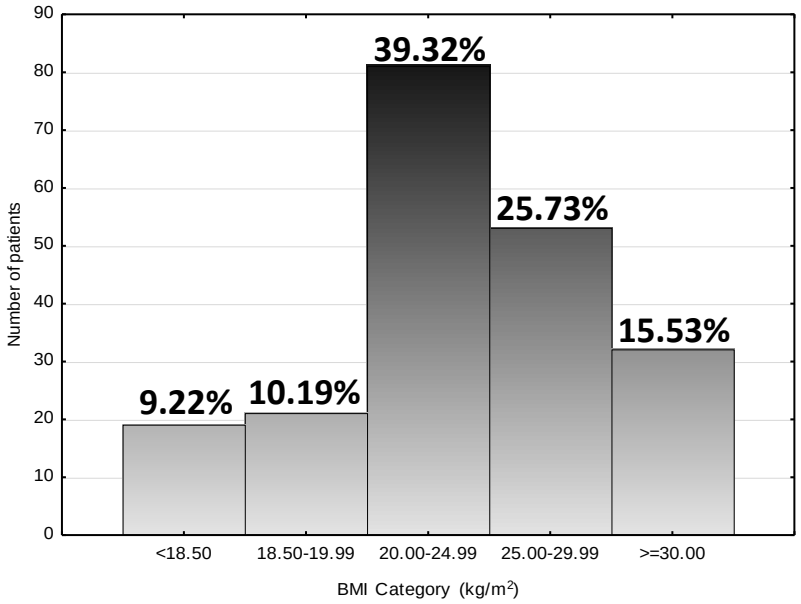


Figure 3.1 Number of patients within the five BMI categories (n=206)

3.1.2 Clinical outcomes

The mean LOS in SICU was 5.75 (SD 5.52) days and the mean LOV was 2.93 (SD 5.08) days. Only five patients (2.44%) died during SICU stay. The mean APACHE II score was 10.41 (SD 5.51). The mean of the minimum s-albumin values was 22.77 (SD 6.20) and the mean of the maximum CRP and WCC levels were respectively 182.01 (SD 117.11) and 15.89 (SD 9.51). Forty-one percent (41.26%, n=85) of SICU patients did not develop any complications whereas 23.30% (n=48) developed one complication, 15.05% (n=31) developed two complications and 20.39% (n=42) developed three or more complications. Regarding the different complication categories, 21.36% (n=44) of SICU patients developed at least one mild complication, 45.63% (n=94) developed at least one moderate complication and 33.01% (n=68) developed at least one severe complication. The average number of total, mild, moderate and severe complications were respectively 1.51 (SD 2.04), 0.28 (SD 0.63), 0.70 (SD 0.98) and 0.53 (SD 0.92). Patient outcomes are summarised in Table 3.3.

Table 3.3 Summary of clinical outcomes observed in patient population (n=206)

Clinical outcome	**Mean (SD)**
LOS (days)	5.75 (5.52)
LOV (days)	2.93 (5.08)
APACHE II score (score)	10.41 (5.51)
Complications (number) Total Mild Moderate Severe	 1.51 (2.04) 0.28 (0.63) 0.70 (0.98) 0.53 (0.92)
Biochemistry Minimum s-albumin (g/l) Maximum WCC (x 10^9/l) Maximum CRP (mg/l)	 22.77 (6.20) 15.89 (9.51) 182.01 (117.11)
Clinical outcome	**n (%)**
Mortality	5 (2.44%)

3.2 PREVALENCE OF MALNUTRITION

The NRST classifications for the various screening tools are summarised in Table 3.4.

Table 3.4 Patient classification according to the various NRSTs[a]

NRST	Well-nourished	Risk of malnutrition	Malnourished
MUST	105 (50.97%)	39 (18.93%)	62 (30.10%)
MNA	63 (30.58%)	109 (52.91%)	34 (16.50%)
SNAQ	132 (64.10%)	14 (6.80%)	60 (29.13%)
NRS-2002	1 (0.49%)	55 (26.70%)	150 (72.82%)
SGA	105 (50.97%)	63 (30.58%)	38 (18.45%)

	Well-nourished	Malnourished
MST	45 (21.84%)	161 (78.16%)

	Well-nourished	Mildly malnourished	Moderately malnourished	Severely malnourished
NRI	3 (1.70%)	4 (2.27%)	37 (21.02%)	132 (75.00%)

[a] **Nutritional Risk Screening Tools**

3.3 NRST PREDICTIONS OF CLINICAL OUTCOMES

3.3.1 MUST

According to the MUST 105 patients (50.97%) were classified as well-nourished, 39 (18.93%) as at risk of malnutrition and 62 (30.10%) as malnourished (Figure 3.2).

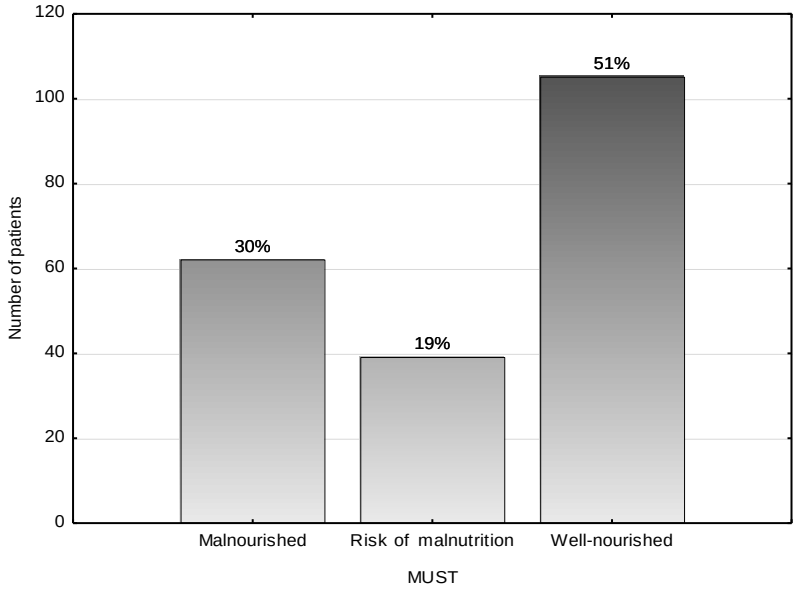


Figure 3.2 Prevalence of malnutrition according to the Malnutrition Universal Screening Tool

No significant correlations were found between the MUST and any of the clinical outcomes. The malnourished patients seemed to have the lowest s-albumin levels and the highest APACHE II scores, but this was non-significant. There was also a trend for the malnourished or at risk of malnutrition patient groups to have a longer LOS and LOV as well as more mild complications and a higher WCC than the well nourished patients, but none of this reached statistical significance. Also, the group at risk of malnutrition seemed to have the worst outcomes for LOS, LOV, mild complications and WCC and not, as may have been expected, the malnourished group. Although not significant, the well nourished group had the highest mortality and the most total, moderate and severe complications. Tables 3.5 and 3.6 summarize the non-significant results for the MUST.

When the group at risk of malnutrition and the group classified as malnourished were analysed together (n=101; 49.03%) and compared to the well-nourished group (n=105; 50.97%), there were still no significant correlations with any of the clinical outcomes measured. The group combining the at risk patients and the malnourished patients had a longer LOS and LOV, higher APACHE II scores, more mild complications, lower s-albumin levels and higher WCC and CRP levels than the well-nourished group, but none of this reached statistical significance. The non-significant results can be seen in Tables 3.7 and 3.8.

Table 3.5 Non-significant clinical outcome results for the MUST[a] nutritional risk categories

	Total	Normal	Risk Malnutrition	Malnourished	p-value	Test
	(n=205)	(n=105)	(n=38)	(n=62)	p=0.91	Kruskal-Wallis test
Mean LOS (days)	5.75	5.37	7.09	5.56		
SD	5.52	4.36	8.47	4.94		
CI	4.99 – 6.51	4.53 – 6.21	4.31 – 9.88	4.31 – 6.82		
	(n=205)	(n=105)	(n=38)	(n=62)	p=0.92	Kruskal-Wallis test
Mean LOV (days)	2.93	2.54	3.81	3.03		
SD	5.08	4.22	6.88	5.15		
CI	2.23 – 3.63	1.73 – 3.36	1.55 – 6.08	1.72 – 4.34		
	(n=197)	(n=102)	(n=36)	(n=59)	p=0.11	Kruskal-Wallis test
Mean APACHE II score	10.41	10.28	9.34	11.24		
SD	5.51	5.48	6.15	5.11		
CI	9.63 – 11.18	9.21 – 11.36	7.31 – 11.47	9.91 – 11.36		
	(n=206)	(n=105)	(n=39)	(n=62)	p=0.61	Kruskal-Wallis test
Mean number of total complications	1.51	1.60	1.46	1.40		
SD	2.04	2.08	2.53	1.60		
CI	1.23 – 1.79	1.20 – 2.00	0.64 – 2.28	1.00 – 1.81		
	(n=206)	(n=105)	(n=39)	(n=62)	p=0.81	Kruskal-Wallis test
Mean number of mild complications	0.28	0.25	0.31	0.31		
SD	0.63	0.60	0.69	0.64		
CI	0.19 – 0.36	0.13 – 0.36	0.08- 0.53	0.14 – 0.47		
	(n=206)	(n=105)	(n=39)	(n=62)	p=0.71	Kruskal-Wallis test
Mean number of moderate complications	0.70	0.78	0.64	0.61		
SD	0.98	1.07	1.01	0.78		
CI	0.57 – 0.84	0.57 – 0.99	0.31 – 0.97	0.42 – 0.81		
	(n=206)	(n=105)	(n=39)	(n=62)	p=0.43	Kruskal-Wallis test
Mean number of severe complications	0.53	0.57	0.51	0.48		
SD	0.92	0.91	1.21	0.72		
CI	0.41 – 0.66	0.40 – 0.75	0.12 – 0.91	0.30 – 0.67		

	(n=176)	(n=90)	(n=33)	(n=53)	p=0.07	Kruskal-Wallis test
Mean s-albumin (g/l)	22.77	23.47	23.28	21.15		
SD	6.20	5.96	6.60	6.17		
CI	21.85 – 23.70	22.22 – 24.72	21.14 – 25.83	19.45 – 22.85		
	(n=164)	(n=83)	(n=31)	(n=50)	p=0.93	Kruskal-Wallis test
Mean CRP (mg/l)	182.01	179.26	200.39	175.16		
SD	117.11	102.94	161.49	102.94		
CI	163.95 – 200.06	156.79 – 201.74	141.15 – 259.62	144.48 – 205.84		
	(n=189)	(n=97)	(n=36)	(n=56)	p=0.45	Kruskal-Wallis test
Mean WCC (x 10^9/l)	15.89	15.34	16.22	16.63		
SD	9.51	9.57	6.50	11.02		
CI	14.52 – 17.25	13.41 – 17.26	14.01 – 18.42	13.68 – 19.58		

[a] **Malnutrition Universal Screening Tool**

Table 3.6 M-L Chi-square test of the presence or absence of death by MUST[a] category (p=0.29)

MUST	Death - present	Death - absent	Row - Totals
Normal	4 (3.81%)	101 (96.19%)	**105**
Risk malnutrition	1 (2.63%)	37 (97.37%)	**38**
Malnourished	0 (0.00%)	61 (100.00%)	**62**
Totals	**5**	**200**	**205**

[a] **Malnutrition Universal Screening Tool**

Table 3.7 Non-significant clinical outcome results for the MUST[a] nutritional risk outcomes

	Total	Well-nourished	At risk of malnutrition + malnourished	p-value	Test
	(n=205)	(n=105)	(n=100)	p=0.70	Mann-Whitney U test
Mean LOS (days)	5.75	5.37	6.14		
SD	5.52	5.36	6.51		
CI	4.99-6.51	4.53-6.21	4.85-7.44		
	(n=205)	(n=105)	(n=100)	p=0.80	Mann-Whitney U test
Mean LOV (days)	2.93	2.54	3.33		
SD	5.08	4.22	5.85		
CI	0.23-3.63	1.73-3.36	2.17-4.49		
	(n=197)	(n=102)	(n=95)	p=0.98	Mann-Whitney U test
Mean APACHE II score	10.41	10.28	10.54		
SD	5.51	5.48	5.57		
CI	9.63-11.18	9.21-11.36	9.40-11.67		
	(n=206)	(n=105)	(n=101)	p=0.76	Mann-Whitney U test
Mean number of total complications	1.51	1.60	1.43		
SD	2.04	2.08	2.00		
CI	1.23-1.79	1.20-2.00	1.03-1.82		
	(n=206)	(n=105)	(n=101)	p=0.69	Mann-Whitney U test
Mean number of mild complications	0.28	0.25	0.31		
SD	0.63	0.60	0.66		
CI	0.19-0.36	0.13-0.36	0.18-0.44		
	(n=206)	(n=105)	(n=101)	p=0.49	Mann-Whitney U test
Mean number of moderate complications	0.70	0.78	0.62		
SD	0.98	1.07	0.87		
CI	0.57-0.84	0.57-0.99	0.45-0.80		
	(n=206)	(n=105)	(n=101)	p=0.51	Mann-Whitney U test
Mean number of severe complications	0.53	0.57	0.50		
SD	0.92	0.91	0.93		
CI	0.41-0.66	0.40-0.75	0.31-0.68		

	(n=176)	(n=90)	(n=86)	p=0.10	Mann-Whitney U test
Mean s-albumin (g/l)	22.77	23.47	22.05		
SD	6.20	5.96	6.40		
CI	21.85-23.70	22.22-24.72	20.67-23.42		
	(n=164)	(n=83)	(n=81)	p=0.84	Mann-Whitney U test
Mean CRP (mg/l)	182.01	179.26	184.81		
SD	117.11	102.94	130.64		
CI	163.95-200.06	156.79-210.74	155.93-213.70		
	(n=189)	(n=97)	(n=92)	p=0.27	Mann-Whitney U test
Mean WCC (x 10^9/l)	15.89	15.34	16.47		
SD	9.51	9.57	9.47		
CI	14.52-17.25	13.41-17.26	14.51-18.43		

[a] **Malnutrition Universal Screening Tool**

Table 3.8 M-L Chi-square test of the presence or absence of death by MUST[a] outcome (p=0.12)

MUST	Death - present	Death - absent	Row - Totals
Well-nourished	2 (2.86%)	68 (97.14%)	**70**
At risk of malnutrition + malnourished	0 (0.00%)	59 (100.00%)	**59**
Total	**2**	**127**	**129**

[a] **Malnutrition Universal Screening Tool**

3.3.2 MNA-SF

Overall the MNA-SF classified 63 patients (30.58%) as well-nourished. One-hundred and nine patients (52.19%) were classified as at risk of malnutrition and 34 (16.50%) as malnourished (Figure 3.3).

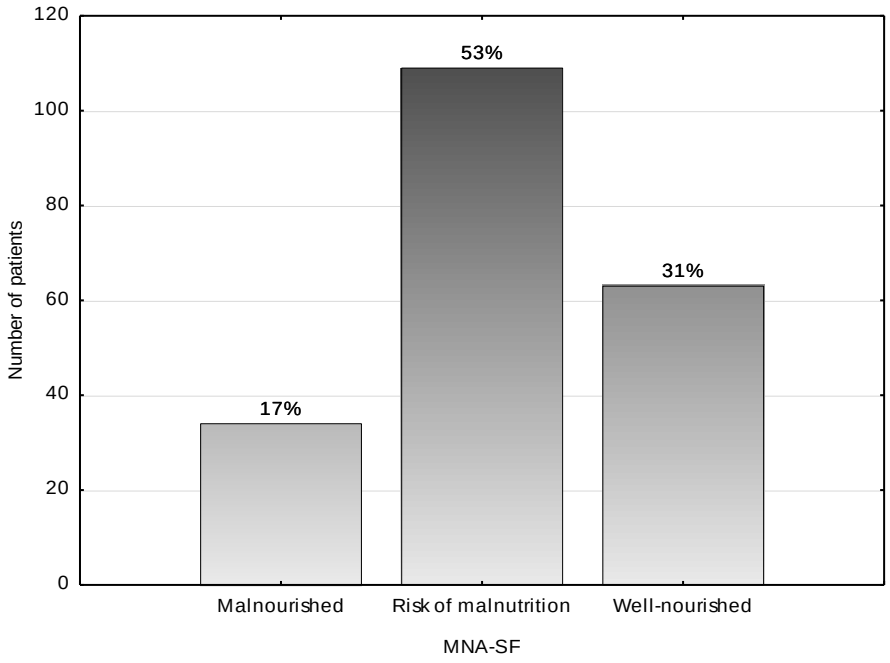


Figure 3.3 Prevalence of malnutrition according to the Mini-Nutritional Assessment - Short Form

A significant correlation was found between the MNA-SF and s-albumin levels (p<0.01; Kruskal-Wallis test) when analysing for all three groups (Figure 3.4). The malnourished patients had a lower mean s-albumin level (19.83; SD 6.89; CI 17.21-22.45) than the well-nourished patients (24.13; SD 5.70; CI 22.56-25.70) and the patients at risk of malnutrition (22.91; SD 6.02; CI 21.68-24.15) When analysing for two groups only, the difference was significant between the malnourished and the well-nourished patients (p<0.01; Bonferroni test) and borderline significant between the malnourished and at risk of malnutrition patients (p=0.05; Bonferroni test). The patients at risk of malnutrition also had lower s-albumin levels than the well-nourished group, but this was not statistically significant.

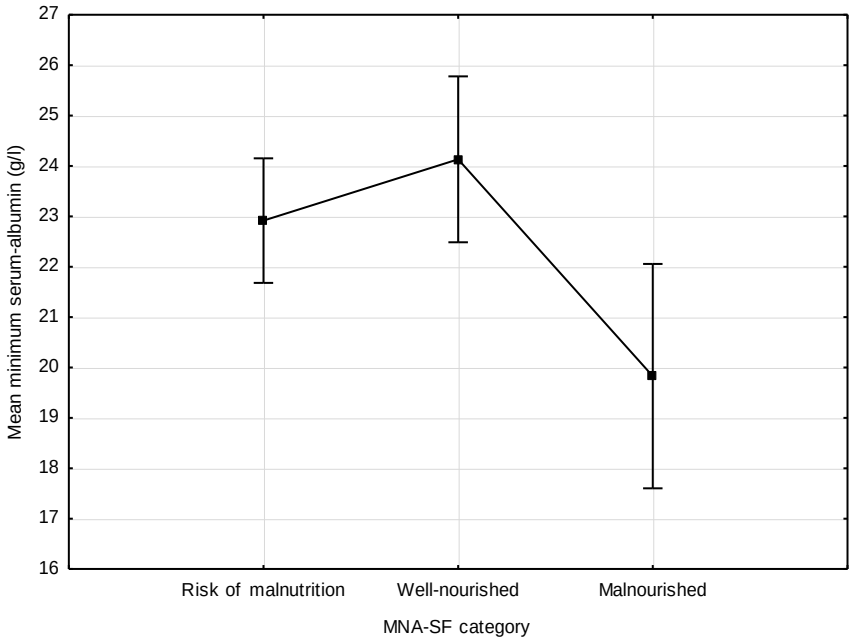


Figure 3.4 Mean minimum serum-albumin per Mini-Nutritional Assessment - Short Form category (p<0.01)

The MNA-SF was also correlated with WCC (p=0.01; Kruskal-Wallis test) when analysing for all three groups (Figure 3.5). The patients at risk of malnutrition had the highest WCC (17.58; SD 11.62; CI 15.27-19.88). Compared to the well nourished patients (13.19; SD 5.35; CI 11.79-14.58) this was significantly higher (p=0.01; Bonferroni test) but not when compared to the malnourished group (15.57; SD 6.62; CI 13.09-18.04). There was also no significant difference between the WCC of the malnourished and well-nourished groups.

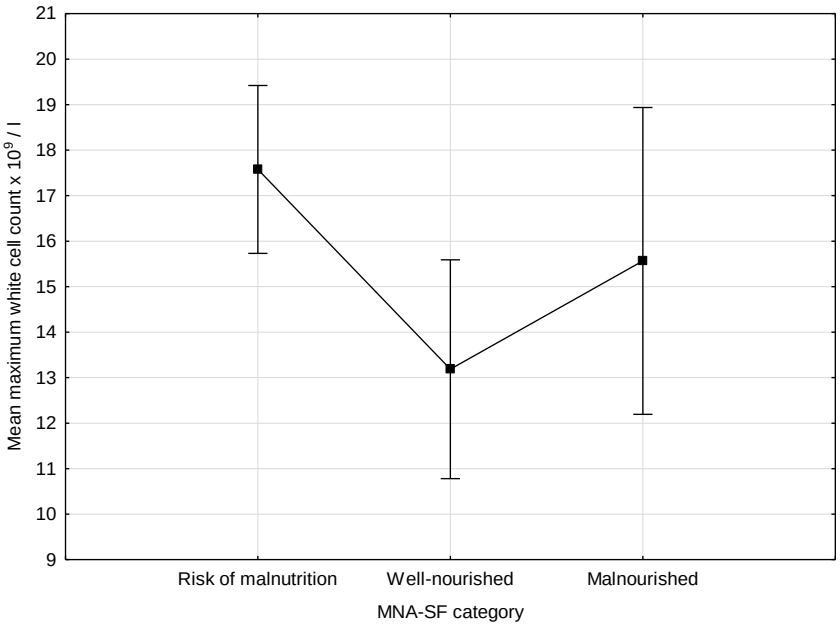


Figure 3.5 Mean maximum white cell count per Mini-Nutritional Assessment - Short Form category (p=0.01)

Although not significant, there was a trend for malnourished patients to have the longest LOS and LOV followed by at risk of malnutrition patients. The APACHE II scores and number of mild, moderate and total complications were also higher in the malnourished and at risk of malnutrition groups than in the well-nourished group, but once again there were no statistical significance.

Tables 3.9 and 3.10 (following pages) summarize the non-significant results of the MNA-SF.

Table 3.9 Non-significant clinical outcome results for the MNA-SF[a] nutritional risk categories

	Total	Normal	Risk Malnutrition	Malnourished	p-value	Test
	(n=205)	(n=63)	(n=109)	(n=33)	p=0.73	Kruskal-Wallis
Mean LOS (days)	5.75	5.39	5.62	6.85		test
SD	5.52	4.44	4.72	8.89		
CI	4.99 – 6.51	4.27 – 6.51	4.73 – 6.52	3.70 – 10.00		
	(n=205)	(n=63)	(n=109)	(n=33)	p=0.78	Kruskal-Wallis
Mean LOV (days)	2.93	2.54	2.80	4.09		test
SD	5.08	4.13	4.57	7.70		
CI	2.23 – 3.63	1.50 – 3.58	1.93 – 3.67	1.36 – 6.82		
	(n=197)	(n=61)	(n=105)	(n=31)	p=0.22	Kruskal-Wallis
Mean APACHE II score	10.41	9.70	10.49	11.52		test
SD	5.51	5.51	5.66	4.93		
CI	9.63 – 11.18	8.29 – 11.12	9.39 – 11.58	9.71 – 13.33		
	(n=206)	(n=63)	(n=109)	(n=34)	p=0.75	Kruskal-Wallis
Mean number of total complications	1.51	1.33	1.55	1.74		test
SD	2.04	1.75	1.98	2.65		
CI	1.23 – 1.79	0.89 – 1.77	1.17 – 1.93	0.81 – 2.66		
	(n=206)	(n=63)	(n=109)	(n=34)	p=0.25	Kruskal-Wallis
Mean number of mild complications	0.28	0.19	0.29	0.38		test
SD	0.63	0.59	0.58	0.82		
CI	0.19 – 0.36	0.04 – 0.34	0.18 – 0.40	0.10 – 0.67		
	(n=206)	(n=63)	(n=109)	(n=34)	p=0.35	Kruskal-Wallis
Mean number of moderate complications	0.70	0.60	0.79	0.62		test
SD	0.98	0.83	1.04	1.04		
CI	0.57 – 0.84	0.39 – 0.81	0.59 – 0.99	0.25 – 0.98		

Mean number of severe complications **SD** **CI**	(n=206) 0.53 0.92 0.41 – 0.66	(n=63) 0.54 0.78 0.34 – 0.74	(n=109) 0.47 0.92 0.29 – 0.64	(n=34) 0.74 1.14 0.34 – 1.13	p=0.22	Kruskal-Wallis test
Mean CRP (mg/l) **SD** **CI**	(n=164) 182.01 117.11 163.95 – 200.06	(n=49) 210.18 114.26 177.36 – 243.00	(n=89) 170.30 122.89 144.42 – 196.19	(n=26) 168.96 84.74 130.69 – 207.23	p=0.12	Kruskal-Wallis test

[a] **Mini-Nutritional Assessment – Short Form**

Table 3.10 M-L Chi-square test of the presence or absence of death by MNA-SF[a] category (p=0.84)

MNA-SF	Death - present	Death - absent	Row - Totals
Normal	2 (3.17%)	61 (96.83%)	**63**
Risk malnutrition	2 (1.83%)	107 (98.17%)	**109**
Malnourished	1 (3.03%)	32 (96.97%)	**33**
Totals	**5**	**200**	**205**

[a] **Mini-Nutritional Assessment – Short Form**

Analyses were also done comparing the well-nourished group (n=63; 30.58%) to a combined group of the malnourished and at risk of malnutrition patients (n=143; 69.42%). This time the MNA-SF categories were significantly correlated with WCC (Figure 3.6) and CRP (Figure 3.7) levels. The combined malnutrition group had a significantly higher ($p<0.01$; Mann-Whitney U test) mean WCC (17.11; SD 10.69; CI 15.26-18.97) than the well-nourished group (13.19; SD 5.35; CI 11.79-14.58). However, their mean CRP level of 170.00 (SD 116.74; CI 148.44-191.56) was significantly lower ($p=0.04$; Mann-Whitney U test) than the mean CRP level of the well nourished group (210.18; SD 114.26; CI 177.36-243.00).

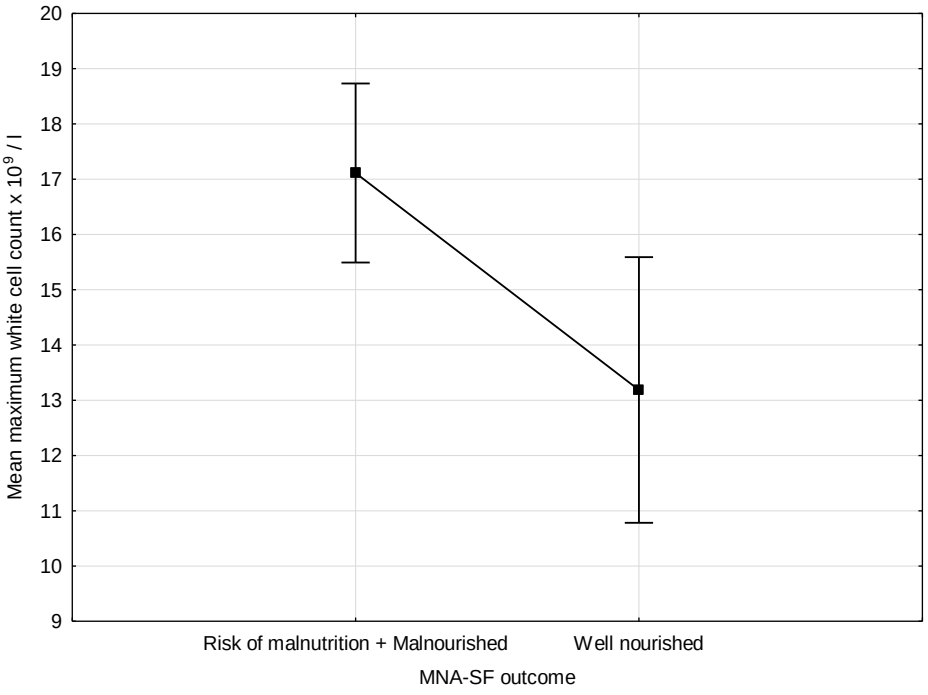


Figure 3.6 Mean maximum white cell count per Mini-Nutritional Assessment - Short Form outcome ($p<0.01$)

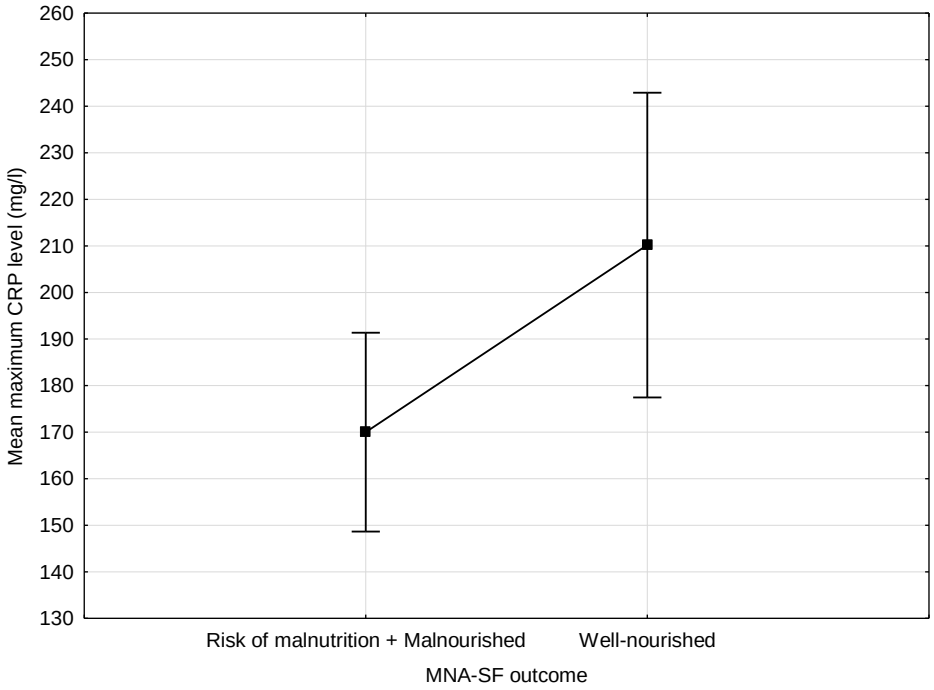


Figure 3.7 Mean maximum C-Reactive Protein level per Mini-Nutritional Assessment - Short Form outcome (p=0.04)

The group combining the at risk of malnutrition and malnourished patients had a longer LOS and LOV, higher APACHE II scores, more total, mild and moderate complications and lower s-albumin scores than the well-nourished group, but this did not reach statistical significance.

The non-significant results can be seen in Tables 3.11 and 3.12.

Table 3.11 Non-significant clinical outcome results for the MNA-SF[a] nutritional risk outcomes

	Total	Well-nourished	At risk of malnutrition + malnourished	p-value	Test
	(n=205)	(n=63)	(n=142)	p=0.95	Mann-Whitney U test
Mean LOS (days)	5.75	5.39	5.91		
SD	5.52	4.44	5.94		
CI	4.99-6.51	4.27-6.51	4.92-6.89		
	(n=205)	(n=63)	(n=142)	p=0.54	Mann-Whitney U test
Mean LOV (days)	2.93	2.54	3.10		
SD	5.08	4.13	5.46		
CI	2.23-3.63	1.50-3.58	2.19-4.00		
	(n=197)	(n=61)	(n=136)	p=0.22	Mann-Whitney U test
Mean APACHE II score	10.41	9.70	10.72		
SD	5.51	5.51	5.50		
CI	9.63-11.18	8.29-11.12	9.78-11.65		
	(n=206)	(n=63)	(n=143)	p=0.50	Mann-Whitney U test
Mean number of total complications	1.51	1.33	1.59		
SD	2.04	1.75	2.15		
CI	1.23-1.79	0.89-1.77	1.24-1.95		
	(n=206)	(n=63)	(n=143)	p=0.24	Mann-Whitney U test
Mean number of mild complications	0.28	0.19	0.31		
SD	0.63	0.59	0.64		
CI	0.19-0.36	0.04-0.34	0.21-0.42		
	(n=206)	(n=63)	(n=143)	p=0.49	Mann-Whitney U test
Mean number of moderate complications	0.70	0.60	0.75		
SD	0.98	0.83	1.04		
CI	0.57-0.84	0.39-0.81	0.58-0.92		
	(n=206)	(n=63)	(n=143)	p=0.50	Mann-Whitney U test
Mean number of severe complications	0.53	0.54	0.53		
SD	0.92	0.78	0.98		
CI	0.41-0.66	0.34-0.74	0.37-0.69		

	(n=176)	(n=53)	(n=123)	p=0.06	One-way ANOVA test
Mean s-albumin (g/l)	22.77	24.13	22.19		
SD	6.20	5.70	6.34		
CI	21.85-23.70	22.56-25.70	21.05-23.32		

[a] **Mini-Nutritional Assessment – Short Form**

Table 3.12 M-L Chi-square test of the presence or absence of death by MNA-SF[a] outcome (p=0.66)

MNA-SF	Death - present	Death - absent	Row - Totals
Well-nourished	2 (3.17%)	61 (96.83%)	**63**
At risk of malnutrition + malnourished	3 (2.11%)	139 (97.89%)	**142**
Total	**5**	**200**	**205**

[a] **Mini-Nutritional Assessment – Short Form**

The MNA-SF is specifically indicated for elderly patients and therefore it was decided to do a separate analysis for the elderly group of patients in the study sample. When only the elderly patients were analysed (n=45), 9 (20%) patients were classified as well-nourished, 27 (60%) as at risk of malnutrition and 9 (20%) as malnourished.

The only significant finding was that s-albumin levels declined with declining nutritional status (p=0.03; Kruskal-Wallis test; Figure 3.8). The malnourished patients had the lowest average s-albumin (19.38; SD 4.81; CI 15.35-23.40) and this was significantly lower (p=0.03; Bonferroni test) than the average s-albumin in the well-nourished patients (27.86; SD 5.84; CI 22.45-33.26). The s-albumin levels in the group at risk of malnutrition (24.64; SD 6.30; CI 22.04-27.24) was higher than the malnourished group and lower than the well-nourished group, but this was not statistically significant.

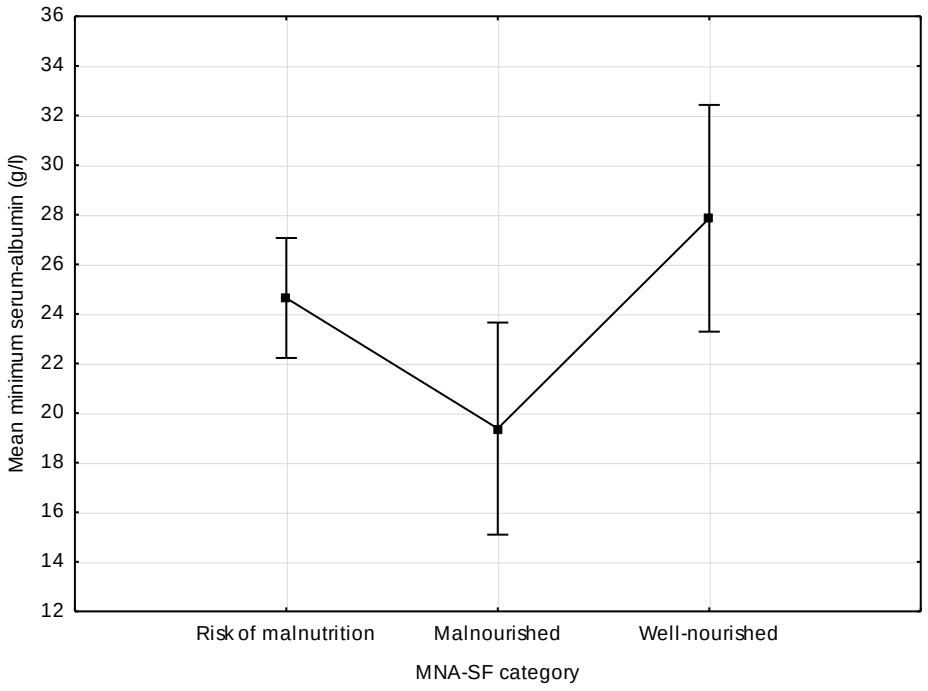


Figure 3.8 Mean minimum serum-albumin level for patients ≥ 65 years per Mini-Nutritional Assessment - Short Form category (p=0.03)

Combining the group at risk of malnutrition with the malnourished group (n=36; 80%) and comparing them to the well-nourished group (n=9; 20%) revealed an almost significant association (Figure 3.9). The combined malnutrition group had borderline (p=0.05) significantly higher WCCs (15.24; SD 4.81; CI 13.59-16.90) than the well-nourished group (11.34; SD 3.80; CI 8.16-14.51; Figure 3.9).

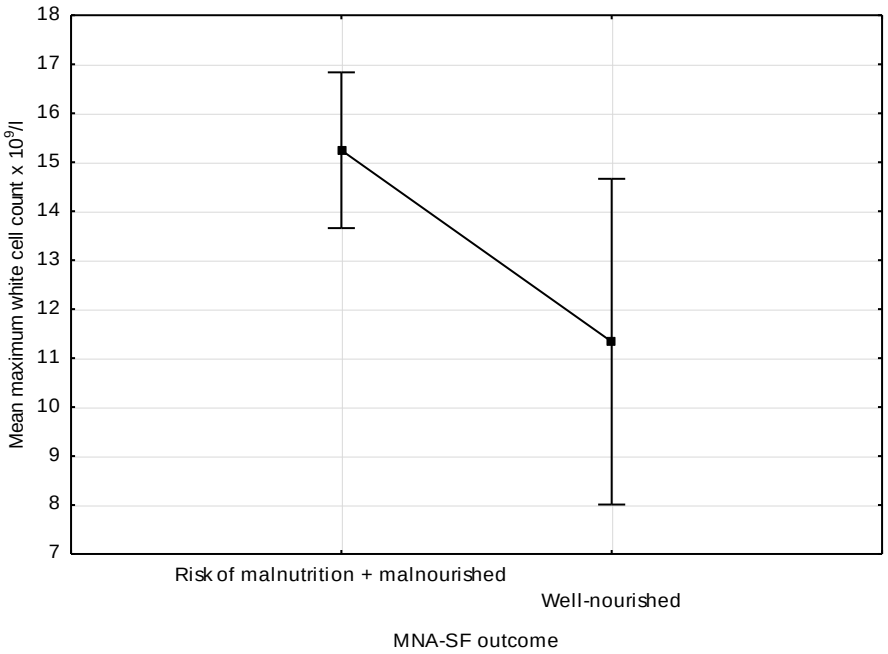


Figure 3.9 Mean maximum white cell count for patients ≥65 years per Mini-Nutritional Assessment - Short Form outcome (p=0.05)

Although none of the other associations seen were significant, a trend for longer LOS and LOV as well as more mild and severe complications was seen when all three groups were analysed. Furthermore, the combined malnutrition group showed a trend for worse results in all of the other outcomes (except mortality) studied.

Tables 3.13, 3.14, 3.15 and 3.16 summarize the non-significant results for elderly patients.

Table 3.13 Non-significant clinical outcome results for the MNA-SF[a] nutritional risk categories for elderly patients

	Total	Normal	Risk Malnutrition	Malnourished	p-value	Test
	(n=45)	(n=9)	(n=27)	(n=9)	p=0.50	Kruskal-Wallis
Mean LOS (days)	6.16	3.29	6.33	8.07		test
SD	7.75	0.79	6.51	13.35		
CI	3.75 – 8.40	2.69 - 3.90	3.76 – 8.91	-2.19 – 18.34		
	(n=45)	(n=9)	(n=27)	(n=9)	p=0.31	Kruskal-Wallis
Mean LOV (days)	2.82	0.56	3.22	3.89		test
SD	6.41	1.13	6.09	9.84		
CI	0.90 – 4.75	-0.31 – 1.42	0.81 – 5.63	-3.68 – 11.45		
	(n=42)	(n=8)	(n=25)	(n=9)	p=0.65	Kruskal-Wallis
Mean APACHE II score	11.98	10.50	12.64	11.44		test
SD	5.50	3.38	5.97	5.83		
CI	10.26 – 13.69	7.67 – 13.33	10.18 – 15.10	6.96 – 15.93		
	(n=45)	(n=9)	(n=27)	(n=9)	p=0.75	Kruskal-Wallis
Mean number of total complications	1.87	1.56	1.96	1.89		test
SD	2.70	1.74	2.59	3.89		
CI	1.05 – 2.68	0.22 – 2.89	0.94 – 2.99	-1.10 - 4.88		
	(n=45)	(n=9)	(n=27)	(n=9)	p=0.75	Kruskal-Wallis
Mean number of mild complications	0.20	0.11	0.15	0.44		test
SD	0.55	0.33	0.36	1.01		
CI	0.04 – 0.36	-0.15 – 0.37	0.00 – 0.29	-0.33 – 1.22		
	(n=45)	(n=9)	(n=27)	(n=9)	p=0.29	Kruskal-Wallis
Mean number of moderate complications	0.93	0.78	1.11	0.56		test
SD	1.30	0.83	1.42	1.33		
CI	0.54 – 1.33	0.14 – 1.42	0.55 – 1.67	-0.47 – 1.58		
	(n=45)	(n=9)	(n=27)	(n=9)	p=0.81	Kruskal-Wallis
Mean number of severe complications	0.73	0.67	0.70	0.89		test
SD	1.27	1.00	1.27	1.62		
CI	0.35 – 1.11	-0.10 – 1.44	0.20 – 1.20	-0.35 – 2.13		

	(n=38)	(n=7)	(n=24)	(n=7)	p=0.90	Kruskal-Wallis test
Mean CRP (mg/l)	148.73	143.13	156.03	129.14		
SD	116.73	121.90	127.57	77.95		
CI	110.37 – 187.10	30.39 – 255.87	102.21 – 209.95	57.05 – 201.24		
	(n=43)	(n=8)	(n=27)	(n=8)	p=0.14	Kruskal-Wallis test
Mean WCC (x 10^9/l)	14.52	11.34	15.33	14.95		
SD	4.85	3.80	4.85	4.99		
CI	13.02 – 16.01	8.16 – 14.51	13.41 – 17.25	10.78 – 19.12		

[a] **Mini-Nutritional Assessment – Short Form**

Table 3.14 M-L Chi-square test of the presence or absence of death in patients ≥ 65 years by MNA-SF[a] category (p=0.47)

MNA-SF	Death - present	Death - absent	Row - Totals
Normal	1 (11.11%)	8 (88.89%)	**9**
Risk malnutrition	2 (7.41%)	25 (92.59%)	**29**
Malnourished	0 (0.00%)	9 (100.00%)	**9**
Totals	**3**	**42**	**45**

[a] **Mini-Nutritional Assessment – Short Form**

Table 3.15 Non-significant clinical outcome results for the MNA-SF[a] nutritional risk outcomes for elderly patients

	Total	Well-nourished	At risk of malnutrition + malnourished	p-value	Test
	(n=45)	(n=9)	(n=36)	p=0.44	Mann-Whitney U test
Mean LOS (days)	6.16	3.29	6.77		
SD	7.75	0.79	8.53		
CI	3.75 – 8.40	2.69 – 3.90	3.88 – 9.66		
	(n=45)	(n=9)	(n=36)	p=0.19	Mann-Whitney U test
Mean LOV (days)	2.82	0.56	3.39		
SD	6.41	1.13	7.06		
CI	0.90 – 4.75	-0.31 – 1.42	1.00 – 5.78		
	(n=42)	(n=8)	(n=34)	p=0.41	Mann-Whitney U test
Mean APACHE II score	11.98	10.50	12.32		
SD	5.50	3.38	5.87		
CI	10.26 – 13.69	7.67 – 13.33	10.28 – 14.37		
	(n=45)	(n=9)	(n=36)	p=0.92	Mann-Whitney U test
Mean number of total complications	1.87	1.56	1.94		
SD	2.70	1.74	2.91		
CI	1.05 – 2.68	0.22 – 2.89	0.96 – 2.93		
	(n=45)	(n=9)	(n=36)	p=0.80	Mann-Whitney U test
Mean number of mild complications	0.20	0.11	0.22		
SD	0.55	0.33	0.59		
CI	0.04 – 0.36	-0.15 – 0.37	0.02-0.42		
	(n=45)	(n=9)	(n=36)	p=0.89	Mann-Whitney U test
Mean number of moderate complications	0.93	0.78	0.97		
SD		0.83	1.40		
CI	1.30	0.14-1.42	0.50 – 1.45		
	0.54 – 1.33				

Mean number of severe complications **SD** **CI**	(n=45) 0.73 1.27 0.35 – 1.11	(n=9) 0.67 1.00 -0.10 – 1.44	(n=36) 0.75 1.34 0.30 – 1.20	p=0.79	Mann-Whitney U test
Mean s-albumin (g/l **SD** **CI**	(n=40) 24.15 6.41 22.10 – 26.20	(n=7) 27.86 5.84 22.45-33.26	(n=33) 23.36 6.33 21.12 – 25.61	p=0.19	Mann-Whitney U test
Mean CRP (mg/l) **SD** **CI**	(n=38) 148.73 116.73 110.37 – 187.10	(n=7) 143.13 121.90 30.39 – 255.87	(n=31) 150.00 117.57 106.87 – 193.13	p=0.90	Mann-Whitney U test
Mean WCC (x 10^9/l) **SD** **CI**	(n=43) 14.52 4.85 13.02 – 16.01	(n=8) 11.34 3.80 8.16 – 14.51	(n=35) 15.24 4.81 13.59 – 16.90	p=0.05	Mann-Whitney U test

[a] **Mini-Nutritional Assessment – Short Form**

Table 3.16 M-L Chi-square test of the presence or absence of death for patients ≥ 65 years by MNA-SF[a] outcome (p=0.57)

MNA-SF	Death - present	Death - absent	Row - Totals
Well-nourished	1 (11.11%)	8 (88.89%)	**9**
At risk of malnutrition + malnourished	2 (5.56%)	34 (94.44%)	**36**
Total	**3**	**42**	**45**

[a] **Mini-Nutritional Assessment – Short Form**

3.3.3 NRS-2002

According to the NRS-2002, 150 patients (72.82%) were classified as malnourished and 55 (26.70%) were classified as at risk of malnutrition. Only one patient (0.49%) was classified as well-nourished and therefore results need to be interpreted with caution (Figure 3.10).

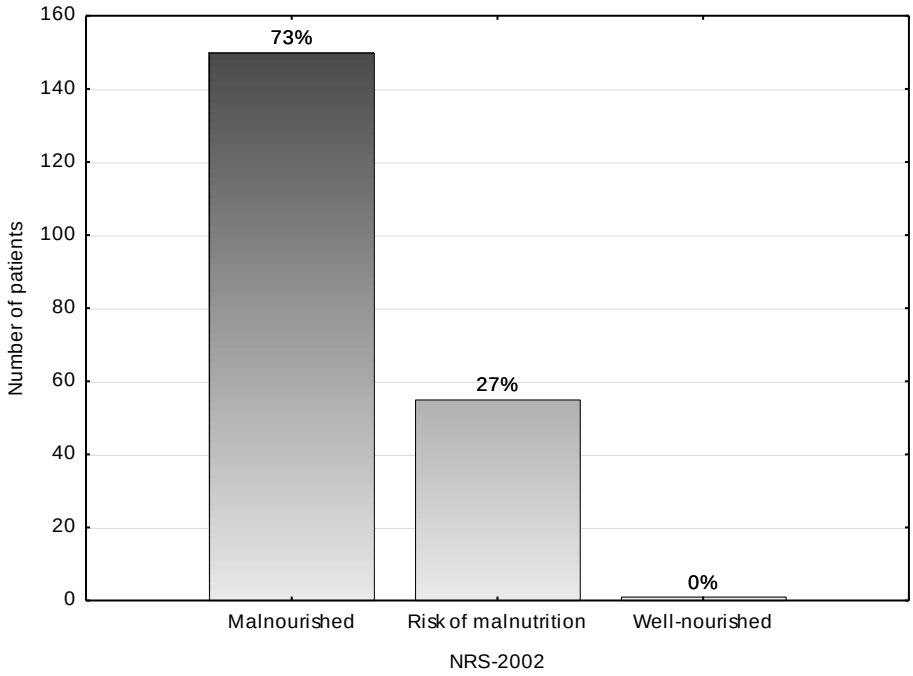


Figure 3.10 Prevalence of malnutrition according to the Nutritional Risk Score - 2002

When analysing all three groups, a significant correlation was found between the NRS-2002 and APACHE II scores (p=0.02; Kruskal-Wallis test). The malnourished patients had a mean APACHE II score of 10.94 (SD 5.31; CI 10.05-11.82) which was higher than the mean APACHE II score of the patients at risk of malnutrition (9.05; SD 5.87; CI 7.47-10.64), although when comparing the two groups only, this was not significant (Figure 3.11). The one well-nourished patient had an APACHE II score of 10 which was not significantly lower than the malnourished group and not significantly higher than the group at risk of malnutrition.

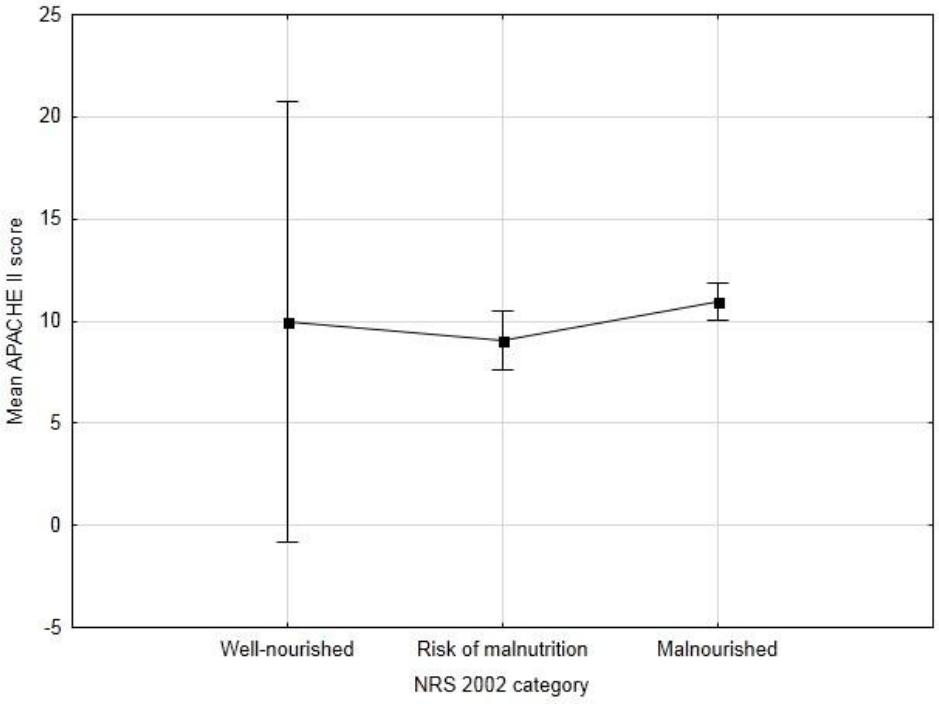


Figure 3.11 Mean APACHE II score per Nutritional Risk Score - 2002 category (p=0.02)

A significant association between the three NRS-2002 classifications and mild (p=0.04; Kruskal-Wallis test), moderate (p<0.01; Kruskal-Wallis test) and total complications (p<0.01; Kruskal-Wallis) was also found (Figures 3.12 below, and 3.13 and 3.14, next page).

The malnourished group had a mean rate of moderate complications of 0.79 (SD 1.03; CI 0.63-0.96) and a mean rate of total complications of 1.75 (SD 2.19; CI 1.39-2.10). Both of these were significantly higher (moderate: p=0.04; total: p=0.01; Bonferroni test) than the mean rate of moderate (0.42; SD 0.71; CI 0.23-0.61) and total (0.84; SD 1.33; CI 0.48-1.20) complications in the group at risk of malnutrition. The mean rate of mild complications was also higher in the malnourished group (0.33; SD 0.70; CI 0.21-0.44) than in the group at risk of malnutrition (0.13; SD 0.34; CI 0.04-0.22, but this was not statistically significant. The one well-nourished patient had the highest rate of mild (1.00), moderate (3.00) and total (4.00) complications, but this was not statistically significant.

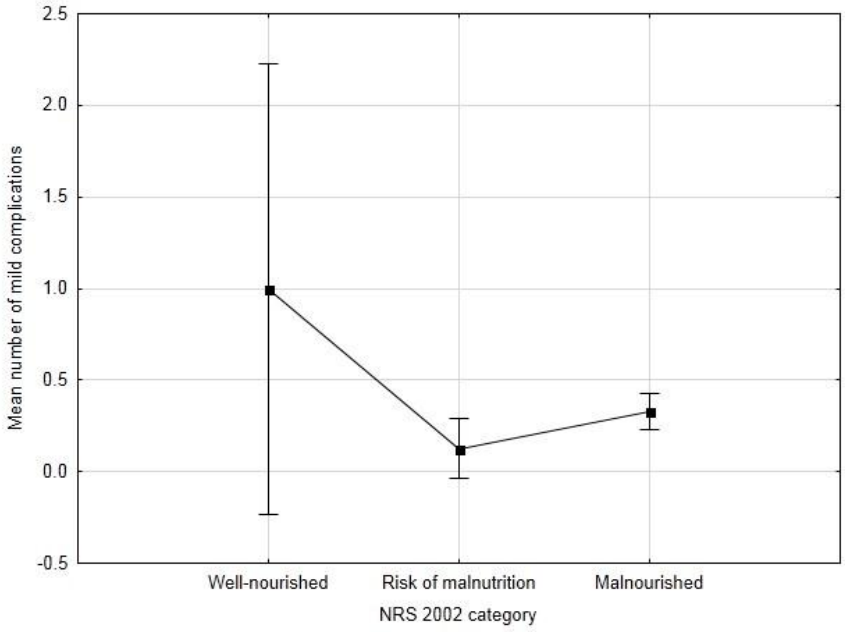


Figure 3.12 Mean number of mild complications per Nutritional Risk Score – 2002 category (p=0.04)

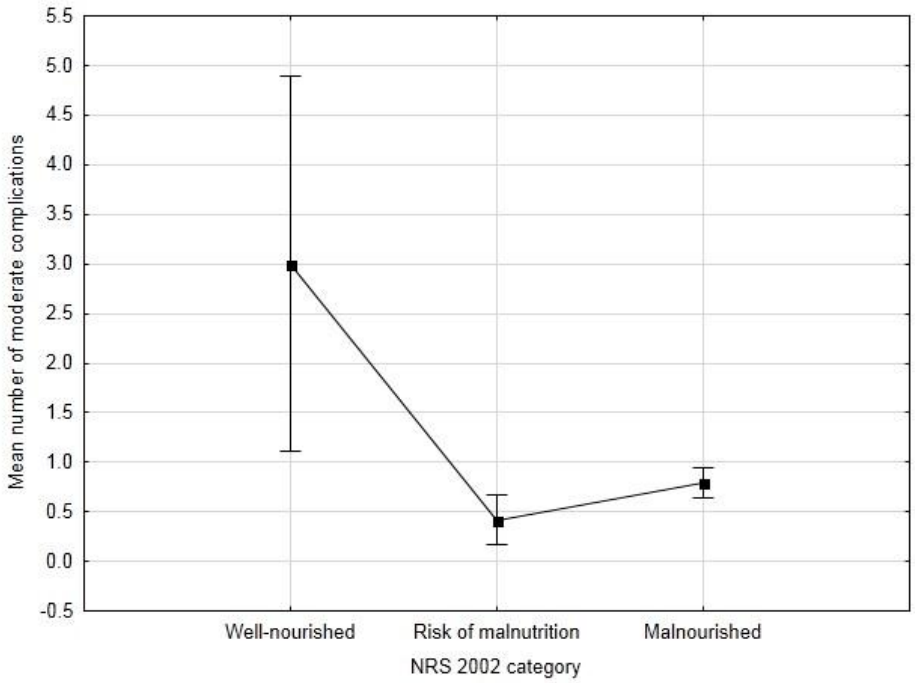


Figure 3.13 Mean number of moderate complications per Nutritional Risk Score - 2002 category (p<0.01)

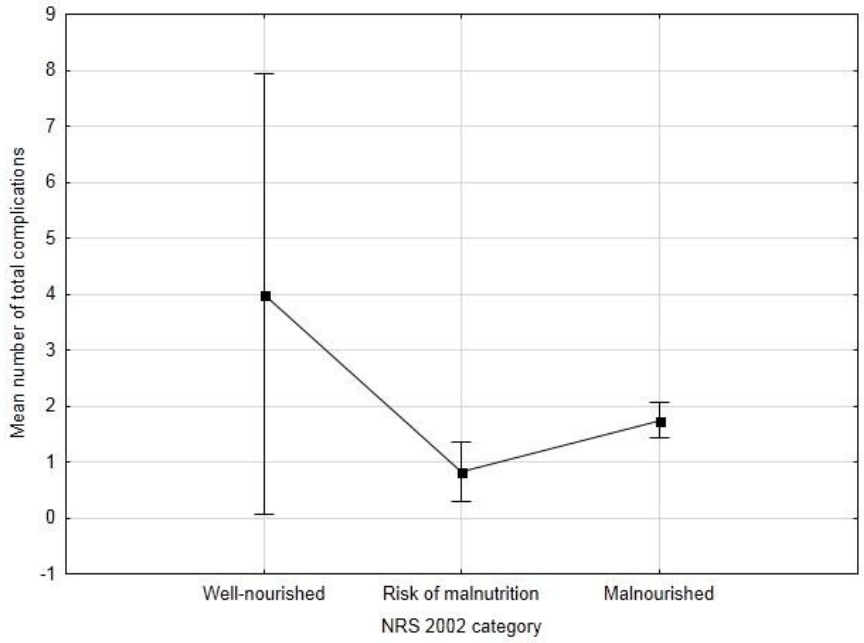


Figure 3.14 Mean number of total complications per Nutritional Risk Score - 2002 category (p<0.01)

When analysing for all three groups no significant correlation was found for LOV. However, comparing only two groups at a time revealed that the malnourished group had a significantly longer (p=0.02; Bonferroni test) mean LOV (3.52; SD 5.73; CI 2.60-4.45) than the group at risk of malnutrition (1.33; SD 2.00; CI 0.79-1.87; Figure 3.15). The well-nourished patient had a LOV of 2.00 days; this was not significantly higher than mean LOV of the group at risk of malnutrition or significantly lower than the mean LOV of the malnourished group.

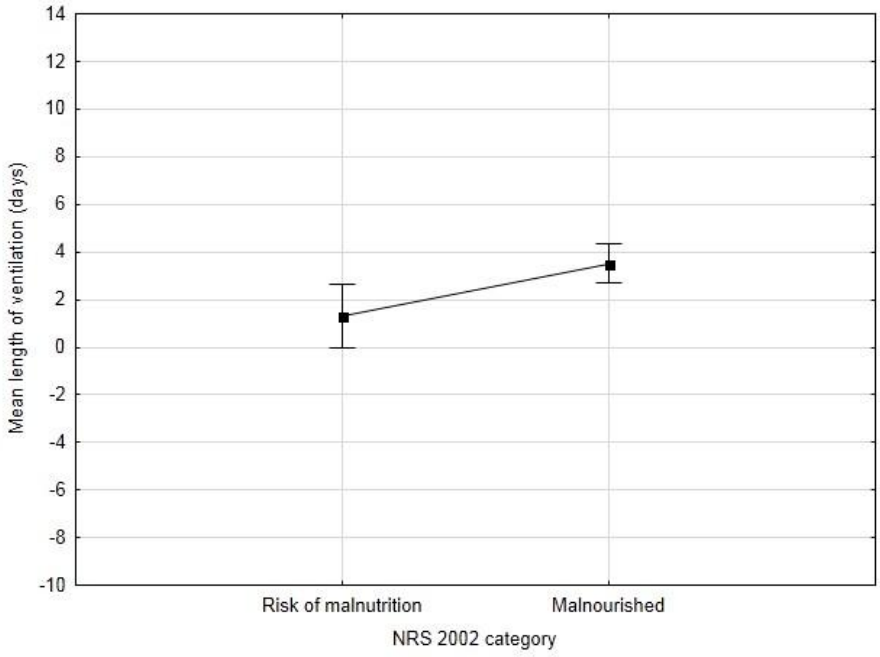


Figure 3.15 Mean length of ventilation in the at risk of malnutrition and malnourished Nutritional Risk Score - 2002 categories (p=0.02)

Analysing for all three groups as well as two groups only revealed a few trends, although these were not significant: the malnourished group seemed to have a longer LOS, a higher mortality, more severe complications, lower s-albumin levels and higher CRP and WCC levels than the group at risk of malnutrition. Tables 3.17 and 3.18 summarize the non-significant results of the NRS-2002.

No analyses were done comparing the well-nourished group to a combination of the at risk of malnutrition and malnourished patients, as the well-nourished group consisted out of only one patient and this would have made comparison futile.

Table 3.17 M-L Chi-square test of the presence or absence of death by NRS-2002[a] category (p=0.20)

NRS-2002	Death - present	Death - absent	Row - Totals
Normal	0 (0%)	1 (100%)	**1**
Risk malnutrition	0 (0%)	55 (100%)	**55**
Malnourished	5 (3.36%)	144 (96.64%)	**149**
Totals	**5**	**200**	**205**

[a] Nutritional Risk Score - 2002

Table 3.18 Non-significant clinical outcome results for the NRS-2002[a] nutritional risk categories

	Total	Normal	Risk Malnutrition	Malnourished	p-value	Test
	(n=205)	(n=1)	(n=55)	(n=149)	p=0.10	Kruskal-Wallis
Mean LOS (days)	5.75	6.96	4.40	6.24		test
SD	5.52		2.74	6.19		
CI	4.99 – 6.51		3.66 – 5.14	5.23 – 7.24		
	(n=205)	(n=1)	(n=55)	(n=149)	p=0.11	Kruskal-Wallis
Mean LOV (days)	2.93	2.00	1.33	3.52		test
SD	5.08		2.00	5.73		
CI	2.23 – 3.63		0.79 – 1.87	2.60 – 4.45		
	(n=206)	(n=1)	(n=55)	(n=150)	p=0.07	Kruskal-Wallis
Mean number of severe complications	0.53	0.00	0.29	0.63		test
SD	0.92		0.60	1.00		
CI	0.41 – 0.66		0.13 – 0.45	0.47 – 0.79		
	(n=176)	(n=1)	(n=43)	(n=132)	p=0.14	One-way
Mean s-albumin (g/l)	22.77	21	24.40	22.26		ANOVA test
SD	6.20		5.84	6.27		
CI	21.85 – 23.70		22.60 – 26.19	21.18 – 23.34		
	(n=164)	(n=1)	(n=40)	(n=123)	p=0.12	Kruskal-Wallis
Mean CRP (mg/l)	182.01	345	158.60	188.29		test
SD	117.11		92.68	123.05		
CI	163.95 – 200.06		128.96 – 188.24	166.33 – 210.26		
	(n=189)	(n=1)	(n=47)	(n=141)	p=0.29	Kruskal-Wallis
Mean WCC (x 10^9/l)	15.89	17.26	15.33	16.06		test
SD	9.51		11.98	8.62		
CI	14.52 – 17.25		11.81 – 18.84	14.63 – 17.50		

[a] Nutritional Risk Score - 2002

3.3.4 SGA

One hundred and five patients (50.97%) were classified as well-nourished according to the SGA. Sixty-three patients (30.58%) were classified as moderately malnourished and 38 (18.45%) as severely malnourished (Figure 3.16).

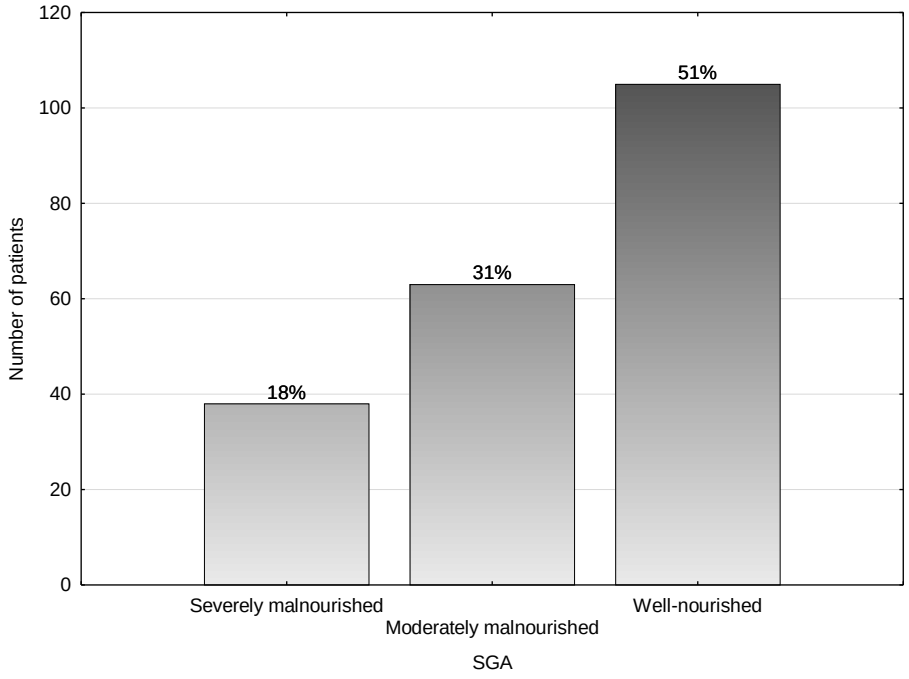


Figure 3.16 Prevalence of malnutrition according to the Subjective Global Assessment

The SGA classifications were significantly correlated with LOS (p=0.03; Kruskal-Wallis test; Figure 3.17), LOV (p=0.01; Kruskal-Wallis test; Figure 3.18), mild complications (p=0.04; Kruskal-Wallis test; Figure 3.19) and s-albumin (p=0.01; Kruskal-Wallis test; Figure 3.20).

In the case of LOS, LOV and mild complications the moderately malnourished patients showed the worst outcomes (LOS: 7.20; SD 7.18; CI 5.39-9.00; LOV: 4.60; SD 6.60; CI 2.94-6.27; mild complications: 0.46; SD 0.86; CI 0.24-0.68) followed by well-nourished patients (LOS:5.32; SD 4.56; CI 4.44-6.21; LOV: 2.41; SD 3.85; CI 1.67-3.16; mild complications: 0.20; SD 0.45; CI 0.11-0.29) and with severely malnourished patients (LOS: 4.50; SD 4.22; CI 3.11-5.89; LOV: 1.55; SD 4.56; CI 0.05-3.05; mild complications: 0.18; SD 0.56; CI -0.00-0.37) showing the best outcomes.

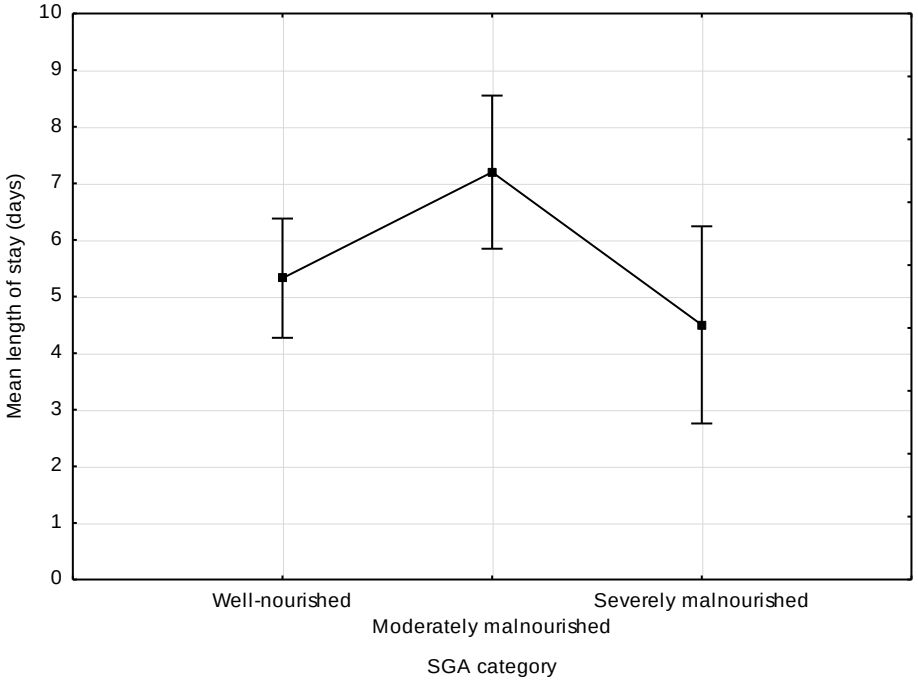


Figure 3.17 Mean length of stay per Subjective Global Assessment category (p=0.03)

When comparing two SGA classifications at a time for LOV, the differences were significant for the moderately malnourished group compared to the well-nourished group (p=0.02; Bonferroni test) and the moderately malnourished group compared to the severely malnourished group (p=0.01; Bonferroni test).

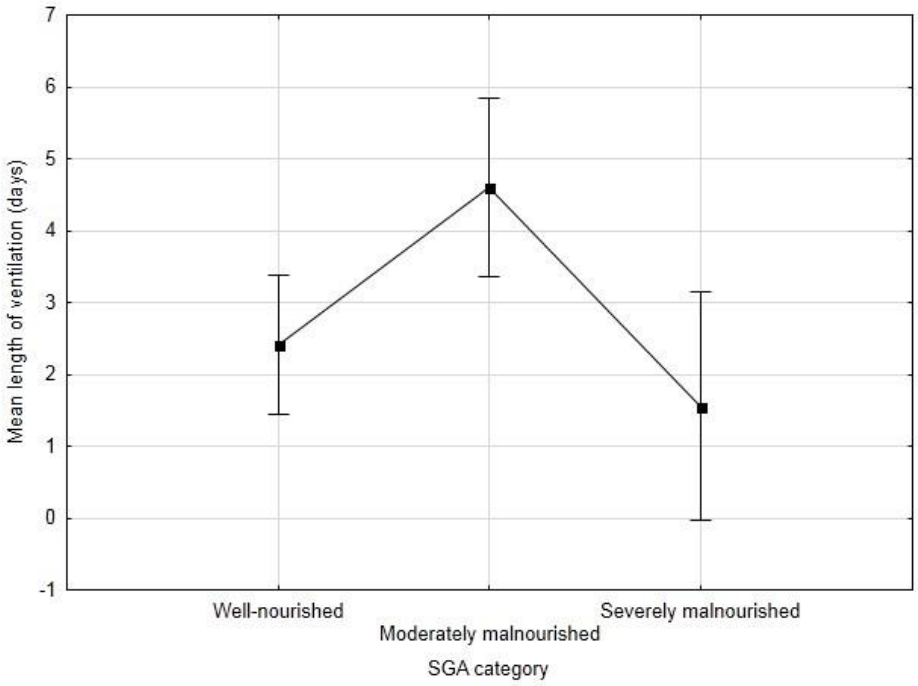


Figure 3.18 Mean length of ventilation per Subjective Global Assessment category (p=0.01)

For mild complications the only significant difference was between the moderately malnourished and well-nourished groups (p=0.03; Bonferroni test).

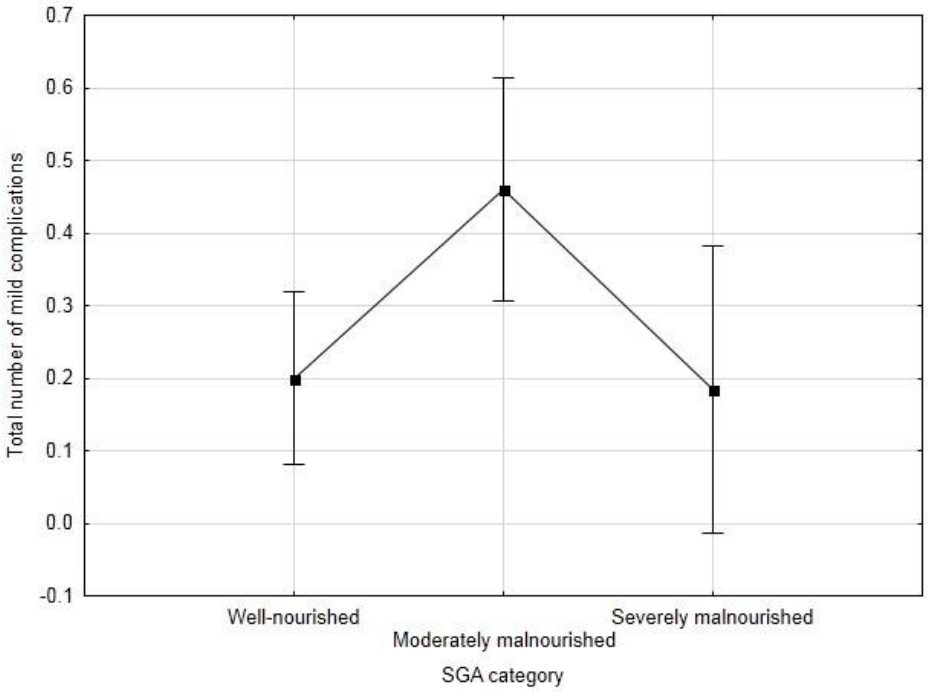


Figure 3.19 Mean number of mild complications per Subjective Global Assessment category (p=0.04)

No statistical significance remained when comparing only two groups for LOS. The moderately malnourished group had borderline longer LOS than the severely malnourished group (p=0.05; Bonferroni test).

S-albumin was lowest in the malnourished group (19.81; SD 5.61; CI 17.79-21.84). This was significantly lower (p=0.01; Bonferroni test) than the well-nourished group (23.70; SD 6.13; CI 22.41-25.00). The moderately malnourished group had the second lowest s-albumin levels (23.00; SD 6.22; CI 21.33-24.67), but this was not significantly different from the malnourished or well-nourished groups (Figure 3.20).

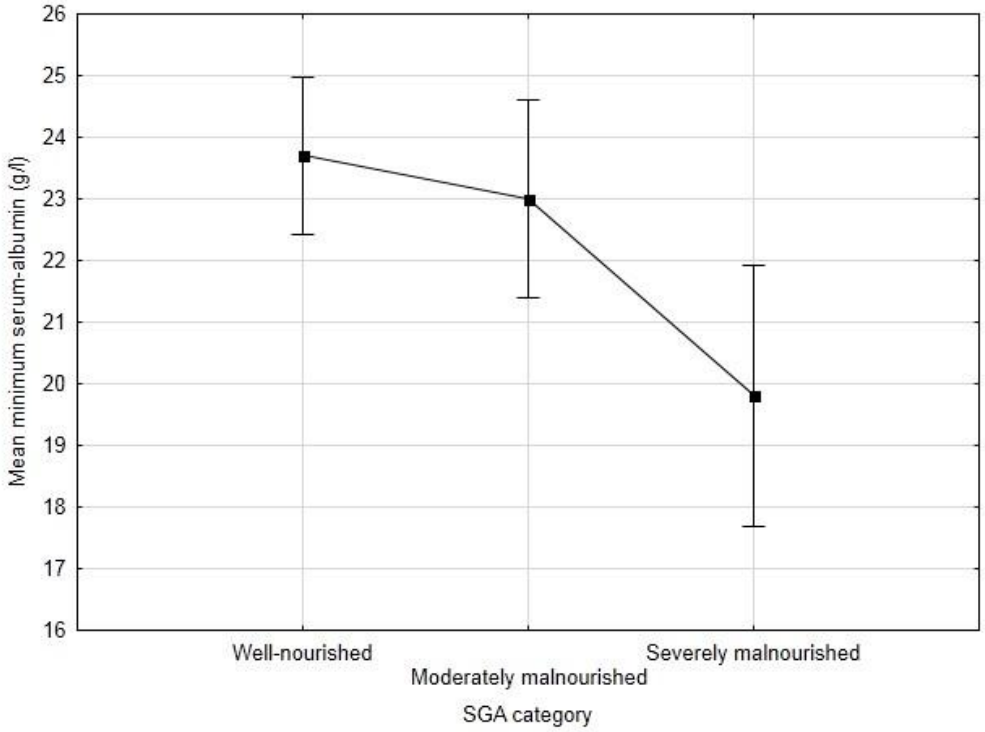


Figure 3.20 Mean minimum serum-albumin per Subjective Global Assessment category (p=0.01)

The moderately malnourished group also showed a (non-significant) trend for higher APACHE II scores, more moderate, severe and total complications, a higher mortality and a higher WCC than the well nourished group. However, for all of these variables the severely malnourished group showed the (non-significant) best outcomes: lowest APACHE II scores, WCC, mortality and least moderate, severe and total complications. The only significant finding was that the moderately malnourished group had more total complications (2.00; SD 2.58; CI 1.35-2.65) than the severely malnourished group (0.97; SD 1.42; CI 0.51-1.44; Figure 3.21).

Tables 3.19 and 3.20 summarize the non-significant results for the SGA.

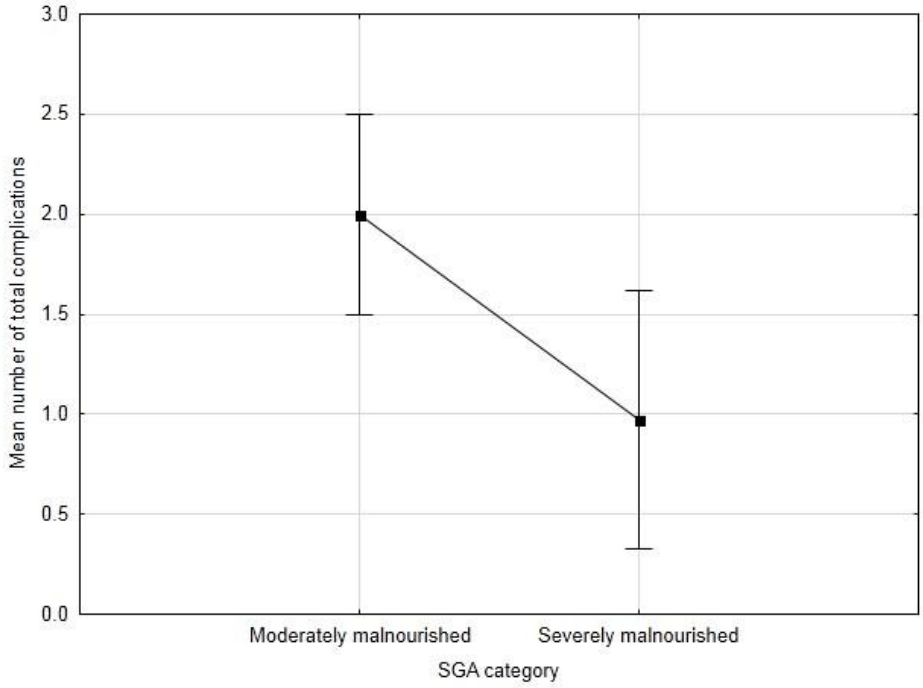


Figure 3.21 Mean number of total complications per moderately and severely malnourished Subjective Global Assessment categories (p=0.04)

Table 3.19 M-L Chi-square test of the presence or absence of death by SGA[a] category (p=0.05)

SGA	Death - present	Death - absent	Row - Totals
Normal	1 (0.96%)	103 (99.04%)	**104**
Risk malnutrition	4 (6.35%)	59 (93.65%)	**63**
Malnourished	0 (0.00%)	38 (100%)	**38**
Totals	**5**	**200**	**205**

[a] Subjective Global Assessment

Table 3.20 Non-significant clinical outcome results for the SGA[a] nutritional risk categories

	Total	Normal	Risk Malnutrition	Malnourished	p-value	Test
	(n=197)	(n=101)	(n=60)	(n=36)	p=0.62	Kruskal-Wallis test
Mean APACHE II score	10.41	10.29	11.02	9.72		
SD	5.51	5.42	6.05	4.83		
CI	9.63 – 11.18	9.22 – 11.36	9.45 – 12.58	8.09 – 11.36		
	(n=206)	(n=105)	(n=63)	(n=38)	p=0.09	Kruskal-Wallis test
Mean number of total complications	1.51	1.42	2.00	0.97		
SD	2.04	1.80	2.58	1.42		
CI	1.23 – 1.79	1.07 – 1.77	1.35 – 2.65	0.51 – 1.44		
	(n=206)	(n=105)	(n=63)	(n=38)	p=0.12	Kruskal-Wallis test
Mean number of moderate complications	0.70	0.72	0.84	0.42		
SD	0.98	0.94	1.15	0.72		
CI	0.57 – 0.84	0.54 – 0.90	0.55- 1.13	0.18 – 0.66		
	(n=206)	(n=105)	(n=63)	(n=38)	p=0.25	Kruskal-Wallis test
Mean number of severe complications	0.53	0.50	0.70	0.37		
SD	0.92	0.86	1.10	0.71		
CI	0.41 – 0.66	0.33 – 0.66	0.42 – 0.98	0.13 – 0.60		
	(n=164)	(n=82)	(n=54)	(n=28)	p=0.11	Kruskal-Wallis test
Mean CRP (mg/l)	182.01	189.89	189.54	144.39		
SD	117.11	110.15	127.24	113.38		
CI	163.95 – 200.06	165.69 – 214.09	154.81 – 224.27	100.43 – 188.36		
	(n=189)	(n=97)	(n=59)	(n=33)	p=0.18	Kruskal-Wallis test
Mean WCC (x 10^9/l)	15.89	15.19	17.52	15.02		
SD	9.51	9.37	10.66	7.42		
CI	14.52 – 17.25	13.30 – 17.08	14.74 – 20.30	12.39 – 17.66		

[a] Subjective Global Assessment

Combining the moderately and severely malnourished patients (n=101; 49.03%) and comparing them to the well-nourished patients (n=105; 50.97%), there were no significant correlations with any of the clinical outcomes. S-albumin was lower in the malnourished group (21.84; SD 6.17; CI 20.53-23.15) than in the well-nourished group (23.70; SD 6.13; CI 22.41-25.00) with a p-value of 0.05 (Mann-Whitney U test) which indicates borderline significance (Figure3.22).

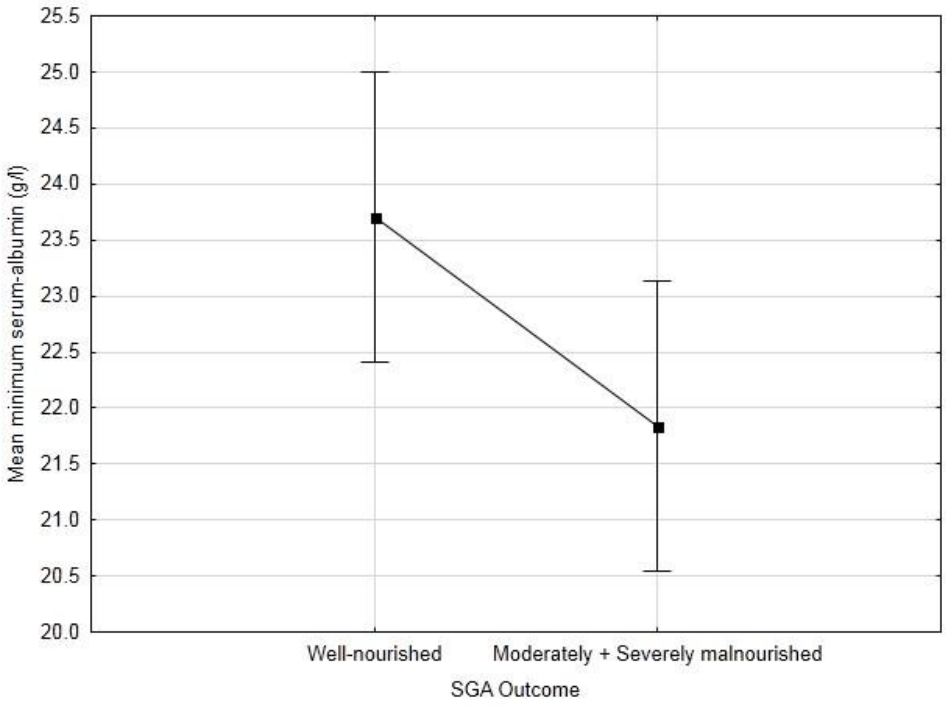


Figure 3.22 Mean minimum serum-albumin per Subjective Global Assessment outcome (p=0.05)

Furthermore, the malnourished group also had a longer mean LOS and LOV, higher mean APACHE II score, more total, mild and severe complications, a higher mean WCC and a higher mortality than the well-nourished group, although this did not reach significance.

Tables 3.21 and 3.22 summarize the non-significant results for the malnourished vs. well-nourished groups.

Table 3.21 Non-significant clinical outcome results for the SGA[a] nutritional risk outcomes

	Total	Well-nourished	Moderately + severely malnourished	p-value	Test
	(n=205)	(n=104)	(n=101)	p=0.27	Mann-Whitney U test
Mean LOS (days)	5.75	5.32	6.18		
SD	5.52	4.56	6.34		
CI	4.99-6.51	4.44-6.21	4.93-7.43		
	(n=205)	(n=104)	(n=101)	p=0.98	Mann-Whitney U test
Mean LOV (days)	2.93	2.41	3.46		
SD	5.08	3.85	6.08		
CI	2.23-3.63	1.67-3.16	2.26-4.66		
	(n=197)	(n=101)	(n=96)	p=0.96	Mann-Whitney U test
Mean APACHE II score	10.41	10.29	10.53		
SD	5.51	5.42	5.63		
CI	9.63-11.18	9.22-11.36	9.39-11.67		
	(n=206)	(n=105)	(n=101)	p=0.83	Mann-Whitney U test
Mean number of total complications	1.51	1.42	1.61		
SD	2.04	1.80	2.27		
CI	1.23-1.79	1.07-1.77	1.17-2.06		
	(n=206)	(n=105)	(n=101)	p=0.37	Mann-Whitney U test
Mean number of mild complications	0.28	0.20	0.36		
SD	0.63	0.45	0.77		
CI	0.19-0.36	0.11-0.29	0.20-0.51		
	(n=206)	(n=105)	(n=101)	p=0.55	Mann-Whitney U test
Mean number of moderate complications	0.70	0.72	0.68		
SD	0.98	0.94	1.03		
CI	0.57-0.84	0.54-0.90	0.48-0.87		
	(n=206)	(n=105)	(n=101)	p=0.77	Mann-Whitney U test
Mean number of severe complications	0.53	0.50	0.57		
SD	0.92	0.86	0.98		
CI	0.41-0.66	0.33-0.66	0.38-0.77		

	(n=176)	(n=88)	(n=88)	p=0.05	Mann-Whitney U test
Mean s-albumin (g/l)	22.77	23.70	21.84		
SD	6.20	6.13	6.17		
CI	21.85-23.70	22.41-25.00	20.53-23.15		
	(n=164)	(n=82)	(n=82)	p=0.28	Mann-Whitney U test
Mean CRP (mg/l)	182.01	189.89	174.12		
SD	117.11	110.15	123.86		
CI	163.95-200.06	165.69-214.09	146.91-201.34		
	(n=189)	(n=97)	(n=92)	p=0.22	Mann-Whitney U test
Mean WCC (x 10^9/l)	15.89	15.19	16.63		
SD	9.51	9.37	9.65		
CI	14.52-17.25	13.30-17.08	14.63-18.62		

[a] Subjective Global Assessment

Table 3.22 M-L Chi-square test of the presence or absence of death by SGA[a] outcome (p=0.15)

NRI	Death - present	Death - absent	Row - Totals
Well-nourished	1 (0.96%)	103 (99.04%)	**104**
Moderately + severely malnourished	4 (3.96%)	97 (96.04%)	**101**
Total	**5**	**200**	**205**

[a] Subjective Global Assessment

3.3.5 SNAQ

The SNAQ classified 132 (64.01%) patients as well-nourished, 14 (6.80%) patients as at risk of malnutrition and 60 (29.13%) as malnourished (Figure 3.23).

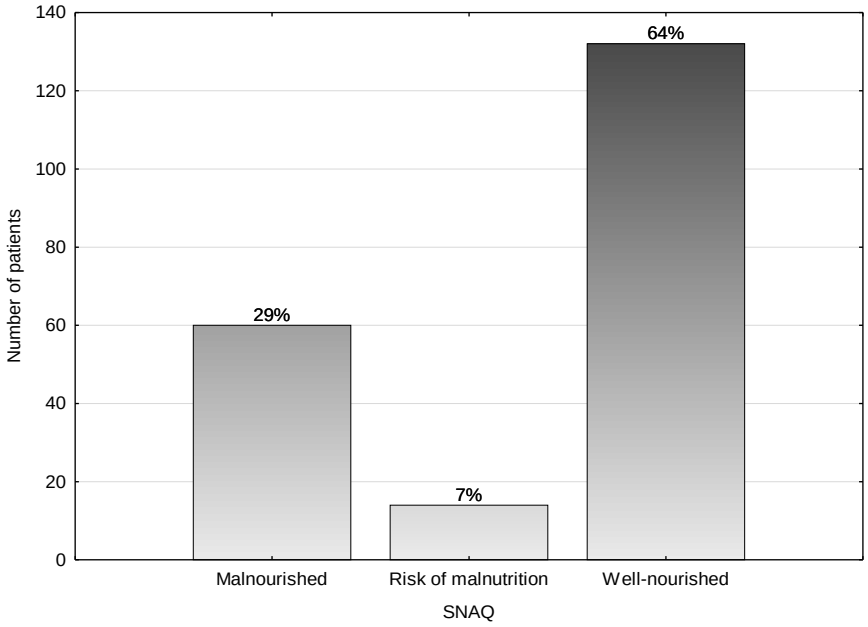


Figure 3.23 Prevalence of malnutrition according to the Short Nutritional Assessment Questionnaire

A significant correlation was found between SNAQ classification and LOV (p=0.02; Kruskal-Wallis test) as well as CRP level (p=0.03; Kruskal-Wallis). The well-nourished group had the longest mean LOV (3.19; SD 4.65; CI 2.39-4.00) followed by the malnourished group (2.67; SD 6.26; CI 1.05-4.28) The group at risk of malnutrition had the shortest LOV (1.57; SD 2.82; CI -0.06-3.2). When comparing only two groups none of the differences remained significant for LOV (Figure 3.24).

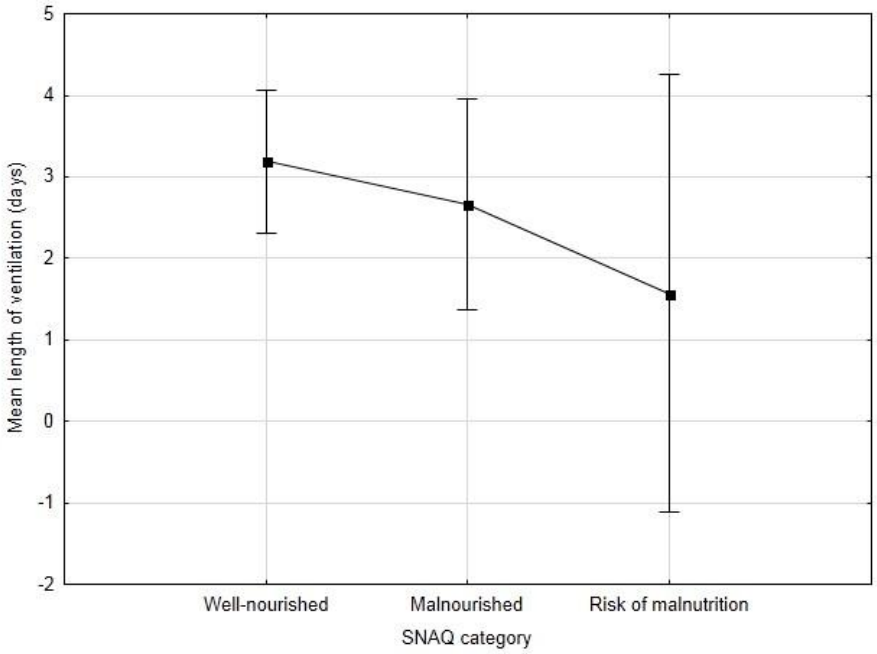


Figure 3.24 Mean length of ventilation per Short Nutritional Assessment Questionnaire category (p=0.02)

The mean CRP level of the well-nourished group was 196.80mg/l (SD 118.14; CI 174.26-219.33) and this was significantly higher (p=0.03; Bonferroni test) than the mean CRP level of the malnourished group of 145.52mg/l (SD 11.58; CI 113.41-177.63). The group at risk of malnutrition had the highest mean CRP level of 201.25mg/l (SD 104.94; CI 113.52-288.98) but this was not statistically different from the malnourished or well-nourished groups (Figure 3.25).

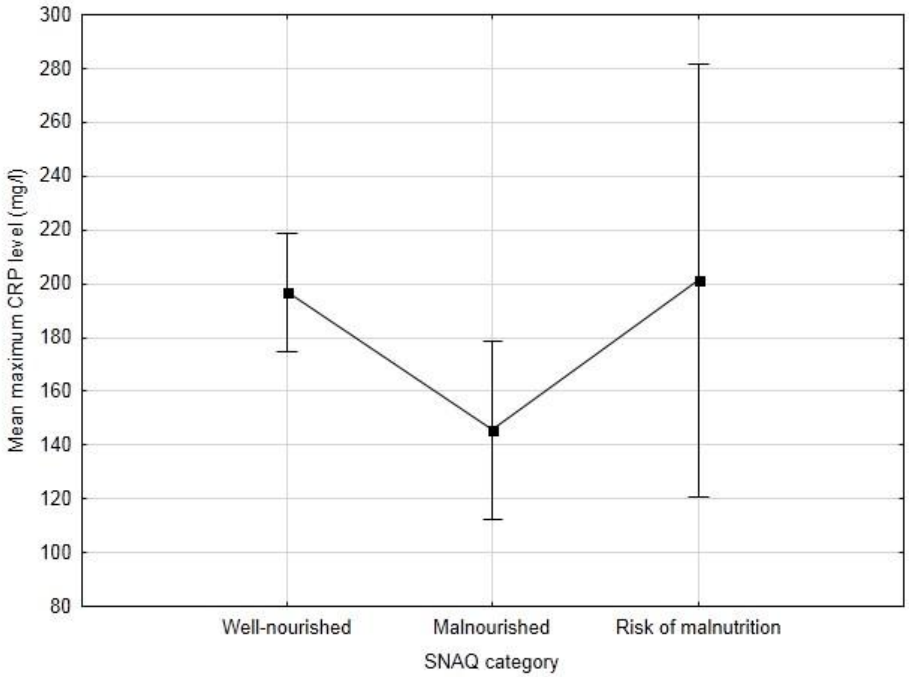


Figure 3.25 Mean maximum C-Reactive Protein level per Short Nutritional Assessment Questionnaire category (p=0.03)

There was a trend for lower s-albumin levels and a higher WCC level in the malnourished and at risk of malnutrition groups, but this was not significant.

The non-significant results of the SNAQ are summarized in Tables 3.23 and 3.24.

Table 3.23 Non-significant clinical outcome results for the SNAQ[a] nutritional risk categories

	Total (n=206)	Normal (n=132)	Risk Malnutrition (n=14)	Malnourished (n=60)	p-value	Test
	(n=205)	(n=131)	(n=14)	(n=60)	p=0.47	Kruskal-Wallis
Mean LOS (days)	5.75	5.89	4.18	5.80		test
SD	5.52	5.02	2.08	6.93		
CI	4.99 – 6.51	5.02 – 6.76	2.98 – 5.39	4.00 – 7.59		
	(n=197)	(n=127)	(n=13)	(n=57)	p=0.14	Kruskal-Wallis
Mean APACHE II score	10.41	10.63	7.69	10.53		test
SD	5.51	5.71	3.07	5.38		
CI	9.63 – 11.18	9.63 – 11.63	5.84 – 9.54	9.10 – 11.95		
	(n=206)	(n=132)	(n=14)	(n=60)	p=0.34	Kruskal-Wallis
Mean number of total complications	1.51	1.62	1.14	1.37		test
SD	2.04	2.00	2.11	2.12		
CI	1.23 – 1.79	1.28 – 1.97	-0.07 – 2.36	0.82 – 1.92		
	(n=206)	(n=132)	(n=14)	(n=60)	p=0.83	Kruskal-Wallis
Mean number of mild complications	0.28	0.29	0.21	0.27		test
SD	0.63	0.64	0.43	0.66		
CI	0.19 – 0.36	0.18 – 0.40	-0.03 – 0.46	0.10 – 0.44		
	(n=206)	(n=132)	(n=14)	(n=60)	p=0.15	Kruskal-Wallis
Mean number of moderate complications	0.70	0.75	0.43	0.67		test
SD	0.98	0.95	1.09	1.02		
CI	0.37 – 0.84	0.59 – 0.91	-0.20 – 1.06	0.40 – 0.93		
	(n=206)	(n=132)	(n=14)	(n=60)	p=0.34	Kruskal-Wallis
Mean number of severe complications	0.53	0.58	0.50	0.43		test
SD	0.92	0.92	0.85	0.93		
CI	0.41 – 0.66	0.42 – 0.74	0.01 – 0.99	0.19 – 0.67		
	(n=176)	(n=115)	(n=9)	(n=52)	p=0.09	Kruskal-Wallis
Mean s-albumin (g/l)	22.77	23.49	22.11	21.31		test
SD	6.20	5.98	6.47	6.48		
CI	21.85 – 23.70	22.38 – 24.59	17.06 – 27.16	19.50 – 23.11		

	(n=189)	(n=125)	(n=11)	(n=53)	p=0.5	Kruskal-Wallis test
Mean WCC (x 10^9/l)	15.89	15.56	17.21	16.38		
SD	9.51	9.24	6.99	10.66		
CI	14.52 – 17.25	13.93 – 17.20	12.52 – 21.90	13.44 – 19.32		

[a] Short Nutritional Assessment Questionnaire

Table 3.24 M-L Chi-square test of the presence or absence of death by SNAQ[a] category (p=0.59)

SNAQ	Death - present	Death - absent	Row - Totals
Normal	3 (2.29%)	128 (97.71%)	**131**
Risk malnutrition	1 (7.14%)	13 (92.86%)	**14**
Malnourished	1 (1.67%)	59 (98.33%)	**60**
Totals	**5**	**200**	**205**

[a] Short Nutritional Assessment Questionnaire

When the group at risk of malnutrition and the malnourished group were combined (n=74; 35.92%) and compared to the well-nourished group (n=132; 64.08%), significant correlations were found with LOV, CRP and s-albumin. The combined malnutrition group had a significantly lower (p=0.03; Mann-Whitney U test) mean s-albumin (21.43; SD 6.44; CI 19.78-23.08) than the well-nourished group (23.49; SD 5.98; CI 22.38-24.59; Figure 3.26).

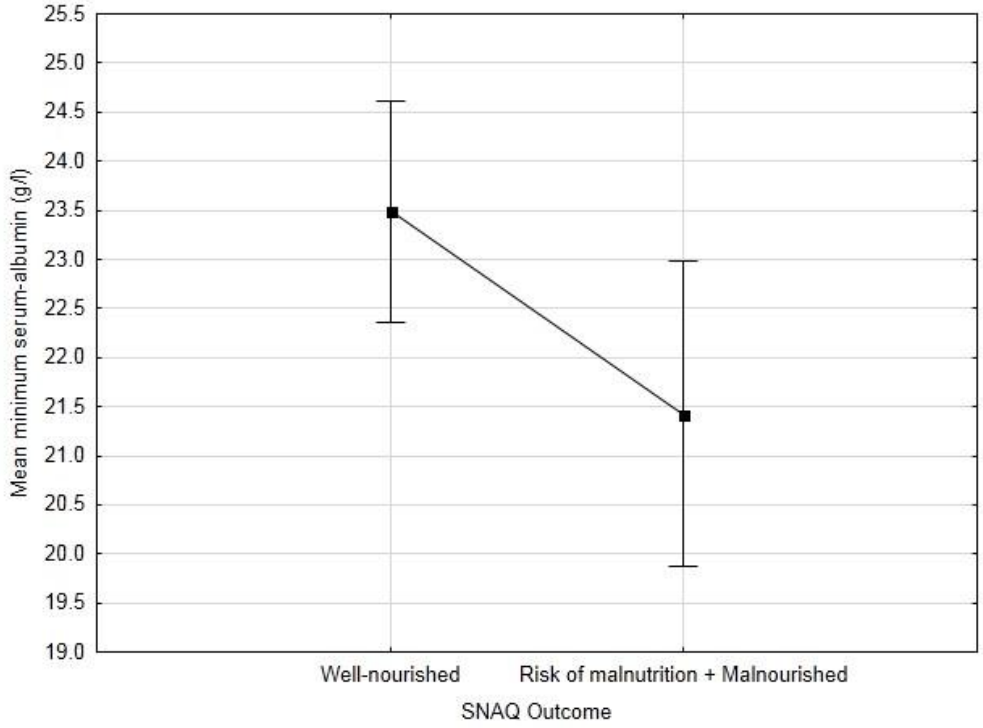


Figure 3.26 Mean minimum serum-albumin per Short Nutritional Assessment Questionnaire outcome (p=0.03)

However, the well-nourished group had a significantly higher (p=0.03; Mann-Whitney U test) mean CRP (196.80; SD 118.14; CI 174.26-219.33) and a significantly longer (p<0.01; Mann-Whitney U test) mean LOV (3.19; SD 4.65; CI 2.39-4.00) than the combined malnutrition group (CRP: 153.48; SD 110.63; CI 123.86-183.11; LOV: 2.46; SD 5.77; CI 1.12-3.80; Figures 3.27 and 3.28, next page).

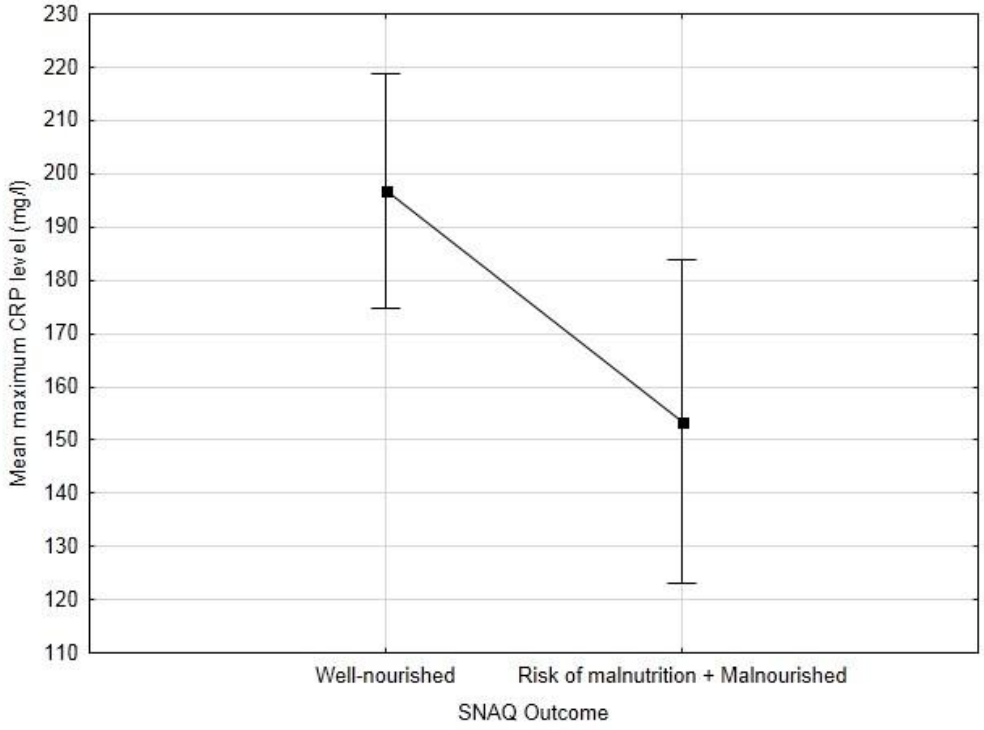


Figure 3.27 Mean maximum C-Reactive Protein level per Short Nutritional Assessment Questionnaire outcome (p=0.03)

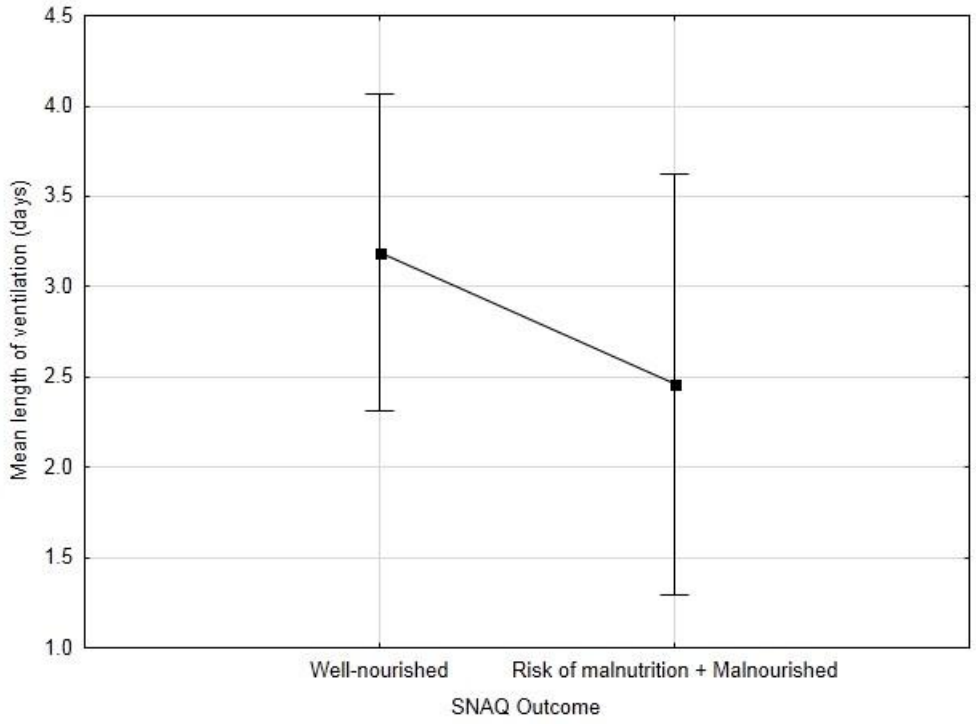


Figure 3.28 Mean length of ventilation per Short Nutritional Assessment Questionnaire outcome (p<0.01)

There was a trend for the combined malnutrition group to have a higher mortality and mean WCC than the well-nourished group, but this did not reach statistical significance.

The non-significant results are summarized in Tables 3.25 and 3.26.

Table 3.25 Non-significant clinical outcome results for the SNAQ[a] nutritional risk outcomes

	Total	Well-nourished	Moderately + severely malnourished	p-value	Test
	(n=205)	(n=131)	(n=74)	p=0.25	Mann-Whitney U test
Mean LOS (days)	5.75	5.89	5.49		
SD	5.52	5.02	6.32		
CI	4.99-6.51	5.02-6.76	4.03-6.96		
	(n=197)	(n=127)	(n=70)	p=0.35	Mann-Whitney U test
Mean APACHE II score	10.41	10.63	10.00		
SD	5.51	5.72	5.13		
CI	9.63-11.18	9.63-11.63	8.78-11.22		
	(n=206)	(n=132)	(n=74)	p=0.20	Mann-Whitney U test
Mean number of total complications	1.51	1.62	1.32		
SD	2.04	2.00	2.11		
CI	1.23-1.79	1.28-1.97	0.84-1.81		
	(n=206)	(n=132)	(n=74)	p=0.68	Mann-Whitney U test
Mean number of mild complications	0.28	0.29	0.26		
SD	0.63	0.64	0.62		
CI	0.19-0.36	0.18-0.40	0.11-0.40		
	(n=206)	(n=132)	(n=74)	p=0.20	Mann-Whitney U test
Mean number of moderate complications	0.70	0.75	0.62		
SD	0.98	0.95	1.03		
CI	0.57-0.84	0.59-0.91	0.38-0.86		
	(n=206)	(n=132)	(n=74)	p=0.26	Mann-Whitney U test
Mean number of severe complications	0.53	0.58	0.45		
SD	0.92	0.92	0.91		
CI	0.41-0.66	0.42-0.74	0.24-0.66		

	(n=189)	(n=125)	(n=64)	p=0.41	Mann-Whitney U test
Mean WCC (x 10^9/l) SD	15.89	15.56	16.52		
CI	9.51	9.24	10.08		
	14.52-17.25	14.52-17.25	14.00-19.04		

[a] Short Nutritional Assessment Questionnaire

Table 3.26 M-L Chi-square test of the presence or absence of death by SNAQ[a] outcome (p=0.86)

NRI	Death - present	Death - absent	Row - Totals
Well-nourished	3 (2.29%)	128 (97.71%)	**131**
Moderately + severely malnourished	2 (2.70%)	72 (97.30%)	**74**
Total	**5**	**200**	**205**

[a] Short Nutritional Assessment Questionnaire

3.3.6 NRI

Only three patients (1.70%) were classified as well-nourished according to the NRI. Four (2.27%) were classified as mildly malnourished, 37 (21.02%) as moderately malnourished and 132 (75.00%) as severely malnourished (Figure 3.29). As the first two groups are very small (n=3, n=4), caution should be taken when interpreting the results.

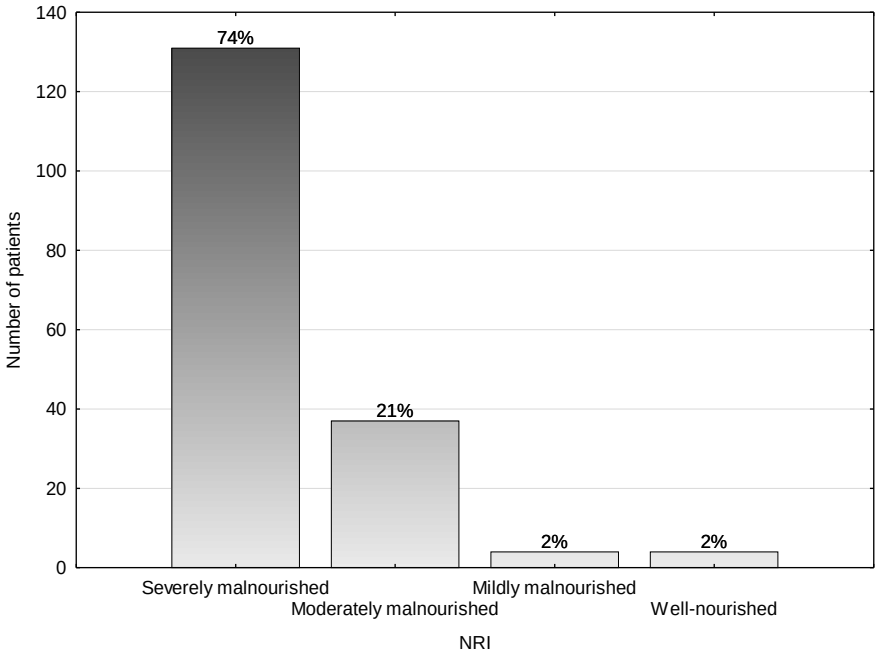


Figure 3.29 Prevalence of malnutrition according to the Nutritional Risk Indicator

When analysing all four groups the NRI was significantly correlated with LOS (p=0.04; Kruskal-Wallis test; Figure 3.30) and LOV (p=0.02; Kruskal-Wallis test; Figure 3.31). The well-nourished group had a mean LOS of 2.69 days (SD 1.09; CI -0.03-5.4) and a mean LOV of 0.00 days (SD 0.00; CI 0.00 – 0.00) which were both shorter than those of all three malnourished groups. The mildly malnourished group had the longest LOS (9.51; SD 3.21; CI 4.39-14.63) and LOV (5.50; SD 3.70; CI -0.38-11.38) followed by the severely malnourished group (LOS: 6.52; SD 6.35; CI 5.42-7.61; LOV: 3.63; SD 5.80; CI 2.62-4.63) and then the moderately malnourished group (LOS: 5.18; SD3.75; CI 3.93-6.43; LOV: 2.27; SD 3.91; CI 0.97-3.58). When comparing only two groups at a time, however, none of the results remained significant for either LOS or LOV.

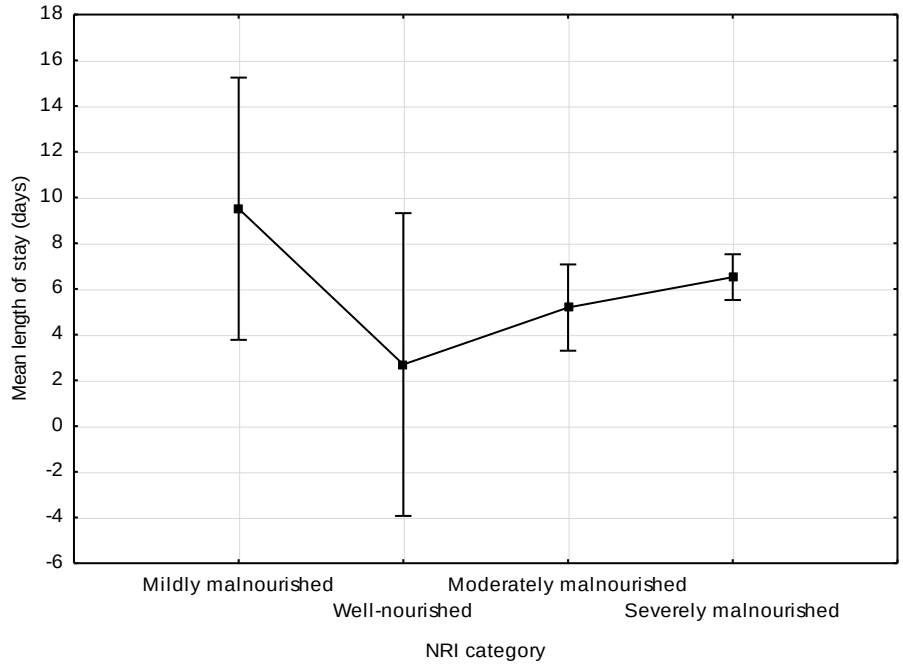


Figure 3.30 Mean length of stay per Nutritional Risk Indicator category (p=0.04)

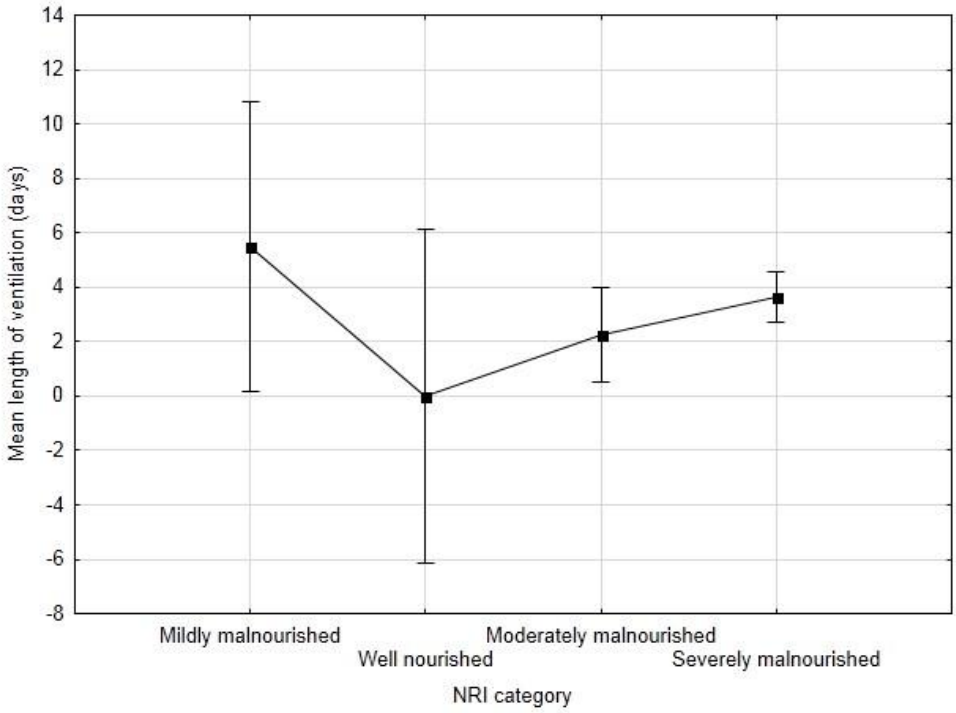


Figure 3.31 Mean length of ventilation per Nutritional Risk Indicator category (p=0.02)

A significant correlation was also found between NRI classification and s-albumin (p<0.01; Kruskal-Wallis test; Figure 3.32). The well-nourished group had a mean s-albumin level of 33.33g/l (SD 9.81; CI 8.95-57.71) which was significantly higher (p<0.01; Bonferroni test) than the mildly malnourished group (30.00; SD 1.15; CI 28.16-31.84) and the severely malnourished group (20.69; SD 4.96; CI 19.83-21.54) and higher, but not significantly, than the moderately malnourished group (28.57; SD 5.14; CI 26.85-30.28). The severely malnourished group had the lowest s-albumin and this was significantly lower (p<0.01; Bonferroni) than moderately and mildly malnourished groups.

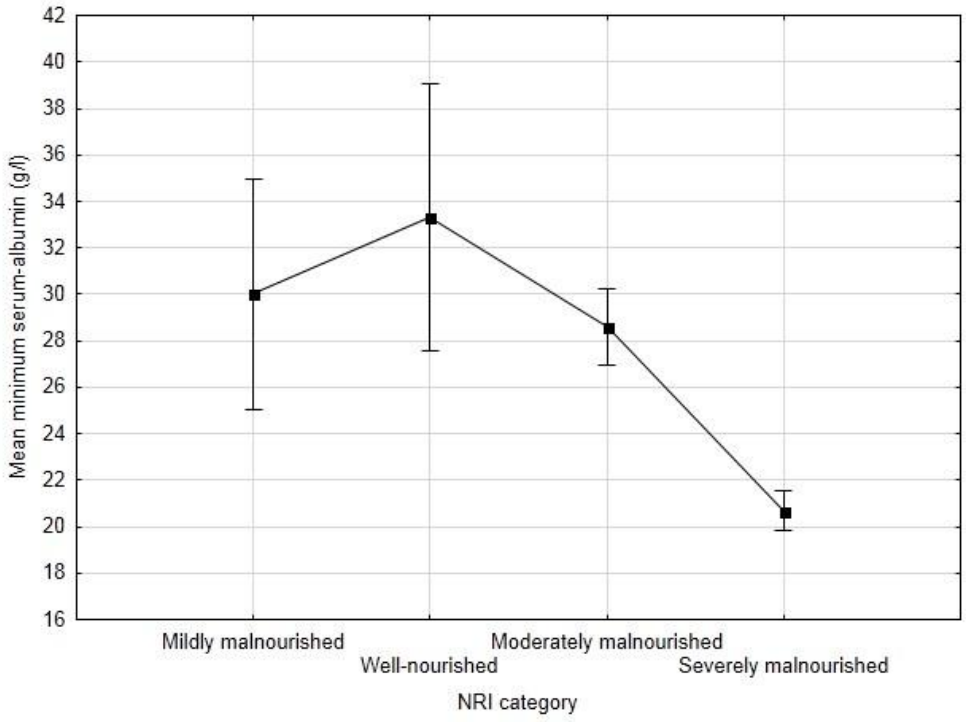


Figure 3.32 Mean minimum serum-albumin per Nutritional Risk Indicator category (p<0.01)

A trend was found for higher mortality in the severely malnourished group, but this was not significant compared to any of the other groups. All three of the malnourished groups also had more moderate, severe and total complications as well as higher CRP levels than the well-nourished group, but this also did not reach statistical significance.

The non-significant results for the NRI can be seen in Tables 3.27 and 3.28.

Table 3.27 Non-significant clinical outcome results for the NRI[a] nutritional risk categories

	Total	Normal	Mild malnutrition	Moderate malnutrition	Severe malnutrition	p-value	Test
	(n=168)	(n=3)	(n=4)	(n=36)	(n=125)	p=0.28	Kruskal-Wallis test
Mean APACHE II score	10.64	13.33	11.50	9.17	10.97		
SD	5.66	5.13	5.07	5.33	5.75		
CI	9.78 – 11.50	0.59 – 26.08	3.44 – 19.56	7.36 – 10.97	9.95 – 11.99		
	(n=176)	(n=3)	(n=4)	(n=37)	(n=132)	p=0.39	Kruskal-Wallis test
Mean number of total complications	1.71	1.00	2.75	1.32	1.80		
SD	2.12	1.73	2.5	1.78	2.21		
CI	1.39 – 2.03	-3.30 – 5.30	-1.23 – 6.73	0.73 – 1.92	1.42 – 2.18		
	(n=176)	(n=3)	(n=4)	(n=37)	(n=132)	p=0.66	Kruskal-Wallis test
Mean number of mild complications	0.32	0.33	0.00	0.30	0.33		
SD	0.67	0.58	0.00	0.66	0.68		
CI	0.22 – 0.42	-1.10 – 1.77	0.00 – 0.00	0.08 – 0.52	0.22 – 0.45		
	(n=176)	(n=3)	(n=4)	(n=37)	(n=132)	p=0.68	Kruskal-Wallis test
Mean number of moderate complications	0.78	0.67	1.50	0.70	0.79		
SD	1.02	1.15	1.73	1.00	1.00		
CI	0.63 – 0.94	-2.20 – 3.54	-1.26 – 4.26	0.37 – 1.03	0.62 – 0.96		
	(n=176)	(n=3)	(n=4)	(n=37)	(n=132)	p=0.06	Kruskal-Wallis test
Mean number of severe complications	0.61	0.00	1.25	0.32	0.68		
SD	0.97	0.00	0.96	0.58	1.04		
CI	0.46 – 0.75	0.00 – 0.00	-0.27 – 2.77	0.13 – 0.52	0.50 – 0.86		
	(n=158)	(n=2)	(n=4)	(n=34)	(n=118)	p=0.24	Kruskal-Wallis test
Mean CRP (mg/l)	184.18	52.00	224.25	170.44	189.02		
SD	117.66	67.88	104.52	94.28	123.76		
CI	165.69	-557 – 661.90	57.94 – 390.56	137.55–203.34	166.45–211.58		

	(n=174)	(n=3)	(n=4)	(n=37)	(n=130)	p=0.94	Kruskal-Wallis test
Mean WCC (x 10^9/l)	16.09	15.14	12.85	14.92	16.55		
SD	9.70	5.59	1.42	5.65	10.76		
CI	14.64 – 17.54	1.26 – 29.02	10.59 – 15.11	13.04 – 16.80	13.04 – 18.41		

[a] Nutritional Risk Indicator

Table 3.28 M-L Chi-square test of the presence or absence of death by NRI[a] category (p=0.40)

NRI	Death - present	Death - absent	Row - Totals
Normal	0 (0.00%)	3 (100.00%)	**3**
Mild malnutrition	0 (0.00%)	4 (100.00%)	**4**
Moderate malnutrition	0 (0.00%)	37 (100.00%)	**37**
Severe malnutrition	5 (3.82%)	126 (96.18%)	**131**
Total	**5**	**170**	**175**

[a] Nutritional Risk Indicator

Analyses were also done comparing the well-nourished and mildly malnourished patients (n=7; 3.98%) to the moderately and severely malnourished patients (n=169; 96.02%). The only statistically significant correlation that was found was with s-albumin (Figure 3.33). The moderately and severely malnourished patients had a significantly lower ($p<0.01$; one-way ANOVA test) mean s-albumin (22.41; SD 5.96; CI 21.51-23.32) than the well-nourished and mildly malnourished patients (31.43; SD 6.00; CI 25.88-36.97).

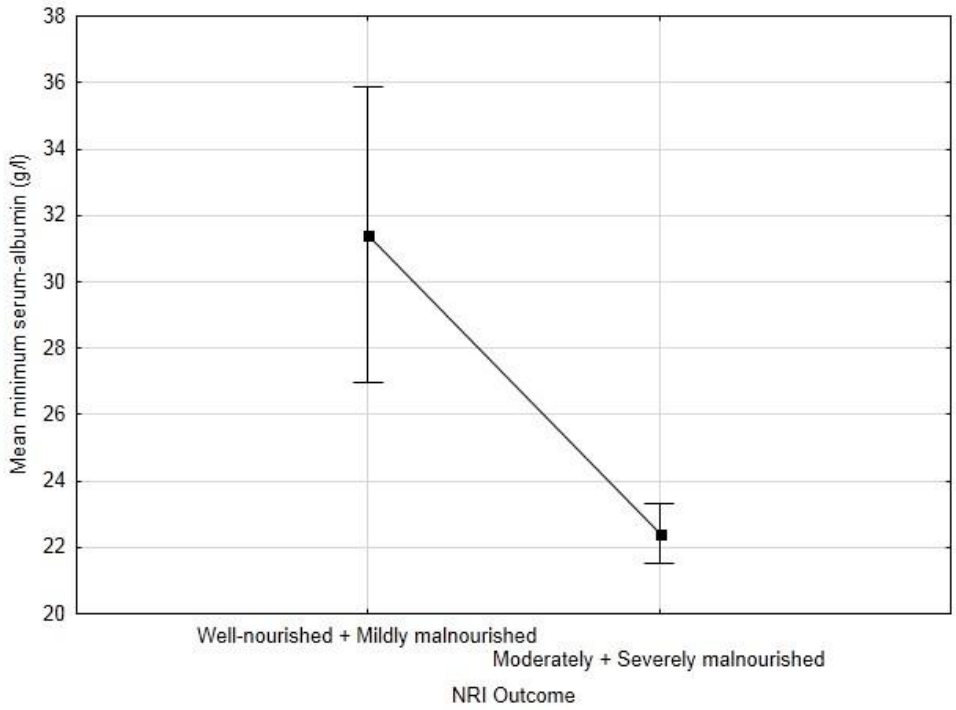


Figure 3.33 Mean minimum serum-albumin per Nutritional Risk Indicator Outcome ($p<0.01$)

There was also a trend for the moderately and severely malnourished patients to have a longer LOV, more mild complications, a higher mortality and higher WCC and CRP levels, but this did not reach statistical significance.

The non-significant results can be seen in Tables 3.29 and 3.30.

Table 3.29 Non-significant clinical outcome results for the NRI[a] nutritional risk outcomes

	Total	Well-nourished + mildly malnourished	Moderately + severely malnourished	p-value	Test
	(n=175)	(n=7)	(n=168)	p=0.73	Mann-Whitney U test
Mean LOS (days)	6.24	6.59	6.22		
SD	5.83	4.34	5.89		
CI	5.37-7.11	2.57-10.60	5.33-7.12		
	(n=175)	(n=7)	(n=168)	p=0.99	Mann-Whitney U test
Mean LOV (days)	3.32	3.14	3.33		
SD	5.40	3.93	5.46		
CI	2.51-4.13	-0.50-6.78	2.50-4.19		
	(n=168)	(n=7)	(n=161)	p=0.31	Mann-Whitney U test
Mean APACHE II score	10.64	12.29	10.57		
SD	5.66	4.75	5.70		
CI	9.78-11.50	7.89-16.68	9.68-11.45		
	(n=176)	(n=7)	(n=169)	p=0.71	Mann-Whitney U test
Mean number of total complications	1.71	2.00	1.70		
SD	2.12	2.24	2.13		
CI	1.39-2.03	-0.07-4.07	1.38-2.02		
	(n=176)	(n=7)	(n=169)	p=0.62	Mann-Whitney U test
Mean number of mild complications	0.32	0.14	0.33		
SD	0.67	0.38	0.68		
CI	0.22-0.42	-0.21-0.49	0.22-0.43		
	(n=176)	(n=7)	(n=169)	p=0.57	Mann-Whitney U test
Mean number of moderate complications	0.78	1.14	0.77		
SD	1.02	1.46	1.00		
CI	0.63-0.94	-0.21-2.50	0.62-0.92		
	(n=176)	(n=7)	(n=169)	p=0.71	Mann-Whitney U test
Mean number of severe complications	0.61	0.71	0.60		
SD	0.97	0.95	0.97		
CI	0.46-0.75	-0.17-1.59	0.46-0.75		

	(n=158)	(n=6)	(n=152)	p=0.75	Mann-Whitney U test
Mean CRP (mg/l)	184.18	166.83	184.86		
SD	117.66	124.05	117.77		
CI	165.69-202.66	36.65-297.01	165.99-203.74		
	(n=174)	(n=7)	(n=167)	p=0.72	Mann-Whitney U test
Mean WCC (x 10^9/l)	16.09	13.83	16.19		
SD	9.70	3.59	9.86		
CI	14.64-17.54	10.51-17.16	14.68-17.69		

[a] Nutritional Risk Indicator

Table 3.30 M-L Chi-square test of the presence or absence of death by NRI[a] outcome (p=0.52)

NRI	Death - present	Death - absent	Row - Totals
Well-nourished + mildly malnourished	0 (0.00%)	7 (100.00%)	**7**
Moderate + severe malnutrition	5 (2.98%)	163 (97.02%)	**168**
Total	**5**	**170**	**175**

[a] Nutritional Risk Indicator

3.3.7 MST

The MST classified 45 patients (21.84%) as well-nourished and 161 patients (78.16%) as malnourished (Figure 3.34). Note that the MST does not have categories for mild/moderate malnutrition or at risk of malnutrition.

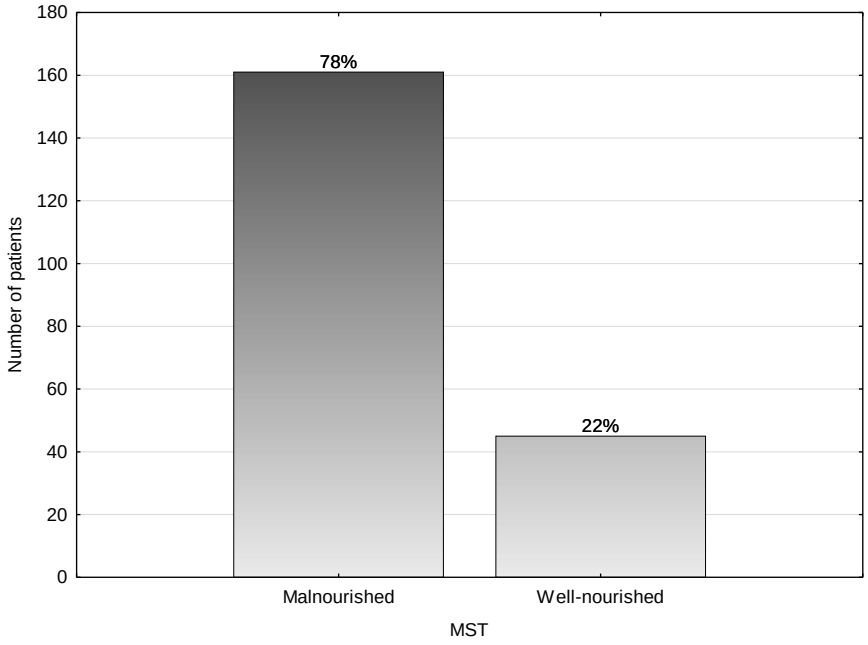


Figure 3.34 Prevalence of malnutrition according to the Malnutrition Screening Tool

The only significant correlation that was found was between MST category and total complications (Figure 3.35). The malnourished group had a mean rate of total complications of 1.70 (SD 2.17; CI 1.36-2.04) and this was significantly higher ($p<0.01$; Mann-Whitney U test) than the mean rate of total complications of the well-nourished group (0.84; SD 1.26; CI 0.47-1.22).

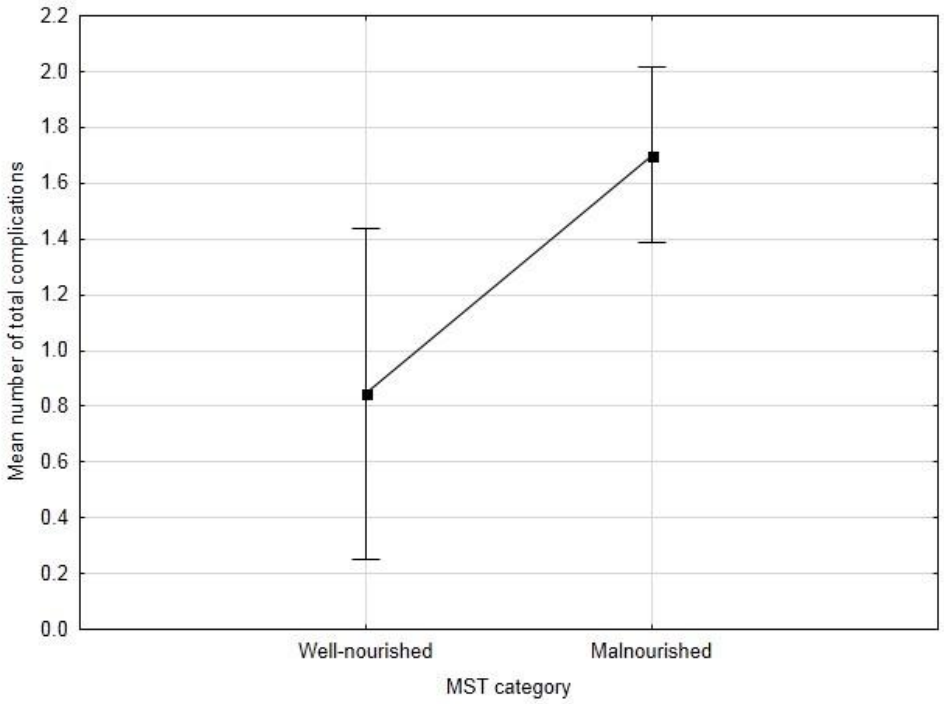


Figure 3.35 Mean number of total complications per Malnutrition Screening Tool category ($p<0.01$)

Almost all the other variables (LOS, LOV, APACHE II score, mild, moderate and severe complications, s-albumin, WCC and mortality) showed worse outcomes for the malnourished group, but none of these reached statistical significance.

Two variables did come close to statistical significance: WCC and APACHE II score were higher (WCC: p=0.06; APACHE II: p=0.07; Mann-Whitney U test) in the malnourished group than in the well-nourished group (Figures 3.36 and 3.37, next page).

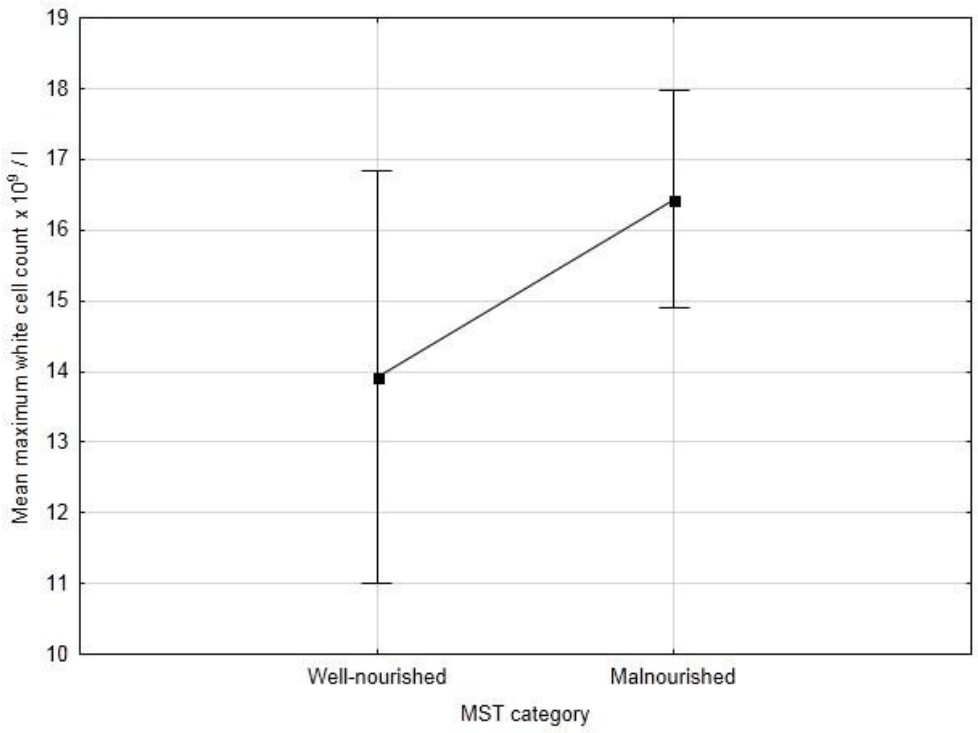


Figure 3.36 Mean maximum white cell count per Malnutrition Screening Tool category (p=0.06)

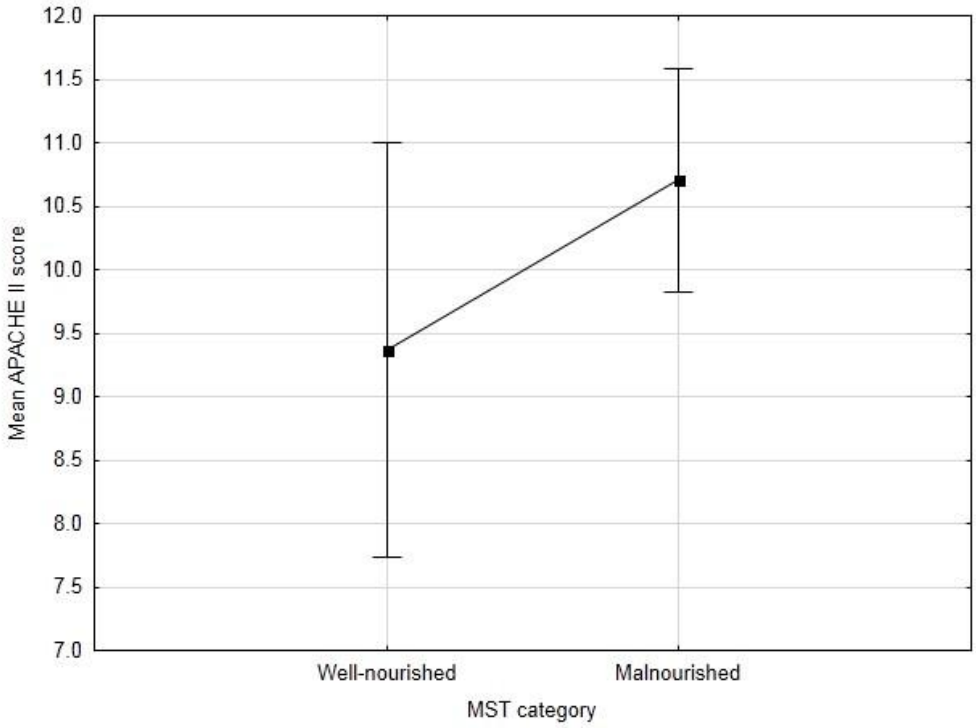


Figure 3.37 Mean APACHE II score per Malnutrition Screening Tool category (p=0.07)

Only the CRP variable showed worse outcomes for the well-nourished group than for the malnourished group, but this was not statistically significant.

The non-significant results for the MST can be seen in Tables 3.31 and 3.32.

Table 3.31 Non-significant clinical outcome results for the MST[a] nutritional risk categories

	Total	Well-nourished	Malnourished	p-value	Test
	(n=205)	(n=45)	(n=160)	p=0.12	Mann-Whitney U
Mean LOS (days)	5.75	4.51	6.09		test
SD	5.52	2.93	6.01		
CI	4.99-6.51	3.63-5.40	5.15-7.03		
	(n=205)	(n=45)	(n=160)	p=0.29	Mann-Whitney U
Mean LOV (days)	2.93	1.69	3.28		test
SD	5.08	2.54	5.55		
CI	2.23-3.63	0.93-2.45	2.41-4.14		
	(n=197)	(n=44)	(n=153)	p=0.07	Mann-Whitney U
Mean APACHE II score	10.41	9.36	10.71		test
SD	5.51	5.67	5.44		
CI	9.63-11.18	7.64-11.09	9.84-11.58		
	(n=206)	(n=45)	(n=161)	p=0.09	Mann-Whitney U
Mean number of mild complications	0.28	0.09	0.33		test
SD	9.63	0.29	0.69		
CI	0.19-0.36	0.00-0.18	0.22-0.44		
	(n=206)	(n=45)	(n=161)	p=0.14	Mann-Whitney U
Mean number of moderate complications	0.70	0.47	0.77		test
SD	0.98	0.69	1.04		
CI	0.57-0.84	0.26-0.68	0.61-0.93		
	(n=206)	(n=45)	(n=161)	p=0.08	Mann-Whitney U
Mean number of severe complications	0.53	0.29	0.60		test
SD	0.92	0.63	0.98		
CI	0.41-0.66	0.10-0.48	0.45-0.75		
	(n=176)	(n=35)	(n=141)	p=0.10	One-way ANOVA
Mean s-albumin (g/l)	22.77	24.31	22.39		test
SD	6.20	5.60	6.31		
CI	21.85-23.70	22.39-26.24	21.34-23.44		

	(n=164)	(n=33)	(n=131)	p=0.19	Mann-Whitney U test
Mean CRP (mg/l)	182.01	213.79	174.00		
SD	117.11	145.54	107.99		
CI	163.95-200.06	162.18-265.39	155.33-192.67		
	(n=189)	(n=41)	(n=148)	p=0.06	Mann-Whitney U test
Mean WCC (x 10^9/l)	15.89	13.93	16.43		
SD	9.51	7.05	10.04		
CI	14.52-17.25	11.70-16.15	14.80-18.06		

[a] **Malnutrition Screening Tool**

Table 3.32 M-L Chi-square test of the presence or absence of death by MST[a] category (p=0.91)

MST	Death - present	Death - absent	Row - Totals
Well-nourished	1 (2.22%)	44 (97.50%)	**45**
At risk of malnutrition + malnourished	4 (2.50%)	156 (97.89%)	**160**
Total	**5**	**200**	**205**

[a] **Malnutrition Screening Tool**

3.4 FEASIBILITY AND APPLICABILITY OF NRSTs

Eighty-six patients (41.75%) were able to provide information on their actual weight and in 10 cases (4.85%) the actual weight could be found in the patient's medical file. More than half (n=110; 53.40%) of the patient population's weight however had to be estimated, due to lack of information on actual weight. Weight loss/gain history could be precisely quantified in 50 of the cases (24.29%), either by the patient or by a friend/family member or from the medical file. In the rest of the patient population (n=156; 75.73%) the weight loss/gain history had to be estimated.

Of the 252 patients that were originally included in the study, 83 (32.94%) patients could not effectively communicate within 48 hours, which was necessary to complete nutritional risk screening. However, 30 (11.90%) of these patients had a friend/family member who could provide the necessary information and for 7 patients (2.78%) the information could be gathered from their medical file. This left 46 patients (18.25%) for whom no screening information could be obtained. They were labeled as failed screens and excluded from data analysis. Figure 3.38 illustrates the availability of data and the number of successful and unsuccessful screens.

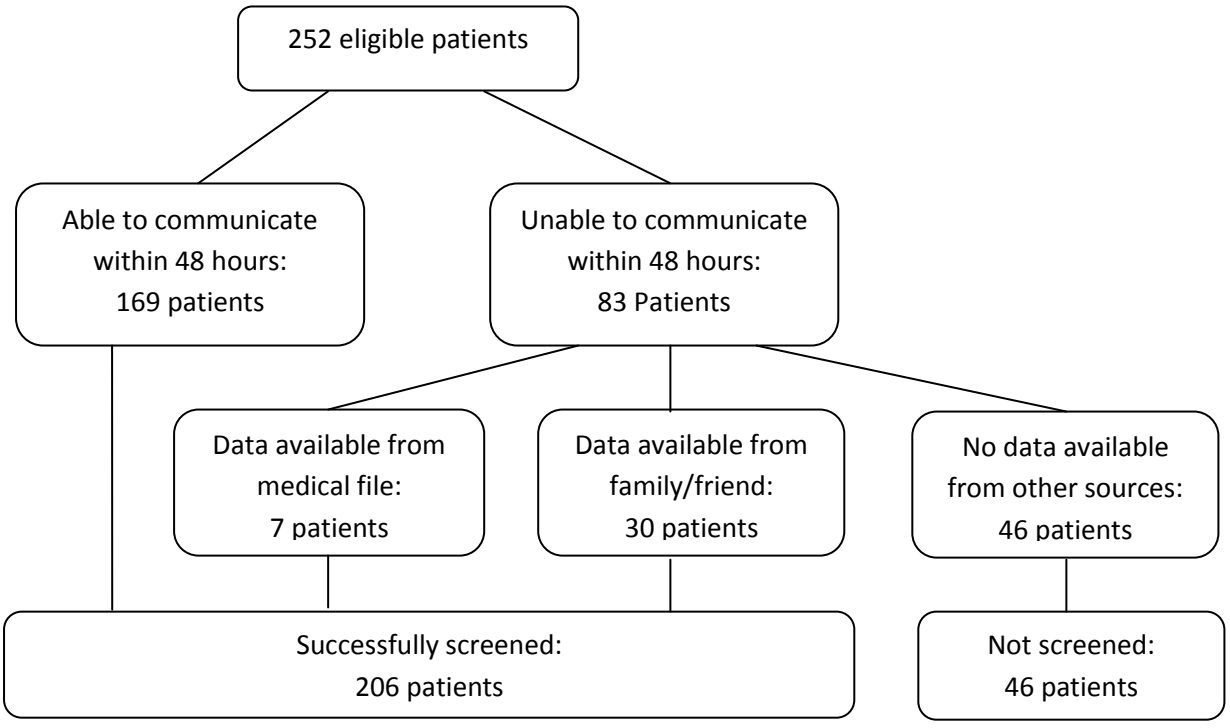


Figure 3.38 The number of successful and unsuccessful screens based on the availability of nutritional risk screening tool information

Of the 206 included patients, 169 (82.04%) could effectively communicate with the researcher within 48 hours to provide information on weight loss, dietary intake, gastrointestinal symptoms and functionality. On average the patients were able to effectively communicate with the researcher on day 2.15 (SD 2.07). More than half of the patients (n=112; 54.37%) could effectively communicate with the researcher on day one and a further 23.30% (n=48) could communicate by day two. However, 37 patients (17.96%) were only able to communicate after day two.

Information on disease severity was available from the medical file for all patients. Similarly, a physical examination could be performed for all patients. S-albumin was tested in only 176 patients (85.44% of the included patient population). On average the s-albumin test results were available by day 0.58 (SD 1.16). One-hundred and twenty-three patients (69.89%) had s-albumin test results available by day one and 31 patients (17.61%) had test results available by day two. In 22 cases (12.51%) the tests were only done or results only became available after day two.

3.5 EXCLUDED PATIENTS

Forty-six patients were excluded from data-analysis due to unavailability of data necessary to complete the various NRSTs. They were however still followed up until discharge or death and observed for clinical outcomes. Table 3.33 summarizes their demographical characteristics, Table 3.34 summarizes their diagnostic categories and Figure 3.39 depicts the spread across BMI categories.

Table 3.33 Demographic characteristics of excluded patient population (n=46)

Patient demographics	n (%)	n (%)
Gender	Male 32 (69.57%)	Female 14 (30.43%)
Age Mean: 46.85 (SD 17.66) years	<65 years 37 (80.43%)	≥ 65 years 9 (19.57%)
Admission status	Emergency 45 (97.83%)	Elective 1 (2.17%)

Table 3.34 Primary diagnosis of excluded patient population (n=46)

Diagnostic group	n (%)
Gastrointestinal surgery	23 (50.00%)
Polytrauma	11 (23.91%)
Gynaecology	2 (4.35%)
Other	2 (4.35%)
Respiratory	2 (4.35%)
Vascular surgery	2 (4.35%)
Assault	1 (2.17%)
Infectious	1 (2.17%)
Trauma	1 (2.17%)

The mean age of the excluded patients as well as their diagnoses was not statistically different from the mean age or diagnoses of the included patients.

On the other hand the excluded patients had a significantly different admission status distribution from the included patients: 97.83% of the excluded patients were emergency admissions versus 57.77% of the included patients ($p<0.01$; M-L Chi-square test). When all of the emergency admissions are considered (included and excluded patients; n=164), 27.44% of them could not be screened and were excluded from data-analysis.

Also, when dividing the patients into age categories, the excluded patients had significantly more patients (80.43%) in the <65 years category than the included patients who had 78.16% ($p<0.01$; M-L Chi-square test).

The excluded patients had a mean BMI of 24.36 (SD 4.77); this was not statistically different from the included patients (p=0.66; T-test). The majority (80.00%) had a BMI of more than 20.00, while 6.67% had a BMI between 18.5 and 19.99 and 13.33% had a BMI of less than 18.5.

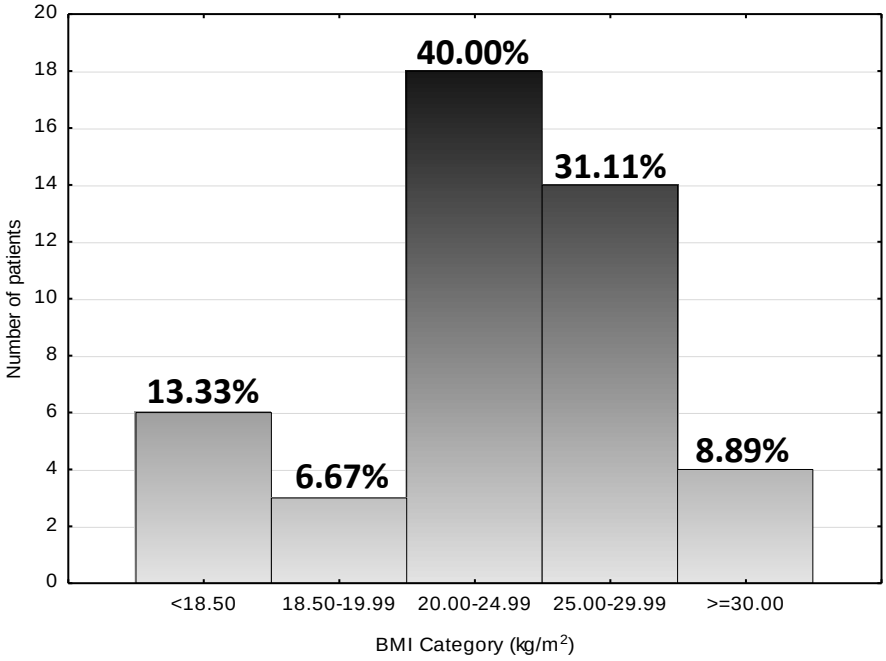


Figure 3.39 Number of patients within the five BMI categories

Table 3.35 summarizes the clinical outcomes observed in the excluded patient group and compares it to the included patient group.

Table 3.35 Clinical outcomes observed in excluded (n=46) versus included patients (n=206)

Clinical outcome	Excluded patients Mean (SD)	Included patients Mean (SD)	p-value
LOS	12.26 (10.19)	5.75 (5.52)	p<0.01 (Mann-Whitney U test)
LOV	9.82 (10.33)	2.93 (5.08)	p<0.01 (Mann-Whitney U test)
APACHE II score	14.95 (7.10)	10.41 (5.51)	p<0.01 (Mann-Whitney U test)
Complications			
Total	3.67 (3.18)	1.51 (2.04)	p<0.01 (Mann-Whitney U test)
Mild	0.50 (0.75)	0.28 (0.63)	p=0.08 (Mann-Whitney U test)
Moderate	1.52 (1.33)	0.70 (0.98)	p<0.01 (Mann-Whitney U test)
Severe	1.65 (1.66)	0.53 (0.92)	p<0.01 (Mann-Whitney U test)
Biochemistry			
S-albumin	20.54 (6.16)	22.77 (6.20)	p=0.03 (One-way ANOVA test)
WCC	18.53 (6.94)	15.89 (9.51)	p<0.01 (Mann-Whitney U test)
CRP	247.23 (104.10)	182.01 (117.11)	p<0.01 (Mann-Whitney U test)
	n (%)	**n (%)**	**p-value**
Mortality	4 (8.89%)	5 (2.44%)	p=0.06 (Mann-Whitney U test)

From the table it can be seen that the excluded patient group showed worse outcomes for all of the variables measured and this was statistically significant for LOS, LOV, APACHE II score, total, moderate and severe complications, minimum s-albumin and maximum WCC and CRP levels. Only number of mild complications and mortality did not reach significance.

3.6 RELIABILITY OF ESTIMATED BODY WEIGHT

Body weight was estimated for study patients by the researcher (dietician 1) and the ICU dietician (dietician 2) and was also calculated using KH and MUAC measurements in a formula. The correlations between these estimations and calculations were tested to provide information about the reliability and validity thereof.

Table 3.36 summarizes the mean values for the estimated body weights, the average estimated body weight and the calculated body weight.

Table 3.36 Summary of average estimated and average calculated body weights of study patients (n=206)

	Dietician 1	Dietician 2	p-value
Weight (kg)	71.69 (SD 17.46)	69.31 (SD 18.45)	p=0.02
BMI (kg/m^2)	25.41 (SD 6.45)	24.65 (SD 7.47)	p=0.04
	Average estimated	**Calculated**	**p-value**
Weight (kg)	70.52 (SD 16.39)	69.88 (SD 14.77)	p=0.28
BMI (kg/m^2)	24.70 (SD 5.67)	24.48 (5.10)	p=0.30

The two dieticians' average estimations differed by just over 2kg. However, a T-test for dependent samples revealed that this difference was statistically significant (p=0.02). When the estimated weights were used to calculate BMI the difference was much less pronounced (p=0.04; T-test for dependent sample). Moreover, a good correlation of r=0.85 was found between the two dieticians' estimations and this was statistically significant at p=0.00 (Spearman rank correlation; Figure 3.40).

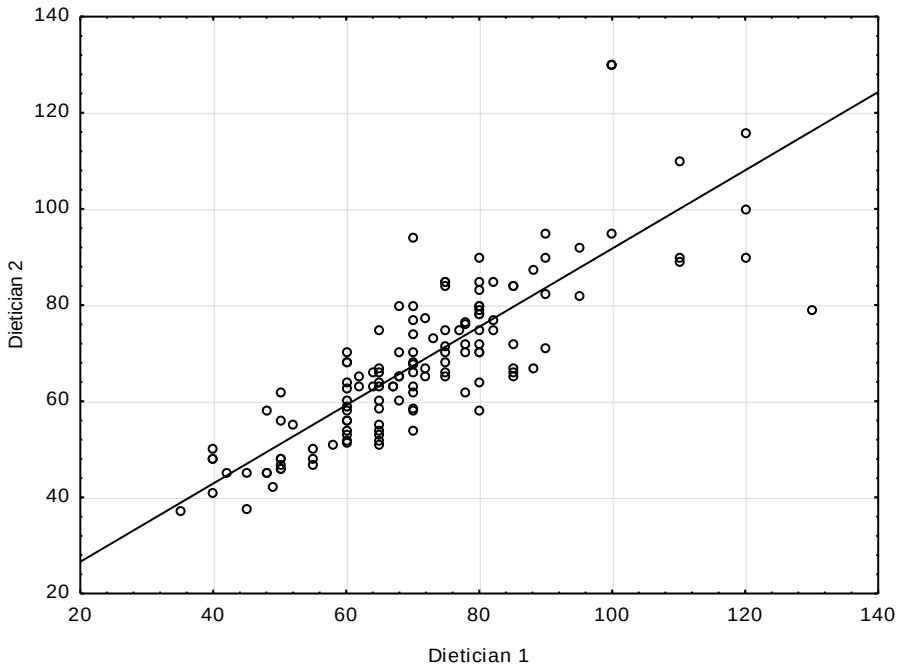


Figure 3.40 Correlation between dietician 1 and dieticians 2's estimated body weights (p=0.00)

The correlation between the average estimated body weight for each patient and the calculated body weight was also measured. A significant positive correlation was found with r=0.88 and p=0.00(Spearman rank correlation; Figure 3.41). A similar correlation (r=0.87; p=0.00; Spearman rank correlation) was found when comparing BMI calculated with estimated body weight and BMI using calculated body weight (Figure 3.42, next page). The differences between the estimated and calculated weights and the estimated and calculated BMI values were non-significant (p=0.28 and p=0.30 respectively; T-test for dependent sample).

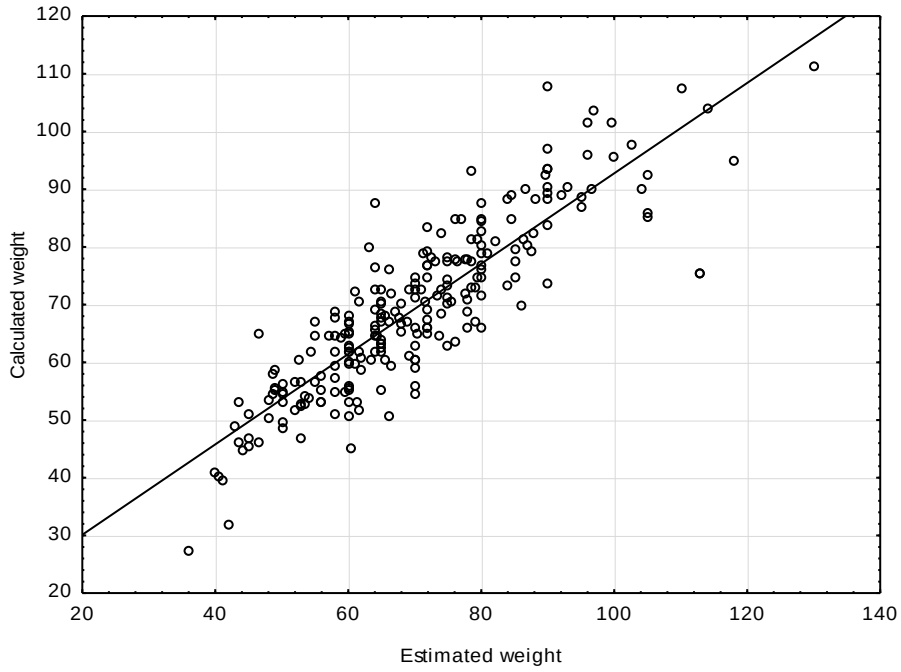


Figure 3.41 Correlation between estimated body weight and calculated body weight (p=0.00)

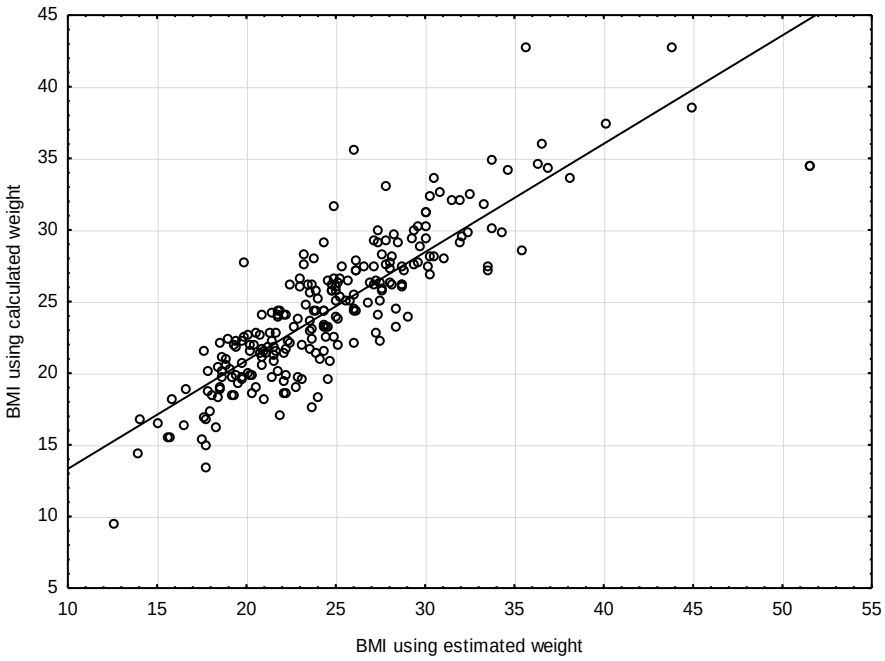


Figure 3.42 Correlation between BMI using estimated body weight and BMI using calculated body weight (p=0.00)

3.7 HYPOTHESIS

Data-analyses have shown that not all NRSTs can effectively predict clinical outcomes in adult patients admitted to the SICU of TAH. Consequently, the hypothesis for this study can be rejected.

CHAPTER 4: DISCUSSION

Nutritional risk screening is currently recommended for all hospitalised patients as a way to improve the recognition and treatment of malnourished patients.[40,42] Malnutrition seems to be a serious and widespread problem with deleterious consequences among hospitalised patients and therefore early recognition and intervention is crucial.[11]

Since ICU patients are hospitalised patients with an exceptionally high risk for disease-related malnutrition,[11] they too should then be screened. However, very little is known about the use of NRSTs in critically ill patients. Are they feasible in this patient population? How well do NRSTs perform in these patients? This study was one of the first to investigate such imperative knowledge. The aims were to determine the NRSTs that could effectively predict clinical outcomes in critically ill patients and to comment on the applicability and feasibility of these tools in this setting.

4.1 PATIENT DEMOGRAPHICS

The present study included a higher number of males than females. A few studies among ICU patients have also reported a higher percentage of males in their study samples.[24,33,187,189] The mean age of the study population was in general younger than previously seen.[24,58,100] However, a large study found an almost exactly similar mean age among their ICU patient population.[187] It has also been reported that surgical ICU patients tend to be younger[189] and this correlates well with the larger percentage of non-elderly patients found in the present study.

The study sample represented a heterogeneous population and included patients from various diagnostic specialties. The majority of patients were however admitted for gastrointestinal surgery. Sungurtekin et al. also reported that among their population of critically ill patients, the most common admission diagnosis were abdominal surgery.[33] In terms of admission status, the present study had a larger percentage of emergency admissions than elective admissions. Similarly, this finding has been reported before.[187]

Based solely on BMI status and using the WHO classification system for BMI[3], almost half of the patients had a normal nutritional status (BMI 18.5–24.99) and only a small percentage had malnourished BMI classifications (BMI <18.5). It is clear that BMI alone is not sufficient to determine undernutrition. Interestingly, a large number of patients were also classified as overweight (BMI 25-29.99)) or obese (BMI >30). This technically also classifies them as malnourished and may indicate an increased risk of complications, but this was beyond the scope of the research project. It does however highlight the challenge of nutritional risk screening in the ICU setting as overweight and obesity can easily mask loss of lean body mass. The average BMI of the study population was on the

border between normal nutritional status and overweight. Both Sorensen et al. and Sheean et al. found that the average BMI of their ICU patients fell into the overweight category.[24,32] It seems that the study population in the present study was slightly leaner, but still on average well-nourished and not malnourished according to BMI status.

4.2 CLINICAL OUTCOMES

The average LOS of the study population was 5.75 days. Previous studies among ICU patients have reported mean LOS ranging from 1.6 to 8 days.[58,187-189] The present study however excluded patients with a LOS of less than 48 hours and therefore it is expected that the average LOS would be towards the higher end of the range. The mortality rate for ICU patients in the literature ranges from 8 to 23.4%.[187,188] In the present study a much lower mortality rate of 2.44% was found. This can once again be explained by the exclusion criteria employed as well as the fact that the study population was younger and also less severely ill. A large study by Strand et al. reported that the median LOS in ICU before death occurs is 1.5 days.[188] As the present study excluded patients with a LOS of less than 48 hours (2 days), a large number of mortality cases could have been excluded. The study population was also younger than many other ICU study samples reported on. It is a well-known fact that increased age is a risk factor for mortality, while younger patients are less likely to die.[31] Similarly, illness severity scoring systems such as the APACHE II scores are good predictors of mortality.[189] The present study population had a mean APACHE II score of 10.41 which is 7.1 to 12.7 points lower than the mean APACHE II scores seen in other ICU populations.[189] A lower APACHE II score lowers the risk of mortality. It is unclear why APACHE II scores were lower in this study population. However, analysis of the excluded patients reveals that a large number of patients with higher APACHE II scores were eliminated from data-analysis. It is also possible that patients with higher APACHE II scores were excluded in the beginning based on the exclusion criteria used in this study (SICU stay of < 48 hours).

More than half of the ICU patients developed at least one complication during the course of their ICU stay and those that developed complications were more likely to experience moderate or severe complications. Previous complication rates for non-ICU patients have ranged from 15 to 28%.[24,49,88,96,98,121] It is however expected that the rate of developing complications would be higher in ICU patients as these patients are more severely ill. Also, studies differ in terms of methodology and the specific complications that are evaluated, which could further explain the discrepancies seen.

As expected the mean-minimum s-albumin levels were well below normal in the present study. Critical illness is known to decrease s-albumin levels by causing capillary leakage and negatively affecting the rate of synthesis and degradation. Dilution of serum-levels may also occur due to administration of large fluid resuscitation volumes.[190] The maximum WCC and CRP levels on the other hand were increased above normal. This is also expected as trauma, infection and inflammation may lead to a rapid increase of these immunological and acute phase markers.[191]

4.3 PREVALENCE OF MALNUTRITION

4.3.1 General prevalence of malnutrition

In general the rates of malnutrition found with the various screening tools tend to correlate well with the rates reported in the literature for ICU patients, while it tends to be higher than what is reported for the general hospital environment. The rate of malnutrition or risk of malnutrition found in this study ranges from 35.93 to 82.04% depending on the screening tool used. This range falls in the malnutrition range of 29-100% reported in the literature for ICU patients.[11,31-33] The MNA-SF, NRS-2002, NRI and MST screening tools showed the highest malnutrition rates (69.41-82.04%) which is higher than the range of 20-59% reported in the literature for general hospitalised patients.[13-21,23-25,38,39] It is however expected that the rate of malnutrition for ICU patients would be higher than in the general hospitalised population,[11] as is also shown by the rate of 29-100% reported for ICU settings. The ICU setting poses a unique risk for malnutrition due to the prevalence of inflammation, hypermetabolism and hypercatabolism induced by critical illness.[6,7] Furthermore, ICU patients are often dependent on alternative methods of feeding such as enteral or parenteral nutrition which are not always administered immediately and at full volume. Feeds are also often interrupted to allow for medical or surgical procedures.[6,7,11] These factors inhibit the provision of adequate energy and nutrients that are vital to attenuate the effects of critical illness and therefore contribute to the development of malnutrition. The MUST, SNAQ and SGA showed slightly lower rates of malnutrition (35.93-49.03%) which correlates with both the ranges found for ICU and general hospitalised patients.

4.3.2 Prevalence of malnutrition according to the MUST

The MUST classified 18.93% of patients as at risk of malnutrition and 30.10% as malnourished. This is similar although towards the higher end to what has previously been reported in general hospitalised patients (10-25% and 18-41% respectively).[16,39,46,48,50,54,56-59] The prevalence of malnourished patients is however much lower than the 77% that was found in another ICU sample.[58] This was however a small study that included only 13 critically ill patients of which 3 were classified

as well-nourished and 10 as malnourished. No other ICU comparisons are available. It is speculated that the MUST tends to overestimate malnutrition and underestimate risk of malnutrition in critically ill patients.[39,49] This is due to the recommendation that an acute disease effect score of 2 should be given to all critically ill patients which would then routinely classify them as malnourished.[46] This should be noted as one of the limitations to the MUST's utility in hospitalised and especially critically ill patients.[46] Not all critically ill patients are equally sick and therefore assigning an acute disease effect score of 2 to everyone could overestimate the prevalence of malnutrition. A system for grading disease severity is necessary. For the present study, the researcher decided not to routinely assign a score of 2 to all critically ill patients. The patients were evaluated as per protocol for general hospitalised patients where an acute disease effect score of 2 was given for the presence of acute disease with the addition of no nutritional intake for >5 days. This was done to avoid the overestimation of malnutrition and could explain the lower rate of malnutrition found. The prevalence of risk of malnutrition is however much higher than the zero rate reported in the other ICU study,[58] indicating that the results of the present study may be a more accurate reflection of nutritional risk in an ICU setting.

4.3.3 Prevalence of malnutrition according to the MNA-SF

Overall the MNA-SF classified 52.91% of patients as at risk of malnutrition and 16.50% as malnourished. Only one study using the newer version of the MNA-SF in hospitalised patients is however available for comparison. The study by Vischer et al. included elderly hospitalised patients of which a slightly greater percentage (26%) were classified as malnourished and a similar percentage (51%) classified as at risk of malnutrition.[75] The fact that the study only included elderly patients could however explain the higher rate of malnutrition. Hospitalised elderly patients are known to present with increased risk of malnutrition.[62] When only the elderly patients in the present study were analysed, a somewhat higher percentage of patients were classified as at risk of malnutrition (60%) and as malnourished (20%), more in line with the findings by Vischer et al.

To compare the malnutrition rate with the results from studies using the older version of the MNA-SF, the group at risk of malnutrition and the malnourished group have to be added together. Doing this, 69.41% of patients from the present study can be considered as nutritionally at risk and this falls toward the higher end of the 28-73% reported in the literature.[49,76-78,84,86,88] This can partially be explained by the fact that previous studies only included general hospitalised patients and a higher rate of malnutrition is to be expected in ICU patients.[11] Then, when looking at the scoring of the question on recent weight loss it is possible that the patients in the present study may have scored lower than usual (a lower total score indicates malnutrition). The MNA-SF provides an option for

when the prevalence of weight loss is unknown. Choosing this option gives the patient a score of 1 which is lower than the score for no weight loss or moderate weight loss of 1-3kg and just higher than the score for >3kg weight loss.[65] Due to the fact that 75.73% of the study population could not provide information on recent weight loss it is reasonable to presume that a large number of the patients scored at least 1 point less than what they would have if they could have quantified their recent weight loss. This could have lead to a higher number of patients scoring less than 12 total marks and being classified as nutritionally at risk.

4.3.4 Prevalence of malnutrition according to the NRS-2002

The NRS-2002 classified 72.82% of patients as malnourished. This is much higher than the range of 6-42% reported in the literature for non-ICU hospitalised patients.[24,30,54,93-99,101-107] Looking at the NRS-2002 screening protocol it can be expected that ICU patients will score higher than general hospitalised patients. According to the protocol, patients requiring intensive care with an APACHE II score over 10, ventilation, inotropic support and whose protein requirements are increased to a level that is difficult to provide should receive a score of 3, which would automatically classify them as malnourished.[53] In the present study, patients were not routinely assigned a score of 3, but were critically evaluated and scored according to disease severity. Therefore only 72.82% of patients were classified a malnourished and not a 100%. Three studies have previously used the NRS-2002 in ICU patients, but only two reported the rate of malnutrition found.[24,100,105] The first was a multicentre Turkish study that included 1655 ICU patients and found that 52% of patients were malnourished.[105] The second was an international study that included ICU patients from four centres. The prevalence of malnutrition according to the NRS-2002 was 87, 93, 97 and 100% at the four centres respectively.[24] The result from the present study is thus more in line with the prevalence of malnutrition seen in other ICU patient populations.

4.3.5 Prevalence of malnutrition according to the SNAQ

The SNAQ classified 6.8% of patients as at risk for malnutrition and 29.13% as malnourished. This is in line with the 5-14% of hospitalised patients previously reported as at risk of malnutrition and the 7-29% reported as malnourished.[54,130,132,133,135] It seems however that in the present study more patients were classified as malnourished and a smaller percentage as at risk for malnutrition. This may be ascribed to the fact that the SNAQ has only previously been studied in non-ICU patients, making comparison challenging. The SNAQ does not include a question on disease severity, but it does include a question on the use of enteral nutrition where patients who have received a supplemental drink or tube feed in the past month will score an extra point.[130] ICU patients, who are highly likely to receive enteral or parenteral nutrition,[7] may thus easily score an extra point here

which would increase their likelihood of being classified as malnourished. Nonetheless, the SNAQ still classified the lowest number of ICU patients as at risk of malnutrition or malnourished, when compared to the other NRSTs.

4.3.6 Prevalence of malnutrition according to the SGA

The SGA classified 30.58% of patients as moderately malnourished and 18.45% of patients as severely malnourished. The percentage of patients classified as moderately malnourished correlates well with the 10-59% previously reported in general hospitalised patients and the 22-46% reported for ICU patients. The percentage of patients classified as severely malnourished also correlates with the 0-42% previously reported for general hospitalised patients, but is higher than the 5-11% previously reported for ICU patients.[16,21,117,138,144,146,148,149,152,157,161,163,175-178,192] The range for ICU patients is based on the results from three studies conducted in ICU settings.[31-33] However, all three were small (n=55, n=57, n=124) and included medical ICU patients only or a mix of medical and surgical ICU patients, whereas the present study included only surgical ICU patients. Patients undergoing surgical procedures are known to have high rates of malnutrition[17] and this could explain why the results from the present study indicate a higher prevalence of severe malnutrition. Almost half (43.69%) of the study participants were admitted post-gastrointestinal surgery, a clinical condition associated with malnutrition rates of up to 82%.[11,23]

4.3.7 Prevalence of malnutrition according to the NRI

The NRI classified 82% of patients with moderate and severe malnutrition which is the highest malnutrition rate found in this study and is also somewhat higher than the range of 24-68% reported in the literature.[39,115,116,118-120] The NRI was developed for its use in surgical patients and most previous study samples have included surgical patients.[109] The effect of surgery on s-albumin has thus been reflected in previous results and cannot explain why a higher rate of malnutrition is seen in the present study. The studies in the literature however did not specifically include ICU patients. The acute phase response, sepsis and other complications can cause a further decrease in s-albumin levels.[9] It is thus possible for surgical ICU patients to have higher rates of malnutrition than surgical patients not requiring intensive therapy. However no data on NRI outcomes in critically ill patients specifically is available for comparison.

4.3.8 Prevalence of malnutrition according to the MST

The MST classified a high percentage of 78.16% patients as malnourished. This is roughly 20% more than the range of 18-55% found in the literature.[51,54,125,127] Once again however, previous studies did not include ICU patients in their study populations. Another rationale for the high percentage of patients classified as malnourished may be found when looking at the question on weight loss

included as one of the components of the MST. The MST, similar to the MNA-SF, provides an "unsure" option for patients who are unsure whether they have lost weight or how much weight they have lost. In this case however, the unsure option gives a score of 2 to the patient, which is all that is necessary to classify them as malnourished.[66] The high percentage of patients (75.73%) in the present study not sure of their weight loss history can thus easily explain the high rate of malnutrition seen. The 78.16% may therefore not be an accurate reflection of malnutrition, but rather a reflection of the number of patients unsure about previous weight loss.

4.4 THE ABILITY OF NRSTs TO PREDICT CLINICAL OUTCOMES

The present study looked at the relationship between NRST classification at admission and clinical outcomes observed during ICU stay. This concept of associating nutritional status with clinical outcomes such as morbidity, mortality and LOS is not new and has been used frequently to assess the performance of NRSTs.[22,24,49,50,56,59,70,88,92,93,96,102,146,167,170] Studying these relationships may be particularly valuable if other measures of performance are challenging e.g. a gold standard measure of nutritional status for comparison is lacking. Currently, very little data is available on the use of NRSTs in an ICU setting and a gold standard measure of nutritional status in this setting is certainly absent. It was therefore decided to study the relationship between nutritional status and clinical outcomes as way of assessing the performance each NRST.

In general the NRSTs studied here could not effectively predict clinical outcomes in ICU patients. In most cases a malnourished or at risk of malnutrition classification was significantly associated with only one or two clinical outcomes. Furthermore, the non-significant trends seen did not always consistently indicate poorer outcomes for the malnourished patients. Only the NRS-2002 and MST showed adequate potential for predicting clinical outcomes in this setting as they reliably determined the group of patients with more adverse outcomes. Still, these trends did not always reach significance and therefore it is difficult to make final conclusions.

4.4.1 MUST

The MUST fared poorly and its malnutrition and malnutrition risk classifications either alone or combined were not significantly associated with any of the clinical outcomes. There appeared to be a few trends for malnourished or at risk of malnutrition patients to have more unfavourable outcomes, but these could not reach significance and were not consistently shown. In some cases the at risk of malnutrition patients or the well-nourished patients actually showed worse outcomes than the malnourished patients, although this was not significantly proven either. The findings are

similar to those seen in a large study (n=705) in a mixed hospital patient population. In this study the researchers could not find any predictive validity of the MUST with regard to LOS, mortality or rate of complications.[49]

In contrast to this, a few smaller studies in general hospitalised patients have found an association between MUST classification and particularly LOS.[16,22,50,51] In the present study a trend for longer LOS was seen when the group at risk of malnutrition was combined with the malnourished group and compared to the well-nourished group. A similar trend was seen when the two malnutrition groups were split, but in this case the group at risk of malnutrition had the longest LOS. The MUST may therefore be able to effectively predict LOS between individuals who are well-nourished and those who show some degree of malnutrition but not between different levels of malnutrition, although this would still have to be proven significant. This would correlate with the results reported by Amaral et al. and Velasco et al. who found that the at risk and malnourished MUST classifications together had a significantly increased LOS compared to the well-nourished classification.[16,51]

However Kyle et al. were able to show that all three MUST classifications are predictive of LOS in medical and surgical hospitalised patients. In this study a cut-off of 11 days was used to define a long LOS, which might explain why different results were seen.[22] In the present study LOS was analysed as a continuous variable and not as a categorical variable. Stratton et al. also demonstrated an association between LOS and all three MUST classifications and in this case LOS was analysed as a continuous variable.[50] Although these results are therefore more comparable, the study only included elderly patients admitted for acute care, which is a very unique patient population. In the same study, Stratton et al. also found an association between MUST classification and in-hospital mortality.[50] This was not seen in the present study; in fact, the well-nourished patients showed a trend for the highest mortality. A similar disparity is seen when comparing the results for total complications to the study done by Velasco et al. Velasco et al. found that the group at risk of malnutrition and the malnourished group together had significantly more complications than the well-nourished group[16], while in the present study the well-nourished group showed a trend (not significant) for the most complications.

No data on the MUST's ability to predict clinical outcomes in ICU patients is available for comparison. It is clear however that the MUST seems unable to effectively predict clinical outcomes in ICU patients. It can be argued that the MUST was initially developed for the community setting and that it may therefore be inappropriate for ICU patients. Still, since its initial development it has successfully been used in many hospital settings as well.[46] Rather, it may be that the MUST is not sensitive enough to the unique risk of malnutrition found in critically ill patients. The first two

components of the MUST look at BMI and percentage of weight loss in the preceding 3-6 months and uses accepted cut-off values in its scoring system.[46] These components have been shown as good indicators of nutritional risk.[3,40] The third component looks at risk of decreased dietary intake and presence of acute disease together.[46] Though both of these components are important determinants of nutritional risk, using them together i.e. both must be present before a score of 2 is added, might impair its ability to identify nutritional risk. Also, the presence of acute disease is not graded, the impact of existing chronic diseases is not measured at all and decreased dietary intake is only indicated when it exists for longer than five days. The critical care setting is clearly associated with acute disease, but not all patients are equally sick. Simply measuring the presence of acute disease might therefore overestimate risk. Ignoring the presence of ongoing chronic disease that might debilitate nutritional status might on the other hand underestimate nutritional risk. Lastly, it is well known that a large energy and protein deficit can rapidly develop in ICU patients due to increased requirements and the effect of metabolic stress.[3] The international guidelines on feeding the critically ill currently recommend that nutrition support should be initiated early and requirements met within 3-4 days after ICU admission to prevent the development of malnutrition and its associated adverse outcomes.[193-195] Using a cut-off of at least five days of poor intake as a determinant of nutritional risk is thus too lenient for an ICU setting and may underestimate the presence of nutritional risk.

The developers of the MUST currently recommend the tool as appropriate for use in all health care settings,[46] though the ESPEN screening guidelines still limit its clinical value to that of the community setting.[40] While it may be used in other hospital settings with adequate reliability and validity, this study indicates that the MUST lacks predictive validity in critically ill patients. This, as well as the absence of any other knowledge on its validity in this setting, discourages the use of the MUST as a screening tool for ICU patients.

4.4.2 MNA-SF

In general the full MNA has been reported to lack predictive validity. The MNA-SF however, especially the most recent form that includes a classification for at risk of malnutrition, has not been studied widely in this regard and therefore it is difficult to make conclusions. However, considering the results of the present the study, it appears the MNA-SF is not able to adequately predict clinical outcomes in critically ill patients.

Overall, the MNA-SF could only effectively predict WCC and s-albumin levels. A significant association was also seen between MNA-SF categories and CRP levels, but in this case the association was inversely related i.e. the well-nourished group showed the highest CRP levels. It is

rather interesting that the MNA-SF classification should be associated with biochemical values since the tool itself does not take any biochemical measures into account. To the author's best knowledge this has not previously been demonstrated with the MNA-SF. A study by Vischer et al. has demonstrated a weak association with s-albumin levels but this was seen using the full MNA and not the short form. In this same study malnutrition according to the MNA was not associated with CRP.[75]

Previous studies among general hospitalised patients were able to find some significant associations between MNA-SF categories and outcomes such as LOS, mortality and complications e.g. Putwatana et al. found that the MNA-SF could predict risk of post-operative complications in all adult abdominal surgical patients[88] and Raslan et al. studied elderly hospitalised patients and showed that the MNA-SF was able to predict LOS, mortality and complications.[49] These studies however did not include ICU patients. In the present study, a trend for longer LOS and more complications was seen, but this was not significant. The present study also did not find a significant or non-significant trend for higher mortality in the malnourished patients. This is similar to the study by Vischer et al. on elderly patients who also did not find an association between the MNA-SF and mortality.[75]

It has been reported that the MNA and MNA-SF may not be sensitive enough to disease-related malnutrition. By design the screening tool measures common conditions found in elderly patients e.g. psychological stress, neuropsychological impairment and functional abilities. Although valid indicators of nutritional risk in elderly, these components are not the best measures for malnutrition brought on by the presence of acute disease.[75] The MNA-SF may thus struggle to predict outcomes in a hospital setting where acute disease and comorbidities are abundant.

Since the MNA-SF was designed for elderly patients, a subgroup-analysis of the MNA-SF was done for all patients ≥ 65 years. However, the MNA-SF did not fare any better when only these patients were studied. Once again only biochemical parameters such as s-albumin and WCC showed significantly worse trends for the malnourished or at risk of malnutrition patients. The other outcomes studied (except mortality) were also systematically worse for the at risk of malnutrition and malnourished patients, but this could not reach significance.

The MNA-SF is supposed to be specifically sensitive to malnutrition in elderly patients.[62] Conversely, the present study did not find that the MNA-SF could predict clinical outcomes any better in elderly patients than in the whole patient population. It seems that even in the elderly, the presence of disease-related factors play a bigger role in the etiology of ICU malnutrition, than the other risk factors measured by the MNA-SF. It is however possible that the group of elderly patients (n=45) was simply too small to detect statistical significance in the trends seen. A more adequately powered

elderly subgroup might detect more significant trends and could reveal greater predictive ability of the MNA-SF in these patients.

4.4.3 NRS-2002

When interpreting the NRS-2002 results one has to bear in mind that the well-nourished group consisted of only one patient. This patient did not show any signs of decreased BMI, reduced dietary intake or recent loss of body mass nor was acute disease with increased nutritional requirements present and therefore the patient scored zero. Normally, this patient would have been eliminated during the initial screening phase of the NRS-2002.[53] However, the initial screening phase was not conducted during this study, because it was assumed that all patients would progress to the second phase of screening based on their admission to the ICU (as indicated by the NRS-2002; see figure 1.3). Even though the patient was therefore classified as well-nourished, he/she still showed poor clinical outcomes. In the results this reflects as a well-nourished "group" with worse outcomes than the malnourished or at risk of malnutrition groups, which may be misleading.

The predictive ability of the NRS-2002 has been well studied. Not only was the NRS-2002 developed based on its ability to predict clinical outcomes, but a number of other studies have also shown positive results.[24,53,92-97] However, this is the first study documenting the predictive ability of the NRS-2002 with regard to a number of clinical outcomes in ICU patients specifically. Leaving the one well-nourished patient out of consideration, the NRS-2002 showed the most potential for its ability to predict clinical outcomes in critically ill patients. In terms of significant results, associations were seen between NRS-2002 classification and APACHE II scores, LOV and mild, moderate and total complications and a trend for worse results for malnourished patients for all the other outcomes measured were also seen.

The present study indicated that the NRS-2002 could predict the group of patients who would have significantly more mild, moderate and severe complications. This is similar to what was seen by Raslan et al. and Raslan et al. in two separate studies among general hospitalised patients (n=705 and n=561).[49,93] Schiesser et al. and Guo et al. also found increased rates of complications among their malnourished gastrointestinal surgery patients as classified by the NRS-2002.[96,98] Moreover a large scale international study on 5051 hospital patients, including a small percentage of ICU patients (6.1%), also reported a higher rate of complications among the malnourished patients.[24]

The present study also found that according to the NRS-2002 the malnourished patients had a significantly longer LOV and higher APACHE II scores than the patients at risk of malnutrition. With regard to LOV, the finding is not only statistically significant, but also clinically significant since the

difference between the two groups is more than two days of ventilation. A longer LOV may increase the risk of ventilator-acquired pneumonia and may lead to a longer LOS which may account for increased hospital costs.[187] The association with APACHE II scores was also significant, but only when all three groups were compared and not when only the group at risk of malnutrition and the malnourished group were compared. Since LOV and APACHE II scores are mostly measured in critically ill patients and the NRS-2002 has not been widely studied in this patient population, no other data is available for comparison.

The non-significant trends seen with the NRS-2002 all indicate worse outcomes in the malnourished group i.e. longer LOS, higher mortality, more severe complications, higher WCC and CRP levels and lower s-albumin levels. Except for biochemical outcomes, which have not been studied elsewhere in relation to the NRS-2002, these trends are generally seen among hospitalised patients. Three large scale studies reported a significantly longer LOS and higher mortality in their malnourished patient groups.[24,49,93] Amaral et al., Guo et al. and Schiesser et al. likewise found a significantly longer LOS in their malnourished patient groups.[95,96,98] Although the association with LOS was non-significant in the present study, the trend may still prove clinically significant. The malnourished patients had a mean LOS that was almost 2 days longer than the group at risk of malnutrition. A difference like that may have substantial cost-implications and to a certain extent proves the clinical utility of this screening tool. With regard to mortality the incidence of death may simply have been too low to pick up a significant difference between risk categories. All of the mortality cases were classified as malnourished by the NRS-2002, but since only five patients died in total the number is too small to prove statistical significance.

The NRS-2002 is currently favoured by ESPEN as the best screening tool to use in hospitalised patients. This recommendation is based on the excellent results seen in terms of predictive ability, reliability and feasibility.[40] It seems that the positive results may to some degree also be true for ICU patients. In the present study the NRS-2002 outperformed the other NRSTs in terms of predicting adverse clinical outcomes. Although not all of the associations seen were statistically significant, the malnourished patients consistently showed worse clinical outcomes than the patients at risk of malnutrition. The clinical importance of some of the trends seen further advocates the NRS-2002's utility in this patient population. Although the results of the present study do not sufficiently prove the NRS-2002's ability to effectively predict clinical outcomes in critically ill patients, it certainly shows potential and merits further investigation.

The NRS-2002 has been praised for its recognition of disease-related malnutrition.[93] The screening tool includes measures of general malnutrition i.e. BMI, weight loss and decreased dietary intake,

but also and with equal emphasis, measures the presence of acute disease. Furthermore, acute disease is graded according to the severity of the disease present.[53] It seems that the focus on acute disease enables the NRS-2002 to more accurately identify malnutrition in ICU patients. It should be noted however that acute disease should still be graded in ICU patients. The present study did not routinely classify patients as malnourished based solely on their admission to ICU. Each patient was evaluated for disease severity using the prototypes outlined by the NRS-2002.[53]

4.4.4 SGA

The SGA classifications were significantly associated with a few of the outcomes studied, but considering the trends seen, could not effectively predict the group of patients who would experience worse outcomes. When all three classifications were studied, the general trend was for the moderately malnourished patients to experience the worst outcomes while the severely malnourished patients experienced the best outcomes. This was significant for LOS, LOV and mild complications and non-significant for APACHE scores, mortality, moderate, severe and total complications as well as CRP levels.

The only outcome that was significantly and successfully associated with the SGA was s-albumin levels. These levels progressively declined as the SGA classification went from well-nourished to moderately and then severely malnourished. This trend has been seen previously in a large, multicentre Brazilian study by Waitzberg et al. as well as a smaller study by Wakahara et al.[17,149] Both of these studies found that s-albumin levels decreased with a declining nutritional status.

When the moderately and severely malnourished groups were analysed together and compared to the well-nourished group, the SGA seemed to fare slightly better with regard to predicting clinical outcomes. Although none of the trends were significant, the malnourished group consistently showed worse clinical outcomes than the well-nourished group. It seems therefore that the SGA is able to detect nutritional risk in critically ill patients, but that is struggles to grade the risk according to severity. However, the trend will still have to be proven significant before conclusions can be made.

The results of the present study differ from previous studies that looked at the SGA's predictive ability among other hospital patient populations. These studies generally found that the SGA is able to effectively predict the groups of patients who would present with significantly more complications, a significantly higher mortality and a significantly longer LOS.[17,21,147,149,153,161,163,167] In comparison to this, the results are more in line with the findings from ICU patient populations where the SGA has been used. For example, Atalay et al. also found no association with LOS or mortality in

a subset of ICU patients (n=55) and the trend for higher APACHE scores among the malnourished patients was also not significant.[31] Sungurtekin et al. also did not find a significant association with LOS and, in line with the present study, found that s-albumin levels were significantly lower in the severely malnourished group than in the well-nourished group. Sungurtekin et al. however found significantly higher APACHE II scores and mortality rates in the malnourished groups. Although a similar trend was seen in the present study, the association was not significant.[33] Lastly, Sheean et al. also studied the SGA in a group of mechanically ventilated ICU patients. Although the primary goal was not to test the predictive ability of the SGA they did report that nutritional risk classifications were not associated with APACHE II scores.[32]

Collectively, the available results on the predictive ability of the SGA in critically ill patients indicate poor performance. Although, Sheean et al. proved that the SGA is a reliable tool to use in this patient setting, they recommended that the validity of the tool should still be tested.[32] In the absence of a gold standard measure of nutritional status with which to compare the SGA, a measure of the tool's predictive ability can be used for validation. The results of the present study, which correlates with previous findings, indicate that the SGA is not a valid tool for critically ill patients. The association between malnourished patients and worse clinical outcomes is weak and only s-albumin levels are significantly and effectively associated with all three SGA classifications.

The SGA was initially developed to determine the risk of patients developing nutrition-associated complications. The original study population did however not include ICU patients and could explain why it does not seem to perform well among the critically ill.[138] It has also been reported that the SGA includes components which may not be accurately measured in critically ill patients e.g. loss of lean body mass may not be evident during the physical examination when fluid disturbances are present.[32] Furthermore the SGA seems to accurately detect chronic malnutrition, but may struggle to detect acute changes in nutritional status.[117] It does not include a measurement of disease severity as one of its components.[43] Although chronic- or starvation-related malnutrition may exist and progress during ICU stay, it is of special importance to detect the risk of acute deterioration of nutritional status due to the presence of disease. It seems that the SGA may not be sensitive enough to disease-related malnutrition.

Interestingly, the original SGA included a component that assessed and rated metabolic stress as either no stress present, mildly/moderately stressed or highly stressed. The authors however recommended excluding this question in the future since it did not seem to influence overall SGA rating and investigators found it difficult to rate.[43] The present study therefore used the SGA form as recommended i.e. without the question on metabolic stress. It can be argued that metabolic stress

will play a greater role in ICU patients and that the question should therefore be included in the screening, but whether this will influence the overall SGA rating in this population is unknown.

One of the SGA studies[32] conducted in an ICU patient population used the older version of the SGA that included the question on metabolic stress. Even though metabolic stress was assessed in this study the prevalence of moderate and severe malnutrition seen (51%) was similar to the present study (49%) and the authors also did not find an association between SGA ratings and APACHE II scores. Furthermore, the well-nourished and malnourished groups had similar ratings of metabolic stress: mild/moderate stress was 82% and 83% respectively and high stress 18% and 17%. This may indicate that metabolic stress rating did not influence the overall SGA rating. It seem therefore that the SGA, with and without the question on metabolic stress, is of equal limited value in critically ill patients.

4.4.5 SNAQ

Only one study has previously looked at the ability of the SNAQ to predict clinical outcomes. This was a controlled trial that studied whether nutritional intervention according to the SNAQ protocol could reduce LOS in malnourished hospitalised patients. The authors were however unable to find a significant reduction when the dietary intervention group was compared to the control group receiving standard nutritional care. Only in a subset of the patients i.e. frail patients with reduced handgrip strength, a significant reduction in LOS was seen with the intervention group.[130] There is thus a lack of information on the predictive validity of the SNAQ, both in ICU and general hospitalised patients.

The present study did not find the SNAQ to have sufficient predictive validity in critically ill patients. Only two significant associations (LOV and CRP) were found when all three SNAQ classifications were compared to clinical outcomes and in both cases the malnourished patients had better results than the well-nourished patients. When the at risk of malnutrition and malnourished groups were analysed together and compared to the well-nourished groups the same significant trends were seen. The only effective prediction that surfaced was that the malnourished patients had significantly lower s-albumin levels compared to the well-nourished patients. This trend has not been studied or reported elsewhere.

A 2006 literature review nominated the SNAQ as one of the two best NRSTs for use in hospitalised patients. This recommendation was based on its ease of use and high sensitivity and specificity seen in the literature.[134] It seems though that the SNAQ may not be applicable for use in ICU patients as in the present study the SNAQ was unable to effectively predict clinical outcomes in the critically ill.

Possible explanations for the SNAQ's poor performance include that it may lack sensitivity towards disease-related malnutrition since the screening process does not include a measure of disease severity. Also, the validity of the question on the use of enteral nutrition (tube feed or supplemental drink) in the past month can be queried.[130] At face value the question appears applicable to ICU patients since a high number of ICU patients are dependent on such sources for dietary intake. However, contrary to general hospitalised patients where initiation of enteral nutrition is a definite sign of insufficient oral intake, ICU patients receiving enteral nutrition may actually have an increased dietary intake compared to those not receiving or tolerating feeds yet. The scoring of the question may thus predispose better nourished individuals to be classified as more malnourished.

4.4.6 NRI

Comparison between the NRI groups is troublesome since a large number of patients were classified as moderately and severely malnourished, while only 7 patients (3.4%) were classified as mildly malnourished or well-nourished. Nonetheless, LOV and LOS were highest in all three malnourished categories compared to the well-nourished group and overall the trends were significant. The NRI could however not effectively predict the malnourished groups with longer LOS and LOV. In both instances the mildly malnourished patients had the longest LOS and LOV followed by the severely and then moderately malnourished patients. None of the differences seen were however significant. It seems therefore that the NRI can identify nutritional risk, but that it struggles to grade severity of nutritional risk. It is also possible that the mildly malnourished and well-nourished groups were simply too small to allow adequate comparison.

A few previous studies have compared NRI categories to LOS, but none have reported on associations with LOV. Similar to the present study, Filipovic et al., Sungurtekin et al. and Kuzu et al. found that mildly, moderately and severely malnourished hospitalised patients all had a longer LOS compared to the well-nourished patients. However they combined all three malnutrition categories and found a significantly longer LOS compared to the well-nourished patients.[121,167,196] In the present study the well-nourished and mildly malnourished groups were combined in an effort to slightly enlarge the number of "well-nourished" patients. Compared to the combined moderately and severely malnourished group the "well-nourished" patients conversely had a slightly longer LOS. The difference of 0.37 days is however non-significant and even though the "well-nourished group" was slightly enlarged, it may still have been too small allow adequate comparison and to detect a genuine and significant trend.

In the present study all five deaths were in the severely malnourished group. However, this was not significantly different from the other NRI classifications, most likely because the overall mortality

rate was too low to detect the difference. Only two small studies in gastric cancer surgery and obstructive jaundice patients respectively have previously reported an association between NRI and mortality: both found a significantly increased mortality in the severely malnourished patients compared to the well-nourished patients.[111,116] The study on gastric cancer surgery patients however interpreted a p-value of 0.06 as significant.[111]

With regard to rate of complications some previous studies have reported a significantly increased rate of complications among malnourished subjects compared to well-nourished subjects,[118,120,121] while others were unable to prove this.[116,122] The present study found a tendency for all three categories of malnutrition to have more moderate, severe and total complications, but the trend was not significant. However, a worse nutritional status was significantly associated with lower s-albumin levels. As s-albumin is one of the two components measured by the NRI to determine nutritional status, it is expected that a strong linear relationship will be seen between the two. Other studies using the NRI have found the same significant trend.[117,119]

In summary, some similarities are seen when the results of the NRI are compared to studies done elsewhere. None of the studies were however conducted on ICU patients and therefore drawing conclusions is difficult. The group sizes of the different NRI categories also did not allow satisfactory comparison. The NRI appears to be able to predict the patients who could suffer from longer LOS, LOV and higher mortality, but a more adequately powered comparison is necessary before final assumptions can be made.

With regard to the screening tool itself, the NRI seems to systematically classify surgical ICU patients as moderately or severely malnourished. This phenomenon most likely occurs due to the low levels of s-albumin seen in this patient population. It raises the question of whether the tool is clinically relevant, even if its predictive validity can be proven in a more adequately powered study. If the vast majority of patients are routinely classified as malnourished then the screening tool does not provide any useful information to help stratify nutritional risk in practice. The phenomenon alternatively points out that essentially the majority of ICU patients are at risk of malnutrition and that stratification may not be necessary.

4.4.7 MST

The MST showed good overall prediction trends: except for CRP levels, the malnourished patients had worse results for all of the outcomes studied. Only the trend for higher total complications was however significant, although the trend for increased APACHE II scores and WCCs almost reached statistical significance (p=0.07 and p=0.06 respectively).

The developers of the MST, Ferguson et al., found similar trends in their validation study among 408 general hospitalised patients. They only studied LOS as an outcome, but also looked at the MST's convergence with other measures of nutritional status such as s-albumin, WCC and CRP levels. In their study the MST could predict the patients with a significantly longer LOS and also the patients with the highest CRP levels and lowest s-albumin levels; the malnourished patients also had higher WCCs and this almost reached statistical significance (p=0.08).[66] In the present study the association between malnutrition and a longer LOS was also seen. Although the association was not statistically significant, the 1.58 day increase in LOS may still be clinically relevant as this has substantial cost implications. If dietary intervention of patients classified as malnourished according to the MST can decrease LOS in ICU, it will go a long way in terms of reducing health care expenses. Two other studies have also looked at the MST's ability to predict LOS. These studies did not analyse LOS as a continuous variable but used a cut-off of 7 and 8 days respectively as an indication of a long length of stay. Nevertheless, comparable to our study a non-significant trend for a longer LOS was seen.[51,127]

Convergent with the study by Ferguson et al., the present study also found higher WCCs and lower s-albumin levels in the malnourished patients. In both studies the association with WCC almost reached significance (p=0.06 and p=0.08) indicating that malnourished patients may be more severely ill with a higher immunological response to illness.[66] In the present study s-albumin was not significantly lower in the malnourished patients, but there was still a nearly two point drop on average in the malnourished group. Ferguson et al. also found that malnourished patients had higher CRP levels that the well-nourished patients, but this was not seen in the present study.[66] CRP was the only outcome studied where the well-nourished patients had worse results than the well-nourished patients; however the difference was not statistically significant. The MST's ability to predict biochemical measures has not been studied elsewhere, including not in ICU patients.

The association with LOV and APACHE II scores has not previously been studied, mainly because the MST has not been studied in an ICU before. In the present study, similar to LOS, the malnourished patients had 1.59 days longer LOV than the well-nourished patients. Again this was not statistically significant, but it may still reveal a clinically significant relationship. The malnourished patients also had higher APACHE II scores indicating that they are more severely ill than their well-nourished counterparts. This association almost reached statistical significance (p=0.07).

With regard to the development of complications, Putwatana et al. found a similar significant trend among abdominal surgery patients to the present study: The rate of post-operative complications was higher in the malnourished patient group. The significance however disappeared after adjusting

for other risk factors associated with increased post-operative complications such as presence of cancer, operative time, previous surgery, wound contamination, blood loss, s-albumin levels etc. The authors concluded that the MST (as well as NRS-2002 and MNA-SF) did not provide any additional information other than what is provided by the known risk factors for post-operative complications.[88] Still, it can be argued that the MST provided a quick and easy way to establish the patients who would suffer more from post-operative complications without considering the wide range of other risk factors. Also, the purpose of nutritional screening is not only to identify risk but more to identify patients who could benefit from nutritional intervention. In theory, dietary intervention for patients classified as malnourished according to the MST should lead to improved outcomes such as decreased post-operative complications.

The results seen in the present study indicate that the MST is able to predict the risk of developing complications in ICU patients. There is also a strong, though not significant, indication that the MST can recognize ICU patients who are more severely ill and have increased immunological responses. The MST can also predict the patients at risk of a clinically significant long LOS and LOV. Patients classified as malnourished according to the MST may thus benefit from nutritional intervention to help improve these clinical outcomes, although this would need to be studied in a randomized controlled trial first.

The MST only measures two components of nutrition risk i.e. decreased appetite and unintentional weight loss. It does not measure disease severity or any biochemical parameters and therefore the association seen with APACHE II scores, s-albumin and WCC is strange. It seems that the combination of the two MST components and the specific cut-offs and scoring system used is able to identify more than just starvation-related malnutrition.

The MST is different in the sense that it does not measure weight loss as a percentage of usual body weight but rather in kilograms ranging from 0-5kg, 6-10kg, 11-15kg and >15kg. Also, similar to the MNA-SF, it provides an option for when patients are unsure about weight loss. These patients are allocated a score of two which routinely classifies them as malnourished.[66] The high prevalence of patients who were “unsure” about their recent weight loss in the present study therefore lead to almost 80% of the study population being classified as malnourished. Even though the MST systematically classified 4 out of 5patients as malnourished, it still seems to be one of the best NRSTs for predicting clinical outcomes in critically ill patients. A bigger sample size of well-nourished patients might allow for better comparisons in the future and may reveal more significant differences of the trends seen in the present study.

4.5 APPLICABILITY AND FEASIBILITY OF NUTRITIONAL RISK SCREENING TOOLS

The clinical value of NRSTs is determined by how easily and accurately a screening tool can be administered in a given patient population. Furthermore, the information generated by screening should be clinically useful i.e. help to stratify patients in terms of nutritional risk in order to direct resource allocation and dietary intervention. It was therefore decided to comment on the feasibility and applicability of each NRST studied here in addition to a measuring their predictive abilities. As this was a secondary study objective the applicability and feasibility was not systematically measured for each screening tool; rather the general availability of information needed to complete the screening tools was measured.

4.5.1 General feasibility of screening

NRSTs could not be completed in 46 (18.25%) of the originally eligible 252 ICU patients. This was due to patients being unable to communicate with the researcher (due to ventilation, sedation, coma or confusion) and the necessary information not being available from other sources. This is a substantial number of failed screens and it means that roughly one in every five ICU patients cannot be screened using the NRSTs studied here. This factor alone raises questions on the applicability of the screening tools in this patient population.

Previous studies have also reported failed screens among their patient populations, even in the general hospital population. Depending on the screening tool used and the patient population studied the rate of failed screens ranged from 1 to 19% and in some studies was even found to be as high as 32%, 41% and 62%.[19,23,24,39,48,54,59,98,104,116,118,121,122] It appears that the rate of failed screens found in the present study is therefore not particularly high as it correlates well with what has previously been seen. Nonetheless, a number of strategies had to be put in place to attain the rate of successful screenings in this study. Most previous studies did not employ such strategies.

The main reasons given for failed screens in previous studies was lack of anthropometrical data i.e. patients unable to be weighed or not knowledgeable about their current weight or weight loss history or patients unable to communicate with the researcher.[19,23,24,39,59,98,104,116,118,121,122] In the present study the only reason for failed screens was patients being unable to communicate with the researcher and for whom no information could be gathered from other sources. With regard to anthropometry, surrogate measurements and estimations were used to obtain the necessary information so that this would not be a limiting factor. In line with other studies, patients who were able to communicate could provide general information on appetite, recent dietary intake and gastrointestinal symptoms. The only limiting factors were therefore ability to effectively

communicate or availability of the information from other sources such as the medical file or friends and family members. If patients had been excluded based on lack of exactly-measured anthropometrical data, then a very high rate of failed screens would have been seen and the study objectives would not have been met.

Of the remaining 206 patients, almost another fifth could not effectively communicate with the researcher by the second day of ICU stay. This was necessary for the completion of the screening tools within 48 hours. Screening needs to be conducted as soon as possible after admission so that he screening outcomes can result in maximum benefits to the patient and hospital.[40] The screening tools could however be completed in these patients as the information was gained from other sources.

4.5.2 Availability of information from additional sources

Other than providing information on illness severity, the medical file did not seem to be a good source of information needed for nutritional risk screening. Only in seven cases (3.40%) could the medical file provide all of the necessary information. Family members or friends fared slightly better at providing information such as dietary intake, recent weight loss and gastrointestinal symptoms and helped to screen 30 of the patients who could not communicate by day two. In total 46 patients had to be excluded as failed screens due to unavailability of NRST information, either from the patient themselves or from additional sources such as the medical file or family members and friends. It has to be noted that family members and friends were only questioned if they visited during day the first 48 hours after admission of the patient or if a telephone number was documented on the patient's chart or medical file. When necessary, only one phone call was made for each patient as per study protocol, even if the call was unsuccessful in obtaining the information. It can be assumed that if repeat calls were made more information would have been gathered, but this would have been too much effort for screening purposes. The whole idea was to measure how readily available the screening information was. It seems that family members and friends could be an important source of NRST information and could increase the number of successful screens by almost 12% without it being too much effort. The medical file however does not provide sufficient information and only increased the number of successful screens by three percent.

A previous study by Sheean et al. also reported on using alternative sources of information for screening mechanically ventilated medical ICU patients. They did not report the exact rate of successful screenings, but according to their article the majority of patients could be screened using the SGA. To gain the necessary information Sheean et al. used the medical file as well as a food and nutrition management software programme used by their institution. Once again they did not report

the exact amount of information available, but they mentioned that information such as height, previous weights, weight loss information and previous dietary treatment information could easily be gained from these sources.[32] This was not the case in the present study. As mentioned above the medical file was a poor source of information and TAH does not use a comprehensive food and nutrition program, the likes of which they had access to. It seems therefore that the relevant patient information was more readily available to them, compared to the present study. Sheean et al. also mentioned that family members or friends were questioned if they visited during the screening window period, but this was secondary to the medical and nutrition information systems.[32] Their study relied heavily on the available medical and nutrition information, whereas the present study found friends and family members to be most helpful in attaining NRST information.

4.5.3 Feasibility and applicability of specific components of nutritional risk screening tools

4.5.3.1 Anthropometry

ICU patients are mostly bedridden and often also sedated or comatose, especially during the first day or two when screening needs to be completed. This challenges the applicability of some of the traditional screening tools as they require an accurate BMI measurement for which current weight and height is needed. For example, the MUST, MNA-SF and NRS-2002 use BMI as a measure of current nutritional status and therefore it was necessary to measure height and weight in the present study.

It was decided to use self-reported height and weight as this has previously been shown to be good surrogate measures for the actual measurements and have been used in this regard before.[24,49,55,58] More than half of the included patients however did not know their current body weight (or were unable to communicate) and therefore it appears that self-reported measures are inadequate to complete nutritional risk screening in ICU patients. Too many patients are unable to communicate effectively or are not knowledgeable about their body weight. Previous studies among other hospital populations have reported similar problems i.e. failed screens due to patients not knowing their current weight or recent weight loss or gain history,[19,24,39,59,98,104,116,118,122] or patients being unable to communicate.[121]

Also, the medical file did not provide much assistance: current weight was documented in only 10 patients. Thus, due to the lack of data on anthropometrical measurements it was necessary to use a surrogate measurement for height (forearm length or bed length) and estimate each patient's body weight. These measurements were feasible in all patients and the validity and reliability thereof is discussed in Section 4.5.4.

4.5.3.2 Recent weight loss

All seven screening tools studied included a measure of recent weight loss as an indicator of changing nutritional status. However, recent weight loss was not a feasible component to measure in this patient population. Less than a quarter of the patients were knowledgeable about their current as well as previous weights and therefore percentage of recent weight loss was mostly unattainable. Consequently, to enable more successful screenings, patients had to be asked to estimate their recent weight loss. Although this can be considered a limitation of the present study, this methodology has been used before in NRST studies.[49,58]

Only the MNA-SF and MST accommodates patients who are uncertain about their weight loss history by providing an "unsure" option for the question on recent weight loss.[65,66] Although this increases the feasibility of completing these NRSTs it may lead to an overestimation of nutritional risk. For example, in the case of the MST, choosing the "unsure" option automatically classifies a patient as malnourished.[66] The MNA-SF measures more components than the MST and therefore the answer of one question does not carry as much weight. Still, the "unsure" score will already place the patient on the borderline of the at risk category where only one more unfavourable outcome can then lead to a worse classification.[65]

Due to the large percentage of patients (>75%) for whom the "unsure" option had to be chosen, it can also be speculated that the question itself does not add value to the screening. Unintentional recent weight loss has been shown to be a good indicator of nutritional risk[40], but if three quarters of the population are not able to accurately answer the question then the applicability of such a question is low.

4.5.3.3 Physical examination

The SGA was the only screening tool that assessed physical appearance as part of its screening procedure. Factors such as muscle wasting, fat wasting and oedema were assessed to provide information about current nutritional status.[43] Although it was possible to conduct the physical examination in all critically ill patients, the validity of such findings has been questioned before. Fluid disturbances and obesity, both of which are common in ICU patients, are known to mask muscle wasting which may lead to an underestimation of malnutrition.[32] A physical assessment may thus be a more feasible way to assess nutritional status, other than BMI measurements, but it may not always be a good indicator of nutritional risk.

4.5.3.4 Disease severity

Disease severity was the most feasible and applicable component of nutritional status assessment included in this study. Information was easily obtained from the medical file in all cases and was consequently not limited by patients' inability to communicate.

Not all of the NRSTs included measured disease severity and those that did, did not measure it equally. The MUST and MNA-SF considers the presence of any acute disease as an indicator of severe illness and does not attempt to grade this.[46,65] This is slightly problematic since almost all critically ill patients have a level of acute disease present, but not all are equally ill. The NRS-2002 on the other hand grades disease severity according to specifically defined prototypes. This might be more appropriate in critically ill patients as it differentiates between different levels of acute disease.

The concept of malnutrition related to the presence of disease has been discussed previously. In the ICU setting the prevalence of disease-related malnutrition is high, probably more so than purely starvation-related malnutrition.[3] It has been deduced that measurement of disease severity is a highly applicable component of nutritional risk screening in ICU patients. Since it is also highly feasible it could be recommended for assessing nutritional risk in the critically ill. An assessment that grades disease severity such as used in the NRS-2002 seems to be most applicable.

4.5.3.5 Serum-albumin

It seems that s-albumin levels are routinely measured in most surgical ICU patients. In the present study 85% of the included patients had s-albumin tests done during their ICU stay. It also seems that in the vast majority of cases the results were available within 48 hours for screening to be completed in time. Only 12.51% of the s-albumin results became available after 48 hours.

The NRI is the only NRST that include s-albumin as one of its components to measure. The tool could not be completed in 30 patients due to no s-albumin tests done in these patients and therefore had the lowest feasibility of all the screening tools studied. As this was a non-invasive study, no additional bloods were drawn for laboratory tests. Kyle et al. and Schneider et al. also reported unsuccessful screens due to the unavailability of s-albumin values in their studies.[39,118] However, a high number of NRI screens were still completed in the present study and most of them could be completed within the first 48 hours after admission. Also, the feasibility may be increased by insisting that s-albumin levels be tested within 48 hours for all ICU patients. This is not an unreasonable request since it is already routine practice in the large majority of patients. Whether

the request is justified however depends on the validity of the NRI in this patient population and if intervention based on screening outcomes could lead to improved patient care.

The validity of s-albumin as a marker of nutritional status also has to be considered. As discussed previously, many factors other than nutritional status impacts on s-albumin levels. Especially in the critically ill the acute phase and inflammatory responses may lead to much lower than normal s-albumin levels.[9] In fact, in the present study, s-albumin levels were so low that only 1.70% of the study sample was classified as well-nourished according to the NRI. Using s-albumin for nutritional screening in ICU patients may therefore lead to overestimation of nutritional risk. Still, although it may not accurately reflect nutritional risk per se, s-albumin levels may be indicative of the level of inflammation present and the risk for developing adverse clinical outcomes.[9,113] Low s-albumin levels for example, have been linked to adverse outcomes such as longer LOS, readmissions, more complications and higher mortality.[9,111,114] It may thus be useful as a general indication of "risk".

Currently, screening guidelines by ASPEN recommends against the use of inflammatory markers for nutritional risk screening, mainly due to the lack of an accurate, nutritionally-related inflammatory marker.[2] Even though s-albumin may be a feasible measure in critically ill patients its use as an indicator of nutritional status is thus not recommended.

4.5.3.6 Dietary intake and GI symptoms

Both dietary intake and GI symptom information was easily obtainable in patients who were able to communicate. It seems therefore that the only limitation with regard to feasibility is the ability of the patients to communicate effectively.

4.5.4 Validity and reliability of weight estimations

The difficulty in obtaining anthropometrical measurements was anticipated by the researcher and she therefore decided to also include surrogate measures for height (forearm length or bed length) and estimations of body weight in the study methodology. The surrogate measures used for height have been shown previously to be valid estimates of standing height.[182] The concept of estimating body weight is also not a new practice; in the SICU of TAH estimating body weight is standard procedure for dieticians who need to calculate energy and nutrient requirements. Even physicians estimate body weight to calculate fluid requirements. A previous international research project has also successfully incorporated body weight estimations as part of the study methodology.[24] Nonetheless, due to the subjective nature of body weight estimations it was necessary to measure the validity and reliability of these "measurements".

To verify reliability, the researcher and ICU dietician independently estimated body weight. A good and significant correlation was seen between the two estimates indicating good reliability. However, when the means of the two estimates were compared a significant difference was revealed which may be indicative of decreased reliability. Nonetheless, when BMI values were calculated from the weight estimates and compared between the two dieticians, the difference was less pronounced. This is of greater importance than the difference between the weights, since BMI is used to complete the screening tools and not body weight. It seems therefore that the reliability of the body weight estimates is adequate.

The average of the dieticians' estimates was used as the average estimated body weight for each patient. BMI was calculated from the average estimated body weight and used for screening purposes. To verify the validity of the average estimated body weight an objective measurement of body weight was used as comparison. This measurement uses KH and MUAC in a formula to determine body weight and is recommended for use as a surrogate measurement in bedridden patients.[183] Comparison between the estimated and calculated variables (weight and BMI) revealed no significant differences. This indicates that the average estimated body weight, derived from the two dieticians' estimations, is a valid estimate of body weight. The same applies to the BMI measurements. Additionally, strong correlations were found between the estimated and calculated body weights and BMIs which further indicates sufficient accuracy.

4.6 EXCLUDED PATIENTS

It is important to consider the group of patients who were eligible for screening, but in whom screening could not be completed due to insufficient information available. They represent a group of patients in whom nutritional risk screening appears to be unfeasible.

The excluded patients differed significantly from the included patients in a number of aspects. First almost the entire excluded patient population were emergency admissions; only one patient was an elective admission. It seems therefore that nutritional risk screening is much more challenging in emergency ICU admissions. It is possible that these patients are more likely to be ventilated, sedated or comatose and that they are therefore less likely to be able to communicate within 48 hours. It is interesting that the diagnostic categories between the included and excluded patients did not differ significantly. This means that the emergency admissions represented the whole spectrum of diagnostic categories and not just one group e.g. trauma patients. The excluded patients had a similar mean age to the included patients, but significantly more of the excluded patients were

classified into the below 65 years age bracket. This implies that non-elderly patients may be more difficult to screen in an ICU.

With regard to patient outcomes, the excluded patients seemed to be more critically ill and presented with much worse clinical outcomes than the included patients. The excluded patients had significantly more total complications and were also more likely to present with moderate or severe complications. They also had a much higher APACHE II scores. On average the excluded patients also required almost 7 days longer ventilation and stay in ICU. Furthermore, the excluded patients presented with a greater increase in inflammatory markers such as WCC and CRP levels and lower s-albumin values.

The important question to ask is what do these findings imply for nutritional risk screening in the ICU? First, it is clear that screening may be less feasible in a specific group of patients i.e. non-elderly, emergency admissions. It may be unfeasible to screen up to a third of the emergency admissions. Second, it appears that the group of patients not screened ise actually that with the greatest risk of poor clinical outcomes. It is likely that they were more prone to malnutrition and that they may have benefited from nutritional intervention. In totality the results indicate that nutritional risk screening has low feasibility in the group of patients that appear to need it most.

Even though some of the NRSTs studied here may show some predictive validity in an ICU setting, it seems that the clinical applicability of these NRSTs is low. The screening tools may identify patients with increased risks for adverse clinical outcomes, but they are unable to identify the patients with the highest risks due to the fact that cannot be completed in these patients.

4.7 STUDY LIMITATIONS

Studying NRSTs in ICU patients presented a huge challenge in terms of methodology. First, many of the patients could not communicate by day two and therefore could not be screened. This meant that they had to be excluded from data-analyses which lead to a somewhat smaller study sample than anticipated. The exclusion of certain patients could also have lead to a biased included patient population which might have affected the study results. The excluded patients were in general more severely ill and showed worse outcomes than the included patients. However, the forced exclusion of certain patients illustrated an important point: nutritional risk screening is not possible in all ICU patients, especially patients who are prone to experience more unfavourable outcomes and are therefore more likely to be malnourished.

Second, due to the fact that the patients studied were mostly bedridden, surrogate measurements had to be performed for anthropometry. A previously validated method was used to measure height, but weight had to be visually estimated. Although visually estimating weight is not a new practice, it is a subjective method for determining body weight which poses an increased risk for inaccuracy. Strategies were however put in place to minimize inaccuracy and to measure the validity of estimations. The average estimated weight showed good correlation and no significant difference to an objective measurement of weight used to control for accuracy. This indicates that although a subjective method was used, it had acceptable accuracy. The objective method is considered too elaborate for screening purposes and therefore it was decided to only use it as a control measure.

Very few patients were able to specify their current as well as previous weights which were needed to calculate weight loss trends. In order to complete screening the patients were thus asked to estimate their own weight loss in terms of mild, moderate or severe. This might not have been an accurate reflection of weight loss trends and can be considered a limitation of the present study.

The methodology for completing the MUST tool was altered slightly. It was decided not to routinely assign a score of two for disease severity to all ICU patients as this would have resulted in a 100% malnutrition rate and would not have allowed for comparison among groups. This methodology has also previsouly been reported to overestimate malnutrition among critically ill.[39,49] Rather, the usual protocol for scoring disease severity in hospitalised patients was followed i.e. a score of two was assigned to acutely ill patients who had or were likely to have no nutritional intake for five or more days.[46] It was anticipated that this would provide a better estimate of nutritional risk in the patient population. This reasoning has also previously been used in another ICU population.[58] Still, changing the way a NRST is applied could impact on its validity and the validity of the results found here and it could therefore be considered a limitation. Either way, the MUST does not seem like an appropriate NRST for ICU patients. Had the recommended scoring for ICU patients been applied it would have provided no useful screening information and using the standard method has shown no positive results for the MUST.

Other than methodological issues, the study results were not favourable in terms of determining the relationship between nutritional status and mortality. Only five cases of death occurred in the included patients representing a 2.44% mortality rate. Although trends were still analysed, no significant associations were seen, most likely because the mortality rate was too low. Furthermore, the groups of patients within the different risk categories of each screening tool were not always evenly numbered. Some groups were small and made comparison between the different risk groups difficult. This especially affected the NRI screening tool where a very small percentage of patients

were classified as well-nourished or mildly malnourished. This hampered comparing the well-nourished patients to the malnourished patients and as such the NRI did not perform very well. It could be worth exploring the predictive ability of the NRI in more adequately powered risk groups.

Lastly, the fact the study population represented a heterogeneous group of patients could have impacted on the results. The NRSTs studied may have performed differently among certain groups of patients with similar diagnoses. However, the objective of the study was to assess the predictive ability of NRSTs in the broad ICU patient population and therefore this aim was met. It is however recommended that the NRSTs are studied among ICU subgroups in future projects.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSIONS

This study aimed to shed light on the use of NRSTs in ICU patients, specifically their ability to predict unfavourable clinical outcomes and their feasibility in this setting. Although the results presented here do not provide conclusive evidence on the topic, a number of important findings were made that can direct future investigation and implementation.

First it can be concluded that only two of the NRSTs studied here showed potential ability to predict clinical outcomes in ICU patients. Both the NRS-2002 and MST could effectively determine the patients who experienced more unfavourable outcomes. LOV, APACHE II scores and the development of complications were significantly worse in the malnourished group according to the NRS-2002, while the malnourished group according to the MST had significantly more complications and borderline significantly higher APACHE II scores and WCCs. Although the rest of the predictions seen were not significant, these two screening tools consistently predicted worse results in the malnourished groups for all of the outcomes studied (except CRP in the MST). Furthermore, in terms of LOS the clinical significance of a 1.5-2 day longer LOS in the malnourished groups cannot be ignored. Still, more conclusive evidence is needed before the use of these screening tools for ICU patients can be validated.

The remaining screening tools (MUST, SNAQ, SGA, NRI and MNA-SF) could not effectively predict clinical outcomes in ICU patients. They showed inconsistent trends for worse outcomes in the malnourished patients and in some cases significantly more favourable outcomes in the malnourished patients. Furthermore, a stepwise worsening of outcomes was not always seen for the different risk categories e.g. in some cases the at risk or moderately malnourished patients showed worse outcomes than the severely malnourished patients.

The second conclusion that can be made is that existing NRSTs do not appear extremely feasible in ICU patients. Although the NRSTs included in this study are generally regarded as applicable for use in hospitalised patients, they all include components of nutritional risk screening that are challenging to measure in the critically ill. This may prevent up to a fifth of ICU patients from being screened. Although it can be argued that screening is still feasible in at least 80% of the population, it appears that the patients systematically excluded from screening are the ones specifically at risk of malnutrition. These patients presented with far worse clinical outcomes which may indicate an increased likelihood of malnutrition and a need for nutritional intervention. It seems therefore that nutritional risk screening is not adequately feasible in ICU patients who need it the most. The main

factor preventing screening was patients not being able to communicate effectively due to sedation, coma, confusion or mechanical ventilation.

Third, with regard to the different components of screening, only one stood out in terms of excellent feasibility and applicability i.e. measurement of disease severity. Information on this component is easily obtainable from medical resources and no patient-interviewer communication is needed. In addition, it forms a vital part of screening for disease-related malnutrition. Two other screening components, s-albumin and physical examination for loss of lean body mass or fat wasting, have acceptable feasibility, but may lack clinical applicability. Both of these components can easily be measured in critically ill bedridden patients, but the accuracy of the findings in terms of indicating nutritional risk is questionable and their use is not currently recommended.

Anthropometrical measurements were the least feasible since all patients were bedridden and few could self-report their own measurements. However, it seems that the surrogate measurements or estimations employed in this study can be used with acceptable accuracy. All other screening components (appetite and dietary intake, GI symptoms, functionality) required a patient that could effectively communicate. If communication was possible, then most of the information could easily be obtained. The only problem was obtaining recent weight loss information since very few of the patients could report on that and it did not seem to be documented in the medical file. In general the medical file was a very poor source of nutritional information and friends and family members were only available and able to provide information to a certain degree.

Lastly, one of the most important findings in the present study is the high rate of malnutrition prevalent among critically ill patients. Depending on the screening tool used, 35.93 to 82.04% of the study population was either at risk of malnutrition or malnourished. Both the NRS-2002 and MST, the NRSTs that showed the best predictive validity in this study, identified more than 70% of the study population as malnourished. This raises an important question: is screening for nutritional risk necessary in a population where most of the patients are likely to be at high risk of malnutrition? According to Elia et al. screening might be of limited value in this situation.[12] Screening takes up time and effort, especially if it requires anthropometry and complex calculations, which may not be justified if the majority of patients are known to be at risk. Furthermore, as most patients will be classified as malnourished and subsequently require dietary intervention; the information provided by nutritional screening may not be clinically helpful in terms of allocating resources. It is however possible that the screening tools studied here were simply not able to stratify nutritional risk adequately. These tools were developed for general hospitalised patients and may therefore not be sensitive enough to ICU malnutrition.

In summary, it seems that most of the NRSTs studied here are not able to effectively predict clinical outcomes in critically ill patients. Only the MST and NRS-2002 have shown adequate potential for predicting clinical outcomes and may be worth exploring further. In addition, nutritional risk screening is unfeasible in a number of patients, especially those who seem to be most at risk for malnutrition. Together with the fact that the screening outcomes may provide little information other than confirming that most patients are malnourished, the findings illustrate the limited value of the NRSTs studied here. There is a need for a screening tool that is feasible in all ICU patients and that is able to stratify nutritional risk to such a degree that it may direct dietary intervention and resource allocation more effectively. So far, the only screening component that has shown potential for inclusion in such a tool, is a measure of disease severity.

5.2 RECOMMENDATIONS

- Since the NRS-2002 and MST fared best in predicting clinical outcomes, it is recommended that these tools should be investigated further. Their predictive validity should be explored in other ICU populations, including medical ICU patients. Furthermore, the convergent validity of the two tools as well as their reliability in ICU patients should be explored.
- The ICU population studied represented a heterogeneous group of patients. It is possible that some of the screening tools studied could perform better in specific patient groups e.g. specific diagnostic or age groups. It is therefore recommended that the data from the present study be analysed for different subgroups of patients or that future studies focus on more homogeneous groups of ICU patients.
- One of the best ways to validate screening tools is to test their performance in a randomized controlled trial. Studies should be designed to test whether specialised dietary intervention is able to attenuate the prevalence of adverse clinical outcomes in malnourished intervention patients versus malnourished control patients. Positive results will go a long way to proving the clinical benefit of screening ICU patients. Both the NRS-2002 and MST can be studied in this regard.
- Lastly, since none of the NRSTs studied here showed excellent feasibility and applicability, it is worth exploring the use of other screening tools in ICU patients or the development of a completely new screening tool. In terms of screening components it is recommended that disease severity be included in such a tool as it has shown high feasibility and applicability in this patient setting.

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ADDENDA

ADDENDUM 1: DATA EXTRACTION FORM

patient sticker

Hospital admission date _____ To ward _____

ICU admission date _____ Time _____

ICU discharge date _____ To _____

LOS _____ LOV _____

Death Y N APACHE:

Medical diagnosis	Medical history	History since admission	Previous medication

	Day 0	Day 1	Day 2	Day 3	Day 4
Complications					
Treatment					

	Day	Day	Day	Day	Day
Complications					
Treatment					

	Day	Day	Day	Day	Day
Complications					
Treatment					

Estimated weight 1: _____ Estimated weight 2 : _____ Race : W / n-W

KH : _____ _____ _____ MUAC: _____ Oedema Yes / No

Real weight: _____ Method: Scale / patient reported / f/f reported / file / unknown

Height: _____ _____ _____ Method: Lower arm / Bed length

Oedema: _____kg Grading: None / Mild / Moderate (Mod) / Severe (Sev)

Usual weight _____ kg / Unknown

Weight loss 1mnths 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 >15 ?

Weight loss 2mnths 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 >15 ?

Weight loss 3mnths 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 >15 ?

Weight loss 6mnths 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 >15 ?

Weight loss 2wks No change Increase Decrease

METHOD OBTAINED: patient (pt) / file / family/friend (f/f) / unknown (?) **Indicate:**precise / estimated

Appetite ↓ No Yes

Intake ↓ No Mod Sev How long: _____

Severity: Suboptimal Full liquid Hypocaloric liquid Starvation

Intake last week: <25% <50% <75% Normal Next 5 days: none >none

Last month Tube feed Supplemental drink None **METHOD OBTAINED:** pt file dr f/f ?

GI symptoms >2weeks None / Nausea / Vomiting / Diarrhoea / Anorexia **METHOD OBTAINED:** pt file dr f/f ?

Nutritional functional impairment No Mod Sev Last 2 weeks: Same Improved Regressed

Mobility Good Mod Bed/chair bound **METHOD OBTAINED:** pt file dr f/f ?

Neuropsychological problems No Moderate dementia Sev dementia/depression

Psychological stress/acute disease in last 3months No Yes **METHOD OBTAINED:** pt file dr f/f ?

Albumin _____ g/dL Available day ___

Subcutaneous fat N Mild Mod Sev

Muscle wasting N Mild Mod Sev

Oedema N Mild Mod Sev

When could patient communicate? Day _____

Could patient quantify wt changes? Yes No Not applicable (no weight changes)