6-2014

Nutrition screening tools and the prediction of clinical outcomes among Chinese hospitalized gastrointestinal disease patients

Fang Wang
Syracuse University

Abstract

Background/Objective: Nutritional Risk Screening 2002 (NRS-2002) and Subjective Global Assessment (SGA) are widely used screening tools, but there is no gold standard for identifying nutritional risk. The purpose of this study was to assess the nutritional risk among hospitalized gastrointestinal disease patients, the agreement between NRS-2002 and SGA, and to compare the clinical outcome predicting capacity of them.

Subjects/Method: This study was an analysis of secondary data including 332 patients collected by gastrointestinal department of Peking Union Medical College Hospital (PUMCH). All questions of NRS-2002 and SGA, complications, length of hospitalization stay (LOS), cost, and death were collected. To assess the agreement between the tools, κ statistic was adopted. Before assessing the performance of NRS-2002 and SGA in predicting LOS and cost using linear regression, full and saturated model was compared via the global f-test. The complications and death predicting capacity of tools was assessed using receiver operating characteristic curves.

Results: NRS-2002 and SGA identified nutritional risk at 59.04% and 45.18%. The agreement between two tools was moderate (κ index >0.50) for all age groups except individuals aged ≤ 20, which was slight agreement (κ index 0.087). The saturated model did not improve the outcomes of LOS and cost. There was no significant difference in the association of one step of NRS-2002 and LOS (B=2.127, p=0.002) and the association of one step of SGA and LOS (B=2.296, p=0.001). One step of SGA was associated with a relatively large increase in cost (B=0.272, p=0.001) compared to one step of NRS-2002 (B=0.086, p=0.000), but the difference was not significant. There was no difference of NRS-2002 (infectious complications: 0.615, death 0.810) and SGA (infectious complications: 0.600, death: 0.846) in predicting infectious complication and death, but NRS-2002 (0.738) had larger areas under ROC curve than SGA (0.552) in predicting non-infectious complications.

Conclusion: The prevalence of nutritional risk of hospitalized patients was high. There was moderate agreement between NRS-2002 and SGA for all ages except ≤ 20 age group. NRS-2002 and SGA have similar capacity to predict LOS, cost, infectious complications and death, but NRS-2002 seems to perform better in predicting non-infectious complications.

Nutrition Screening Tools and the Prediction of Clinical Outcomes among Chinese Hospitalized Gastrointestinal Disease Patients

by

Fang Wang

B.S., Tianjin Medical University, 2012

Thesis

Submitted in partial fulfillment of the requirements for the degree of

Master of Science in *Nutrition Science*

Syracuse University

June 2014

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Chapter Ⅰ: Introduction

Introduction

Malnutrition occurs due to energy imbalance either from overnutrition or undernutrition. Undernutrition results from energy, protein and other macro- and micronutrient deficiencies due to decreased nutrient intake or increased nutrient demand of diseases. Undernutrition is a common problem in hospitals and other health care centers, with prevalence ranging from 10% to 60% among patients (Bruun *et al*., 1999; Edington *et al*., 2000; Waitzberg *et al*., 2001; Valero *et al*, 2005). In gastrointestinal wards prevalence of malnutrition tends toward the higher range due to the complications of eating and nutrient absorption caused by gastrointestinal diseases. Malnutrition is related to poor clinical outcomes for both individual patients and clinical units, including longer length of hospital stay (LOS), increased cost, complication incidence, and death rate (Baldwin and Parson, 2004; Winter *et al*., 2001; Holmes 2007; Kubrack and Jensen, 2007). Appropriate and effective nutrition intervention could decrease risk and prevalence of malnutrition and prevent its related complications. Conversely, inappropriate nutrition support results in wasted medical resources and an increased burden on health care providers (Xiaokun *et al.*, 2009). To improve clinical outcomes and save medical resources, it is important to identify patients at risk for malnutrition. As the pre-step of nutrition care process (NCP), nutrition screening aims to detect nutritional risk, allowing dietitians to provide nutrition intervention for at risk patients in order to improve clinical outcomes. A good nutrition screening tool is positively correlated with clinical outcomes, and has clinical outcome predicting capacity. However, there is no gold standard for nutritional risk screening.

Among many nutrition screening tools the Nutrition Risk Screening 2002 (NRS-2002) and Subjective Global Assessment (SGA) are two in wide spread use. They assess a patient's risk of nutrition depending upon weight and dietary changes, a patient's disease state, and physical examination (waist circumference, edema, muscle wasting, etc.) The NRS-2002, introduced by European Society for Parenteral and Enteral Nutrition (ESPEN), has been applied and reported among Chinese patients (Chen, *et al*, 2005). The SGA application is not as well studied and there is limited data comparing SGA and NRS-2002 among Chinese gastrointestinal patients.

Specific Aims

The objectives of this study are to assess prevalence of nutritional risks determined by

NRS-2002 and SGA among patients in a gastrointestinal ward, and then compare the agreement between these two screening tools. Additionally, this study examines the association between results of the two screening tools and the clinical outcomes of death, complication incidence, cost and LOS, according to different age groups in order to assess determine accuracy for determining nutritional risk. Findings could benefit health care providers such as nurses and clinical dietitians to choose the most appropriate screening tool for gastrointestinal inpatients.

Chapter II: Literature review

Background

Malnutrition is a broad term that can be used to describe imbalance between energy intake and output, from over-nourishment, which is often seen in developed countries, to under-nourishment, which is seen in many developing countriess. Undernourishment also occurs in hospitals and residential care facilities in developed nations, due to increased nutrient requirement of disease(s) and reduced nutrient intakes. Malnutrition causes functional impairment or organ damage, and is associated with negative outcomes for patients, such as higher infection and complication rates (Chandra and Kumary, 1994; Baldwin and Parker, 2004), increased muscle loss (Chandra and Kumary, 1994; Winter, 2001), delayed wound healing (Chandra and Kumary, 1994; Baldwin and Parker, 2004; Winter *et al*., 2001), longer length of stay (Braunschweig *et al*., 2000; Gout *et al*., 2009), and increased morbidity and mortality (Holmes, 2007; Kubrack and Jensen, 2007; Allison, 2000; Middleton *et al*., 2001). Despite its high occurrence, the nutritional status of hospitalized patients is seldom assessed by most medical professionals due to a lack of medical awareness of malnutrition and its importance (Waitzberg, *et al*., 2001; Gout *et al*., 2009; Middleton *et al*., 2001; O'Flynn *et al*., 2005).

Although medical, surgical, nursing and nutrition support services continue to improve in quality, malnutrition and lack of awareness of it are still reported as significant problems all over the world (Gout *et al*., 2009; Middleton, *et al*., 2001; O'Flynn *et al*., 2005). Depending on the population, pathology and test used, the prevalence of malnutrition ranges from 10% to 60% among hospitalized patients (Bruun et al., 1999; Edington *et al*., 2000; Waitzberg *et al*., 2001; Cereceda, *et al.*, 2003; Van Bokhorst-de van der Schueren *et al*., 2004; Valero *et al*., 2005; Barker *et al*., 2011).

When an individual becomes sick, the immune system gets activated, and chemical messengers (eg. cytokines) and inflammatory factors are produced and secreted, which increase nutrient needs. Digestive organs including the oral cavity, esophagus, stomach, small and large intestine, liver and pancreas are responsible for nutrient digestion, absorption and utilization. In the gastroenterology department, patients usually have functional disorders of digestion, absorption and utilization. Therefore patients who have had gastrointestinal problems and who have undergone gastrointestinal surgery constitute an important risk group for malnutrition (Tian and Chen, 2005). In addition to the increased nutrient requirements of disease, patients with stomach or esophageal cancer have reduced oral nutrient intake, due to blockage and encroachment of tumor. When a patient has liver, gallbladder or pancreatic disease (e.g. inflammation, gall bladder stones, cancer, etc.), nutrient digestion is impaired due to decreased secretion of bile and various digestive enzymes. Intestinal diseases (e.g. inflammatory bowel disease, cancer, etc.) damage absorptive function since intestines are the major area for nutrient absorption. The Romanian Society for Gastrointestinal Patients conducted a multicenter prospective cohort study to assess prevalence of malnutrition, and showed that around 19% of patients referred to gastroenterology tertiary center in Romania had malnutrition or were at risk of it (Gheroghe, *et al*., 2010).

In China, gastrointestinal diseases remain the most prevalent leading cause of hospitalization (Zhang, *et al*., 2006). However, there is limited data on the prevalence of hospital malnutrition in Chinese gastroenterology departments. One of the objectives of this study is to access the prevalence of nutrition risk and undernutrition in gastroenterology department of a Chinese hospital.

Etiology of Malnutrition

Malnutrition can develop as a consequence of increased requirements from the disease(s), complications of underlying illness, such as poor absorption and excessive nutrient losses, or from a combination of these factors (Naber *et al*.,1997; Sorensen *et al*. 2008), which may explain the high occurrence rate of malnutrition in hospital. In addition to a patient's disease, various risk factors for malnutrition include social segregation, age, psychological factors, economic status, lack of medical awareness and longer hospitalizations (Waitzberg, *et al*, 2001; Jeejeebhoy, 2000). Personal contributors to malnutrition include age, pathy/depression, disease (e.g. cancer, diabetes, cardiac, gastrointestinal), inability to buy, cook or consume food, inability to chew or swallow, limited mobility, sensory loss (taste, smell), treatment (ventilation, surgery, drain tubes), drug therapy, etc. Organizational contributors to malnutrition include failure to recognize malnutrition, lack of nutritional screening or assessment, lack of nutritional training, failure to record height and weight, failure to record patient intake, lack of adequate intake, lack of staff to assist with feeding, and lack of recognition of the importance of nutrition (Kubrack and Jensen, 2007; Butterworth, 1974; Buzby *et al*., 1980). Additinally, confusion regarding responsibility for a patient's nutritional status if often unclear within hospitals.

Consequences

Malnutrition has often been referred to as the "skeleton in the hospital closet", because it is often neglected, undiagnosed and untreated (Butterworth, 1974; McKee, 2006; Ferguson and Capra, 2001). The negative consequences of malnourishment have been well demonstrated in the studies. Many studies have demonstrated that malnutrition is one of the main factors influencing clinical outcomes (Mariana *et al.*, 2010; Velasco *et al.*, 2011). In a study by Ottery (1994), about 20% of cancer patients died from malnutrition or its relative complications rather than the direct effects of malignant disease. Malnutrition is related to higher rates of infectious and non-infectious complications, organ failure, decreased wound healing, and increased LOS (Chima *et al.*, 1997; Robinson *et al.*, 1987), augmented morbidity and mortality and suboptimal response to regular medical treatment (VATPNCSG, 1991), both in acute and chronic diseases. (Norman *et al*., 2008; Sorensen *et al.,* 2008). Generally, consequences of malnutrition can be separated into two main categories: consequences for patients, and consequences for the health care facility.

Consequences for the patient

Malnutrition causes impairment at cellular, physical and psychological levels (Holmes, 2007; Kubrack and Jensen, 2007; Allison, 2000). The impairment is influenced by many factors, including the patient's age, gender, severity of illness, and current food intake. On a cellular level, malnutrition impairs the body's ability to generate the effective immune response to infection, which makes infection harder to detect and treat (Scrimshaw and DanGiovanni, 1997). For instance, impaired immune function leads to infectious complications in malnourished patients, because of decreased humoral and cellular immunological response (Chandra and Kumary, 1994; Van Der Hulst *el al*., 1998).

On a physical level, malnutrition causes the loss of muscle and fat mass. Muscle dysfunction, in particular, thoracic muscles, may explain the high incidence of pneumonia among malnourished patients (Efthimiou, *et al*, 1988). Bouchard *et al.* (2007) also reported the association between aspiration pneumonia and malnutrition in patients - patients with weakened respiratory and thoracic muscles cannot cough out sputum that contains bacterial materials. The guts of patients with malnutrition exhibit impaired digestion and absorption functions (Chandra and Kumary, 1994; Van Der Hulst *et al*, 1998). Wound recovery is also adversely affected by malnutrition (Hill and Haydock, 1989), since the wound healing process requires protein and other significant micronutrients, including zinc, vitamin C and others. to participate in tissue regeneration. Anemia is widely known to be caused by iron, B12 or folate deficiency. Malnutrition also increases the risk of pressure ulcers, increases infection risk, decreases nutrient intestinal absorption, alters thermoregulation and compromises renal function (Naber *et al*. 1997; Holmes, 2007; Allison, 2000).

On the psychological level, malnutrition is related to fatigue, apathy, depression, and poor appetite, which will delays recovery, increase anorexia and convalescent time (Kubrack and Jensen, 2007).

It is widely verified in the literature that LOS is significantly longer in malnourished patients (Norman *et al*., 2008; Braunschweig *et al.*, 2000; Thomas *et al*., 2002; Kruizenga *et al*., 2005), because malnutrition influences almost every organ and/ or system of the human body. An Australian study indicated that malnourished patients have 5 days longer LOS than well-nourished patients, which is a significant difference (Middleton *et al*., 2001). A study conducted in the United States showed that patients who were admitted with some degree of malnutrition, and those patients who had a decline in nutritional status during their hospitalization, had significantly longer hospital stays (by an average of 4 days) than patients both admitted and discharged as well nourished (Braunschweig *et al.*, 2000).

In addition to longer LOS, patients with malnutrition have higher risk of suffering complications during their period of hospitalization than patients who are in a well-nourished state (Braunschweig *et al*, 2000). Complications can occur when an unexpected accident or disease adds to a pre-existing illness without being specifically related to the illness (Naber *et al*., 1997). Malnourished patients had significantly higher risks of both infectious and non-infectious complications (Kuzu *et al.*, 2006), and thus had augmented mortality rates (Allison, 2000; Middleton *et al*., 2001; Gallagher-Allred *et al.*, 1996). Non-infectious complications, like respiratory failure, cardiac arrest and atrophy of visceral organs (Chandra, 1994; Holmes, 2007; Kubrack and Jensen, 2007), are related to decreased muscular functional capacity together with contractility dysfunction of the respiratory muscles and loss of cardiac function, resulting from malnutrition (Isabel *et al*., 2003).

Consequences for the health care facility

Malnutrition leads to additional stress for health care facilities. Due to higher rates of infections and pressure ulcers, malnourished patients often need more intensive nursing care, more medications, and are less independent due to muscle loss, which lead to longer lengths of hospital stay, when compared to well- nourished patients (Middleton *et al.*, 2001; Pirlich *et al.*, 2006; Waitzberg *et al*., 2001; Funk, 1995). All these issues combined indirectly increase hospital costs related to treating the patient, secondary to the management of their primary medical reason for admission (Allison, 2000; Chima *et al*., 1997). A Brazilian study found that malnourished patients represented a mean daily expense of US $ 228.00/patient compared to the US$ 138.00/patient in the well nourished, which represented a higher cost of 60.5% for malnutrition.

Malnutrition Intervention

In order to prevent or reverse the related negative clinical outcomes, it is imperative to provide nutritional support and therapy to patients with nutritional risk. Lack of appropriate nutritional support during hospitalization may worsen patients' nutritional status (Brown, 1991).

Nutritional support and intervention, including oral nutritional supplements, enteral and parenteral feeding, have a positive correlation with clinical outcomes (Odelli *et al*., 2005; O'Flynn *et al*., 2005; Stanga *et al*., 2007) by reducing complication rates, hospital LOS and costs (Elia *et al*., 2005; Kruizenga *et al*., 2005). In the gastroenterology department, perioperative nutrition support is beneficial for moderately and severely malnourished gastrointestinal cancer patients so as to reduce surgical complications and mortality (Guohao *et al.*, 2006).

Some studies have indicated the benefits of nutritional interventions for malnourished patients. A study of 19 U.S. hospitals showed that hospital LOS was influenced by the degree of nutritional care received by malnourished patients (Smith, 1997). Patients who received both early nutrition intervention and frequent high quality nutrition services, averaged a 2.2 day shorter LOS than those who received medium quality nutritional care (defined as early intervention OR frequent use of nutrition services). Patients who received low quality nutritional care (later or no intervention and/or infrequent or no use of nutrition services) had the longest average LOS.

Hospital length of stay and cost are widely used indicators for clinical outcome measurements (Seehusen, 2010). Appropriate, effective and efficient clinical pathways and treatment could reduce LOS and cost. Patients in China have to pay for the extra services and health care in hospital, such as feeding assistance, nursing care, etc. because government and insurance only pay for a small part of the cost. Therefore the longer they stay, the higher the costs incurred. Complication occurrence increases the difficulties of treatment, postpones recovery, and also increases LOS and cost. Physicians spare no efforts to prevent and control complications for inpatients. The aim of medical treatment is to prevent death, so death rate is commonly used to assess clinical outcomes, and effectiveness of clinical treatment. Because hospital LOS, cost, infectious and non-infectious complication rate, and death rate are associated with nutritional status, and they are often regarded as measurements of medical treatment effectiveness, they are defined as clinical outcomes in this study.

Nutrition screening

Nutrition screening precedes the nutrition care process (NCP, including assessment, diagnosis, intervention, and monitoring and evaluation). It is a significant part of the design of a nutritional plan during admission (Velasco *et al*., 2011). The occurrence of malnutrition among patients is based not only on the patient population being surveyed, but also on the different nutritional screening tools being used. For the same group of subjects, the reported prevalence of malnutrition varied by different assessment methods. There was a study conducted in Berlin, the nutritional status detected among 287 patients during admission to hospital showed that 26.1% patients were detected with malnutrition according to the Subjective Global Assessment (SGA) and only 3.8% patients had a BMI<18.5, which was the diagnostic criteria for malnutrition when using BMI alone (Norman *et al*., 2005). In China, Wu *et al.* (2005) investigated the nutritional status of 4012 patients via using different kinds of nutritional assessment methods. The prevalence of malnutrition in their study was 50.6%, 38.8%, 35.4%, 24.4%, or 21.3% according to triceps skinfold thickness (TSF), SGA, prealbumin (PA), albumin (ALB), and BMI, respectively (Wu *et al.*, 2005). Thus, the choice for nutritional assessment is quite subjective, controversial, and subject to much confusion.

Importance of screening

Nutritional status is known to worsen during hospital stay partly due to poor recognition by the medical staff and adverse clinical routines (Norman *et al.*, 2008). Although malnutrition undeniably promotes morbidity, and appropriate nutritional therapy is available in affluent countries, only a small percentage of malnourished patients receive nutritional support, including oral nutrient supplements, enteral or parenteral nutrition therapy (Correia and Campos, 2003; McWhirter and Pennington, 1994; Rasmussen *et a*l., 2004). The reasons are lack of awareness and adverse hospital routines (McWhirter and Pennington, 1994).

The World Health Organization describes screening as a simple test to identify the patients who have disease but do not have symptoms. In 2002, ESPEN defined nutrition screening as a rapid and simple method conducted by admitting staff to accurately identify those patients who are malnourished or at risk of malnutrition, and who could benefit from nutritional therapy and support (Kondrup *et al*., 2002). Nutrition screening can be performed by any trained health professional, but is usually conducted by nursing or nutrition assistant staff. When the patient is found to be malnourished or at risk, the full NCP, including assessment, diagnosis, nutrition therapy as well as monitoring and evaluation is provided. It is important to distinguish screening from the nutritional assessment, which provides the clinician additional data on patient nutritional status through a detailed detection of metabolic, nutritional or functional aspects by a clinician, dietitian or other health providers (Kondrup *et al*., 2002).

Generally, patients are referred to a dietitian by medical and other health providers to provide further NCP and nutrition intervention if it is necessary, and little time is left for these health providers to screen additional patients (Ferguson and Capra, 1998). Therefore many malnourished patients in hospital are not identified as such, and thereby not referred for nutrition assessment and intervention. In some countries, such as the United Kingdom, United States, the Netherlands and some parts of Denmark, nutrition screening on patient admission is mandatory, with satisfactory hospital accreditation dependent on this being carried out (Elia *et al*.,2005). In China, however, this is currently not the case. Few hospitals whose dietitians participated in a survey carried out routine nutrition risk screening, unless required by hospital policy.

On one hand, nutrition intervention could bring benefits for malnourished patients, such as less complication, shorter LOS, less medical cost, etc. On the other hand, unnecessary nutrition intervention is a waste of money, time and medical resources. Inappropriate use of nutritional support was observed among inpatients (Xiaokun *et al*. 2009). A randomized control trial (RCT) indicated that in order to avoid wasting of resources, the precondition of achieving benefit from nutritional support is that the patients are already diagnosed as malnourished or at risk of malnutrition (VATPNCSG, 1991; Johansen *et al.*, 2004). Considering that China is currently facing a shortage of medical resources, as well as enormous pressures on health care providers, a screening method which could best reflect the nutritional status of patients is one of the most crucial challenges in nutritional support practice.

Because proper nutritional support can reduce the prevalence of hospital malnutrition and costs, nutritional risk screening is needed for early identification of malnutrition and risk of malnutrition, initiation of further nutrition assessment, nutrition therapy and support, and to prevent unnecessary medical cost. Many validated tools for nutrition risk screening and nutrition assessment exist for the clinician to use in assisting with accurate identification, referral and treatment of patients who are malnourished or at risk of malnutrition. The Academy of Nutrition and Dietetics, formerly known as the American Dietetic Association, defines nutrition risk screening as “The process of identifying patients with characteristics commonly associated with nutritional problems who may require comprehensive nutrition assessment” (ADA, 1994).

According to Resolution ResAp (2003) of the Council of Europe on food and nutritional care in hospitals (Council of Europe, 2003), the nutritional risk of all patients should be routinely assessed either before or at admission, so that a nutritional intervention can be provided (Velasco *et al.*, 2011). This assessment should be repeated regularly, with intervals depending on the level of nutritional risk, during the hospital stay. If nutritional status and disease have influences on patient outcomes, it is crucial both to treat the disease and nourish the patient. Therefore, it is fundamental to understand the significance of nutritional therapy in improving the clinical outcomes of those who have trouble to get enough nutrients and calories during their disease process, and function of nutrition support is similar to what left ventricular assistant device (LVAD) shows to patients with heart failure, or ventilator support to patients with respiratory failure (Isabel, 2003).

Screening tools

Numerous nutrition screening tools exist to identify risk of malnutrition, all of which include the consideration of disease, age, recent weight changes, and dietary changes. The risk should be assessed by tools routinely used at admission in an attempt to reduce nutrition-related complications.

A good nutritional screening tool is regarded as being sensitive, specific and applicable (Anthony, 2008), because it uses the criteria to identify patients who need nutritional support and could benefit from it. Depending on different screening methods and tools, the malnutrition incidence of inpatients from different countries ranges from 10%-60%. Over 70 nutritional screening tools have been described in various populations (Green and Watson, 2006), but they present differences in validity, reliability, ease of use and acceptability (Elia *et al*., 2005). Most screening tools are based on variables such as recent weight loss, food intake, body mass index and severity of disease.

Subjective global assessment (SGA)

As reported, SGA was one of the most widely used tools among all the screening tools for its subjective characteristic allowing dietitians to catch subtle changes in clinical variables (Lisa, 2011). SGA is a questionnaire covering the medical history of patient (including weight loss, recent changes in food intake, gastrointestinal tract symptoms, changes in functional capacity in relation to malnutrition and underlying diseases), and brief physical examination (including muscle, subcutaneous fat, edema and ascites), and also the overall judgment of the patient's status from clinicians. A high degree of inter-rater reproducibility has been shown for SGA, with 91% of surgical patients classified by SGA having two clinicians agreeing on SGA classification (Detsky *et al*., 1987). In 2002, the American Society of Parenteral and Enteral Nutrition (ASPEN) recommended SGA as a nutrition screening tool for malnutrition risk and degree. Patients are classified as well nourished (A), suspected malnourished (B), and severely malnourished (C).

NRS-2002

In 2002, the European Society of Parenteral and Enteral Nutrition (ESPEN) published a new screening tool—Nutrition risk screening (NRS-2002), which was based on interpretation of retrospective nutrition risk screening of 128 randomized control trial (RCT) studies. NRS-2002 measures four aspects including anthropometry (BMI), recent weight loss, recent nutrient intake changes, and also the subjective assessment of disease severity (based on increased nutrition requirements and/or metabolic stress), to generate a nutrition risk score (Anthony, 2008). The NRS score also evaluates the degree of malnutrition risk. A score at or above 3 indicates that the patient is at risk of malnutrition, and patients with scores less than 3 are classified as no at risk (Kondrup *et al*., 2003). The subjective grading of illness severity may not definitively reflect current nutritional status and the tool cannot be used to diagnose malnutrition. But the NRS-2002 has, been recommended for use in hospitalized patients by ESPEN and may be useful for prompting the initiation of nutrition support (Kyle *et al*., 2003; Kondrup *et al.*, 2003).

From 2003 to 2006, a survey was conducted by the Chinese Medical Association in order to access the application of NRS for over 15,000 patients in 12 cities through the country, and it showed that NRS was an appropriate method for Chinese inpatients. However, as a screening tool, NRS only determines nutrition risk, but cannot determine the degree of malnourishment (Chen *et al.*, 2005).

Association between SGA and NRS-2002

SGA and NRS are two screening tools based on different theories, and they have their own advantages and disadvantages. Even though there is no gold standard for nutrition screening, SGA is often used as a criterion method to evaluate the sensitivity, specificity and predictive values of other screening tools (Velasco *et al*., 2011). A recently published study (Velasco *et al*., 2011) has indicated that when compared with SGA, NRS-2002 has high specificity, sensitivity, and good positive and negative predictive values. A nutritional screening tool is expected to accurately indicate nutritional status, and there is an association between malnutrition and clinical outcomes, so the malnutrition screening tool should generate results that are consistent with clinical outcomes. In other words, when a patient is determined as malnourished or at risk of malnutrition, the probability of occurrence of adverse clinical outcomes should be significantly higher than for other patients. Thus dietitians could use the result generated by the screening tool to determine the necessity of nutrition intervention, because unnecessary nutrition intervention may waste money and medical resources. NRS-2002 has been shown to be able to discriminate malnourished from well nourished patients, and non-malnourished patients were classified as not being at nutritional risk (Velasco *et al*., 2011). Moderate agreement was observed between NRS-2002 and SGA (Velasco *et al*., 2011).

Because nutrition screening tools detect malnutrition, it is important to determine the appropriate, sensitive and subjective tool that can be used for patients, but there is limited data comparing use of NRS-2002 and SGA among Chinese gastrointestinal patients.

To choose a screening tool for use in a hospital setting, it is helpful to verify its performance by comparing nutritional risk with clinical outcomes (Stratton *et al.*, 2005). Even though it is hard to predict malnutrition markers, many researchers are dedicated to finding or establishing desirable prediction measurements associated with nutritional status. As a result, the association between different nutritional screening and assessment tools and unfavorable clinical outcome has been studied (Sungurtekin *et al*, 2004; Bauer *et al*, 2005; Kyle *et al*, 2005).

Several studies have demonstrated the effect of nutritional status on the development of infectious and non-infectious complications (Sorensen *et al.*, 2008; Lobo *et al*., 2009). The validity of a screening tool is dependent on its ability to predict outcomes. The association between nutritional status and increased morbidity/ mortality in at-risk patients has long been studied (Buzby *et al*., 1980; Smith and Hartemink, 1988; McWhirter, 1994). These days, many studies use nutritional screening and nutritional assessment tools to predict unfavorable clinical outcomes (Amaral *et al*, 2007; Sungurtekin *et al*, 2004; Bauer *et al*, 2005).

Present study

Malnutrition prevalence among hospitalized gastrointestinal patients has not been previously reported in China, this study examined the prevalence in gastrointestinal department of a hospital. Different populations have different characteristics, values, beliefs, and the perceptions of health conditions, thus one screening tool might not be appropriate for all patients. Also a single screening tool may not be applicable to patients with different diseases. Sensitivity and specificity of NRS-2002 and SGA were significantly different when the results were stratified by age (Velasco *et al*., 2011). In Velasco's study, all the screening tools identified more elderly patients at nutritional risk (Velasco *et al*., 2011). It could be explained by the fact that elderly patients are at increased nutritional risk compared with younger people. Moreover, the difference was particularly relevant with NRS-2002, since this tool has an age adjustment for patients over 70 years old. Therefore, it is necessary to compare sensitivity, specificity, positive predicted value and negative predicted value of each test according to patients of different age and gender subgroups.

NRS-2002 has been applied among Chinese patients (Weiping *et al*., 2009), but SGA has not been fully investigated. Therefore this study compared the two screening tools by testing the agreement between them on malnutrition screening. The negative impact of malnutrition on patient outcomes is well established. Unfortunately, disease and nutrition influence each other. In other words, the underlying disease can cause secondary malnutrition, and malnutrition may adversely influence current diseases (Jeejeebhoy, 2000). Thus it is difficult to conclude that malnutrition alone contributes to poor patient outcomes. However, evidence getting from hunger strikers that did not suffer from any disease, demonstrated that when people suffer more than 38% of weight loss, one-third of those people died (Allison, 2000). Even short periods of fasting may lead to metabolic dysfunctions. An overnight fast in well-nourished individuals, scheduled for surgery, led to peripheral insulin resistance, with simultaneous negative nitrogen balance in the post-operative period (Ljungqvist *et al*., 2000). The Minnesota semi-Starvation Experiment documented the physical and psychologic effects of malnutrition (Keys, 1950). In that experiment, 36 healthy young men were enrolled and were subjected to semi-starvation in which most lost >25% of their weight. The results of the experiment indicated that diet itself have a significant influence on body functions, such as blood temperature, blood pressure, serum cholesterol level, heart rate, immune function deficient, anemia, apathy, irritability, neurological deficits and lower extremity edema (Williamson., 2004).

Besides nutrition, many other factors influence clinical outcomes (hospital LOS, morbidity, mortality, complications, and hospital costs), including presence of cancer and infection, age above 60 years old whether patients are undergoing clinical treatment or not (Velasco *et al*., 2011). NRS-2002 and SGA include questions related to disease, age, weight changes, dietary changes, etc., which can cover almost all factors, so it can predict clinical outcomes. This study tested the clinical outcome predicting power of NRS-2002 and SGA in different age and gender groups. Findings can be used by health providers to determine which tool best identifies nutritional risk of the patients.

Chapter III: Methods

Objectives:

1. To assess the prevalence of nutritional risk in gastroenterology department of a Chinese hospital.

2. To assess the agreement between two widely used nutrition screening tools in clinical practice, NRS-2002 and SGA, for patients in different age groups.

3. To compare the clinical outcome predicting capability of NRS-2002 and SGA, so as to select the appropriate screening tool for Chinese patients in different age groups with gastrointestinal diseases.

Method: A secondary data analysis

The clinical investigation was carried out in gastrointestinal wards, and the original data was collected by Peking Union Medical College Hospital (PUMCH). The original data included age, gender, nutritional screening, and complications, which were achieved through interview by clinical dietitians at PUMCH. Death, LOS and cost information was also collected from the medical records of patients. The investigation was approved by Institutional Review Board of PUMCH in China in

2008 (Registration No. S-203). The present data analysis was approved by the Institutional Review Board of Syracuse University in 2013 (IRB# 13-283).

Data collection:

The age of recruitment started from 18 years old, because the study was conducted in an adult department. The inclusion criteria were: 1. Gastro-enterology patients aged between 18 and 90 years old; 2. Scheduled to stay at least one night in hospital; 3. No surgery planned before 8 a.m. on the following day; 4. Voluntary participation; 5. Ability to communicate for interviewing and answering questions. Patients with less than one day LOS and surgery planned for the following day were excluded in the study due to the limited time schedule for screening, one day was too short a time to complete any documented report. Patients who were sent to intensive care unit (ICU) directly or had critical illness were not included in the study because there was not possible to complete nutrition assessment within 24 hours of admission. Additionally, patients in those situations cannot be interviewed for nutrition screening. Women who were pregnant, breast feeding, or gave birth within the past six months were also excluded.

Open enrollment occurred through the 2008, all patients who met the criteria and wanted to participate in the research voluntarily were included in the sample. The goal was to recruit approximately equal numbers of men and women in order to decrease gender bias, and to cover people of all ages, since the objective of the study was to find the appropriate nutrition screening tool for patients from different age groups. All participants provided informed consent forms that were approved by the Institutional Review Board of PUMCH. Within one year from enrollment, between January 2008 and December 2008, 334 inpatients who were admitted and managed in the Gastrointestinal Department of PUMCH and agreed to participate in the research were studied. However, two subjects were excluded due to incomplete data (one patient missed SGA and NRS-2002, and the other patient miss SGA).

Study enrollment led to 191 males and 141 females (proportion of 1.35:1). Ages ranged from 18 to 86 years (median age was 47 years). For convenience, age groups were broken down into cohorts of 15 years starting from the age of 20. Therefore, there were ≤20, 21-35, 36-50, 51-65, 66-80, ≥81 years old groups.

Nutritional risk assessment was performed within 24 hours of admission using the

NRS-2002 and SGA screening tools. Simultaneously, anthropometric parameters (height, fasting weight, BMI), age, and the diagnosis were collected for each patient. The dietitians weighed and measured the participants wearing a hospital gown with shoes off, with the same standard scale, and before meals in the morning. The height of the patient was measured to the nearest 0.5 cm, and weight was measured to the nearest 0.5 kg. The other related information, such as the complications or morbidities diagnosed on admission was collected from the patients' medical record. The dietitians continued to visit patients and collected the complication incidence, LOS, cost and death when patient discharge. Inpatients were reassessed every 7+/-1 days when their LOS was more than one week. After screening, participants with nutritional status as malnutrition or at risk of malnutrition determined by any or both of NRS-2002 and SGA were referred to clinical dietitians for further nutritional care using the Nutrition Care Process (NCP), including nutrition assessment, diagnosis, intervention, and monitoring or evaluation. When patients were diagnosed as being malnourished, they received nutritional support, including oral nutrient supplement, enteral or parenteral nutrition if necessary, and nutrition education or counseling.

In order to control the quality of data, all the surveys were completed within 24 hours by clinical dietitians. In order to limit the subjective variability of dietitians, nutritional screening was completed by the same dietitian for a single patient. Moreover, Case Report Forms (CRFs) were double checked one day before the patient left in order to secure the integrity and authenticity of the forms.

Screening tools:

NRS-2002 and SGA were used for nutrition screening for all participants by clinical dietitian in hospital. For NRS-2002, three factors (BMI, weight loss and nutritional intake) were all considered in the nutritional evaluation. A total score exceeding 3 suggests nutritional risk, whereas less than 3 suggests no nutritional risk temporarily, except for patients with ascites or pleural fluid in accordance with the diagnosis by physicians.

SGA included medical history and physical examination sections. The medical history section evaluated the patient’s answers to questions about four aspects, including recent weight change, dietary intake, gastrointestinal symptoms and functional impairment. Patients were rated as nourished (A), mildly and moderately malnourished (B), or severely malnourished (C) relying on the results and evaluation about weight and dietary changes, gastrointestinal symptoms and functional problems. During physical examinations, a patient's loss of subcutaneous fat, muscle wasting, edema and ascites of patients were examined and recorded by dietitians. Depending on the results of the physical examination, patients were rated as well, moderately malnourished or severely malnourished. After both the survey and physical examination were performed, the dietitians provided an overall SGA classification corresponding to his or her opinion of the patient's nutritional status by clinical judgment.

Patients with a score of 3 or above on the NRS-2002 were considered malnourished according to the NRS-2002. Patients scoring B (suspected malnourished) or C (malnourished) on the SGA were considered malnourished according to the SGA.

Outcomes:

LOS, incidence of complication, including infectious- and non-infectious ones (any or none), cost of hospitalization, and death were selected as indicators of clinical outcomes because they are influenced by nutrition status, and they can reflect the effectiveness and efficiency of medical and nutritional intervention. The infectious complications included wound infection, abdominal infection, perianal abscess, tuberculosis, systemic inflammatory response syndrome (SIRS), positive culture test, pneumonia, urinary tract infection, abdominal fistula infection, pressure sores, fungal infection, and oral infections. Non-infectious complications included anemia, myocardial infarction, upper gastrointestinal bleeding, and organ failure. Any new onset diseases mentioned above were considered as complications.

Analysis:

Objective 1. To assess the prevalence of nutritional risk in gastroenterology department of a Chinese hospital.

The prevalence of nutritional risk detected by NRS-2002 and SGA was calculated for the total patient population and for categorized age groups.

Objective 2. To assess the agreement between NRS-2002 and SGA for patients in different age groups.

Cohen's (kappa) was run to assess the agreement between classifying patients as malnourished with NRS-2002 and classifying patients as malnourished with SGA with 95% confidence intervals (CI). The results were interpreted as follows: <0, no agreement; 0 to 0.19, poor agreement; 0.20 to 0.39, fair agreement; 0.40 to 0.59, moderate agreement; 0.60 to 0.79, substantial agreement; and 0.80 to 1.00, almost perfect agreement (Landis, 1977).

Objective 3. To compare the clinical outcome predicting capability of NRS-2002 and SGA.

In order to compare the association of NRS-2002 or SGA and clinical outcome (LOS and cost), scores or levels were adopted. Linear regression was used for assessing the performance of NRS-2002 and SGA in predicting LOS and cost. Five patients who died during hospitalization were excluded from LOS analysis, so the performance of NRS-2002 and SGA was assessed for 327 subjects. LOS and cost were not normally distributed, so the outcomes were log-transformed. Age was categorized as four groups and was included as a categorical variable because the relationship between age and the outcomes was assumed to be nonlinear. Gender and the presence of infectious and non-infectious complications were included as covariates. To test whether the NRS-2002/SGA predicted better or worse for different age groups, a global f-test (Equation 1) was used to compare a full model for LOS and cost with a saturated model including the interaction between NRS-2002/ SGA and categorized age. The accuracy of NRS-2002 and SGA could be compared through R square comparison, as well as determining the amount of variance each screening tool accounted for in the model.

Equation 1: Global F test for determining if interaction term improves the linear model.

$$F=\frac{(SS1-SS2)/(df1-df2)}{SS2/df2}$$

SS: sum of square; df: degree of freedom.

Considering that complications and death are categorical variables, Receiver operating characteristic (ROC) curve (Zou *et al*, 2007; Zweig, 1993) was applied to assessing the predicting capacity of NRS-2002 and SGA for clinical outcomes of infectious, non-infectious complications, and death. Specificity and sensitivity could be achieved from the ROC curve analysis, and accuracy of the diagnostic test was evaluated by the area under the ROC curve. The results were interpreted as follows: 0.9-1, excellent; 0.80-0.90, good; 0.70-0.80, fair; 0.60-0.70, poor; 0.50-0.60, fail. The

ROC curve analysis of LOS excluded the patients who died during hospitalization, so the performance of NRS-2002 and SGA was assessed in 327 patients.

For all analyses, statistical significance was set at $P \leq 0.05$. Data was analyzed by using the statistical package IBM SPSS Statistics (IBM Corp., USA) version 20 for Windows.

Chapter Ⅳ: Results

Demographic data

A total of 334 patients were enrolled into the study throughout the course of the year from the gastrointestinal department of PUMCH. However, the data of two subjects were incomplete, and those two subjects were excluded from any analyses. Therefore, there were 332 patients (99.40% of total patients recruited) with complete data. Of these patients, 141 (42.47 %) were female and 191 (57.53 %) were male. Ages ranged from 18 to 86 years old. The mean age was 53.0 years old (SD 17.99 years), and median age was 47 years old. Among patients, 14 subjects were aged ≤ 20, 54 subjects were aged 21-35, 68 subjects were aged 36-50, 94 subjects were aged 51-65, 90 subjects were aged 66-80, and 12 subjects were aged ≥ 80 years old.

The prevalence of nutritional risk

The nutritional risk rates differed depending on the screening tool used. The prevalence of nutritional risk among all patients was 59.04% according to the NRS-2002, and 45.18% according to SGA. The detailed nutritional risk determined by NRS-2002 and SGA according to different age groups is shown in figure 1. Among the different age groups upon admission, the highest prevalence of nutritional risk was in ≥ 81 years old group detected either by NRS-2002 or SGA, and the lowest prevalence of nutritional risk was in 51-65 years old group. The prevalence of nutritional risk in those patients older than 65 years old was 62.75%, which was much higher than that of patients younger than 65 years (57.40%).

Agreement between NRS-2002 and SGA

Cohen's κ (kappa) was performed to determine the agreement between NRS-2002 and SGA on whether 332 individuals exhibited malnutrition. There was moderate agreement between these two screening tools, κ=0.514 (95% CI, 0.428 to 0.604), $p<0.0005$. When stratifying by age, moderate agreement was observed for all age groups with the exception of individuals aged ≤20. Among individuals ≤20 years, only slight agreement was observed. Detailed nutritional risk and κ-index for each age group is shown in Table 2.

Association between nutritional risk screening and clinical outcomes

Five patients died (1.51%) during the hospitalization, one in ≤20 age group, and two in the 51-65 and 66-80 age groups, respectively, resulting in 327 patients for LOS analyses. The mean LOS from admission to discharge was 23.43 days (SD 19.38 days). The mean cost of hospitalization was 25106.00 Chinese Yuan (4030.37 USD) (SD 30985.46 Chinese Yuan, 4976.23 USD). Detailed clinical outcome data, including LOS, cost, death rate, infectious and non-infectious complications for different age groups are shown in Table 2 for the patients identified by the NRS-2002 and SGA tools as being nutritionally at risk.

Eighty-one (24.40%) patients had infectious complications, which included among other conditions wound infection, abdominal fistula infection, SIRS, positive blood culture test, pneumonia, urinary tract infection, and abdominal infection. Among the 81 participants with an infectious complication, 60 (74.07%) and 47 (58.02%) were detected as having nutritional risk by NRS-2002 and SGA, respectively.

Twelve (3.31%) patients experienced non-infectious complications, including among other conditions anemia and myocardial infarction. Among the 12 patients with a non-infectious complication, 9 of them (75%) were classified as nutritional risk by NRS-2002, while 5 of them (41.67%) were classified as nutritional risk by SGA.

The patients' infectious, non-infectious complications and death are presented in the Appendix for the patients identified by the NRS-2002 and SGA tools as being nutritionally at risk. Inclusion of the interaction between the screening tool (NRS-2002 or SGA) and categorized age did not improve the model for the outcomes of LOS and cost (Table 3).

For the outcome of cost, there was no significant difference in the association of one step of NRS-2002 and cost (B=0.127, p=0.002) and the association of one step of SGA and cost (B=0.296, p=0.001). For the outcome of LOS, one step of SGA was associated with a relatively large increase in LOS (B=0.272, p=0.001) compared to one step in NRS-2002 (B=0.086, p=0.000). There were not large differences in the predictive ability of the models with NRS-2002 or SGA for either outcome of LOS and cost (Table 4).

The results of area under ROC curve analysis showed that the unfavorable clinical outcome predicting capacity of NRS-2002 and SGA was generally better than random guessing (Figure 2, Table 5). The comparison between the area under the ROC curve values for the NRS-2002 and SGA indicated that NRS-2002 was not different from SGA for predicting infectious complications and death. Depending on the cut point guide for classifying the accuracy of a diagnostic test, NRS-2002 and SGA had poor predicting capacity for infectious complications (0.60-0.70), and good predicting capacity for death (0.80-0.90). For non-infectious complications, NRS-2002 had fair predicting capacity (0.70-0.80), whereas SGA had poor predicting capacity (0.50-0.60).

Chapter Ⅴ: Discussion

Suitability of NRS-2002 and SGA

In contradiction to some misgivings about the routine use of SGA (Panwadee, 2004) nearly all the patients in PUMCH could complete the NRS-2002 (99.7%) and SGA (99.4%) screening processes. Other studies have also found the vast majority of patients capable and willing to complete the NRS-2002 and SGA (Chen *et al*.,2005; Xiaokun *et al.*, 2008; Kyle, 2003). The NRS-2002 can be completed in a few minutes, but examiner training may be required to improve competency before using SGA properly due to the subjective nature of the SGA including brief physical examination. Further studies will assess and compare the amount of time spent on each tool, the feedback about the questions from patients, and the preference for using either screening tool from clinical dietitians or other related health providers.

Prevalence of nutritional risk

Nutritional risk among patients was high, measured at 59.04% for the NRS-2002 and 45.18% for the SGA, which was consistent with other studies, but in the upper level of the nutritional risk ranges of 10-60% depending on the tool used (Bruun *et al*.

1999; Edington *et al*., 2000; Waitzberg *et al*., 2001; Cereceda *et al.*, 2003; Van Bokhorst-de van der Schueren et al., 2004; Valero *et al.*, 2005; Xiaokun *et al*., 2009; Mariana *et al*., 2010; Gout, 2009; Pirlich *et al.*, 2006; Rasmussen, 2004). A possible reason for the high prevalence of malnutrition might be the fact that PUMCH was a referral hospital dealing with the most difficult diseases, so health condition of patients who went there may have been more severe with higher levels of malnutrition than patients with less severe conditions. Comparatively, Johns Hopkins Hospital in US reported that the prevalence of nutritional risk was 51.0%, and the highest nutritional risk was often observed in gastrointestinal department (Xiaokun *et al.*, 2008). Gastrointestinal diseases often cause decreased food intake and many patients experience weight loss. Moreover, a Danish study showed a 57% malnutrition rate in gastro-surgery departments, which was the highest among all hospital departments (Rasmussen *et al.*, 2004). Higher rates of malnutrition and nutritional risk in gastrointestinal are logical as gastrointestinal diseases often decrease food intake and experience weight loss. Another possible reason that the prevalence of malnutrition risk was so high might be that gastrointestinal patients are more likely to self-report their weight loss and reduced food intake when admitted to hospitals than patients with other conditions (Xiaokun *et al.*, 2009), therefore perhaps biasing a comparison between GI and patients from other wards. Additionally, the inclusion of surgery patients might be a reason for the high prevalence of nutritional risk. The high prevalence of nutritional risk demonstrates the need for including nutrition screening as a part of the admission process in Chinese hospitals, particularly among GI disease patients.

A higher prevalence of nutritional risk was observed in older aged patients (>66 years), which was in agreement with previous studies (Marshall *et al.*, 1999; Sullivan *et al.*, 1999; Velasco *et al.*, 2011). Age is known to be a powerful contributor to the development of malnutrition (Velasco *et al.*, 2011). Surprisingly, higher malnutrition rate was observed among patients ≤ 35 years compared to 36-50 and 51-65 years old groups by both NRS-2002 and SGA, particularly in the ≤ 20 year old group. No data was available in this study on known risk factors for malnutrition such as social segregation, psychological factors, economic status, and lack of medical awareness which may have played a role in this age group (Matthias *et al.*, 2006, Waitzberg *et al.*, 2001). Moreover, an objective of the current study was to assess the prevalence of nutritional risk and not the severity of malnutrition (Chen *et al.*, 2005). It is possible that the frequency of nutritional risk among younger adults was high, but their extent of malnutrition was not as high as for older adults. Further study is needed to refine screening instruments that assess malnutrition severity.

The nutritional risk prevalence detected by NRS-2002 was higher than that detected by SGA for the total population and patients of different age groups. The SGA focuses more on chronic or established nutrition risk instead of acute nutritional changes compared to the NRS-2002, which may explain the discrepancy. For example, the physical examination of SGA includes the changes of subcutaneous fat and muscles, which are long term results of malnutrition. Acute cases of malnutrition may not be recognized by the SGA (Christensson *et al.*, 2002), which has been recognized as an index of sickness instead of nutrition (Jeejeebhoy, 1990).

Selection bias in this study may have lead to an underestimate of the prevalence of nutritional risk. Children, pregnant and breast-feeding women were excluded because the aim of the study was to evaluate the application of nutritional screening tool in an adult population, and those populations require specific nutritional assessment tools. Patients with critical illness, those admitted directly to ICU, or those who were unable to communicate were not included in the present study because there was limited opportunity to interview them. Therefore, the nutritional risk as evaluated in this study may not accurately reflect the overall situation of patients in gastrointestinal department of PUMCH, most likely underrepresenting the nutritional risk of the populations excluded from the current study.

Agreement of NRS-2002 and SGA

Moderate agreement was observed in this study between NRS-2002 and SGA for the total population (κ statistic, 0.514), which was similar to results of previous studies conducted by Kyle *et al.* (2006) and Velasco *et al.* (2011) with κ statistics of 0.48 and 0.620, respectively. When categorizing into age groups, the subgroups with the population at and above 36 years old had moderate agreement between NRS-2002 and SGA. However, there was poor agreement between the two screening tools for population less than 35 years old, which was driven by the ≤ 20 year old group. There was slight agreement between NRS-2002 and SGA for ≤ 20 years old group. A small sample of 14 patients ≤ 20 years old however limits much interpretation of the κ statistic of that age group. Currently, there was no gold standard for nutritional risk screening for adults of any age groups.

Clinical outcome predicting capacity

The objective of nutritional screening is to accurately identify those patients who are more likely to experience malnourishment or risk of malnutrition and who could benefit from nutritional therapy. This study evaluated the ability of the NRS-2002 and SGA to predict clinical outcomes (LOS, death, infectious and non-infectious complications) in Chinese patients with gastrointestinal disease, and these widely used screening tools were significantly associated with clinical outcomes. This study included hospitalized adult patients with a variety of diseases that were treated both via non-surgical and surgical methods. To our knowledge, this is the first study to evaluate the application of SGA among Chinese hospitalized patients.

In this study, positive relationships were demonstrated among nutritional risk detected by NRS-2002 and SGA and LOS, and hospitalization cost. In other words, patients with higher nutritional risk were more likely to experience more infectious and non-infectious complications, longer LOS, higher cost, and death rate. NRS-2002 and SGA had generally good clinical outcome predicting capacity for death, infectious and non-infectious complications (area under ROC curve > 0.50). There was not a significant interaction between age and NRS-2002 and SGA, suggesting that NRS-2002 or SGA did not perform much differently according to ages. However, the R-square of each model was small, so it is possible that the relationship between NRS-2002 or SGA and clinical outcome was non-linear and needs to be further explored. Future studies, researchers should try other analysis methods to assess the relationship among NRS-2002 or SGA and clinical outcomes. The association among nutritional status, LOS, and cost is not necessarily a causal relationship; rather LOS and cost might be a reflection of the severity of the underlying disease, economic status, and even educational status of the patients and their families. Other factors influencing clinical outcomes were not included in the data collection, such as the severity of disease and types of nutritional support provided for patients. However, because the purpose of this study was to compare the performance of NRS-2002 and SGA, the failure to consider the severity of disease would not influence the comparison of the two screening tools. The inclusion of disease severity greatly complicates modeling approaches with many independent variables all at great risk of colinearity. Some researchers have taken the severity of disease into account, by classifying disease into different levels (Xiaokun *et al.*, 2009), or just classifying as severe disease and non-severe disease (Panwadee, 2005). Moreover, people who found to have nutritional risk would get further NCP and nutrition intervention if needed, which would influence the clinical outcomes. Therefore, it is possible that the failure to consider the further nutrition intervention lead to the low R-square.

The linear regression for the association among screening tools and LOS and cost showed that there were not large differences in the predictive capacity of the models with NRS-2002 or SGA for either LOS or hospitalization cost. Even though compared to NRS-2002, one step of SGA was associated with a relatively large increase in cost, there were not large differences in the predictive ability of the models with NRS-2002 or SGA for either outcome of LOS or cost. This could be explained by the fact that NRS-2002 was designed for people from all age groups. In addition, NRS-2002 took the influence of age into account in that when a patient was over 70 years old, the score would add 1.

The area under ROC for the association between screening tools and complications and death revealed that both NRS-2002 and SGA had generally good predictive capacity for complications (>0.500), and especially for death (>0.800). The two screening tools did not perform differently for predicting infectious complications and deaths, but NRS-2002 was more accurate than SGA to predict non-infectious complications.

It is worth noting that NRS-2002 had identified a higher portion of patients at nutritional risk compared to SGA (59.04%:45.18%). NRS was also more efficient than SGA in predicting non-infectious complication. Previous studies conducted by Mariana (2010) and Kyle *et al*. (2005) indicated that NRS-2002 had a good predictive capacity for clinical outcomes even though it detects the lowest rate of nutritional risk. The screening tools they compared were NRS-2002, Malnutrition Universal Screening Tool (MUST), Nutritional Risk Index (NRI). even Kyle *et al*. (2005) study included SGA, using it as gold standard to assess the specificity and sensitivity of the other screening tools. The finding of this study corroborated those studies that

NRS-2002 might provide a best yield at the current criteria for nutritional risk detection, even though further studies are needed to verify it.

Since inflammation is regarded as a significant factor which increase the nutritional risk, and may influence the response to nutrition intervention and clinical outcomes (National Alliance for Infusion Therapy and the ASPEN Public Policy Committee and Board of Directors, 2010; Jensen *et al.*, 2009; 2010). Failure to recognize and address the inflammation problem is likely to progress to a severely malnourished state (Cruz-Jentof, 2010; Han, 2011; Benton, 2011; Jensen *et al.*, 2009; 2010). However, current screening tools fail to take inflammation into consideration, which may increase the risk of unrecognized nutritional risk.

Conclusion

Although health care providers are starting to pay attention to the nutrition problem of patients, the prevalence of nutritional risk was still high among hospitalized GI disease patients (59.04% by NRS-2002, 45.18% by SGA), particularly elder people at and above 65 years old (62.75% by NRS-2002, 50.00% by SGA). Therefore, among Chinese patients, in particular GI disease patients, nutritional screening should be provided when admission in order to improve the nutritional risk. Clinical outcomes are influenced by malnutrition, and appropriate nutritional supports are important to improve the unfavorable clinical outcomes. Both the NRS-2002 and SGA worked well in this population of GI patients in China, and they did not perform differently for patients of different ages. However, the relationship between malnutrition and clinical outcomes should be further explored, since many other factors including social factors, severity of diseases and nutrition intervention, influence the clinical outcomes. There was a significant association between clinical outcomes (LOS, hospitalization cost, complications and death) and nutritional risk by NRS-2002 and SGA. There was no significant difference of LOS, cost, infectious complications and death predicting capacity of NRS-2002 and SGA, however NRS-2002 performed better in predicting non-infectious complications. As a result, in the practice, dietitians could use either NRS-2002 or SGA for nutrition screening in order to predict LOS, cost, infectious complications and death, and also provide further NCP and nutrition intervention based on the result of nutrition screening. However, if the health providers would like to predict non-infectious complications, NRS-2002 is a better tool.

Since the role of inflammation plays in malnutrition and clinical outcomes, researchers should take inflammation into consideration. Depending on the consensus statement of the Academy of Nutrition and Dietetics/ ASPEN (Jane, 2012), the following six factors is recommended for nutritional risk identification, including insufficient energy intake, weight loss, muscle mass loss, subcutaneous fat loss, fluid accumulation that may sometimes hide the underlying weight loss, and impaired functional status which can be measured by hand grip strength. Moreover, when making nutrition screening, the dietitians should recognize the degree of inflammatory response that a patient may experience during illness, and find the appropriate laboratory marker for inflammation.

Appendix

Table. Type of complications and nutritional risk

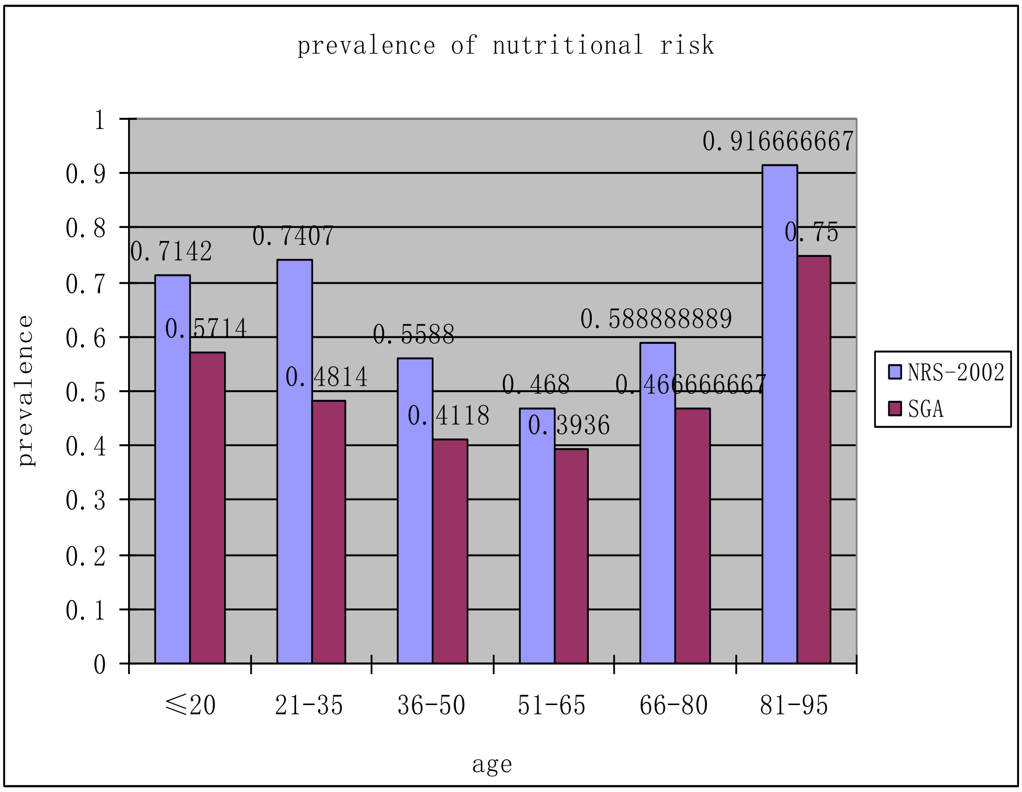
Patient characteristic/ Outcome		Tool used for nutritional assessment	
	n	NRS-2002, % (n)	SGA, % (n)
Infection complication	81	74.07% (60)	58.02% (47)
Wound infection	1	100% (1)	100% (1)
Abdominal fistula infection	1	0% (0)	0% (0)
SIRS	62	80.64% (50)	62.90% (39)
Blood culture examination	31	67.74% (21)	61.29% (19)
Pneumonia	21	66.67% (14)	61.70% (13)
Urinary tract infection	19	63.16% (12)	47.37% (9)
Abdominal infection	15	66.67% (10)	60.00% (9)
Others[1]	15	93.33% (14)	66.67% (10)
Non-infection complication	12	75% (9)	41.67% (5)
Anemia	3	66.67% (2)	33.33% (1)
Myocardial infarction	4	100% (4)	25% (1)
Others[2]	5	60% (3)	60% (3)

NRS-2002, Nutritional Risk Screening 2002; SGA, Subjective Global Assessment.

1. Other infection complications include fungal infections (n=1), oral (n=6), intestine (n=1), bile conduct infections (n=1), blood infection (n=1), perianal abscess (n=1), tuberculosis (n=2), catheter infection (n=1), and pressure sores (n=1).
2. Other non-infection complications include fistula (n=1), upper gastrointestinal bleeding (n=1), peritoneal drainage (n=1), and renal failure (n=1), not clear (n=1).

Tables and Figures

Figure 1. Prevalence of nutritional risk for different age groups.



NRS-2002, Nutrition Risk Screening 2002; SGA, Subjective Global Assessment

Table 1. Agreement between NRS-2002 and SGA: κ-index

Age group	n	Nutritional risk detected by NRS-2002 (%)	Nutritional risk detected by SGA (%)	κ-index
≤20	14	71.42	57.14	0.087
21-35	54	74.07	48.14	0.418
36-50	68	55.88	41.18	0.539
51-65	94	46.80	39.36	0.590
66-80	90	58.89	46.67	0.495
81-95	12	91.67	75.00	0.429
total	332	59.04	45.18	0.514

NRS-2002, Nutrition Risk Screening 2002; SGA, Subjective Global Assessment

Table 2. Detailed clinical outcomes for different age groups.

Age group	n	Nutritional risk detected by NRS-2002 n(%)	Nutritional risk detected by SGA n(%)	LOS (days)	Cost (USD)	Death rate (%)	Infectious Complications (%)	Non-infectious Complications
≤20	14	10 (0.7142)	8 (0.5714)	31.23	4475.02	1 (7.14)	5 (35.71)	1 (7.14)
21-35	54	40 (0.7407)	26 (0.4814)	24.78	3801.31	0	35 (64.81)	2 (3.70)
36-50	68	38 (0.5588)	28 (0.4118)	26.90	4180.18	0	17 (25.00)	0
51-65	94	44 (0.4680)	37(0.3936)	24.41	4101.90	2 (2.13)	21 (22.34)	2 (2.13)
66-80	90	53 (0.5889)	42 (0.4667)	18.55	4106.66	2 (2.22)	21 (23.33)	7 (7.78)
81-95	12	11 (0.9167)	9 (0.7500)	17.58	2564.63	0	3 (25.00)	0
total	332	196 (0.5904)	150 (0.4518)	23.56	4030.51	5 (1.51)	81 (24.40)	12 (3.61)

LOS, length of hospital stay; NRS-2002, Nutritional Risk Screening 2002; SGA, Subjective Global Assessment.

Cut points: NRS-2002, at nutritional risk when the score is ≥3; SGA, at nutritional risk when the level is B or C.

Table 3. Model comparison and f-test.

Withdrawal assessment	outcome	Sum of square	Degree of freedom	F-test
NRS-2002, Full model	LOS	28.678	7	0.366
NRS-2002, Saturated model	LOS	32.212	10	
SGA, full model	LOS	30.798	7	0.289
SGA, Saturated model	LOS	33.720	10	
NRS-2002, Full model	COST	69.954	7	0.234
NRS-2002, Saturated model	COST	75.229	10	
SGA, full model	COST	67.084	7	0.289
SGA, Saturated model	COST	74.167	10	

Full model included categorized age, gender, infectious and non-infectious complications.

NRS-2002: Nutrition risk screening 2002; SGA: Subjective global assessment; LOS: Length of stay

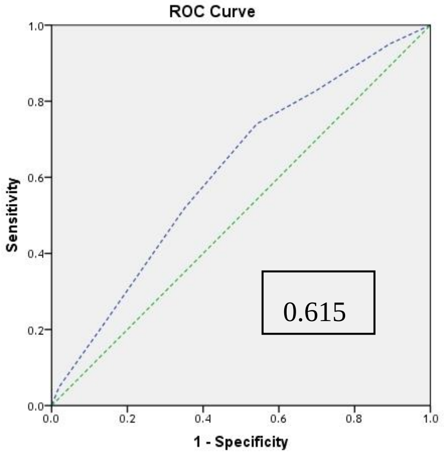
Table 4. Relationship between nutritional risk and LOS and cost.

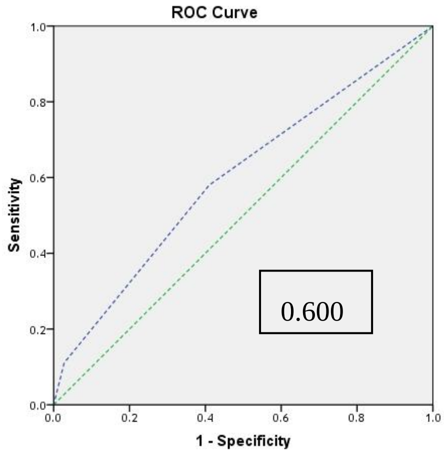
Outcome	assessment	B	t	*p*-value	R square
LOS	NRS-2002	0.086	3.061	0.002	0.130
	SGA	0.272	3.613	0.001	0.140
Cost	NRS-2002	0.127	3.788	0.000	0.198
	SGA	0.296	3.309	0.001	0.190

NRS-2002: Nutrition risk screening 2002; SGA: Subjective global assessment; LOS: Length of stay

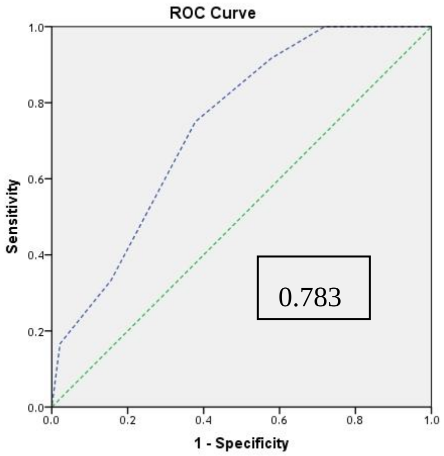
Figure 2. Nutritional screening tools and evaluated clinical outcomes including infectious and non-infectious complications, and death.

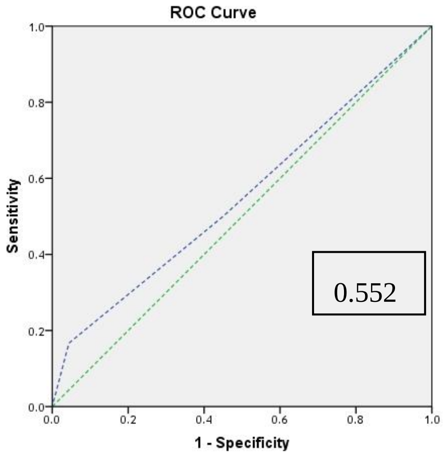
Infectious complications: NRS-2002 SGA



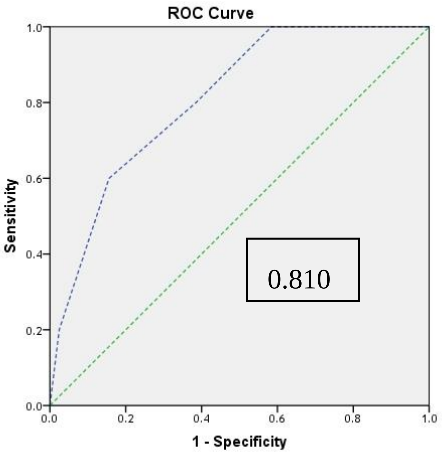


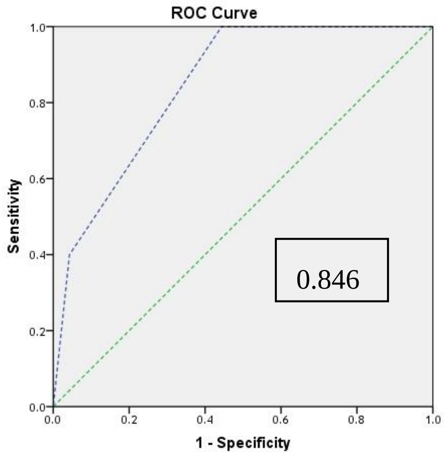
Non-infectious complications: NRS-2002 SGA





Death: NRS-2002 SGA





The most effective tool in predicting unfavorable clinical outcomes is that with the largest area under the receiver operating characteristic curve. NRS-2002, Nutritional Risk Screening 2002; SGA, Subjective Global Assessment.

Table 5. Clinical outcomes and area under ROC curve values of the two nutritional screening tools according to evaluated outcomes

Screening tool	Clinical outcomes (area under ROC curve)		
	Infectious complications	Non-infectious complications	Death
NRS-2002	0.615	0.738	0.810
SGA	0.600	0.552	0.846

NRS-2002, Nutritional Risk Screening 2002; SGA, Subjective Global Assessment.

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VITA

Name of author: Fang Wang

Place of birth: Tianjin, China

Date of birth: May 23, 1988

Graduate and undergraduate schools attended:

Tianjin Medical University, Tianjin, China

Degrees Awarded:

Bachelor of Medicine, 2012, Tianjin Medical University

Professional experience:

Internship, Peking Union Medical College Hospital, 2013

Tianjin the Third Hospital, 2011-2012