Use of Malnutrition Screening Tools by Paediatric Nurses in Acute Hospital Settings:

A Systematic Literature Review

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Abstract

Background: *Malnourishment is detrimental in a hospital setting, and all children are at risk of malnourishment once admitted. Malnutrition screening tools (MSTs) are meant to identify inpatients most at risk, and yet some are more reliable, sensitive, and selective than others. While many MSTs have become available over the past two decades, no gold standard exists. Although many widely used MSTs have strengths, it is not always efficacious to utilize them in clinical practice. Keywords: malnutrition screen tools, paediatrics, anthropometry, nursing*

Aim: *The objective of this research is to analyse the strengths and limitations of some of the most common MSTs so that nurses will better understand how and why MSTs are used and what issues may arise in the process.*

Methods*: A systematic review of the literature was conducted to evaluate MSTs frequently used by nurses in acute hospital settings to assess paediatric patients. Using the Cochrane method to guide this review, eight studies were selected that assessed malnutrition screening by nurses in children ages 0-18 years in a hospital or acute care setting. In addition, the studies selected were observation cohorts or randomised control trials.*

Results*: The review found five paediatric malnutrition screening tools that were validated for use in clinical settings: Paediatric Yorkhill Malnutrition Score (PYMS), Screening Tool for the Assessment of Malnutrition in Paediatrics (STAMP), Screening Tool for Risk on Nutritional Status and Growth (STRONGkids), Paediatric Nutrition Screening Tool (PNST), and Subjective Global Nutrition Assessment (SGNA).*

Conclusion: *Nurses play a vital role in detecting malnourished paediatric patients in acute settings. Based on the findings, it becomes evident that each of the MSTs has its unique strengths and weaknesses depending on if the tool is suited for the specific patient. Understanding how and why to use particular tools by nurses can help create more effective screening practices. Additional research needs to be done to address the screening complications of chronic illness and obesity as well as study how to budget shortcomings impact effective malnutrition screening.*

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List of Abbreviations

Abbreviation	Definition
ASPEN	American Society for Parenteral and Enteral Nutrition
BMI	Body mass index
CCLD	Cholestatic liver diseases
CHW	Community health worker
CMAM	Community Management of Severe Acute Malnutrition
DGH	District General Hospital
EHR	Electronic health record
EHR-STAMP	An integration of electronic health records and the Screening Tool for the Assessment of Malnutrition in Paediatrics tool
ESPEN	European Society of Clinical Nutrition and Metabolism
EU	European Union
FELANPE	Federation Of Parenteral and Enteral Nutrition
GLIM	Global Leadership Initiative on Malnutrition
ICD-10	International Classification of Diseases
iNews	Infant Nutrition Early Warning System
LOS	Length of stay
LR 1^{st}	Low- and medium-risk categories grouped
MST	Malnutrition Screening Tool
MUAC	Mid-upper arm circumference
NCD	Noncommunicable disease
PNRS	Paediatric Nutrition Risk Score
PNRT	Paediatric Nutritional Screening Tool
PNSS	Paediatric Nutritional Screening Score
PNST	Paediatric Nutrition Screening Tool
PRAT	Pilot Paediatric Risk-Assessment Tool
PYMS	Paediatric Yorkhill Malnutrition Score
QUADAS	Quality Assessment of Diagnostic Accuracy Studies
RHSC	Royal Hospital for Sick Children
SAM	Severe acute malnutrition

SDG	Sustainable Development Goal
SGNA	Subjective Global Nutrition Assessment
STAMP	Screening Tool for the Assessment of Malnutrition in Paediatrics
STRONGkids	Screening Tool for Risk on Nutritional Status and Growth
TPH	Tertiary Paediatric Hospital
UK	United Kingdom
UN	United Nations
WHO	World Health Organisation
WHZ	Weight-for-height Z-score

Chapter 1: Introduction

Childhood malnutrition is a global issue. Poor access to nutritious foods, or an overabundance of unhealthy food, can result in malnutrition. The World Health Organisation (WHO) describes malnutrition as “deficiencies, excesses, or imbalances” in the amount of food, energy, and nutrients that an individual consumes (1). Malnutrition in every form is considered a serious challenge by the WHO, and the UN has specifically set global nutrition targets that aim to combat this issue (1). In addition, the Sustainable Development Goal 2 sets a target to increase food security, end hunger, and improve nutrition by the year 2030 (1). The global action that is being taken on malnutrition underscores the severity of this issue.

Undernutrition has four categories: wasting, stunting, underweight, and vitamin and mineral deficiencies (1). Wasting refers to individuals with a low weight-for-height ratio, evidenced by severe weight loss, either because an individual has not eaten enough or their bodies have succumbed to illness, such as diarrhoea or anaemia. Stunting means an individual has a low height-for-age ratio and is typically caused by chronic undernutrition. An underweight individual has a low weight-for-age ratio (1). According to recent data from the WHO, approximately 155 million children under the age of five are stunted worldwide, while 45% of deaths in children are caused by undernutrition in low and middle-income countries (1).

Malnutrition can also be described as “micronutrient-related nutrition,” which refers to the body not getting enough micronutrients, and this impacts how the body produces enzymes, hormones, and other necessary substances that are required for proper growth and development (1). Children are more likely to be at risk of deficiencies in iodine, vitamin A and iron (1). Micronutrient deficiency is a global problem that has been described as the “hidden hunger,” primarily impacting underdeveloped and developing countries (2). These deficiencies in children can cause a wide range of issues, including the increased risk of infectious disease, death, blindness, and anaemia. Malnutrition, in the form of overnutrition, can also cause obesity, as imbalances occur between energy intake and expenditure (1). Chronic obesity can lead to diet-related non-communicable diseases (NCDs) such as cancer, diabetes, and cardiovascular diseases (1). Over forty-one million children under the age of five are overweight, and in low- and middle-income countries, this number is increasing (1). As such, childhood obesity becoming a chronic lifelong problem also places children at later increased risk for developing NCDs.

Ideally, malnutrition screening effectively identifies issues early, and intervention can take place outside of hospital settings. Early detection of childhood malnutrition at primary healthcare facilities could prevent up to 500,000 annual deaths (3). However, early detection often is complicated due to a range of challenges, including lack of training, appropriate tools, and awareness (3). Consequently, it is critical that malnutrition and its risk factors are detected early in hospitalised children. Malnutrition rates in hospitalised children can range anywhere from 6.1% to 55.6%, with multiple studies showing wide ranges (4).

Malnutrition screening tools (MST) have been developed to provide early detection for at-risk individuals or help identify those who are already malnourished (3). MSTs have been used since 1995 in high-income countries for detecting malnutrition in hospitalised children. When used correctly, MSTs can identify children with nutritional deficiencies, reduce healthcare costs and improve health outcomes. A screening tool can identify the risk or presence of malnutrition, and depending on the level of malnutrition, patients could potentially be referred to a dietitian who can provide a complete nutritional assessment or recommend an intervention. However, there are many tools available, and the ability of these tools to identify at-risk children, when completed by healthcare professionals such as nurses, requires further evaluation (4).

Thesis structure

The following structure was used in this thesis:

Chapter One provides an introduction to the topic of malnutrition and its various forms.

Chapter Two contains a literature review of both the existing scholarship on malnutrition and the various screening tools that can be used in either acute care or hospital settings.

Chapter Three describes the methods undertaken to conduct a systematic review of the literature to identify the MSTs used in hospital settings by nurses to assess paediatric patients.

Chapter Four details the results of the systematic review and identifies the screening tools used by paediatric nurses.

Chapter Five discusses the main findings of the systematic review, comparing and contrasting the various tools available to screen for malnutrition.

Chapter Six outlines the significant conclusions that this study has found, with future research recommendations included.

Contributions of the researcher

Author	Contribution to the thesis
Yi Ren – Research student	- Primary author of thesis - Prepared PROSPERO registration - Developed search strategy with librarian - Defined inclusion and exclusion criteria - Searched all databases - Retrieved all search results - Removed duplicate studies - Screened titles and abstracts for inclusion - Completed full text reviews for inclusion - Extracted data from included studies - Performed a quality analysis of included studies - Interpreted results
Dr Amy Lovell – Secondary supervisor	- Assisted with PROSPERO registration - Second independent reviewer for title and abstract screening and full text reviews - Advised on data analysis and interpretation - Revised and approved the thesis chapters
Professor Clare Wall – Primary supervisor	- Assisted with PROSPERO registration - Advised on data analysis and interpretation - Revised and approved the thesis chapters

Chapter 2: Literature Review

Malnutrition is considered a "global disease burden," contributing to more than one-third of childhood deaths around the world (5). Although some efforts are underway to address this crisis, research indicates a general lack of significant progress toward reaching the 2025 targets set by the World Health Assembly and the Sustainable Development Goal (SDGs) of achieving zero hunger by 2030 (3).

Malnutrition is characterised by excesses, deficiencies, or imbalances in the amount of energy and nutrients that an individual consumes and can be subcategorized as stunting, undernutrition, and underweight (1). Although malnutrition is a universal problem, it can take various forms and is caused by many factors beyond simply not having sufficient food (1). Whether high-income or low-income, countries around the world battle with the different forms that malnutrition can take (1).

Severe acute malnutrition (SAM) is a significant problem worldwide (5). An estimated twenty million children experience severe malnutrition, and one million children die every year as a result (5). SAM is a factor in half of the ten million childhood deaths worldwide, indicating that this is a severe public health crisis that needs attention (5). Acute malnutrition is often associated with periods of sudden or sharp food shortages that can result in loss of body fat or the wasting of skeletal muscle (5). Food shortages can be caused by extreme weather, crop failures, political conflict, war, or pandemics. SAM is characterized as a severely low weight-for-height z-score of -3 below the median growth standard established by the WHO, or a weight-for-height ratio of less than seventy percent (5). Signs of SAM are visible wasting, oedema in the limbs, or, for children between 6-59 months, an arm circumference of less than 115 mm (5). Common comorbidities associated with SAM are pneumonia, anaemia, tuberculosis, and vitamin A deficiency, but the most significant contributing factor to death is age (5). This is why early detection is critical as a measure of preventative care so that interventions can be administered before malnutrition becomes severe in children (5). Research indicates that when children with SAM are treated according to WHO protocols, the fatality rate can be reduced to as low as five percent in communities and outpatient treatment health facilities, although there were less noticeable differences in hospital settings (5).

2.4 Malnutrition's Causes & Consequences

Malnutrition is often associated with poor diet and/or lack of access to health services (11). Another critical factor that can increase the risk of malnutrition is poverty, and the WHO notes that a "cycle of poverty and ill-health" is often the outcome of malnutrition, with increased health care costs causing decreased productivity and loss of income (1). In turn, this loss of income then creates more risks for malnutrition, creating a cycle. It is important to also note that women and children are particularly at risk for malnutrition (1).

2.4.1 Malnutrition in Developing Countries

Malnutrition is a significant problem in developing countries, especially in areas where poverty or food insecurity is prevalent. Malnutrition accounts for over ninety percent of the developing world's nutrition-related illnesses, and one-third of these cases can be found in Sub-Saharan Africa (11). Of the 148 million underweight children in the world, thirty-six million are in Sub-Saharan Africa, and seventy-eight million are in South Asia (12). According to a 2012 study of malnutrition in developing countries, twenty-six percent of children in the developing world were considered stunted, three percent severely wasted, and forty-five percent of deaths under the age of five were attributed to malnourishment (13). Experts claim that malnutrition is the most important factor in a developing nation's burden of disease, directly causing the deaths of three hundred thousand people annually, with half of those deaths occurring among young children (14).

Morbidity among the under-five year old demographic is often related to problems associated with poverty and other diseases such as malaria, diarrhoea, and tuberculosis. Malnutrition compounds and complicates these associated health problems (11). Sub-Saharan Africa and parts of southern Asia are at higher risk of malnutrition because, in some regions, people do not have reliable access to basic macronutrients such as proteins, fats, and carbohydrates, and foods can be deficient in essential minerals and vitamins (14).

In the twenty-first century, communities in developing countries often experience a "double burden of disease," as underweight and overweight children coexist, sometimes even in the same households (13). Between 1990 to 2011, the global childhood obesity rate doubled as a result of poor food quality (13). In Africa, for instance, seven percent of children under the age of five were considered obese, while in Asia, the figures are closer to five percent in this demographic (13). In both underweight and overweight children, micronutrients are deficient (13).

In developing countries, problems associated with malnutrition reveal urban-rural disparities (11). In Tanzania, one of the poorest countries in the world, rates of malnutrition are much higher in rural areas compared to the cities (11). Recent research considers malnutrition rates among children under five years old in the Bagamoyo District, considering data from local hospitals and health facilities in small towns in regions such as Kiwangwa, Fukayosi, and Yombo (11). Among the 63,237 children participating in the study, researchers collected anthropometric measurements of weight, height, age, and mid-upper arm circumference (MUAC), comparing this data to reference statuses. Researchers found that children in rural towns experience higher rates of underweight, stunting, and wasting than children in cities (11). Males were significantly more malnourished than females in all three types of malnutrition: stunting, wasting, and underweight (11). The study shows that children at rural hospitals in developing countries experience moderately higher rates of malnutrition, indicating a need for hospital-based interventions to detect malnutrition in developing countries, in both urban and rural health clinics.

Severe acute malnutrition (SAM) can be complicated by related illnesses such as diarrheal disease or acute gastroenteritis. A study conducted between 2013 and 2015 at the Hiwot Fana Specialized University Hospital paediatric wing in Ethiopia aimed to identify the most prevalent causes of death in SAM patients between the ages of 6-59 months (5). Acute gastroenteritis was present in fourteen of the fifteen deaths occurring among hospitalised children. Health practitioners identified SAM by grade three oedema, looking for signs of severe wasting and considering other common symptoms of malnutrition such as body swelling, diarrhoea, and vomiting (5). The study indicates that SAM mortality caused by the complication of acute gastroenteritis is common and ultimately manageable if proper treatment and vigilance are undertaken (5).

2.4.2 Malnutrition in Developed Countries

Although less common, paediatric malnutrition is also a problem in developed countries and is often linked to chronic disorders (15). McCarthy et al. review malnutrition prevalence studies to present evidence of moderate and severe undernutrition in children in countries across the developed world. For example, 19.5% of children in Canadian hospitals were found to be at least mildly undernourished using growth parameters as measurement (16). However, the researchers concluded that determining the exact prevalence of malnutrition in developed countries was a challenge due to the varying tools used to define malnutrition (16). Spoede et al.'s systematic review of research found that paediatric malnutrition was related to both underweight and overweight conditions in American children (17). It is important to note that malnutrition can also take the form of overnutrition or an excess intake of energy that can lead to weight gain and obesity.

Likewise, micronutrient deficiencies can also result from malnutrition in overnutrition. In a study of 8,167 children, researchers discovered that household food insecurity from kindergarten to grade three is a predictor of obesity in later grades, specifically between grades five to eight (17).

A leading factor of malnutrition in developed countries is food insecurity, defined by Spoede et al. as "the limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable food in socially acceptable ways" (17). Food insecurity is high in developed countries, with rates ranging from eighteen to twenty percent of the population, indicating that social welfare programs and stronger economies alone do not prevent malnutrition (18). In 2013, sixty million people in higher-income countries, 7.2% of the population, relied on food banks (18). On a state-by-state level, poverty figures prominently in the level of food insecurity. For example, in Australia, the estimated rate of food insecurity is 21.7%, impacting 4.6 million people(18). In Japan, food insecurity affects 15.7% of the population, or 19.8 million people(18). In Canada, the food insecurity rate is 7.7%, impacting 1.9 million people. In the European Union (EU), 8.7% of the population, or 43.6 million people, whereas in the United States, fifteen percent of the population experiences food insecurity (18). Children are susceptible to malnutrition in this demographic. A New Zealand health survey found that 19% of children lived in food-insecure households that could be classified in the severe-to-moderate category (19). Additionally, approximately 1 in 5 children in the country experienced food insecurity (19).

Food insecurity can lead to or exacerbate adverse physical and mental health conditions(17). In the United States, food insecurity contributes to increased instances of childhood depression, microaggressions, and anxiety (17). Children in households experiencing food insecurity are 1.4 times more at risk of developing asthma and two to three times more likely to develop anaemia(17). The rate of food insecurity is also more prevalent in ethnic neighbourhoods (17). In Hispanic households in the United States, for instance, up to 18.5% of families experience food insecurity, and among black households, the rate is higher, at 22.5% (17). Compared to the national average of 15%, minority populations generally experience higher levels of poverty and food security, as the two problems are interrelated.

2.4.3 Short-term Outcomes of Malnutrition

Short-term outcomes of paediatric malnutrition in hospitals include a higher risk of infection, compromising health on many levels (20). Infections such as acute gastroenteritis and respiratory tract infections can impair a child's nutritional status and this can cause further malnutrition, contributing to a catabolic state (20). Complications from infection can prolong recovery, decrease the efficacy of treatment, delay growth and development and increase hospital stays (220). In a multicentre study of 2,567 children across twelve countries in Europe, researchers reported that the longer a child stays in the hospital the more likely they are to develop moderate to severe malnutrition (20).In the study, the average length of stay was 6.83 days and children who averaged over nine days in the hospital were more likely to experience severe malnutrition (20).

2.4.4 Long-term Outcomes of Malnutrition

Long-term adverse outcomes include an increased likelihood of morbidity and mortality. Other less severe but still compromising long-term outcomes of malnutrition can consist of cognitive and developmental delay, muscle weakness, and immune dysfunction (16). Stunting, for instance, has been associated with poor mental development, behavioural abnormalities, and poor academic achievement (20). Malnourished children, if treated early enough, may catch up to others in terms of cognitive and physical development. Long-term sociocultural and economic outcomes also relate to the economy and public health (16). Disease-related malnutrition in the UK, for instance, costs £13 billion per year (16). In the Netherlands, costs associated with hospitalizing children in the Dutch state-run medical system are upwards of fifty-one million euros per year (16). Thus, on individual, family, community, and national levels, malnutrition can lead to severe long-term consequences.

2.5 Paediatric Malnutrition in the Acute Care Setting

Paediatric malnutrition often occurs in hospital settings because, in this environment, food consumption can be significantly reduced, or, conversely, increased caloric requirement can occur due to disease-induced high catabolic states (21). The metabolism of children is unique compared to adults (21). Illness can impact a child's ability to properly consume food, decreasing their nutritional intake. Certain drugs can lead to anorexia, anaemia, nausea, vomiting, and diarrhoea, further complicating nutrient intake and retention (21). Upon hospital admission, a child's nutritional status can deteriorate (21). A recent study of hospitalisations in Turkey shows that up to 39% of admitted paediatric patients experienced undernutrition and that 64% of them had a chronic underlying disease that resulted in stunting (20). Nutrition levels can be impacted by chronic conditions, inflammatory responses, and non-illness factors like food availability and behaviour (20).

Hospitals may not have proper MSTs on hand to detect and identify malnutrition. There may be limited nurses and hospital staff who can administer such tests, or it may not be a mandatory requirement. A recent Italian study of 496 paediatric patients found that the number of children who left the hospital with malnutrition outnumbered the number of children who entered the hospital with malnutrition (21). Results are consistent among other studies in other countries. Kazem et al., for example, found that 51.1% of children under five lost weight during hospital stays, and Rocha et al. found that 51.6% of children under five lost weight while hospitalised (21). Kazem et al. found that the children who were classified as having mild malnutrition or normal nutrition at admission were particularly at risk for hospital-acquired or complicated malnutrition (21). While a variety of factors may contribute to these statistics, research indicates that hospitals must do more to assess and monitor nutrition levels in paediatric patients.

Hospital food services contribute to malnutrition among paediatric patients in hospitals (16). Food service programs often receive budgets that are inadequate to consistently deliver healthy meals to patients (16). When hospitals experience budget cuts, food service resources are often the first to be reduced (16). Hospitals generally offer only a limited selection of food, and many of the meal choices are not child-friendly. Inflexible meal times may not align with patient eating habits and needs, and these problems can lead to poor nutritional intake. If patients consume less than fifty percent of hospital food, this can both decrease their weight and increase the length of stay (LOS) at hospitals (16).

The shortcomings in hospital food services reveal a need for better services that promote healthy eating habits (16). This is especially important in a hospital setting, where children may be intimidated and ill(16). The inadequacy of hospital food is related to malnutrition issues among paediatric patients, although this issue is only of indirect concern within the context of this research. Research from Canada indicates that hospital food service programs could do more to ensure that paediatric patients are getting adequate nutrition during hospital stays (16). Implementing a hotel-style meal service model, for instance, instead of simply delivering food at established times throughout the day, encourages children to consume food that is delivered. Altering the delivery method of food can lead to a more positive food consumption environment (16). A study by Williams et al. found that when children have the option to order food from the kitchen at any time of the day, between 7 am to 7 pm, they experienced 28% higher caloric intake, 18% higher protein intake, and a large reduction in food waste, saving hospitals approximately $35,712 a year (16).

Length of stay (LOS) is another major factor that can influence malnutrition rates in hospitals. In a clinical setting, patients who stay in the hospital longer are at higher risk of malnutrition because patients are less mobile and eat less, factors that can lead to the reduction of muscle mass and weight loss. Reduced muscles and fat mass are associated with lower nutrition reserves (22). Clinical dietetic interventions should include routine nutritional assessments, feeding protocols, and interhospital support that aims to improve nutrition in paediatric patients (22). Vega et al. find that when health care centres support dietitians in enteral and parenteral nutrition, patients experience an overall positive trend in weight-for-age z-scores (22).

In developed countries, children are most at risk of malnutrition when they are in acute care settings, live in at-risk social environments, or have specific health needs (17). Food insecurity contributes to the rising rates of undernourished and over-nourished children, contributing to or exacerbating chronic illnesses that may lead to paediatric hospitalization(17). Additionally, paediatric malnutrition can also be caused or exacerbated in hospital settings due to illness (21). The hospital's food service may also adversely affect the nutrition intake of children if child-friendly meal choices are not available (16).

2.6 Malnutrition Screening Tools

There are five commonly used, validated paediatric malnutrition screening tools routinely used in clinical settings. These include the Paediatric Nutrition Risk Score (PNRS) (23), the Screening Tool for the Assessment of Malnutrition in Paediatrics (STAMP) (23), the Paediatric Yorkhill Malnutrition Score (PYMS) (23), the Screening Tool for Risk on Nutritional Status and Growth (STRONGkids) (23) and the Paediatric Nutrition Screening Tool (PNST) (23). Other less common MSTs include the Paediatric Nutritional Screening Score (PNSS), the Infant Nutrition Early Warning Score (iNews), and the Paediatric Nutritional Screening Tool (PNRT).

2.6.1 *Paediatric Nutrition Risk Score (PNRS)*

The Paediatric Nutrition Risk Score (PNRS) was developed by Sermet-Gaudelus et al. in 2000 (24). PNRS is designed to identify children who might be at risk of losing two percent or more of their weight during hospitalization (24). However, as with all tools, limitations exist. The main weakness of PNRS is that it cannot be administered immediately upon hospital admission because it requires monitoring of nutritional intake of patients over a forty-eight-hour period, limiting the potential for early intervention. Although PNRS is easy to use, another weakness is that it requires trained personnel to assess the dietary intake against estimated requirements (24).

A South Korean study by Lee and Yang compared four MSTs used with 559 patients in tertiary hospitals (25). The PNRS test detected a high-risk of malnutrition in 16.6% of participants, while STAMP revealed a high risk of malnutrition in 48.8% of participants. PYMS found 48.1% of the participants to be of high risk. STRONGkids identified 5.5% of patients at high risk for malnutrition (25). Some alignments between PNRS and STRONGkids were evident compared to other tools, and yet results indicated that PNRS was much less sensitive than PYMS or STAMP. PNRS also identified more patients with low-to-medium risk for malnutrition. Comparing the MSTs, results showed a high degree of variability among tests, indicating that nurses and other healthcare workers cannot just use any tool at their disposal but must choose an MST that is most suitable for the distinct clinical setting (25). For instance, PYMS and STAMP may be more capable of identifying stunting and wasting, as it recognises low body mass indexes (BMIs) better (25). Since wasting and stunting are signs of severe malnutrition, these two tools may be better applied to settings that aim to detect SAM.

2.6.2 ***Screening Tool for the Assessment of Malnutrition in Paediatrics (STAMP)***

STAMP was developed by McCarthy et al. in 2012 and is comprised of a three-step assessment that collects data about weight-for-age, reported weight loss, changes in appetite, nutritional risk of disease, and discrepancies between weight and height (24). In the original validation study of 238 paediatric patients, STAMP showed moderate reliability (24). Ong et al. conducted a cross-sectional study of two paediatric wards in public hospitals in Malaysia, comparing two nutrition identification tools, STAMP, a malnutrition screening tool, and Subjective Global Nutrition Assessment (SGNA), a nutrition assessment tool (26). The researchers made objective assessments considering anthropometry factors, including weight, height, MUAC, dietary intake, and biochemical markers such as C-reactive protein and total lymphocytes (26). Results show that while SGNA identified malnutrition risk in 45% of the children, STAMP identified 79% of children to be at risk of malnutrition. The nurses' observational assessments found malnutrition risk in only 46% of participants (26). The SGNA tool showed a specificity of 70.45%, four times higher than the specificity of STAMP at 18.1% (26). This suggests that there is more agreement between SGNA and objective measurements, while the STAMP tool tends to over-diagnose or misdiagnose children, making the SGNA tool more valid for evaluating malnutrition in hospitalised children.

It is important to note differences between screening tools, such as STAMP, and assessment tools, such as SGNA. Screening tools are helpful in the context of daily routines, to check for potential risks of malnutrition or existing malnutrition in patients, as screening tools are standardised, validated, economical, quick and easy to use, and exhibit moderate to high levels of specificity and sensitivity (27). Screening tools should be used in paediatric care settings within twenty-four to forty-eight hours when children first enter the health care facility (27). They can also be employed in regular intervals, every week, for instance (27). If nutritional screenings are part of clinical protocols, detection of certain levels of malnutrition can be referred to a dietitian or paediatrician for further analysis.

Nutrition assessment tools should be used after screening tools are used, as they allow nurses to gather additional information through physical examinations, data that is more nutrition-specific (27). According to Rebert et al., “Screening assesses risk whereas assessment determines nutritional status” (27). Nutritional assessments measure oral nutritional intake as well as energy, protein, and micronutrients, and these are vital steps for assessing whether a nutritional imbalance exists (27). Nutrition assessment tools help practitioners define what the specific problem is so that proper intervention can be determined and administered to paediatric patients.

STAMP is widely utilized because it is quick and easy to use. STAMP incorporates information that nurses would generally get when patients are admitted and undergo a nutrition screening process (28). STAMP uses anthropometric data to assess patients. Chourdakis et al. compared STAMP, PYMS, and STRONGkids, in a large clinical trial of 2,567 inpatients at fourteen hospitals across twelve European countries (29). Results showed that while risk classification was around 41% across all three tools, STAMP classified 23% of children as high risk, PYMS classified 25% and STRONGkids classified 10% of patients at high risk (29). Of these high-risk patients, STAMP detected that 19% of them had a low BMI and that 14% of patients had low height-for-age scores. PYMS detected that 22% of the high-risk patients had a low BMI and that 8% of them had a low height-for-age. STRONGkids showed 23% for low BMI and 19% for low height-for-age (29). Variations within the results of these different assessments show that the identification and classification of malnutrition were not consistent across all three tools, suggesting that while all the nutritional tools have similar steps and procedures, not all of them provide adequate and accurate assessments.

STAMP has been modified and updated over time. A study by Reed et al. found that no paediatric nutrition screening tool was compatible with electronic health records (EHR) (30). Consequently, Reed et al.’s interprofessional team modified the STAMP tool, integrating it with EHR to create a newer version called EHR-STAMP (30). The researchers designed the EHR-STAMP so that it would automatically retrieve anthropometric data from a patient's chart and assign a score. This means that one-third of the data processing in EHR-STAMP is done automatically, reducing the need for clinicians to input data manually. The other major benefit of this newer version of STAMP is that it utilizes the EPIC platform, which is the biggest EHR provider in the United States(30).

To test the validity of EHR-STAMP, Reed et al. assessed a total of 3,553 paediatric inpatients between August 2017 and May 2019. Results over the nearly two-year study indicate that EHR-STAMP has an accuracy of 85%, the sensitivity of 89%, specificity of 97%, a positive predictive value of 60%, and a negative predictive value of 94% (30). This suggests that the EHR-STAMP has become a very reliable tool for detecting malnutrition in paediatric patients in a clinical setting, as it is compatible with EHR and incorporates current indicators recommend for paediatric malnutrition assessment (30).

2.6.3 *Paediatric Yorkhill Malnutrition Score (PYMS)*

PYMS was developed by Gerasimidis et al. in 2010 and considers four data sets: body mass index (BMI), changes in nutritional intake, history of weight loss, and severity of underlying disease on nutritional status (24). Like STAMP, PYMS includes anthropometric measures. Of the 247 children in the Gerasimidis et al. validation study, 59% were rated as high risk using the PYMS. Of that figure, 47% of these cases were confirmed to be of high risk when rated against a nutritional assessment (24). In this study, 53% of children were misidentified and misrepresented to dietitians, suggesting a low specificity (24).

A study by Lestari et al. compared the sensitivity and specificity of PYMS and STRONGkids against the SGNA nutritional risk standards of disease, considering discrepancies between weight and height (31). Considering eighty-one paediatric patients between the ages of one and sixteen years, researchers found that PYMS was the better tool to use in identifying malnutrition risk because it had a very high sensitivity rate of 95.7% and a specificity of 66.7% (31). Researchers also found that PYMS requires nurses to have more education and training compared to STRONGkids, which does not require any calculations. Of the three nurses participating in the study, two found the PYMS calculations more difficult and all three stated that the tool added more to their workloads (31).

2.6.4 *Screening Tool for Risk on Nutritional Status and Growth (STRONGkids)*

STRONGkids was developed and tested by Hulst et al. in 2010 and is based on four data sets: a subjective clinical assessment, high-risk diseases assessment, nutritional intake assessment, and weight loss assessment (24). In the validation study by Hulst et al., STRONGkids was tested on 424 children in thirty-seven general hospitals across the Netherlands. Hulst et al. found that decreases in z-scores correlated with increased risk, suggesting that the higher the STRONGkids score, the greater the risk of malnutrition when compared to anthropometric measurements (24).

Unlike STAMP or PYMS, STRONGkids does not incorporate anthropometric measures, as it relies mainly on a visual inspection of the body when children are admitted to health care centres (24). A limitation of the STRONGkids is that it requires healthcare workers to complete a subjective clinical assessment (31). The STRONGkids depends on nurse observations, whether a patient appears lean or gaunt, rather than taking into account the patient's history of weight loss, food habits, or predictive effects of a given disease on nutrition (31). STRONGkids was found to have a weaker sensitivity and specificity than PYMS at 52.5% and 41.7%, respectively (31). The STRONGkids only predicts a high risk of malnutrition in 5.5% of the paediatric population whereas PYMS predicted 47.8% and STAMP predicted 48.8%, suggesting that the STRONGkids is the least reliable of the MSTs.

2.6.5 *Paediatric Nutrition Screening Tool (PNST)*

PNST was developed by White et al. in 2016. The test consists of four screening questions to assess malnutrition, none of which rely on anthropometric measurements or information about past medical conditions (24). The test takes, on average, less than five minutes to complete. White et al. employed PNST in a study of 295 children in Australia, from neonates to age sixteen years. The study showed that PNST had a high sensitivity of 77.8% and a specificity of 82.1% (24).

In a recent study in Canadian hospitals, where malnutrition was detected in up to 51% of paediatric patients, Carter et al. considered which screening tools were best to assess malnutrition in children, using both STRONGkids and PNST (23). They showed that malnutrition was associated with increased LOS, mortality, morbidity, and increased risk of infection (23). The researchers conducted both tests in random order on patients between the ages of one month to seventeen years old. Using standard cut-offs, Carter et al. found that STRONGkids only had a 35% specificity rate, meaning that it misidentified children at risk of malnutrition even when they were well-nourished 65% of the time. PNST also had a very low sensitivity rate of 58% (23). These findings suggest that using standard cut-offs, neither STRONGkids nor PNST are particularly effective in screening children at risk of malnutrition, but the use of PNST with adjusted cutoffs does increase its reliability and validity (23).

Both tests identified children at risk when they were well-nourished. When researchers changed the nutrition-risk cut-offs, better risk classification was achieved (23). For example, when nutrition-risk cut-offs were adjusted, sensitivity improved to 87% from 58%. Specificity slightly decreased but remained higher than that of the STRONGkids. PNST was shown to perform better for paediatric patients who were admitted with underlying medical diagnoses such as cardiac, gastrointestinal or metabolic conditions. Neither tool missed a child who was severely malnourished (23).

Although screening tools for paediatric malnutrition have some value in terms of detection, treatment, or prevention of wasting, stunting, or underdevelopment in children, questions remain considering the accuracy of MSTs. Marino et al. find that the wide-scale use of screening tools outside of research settings may be limited, as many MSTs exhibit high sensitivity but weak specificity, which can lead to overdiagnoses (32). Although the WHO recommends using z-scores, such as weight-for-age, weight-for-height, BMI, and height-for-age in clinical settings, to determine growth characterizations, there is little consensus about definitions and how to determine nutritional cut-off points in the tests (32). These issues can impact how nurses, healthcare workers, and dietitians utilize the information they collect in hospitals, impacting assessments and decision-making when dietitians recommend interventions.

2.6.6 Paediatric Nutritional Screening Score (PNSS)

The Paediatric Nutritional Screening Score (PNSS) was developed specifically for use in the Chinese population. Hulst et al. indicate that while STRONGkids, PYMS, and STAMP were developed in Europe, the selection and interpretation of various MSTs may differ according to racial and ethnic groups, and thus, they may have shortcomings as diagnostic tools in a Chinese clinical environment (33). Hulst et al. considered three new tools developed to screen for malnutrition in a mixed paediatrics setting, PRAT (Pilot Paediatric Risk-Assessment Tool), used to assess aetiology-based risk factors, iNews (Infant Nutrition Early Warning Score), used exclusively for neonates and PNSS (Paediatric Nutritional Screening Score), developed specifically for the Chinese population (33). PNRT (Paediatric Nutritional Screening Tool), an easy-to-administer, a universal weekly screening tool used to assess children admitted into prolonged hospital stays, was also considered. Although this research focuses on screening for malnutrition in acute settings, understanding the risks associated with LOS hospitalization is also necessary, as often acute treatment requires longer hospital stays.

PNSS was developed based on nutritional screening guidelines set forth by the European Society of Clinical Nutrition and Metabolism (ESPEN) and was modified for Chinese clinical practice. PNSS consists of three components, assessments of disease with malnutrition risks, assessments of changes in food intake from week-to-week and an assessment of nutritional status as indicated in anthropometric measures (34). Each component of PNSS receives a score from between zero and two, for a total of six points. PNSS can be used to assess malnutrition risk in cases of illnesses such as diabetes, anaemia or diarrhoea, and in cases where paediatric patients have undergone minor surgery, as both disease and trauma can increase the risk of malnutrition (34). The administering healthcare worker or clinician measures the body composition of children older than three using a bioelectrical impedance analyser, a procedure sustained for at least two hours. The analyser measures fat-free mass, which can then be compared to Chinese-specific value references. Patients are classified as either experiencing undernutrition or no undernutrition (34).

Hulst et al. found PNSS to be a valid and reliable screening tool for early detection of malnutrition risk in Chinese paediatric patients. Undernutrition was correlated with longer hospital stays and higher weight loss (34). The sensitivity of PNSS was 82%, the specificity was 71%, and the negative predictive value was 92%, meaning that PNSS has a similar sensitivity to STRONGkids but higher specificity. PNSS has a higher sensitivity than either STAMP or PYMS and a similar negative predictive value (34). Although the study validates the efficacy of PNSS, the results are not conclusive. The researchers collected data from one health care centre. A broader study, across multiple centres, could cross-validation these findings.

2.6.7 Infant Nutrition Early Warning Score (iNews)

Infants may suffer from unrecognised nutritional issues when they are hospitalised, and yet few tools have been developed to exclusively assess infant nutrition. As with PNSS, iNews was developed based on European Society for Clinical Nutrition and Metabolism (ESPEN) recommendations for nutritional screenings. In research conducted in the UK, Greece, and Iran of 499 hospitalised neonates, Gerasimidis et al. tested the weight, skinfold thickness, and MUAC (35). Four a priori predictors of iNews include considerations of weight, level of practitioner concern, reported decreases of dietary intact, and the assessor’s judgment concerning the admission condition, indicating why the infant was hospitalised (35).

For hospitalised infants, iNews proves to be a reliable and valid nutritional risk tool, as it exhibits a strong ability to identify dietetic input. Gerasimidis et al. found that iNews had a sensitivity of 84%, a specificity of 91%, and a positive predictive value of 49% in the UK cohort. In the Greek cohort, iNews demonstrates 86% sensitivity, 78% specificity, and 53% positive predictive value (35). Gerasimidis et al. show that of the four a priori predictive elements, anthropometric data and history of weight loss/gain were most valuable and that reduced dietary intake was of lesser value when assessing risk (35).

2.6.8 Paediatric Nutritional Rescreening Tool (PNRT)

PNRT was developed by White et al. as a simple, quick, and universal rescreening tool that could be used by nurses and dietitians each week for children experiencing extended LOS, to assess nutritional deterioration during a hospital stay (36). White et al. studied sixty-one paediatric patients, from infants to age sixteen, who were admitted to the hospital for over seven days. After the initial screening, using PNST upon admission, White et al. found that two overarching questions were most valuable to PNRT. The first question considers whether the child has lost weight or experienced insufficient weight gain over the period of seven days. The second question asks whether the child has experienced reduced nutritional intake. The first question, concerning weight loss and insufficient weight gain, was found to have a 71.4% sensitivity and 87.8% specificity. The second question, concerning reduced nutritional intake, reveals a 61.9% sensitivity and 82.2% specificity.

Researchers did not collect data to assess interrater reliability, meaning that the PNRT has not been fully validated yet. However, PNRT has some advantages over other types of assessments because the tool can be administered periodically and the questions are simple, only requiring yes and no responses. Also, PNRT does not require a specialist to ask the questions, and it can be administered quickly, within five minutes, incorporated into routine nursing practices. PNRT is to be used in conjunction with a PNST that is administered upon admission. While PNRT can add value to the treatment and prevention of nutritional deterioration in paediatric patients with longer LOS, it does not enable practitioners to assess nutritional deficiencies in a straightforward way. Still, it is only effective for identifying further nutritional deterioration.

2.7 Administering Screening Tools in Hospital Settings

Important factors that should be considered when assessing which MST is best to use in a given clinical setting are reliability, level of expertise, the efficiency of administration, and level of expertise. The reliability of an MSTs is an important factor because this data is then interpreted by a paediatrician or registered paediatric dietitian, and accurate information can determine health outcomes. Depending on the clinic setting, expertise may vary. While STAMP and PYMS were developed to be administered by certified nurses in a clinical setting, PNRS may require additional, specialized staff, such as a dietitian, who can assess nutritional levels and assess results (37). While STRONGkids was developed for junior physicians or paediatricians to administer, Lestari et al. finds that nurses and clinical staff were able to use it effectively (31). The efficiency of administration, or how fast and easy a given MST is to administer, makes a difference in busy clinics where health practitioners may face many other demands. MSTs differ in terms of how easy and quickly they can be administered. On average, for example, STAMP takes ten to fifteen minutes to conduct while STRONGkids only takes about three to five minutes. Some diagnostic tests require lengthy protocols and detailed assessments and analysis, while a routine PNRT can be quickly incorporated into routine nursing duties.

2.7.1 Administration of MSTs by Healthcare Workers

When paediatric malnutrition is diagnosed in a timely and consistent manner, the earlier intervention can be developed to improve long-term health outcomes (4). By identifying malnutrition at an early stage, paediatricians can work with dietitians to develop nutrition management plans and build nutrition support teams that can help paediatric patients. Once malnutrition screening identifies a child with a high risk of malnutrition, a referral to a dietitian usually results (32). Depending on classifications as either low, medium, or high, patients may be given subsequent screenings and have their nutritional intake monitored (32).

In hospital settings, healthcare workers administer the MSTs, but this duty frequently is fulfilled by nurses due to their level of involvement with patients and patient care. In Australian hospitals, it is noted that the initial screening process involved in admissions provides a good opportunity for this type of malnutrition screening (38). In addition, nurses are increasingly effective in these duties due to their increasing proficiency using the wide variety of MSTs available (38). However, it is noted that a significant barrier to screening revolves around the need for nurses to multi-task and prioritise their duties which can leave little time for MSTs (38). As such, a study by Porter et al. concluded that a culture of collaboration between dietitians and nurses was needed to ensure that healthcare workers had the necessary screening skills and that there is a coordination of effort (38).

2.7.2 Validity of Malnutrition Screening Tools for Identifying Risk

While the individual validity of each MST is discussed in greater detail in the previous section, in review, the STAMP has been validated and is widely used because it is efficient and relies on information that is attained during a patient's admission screening process (30). The STRONGkids has also shown strong intra and inter-rater reliability rates and both the STAMP and STRONGkids are the most accepted MSTs for clinical use (4). STAMP was confirmed against anthropometric measurements as a reference standard in at least five studies while the STRONGkids has been confirmed in at least nine studies (4). The STRONGkids also aligns with the standards established by the Society of Gastroenterology Nurses and Associates (SGNA) SGNA shows the highest sensitivity yet low specificity (4). Conversely, PNST was validated in just one study against anthropometric measurements and SGNA standards and PYMS was validated in three studies using the same standards. SGNA gave PYMS a fair rating in terms of sensitivity and specificity. Compared to STAMP and STRONGkids, PYMS had better validation in terms of body mass index (BMI), sensitivity, and specificity. When STAMP, STRONGkids, PNRS, and PYMS were assessed using the WHO's International Classification of Diseases (ICD-10) reference standards, validation was generally poor or inadequate (4), revealing that no available MST is perfect and more development is necessary.

2.7.3 Screening for Malnutrition in Developing Countries

Health practitioners in developing countries utilize a range of methods to detect malnutrition in children. In addition to looking for signs of oedema and wasting, health practitioners often measure a child's mid-upper arm circumference (MUAC) to detect, diagnose, and treat SAM (39). Bliss et al. conducted a systematic literature review of studies that used the MUAC method to diagnose children 6-59 months of age with severe acute malnutrition (39). This review concluded that community health workers (CHWs), when provided adequate training and supervision, can effectively use MUAC to detect under or overnourished children, and community-level health care can serve to decentralize care for severely malnutrition children, relieving burdens on health care systems (39). Although the MUAC method itself shows promise, the review was limited in scale as the articles focus on a narrow geographic scope.

Using multiple malnutrition screening tools may provide more comprehensive and conclusive results. In a study of children in southern Ethiopia, Tadesse et al. compared two different anthropometric indicators for detecting SAM, including MUAC and a weight-for-height Z-score (WHZ) that measures levels of wasting (40). Anthropometry involves measuring a child's body size and proportions, then comparing the Z-score, or mean value of standard deviation, according to the Child Growth Standards recommended by the

WHO ((40). Children must meet one or more of three standards to be diagnosed with SAM. First, to be considered malnourished, children must have a WHZ score of less than -3. Second, they must show signs of bilateral pitting pedal oedema, a condition where excess fluids concentrate in the limbs, causing swelling. Third, malnourished children should have a MUAC of less than 11.5 cm (12).

Methods may vary depending on the setting and level of available expertise. As discussed, MUAC measures the upper arm circumference of children. This is often used in community and emergency settings rather than exclusively in hospital settings to detect SAM. This is because MUAC is comparatively simple, cost-efficient, and only requires one person to perform the procedure (40)). The MUAC can be administered by people who only have minimal training with the method, and therefore, it has its advantages in some circumstances, especially in areas where access to medical care is limited (40). The WHZ test involves measuring a child's growth and comparing it with the WHO's growth standard curve, which established a cut-off value of <-2 or >+2 Z scores (40). The established cut-off points for WHZ take into account the central 95% of the normal range. Parameters of the MUAC diagnostic range are established using statistical analyses from nutritional surveys (40).

Due to improper administration and assessment, inaccurate results can compromise the validity of diagnostic tests, to varying degrees. A recent study by Maphosa et al. considered the value of various Malnutrition Screening Tools (MST) in predicting early malnutrition signs, looking at data from countries across sub-Saharan Africa (3). Countries in Sub-Saharan Africa routinely use MSTs to detect malnutrition in children under five years old, employing a range of anthropometric assessments. Height-for-age, WHZ, weight-for-age, and MUAC were found to be the most widely inaccurate and inadequate, many of these issues the result of a lack of medical expertise and training, insufficient awareness of nutrition, shortages in equipment and personnel, or limited availability of nutritional information (3). Health outcomes may not be ideal with flawed results and interventions can be compromised by misdiagnosis and inaccurate assessments (3).

In the past, WHO guidelines for treating SAM were meant strictly for inpatient care (40). In recent years, the WHO developed the Community Management of Severe Acute Malnutrition (CMAM), offering advice for health care professionals treating children in both inpatient and outpatient facilities (40). This has helped extend the potential of community-based diagnostics efforts to some degree. The MUAC and WHZ are independent anthropometric indicators commonly used for diagnosing and treating children with SAM, and yet they each has strengths and weaknesses depending largely on how, where, by whom, and to whom they are administered (40). WHZ has become the preferred choice within many primary health care facilities in the developing world, and yet WHZ has less value in the field, in a CHWs setting, because the technical aspects of this diagnostics tool make it less practical for non-medical professionals (40). Because of this, two-stage referral and admission systems are recommended, whereas CHW personnel can help identify children with SAM, utilizing MUAC (40). Community members can then refer potentially malnourished children to a health clinic where a nurse, dietitian, or health practitioner can use WHZ to determine if the child is qualified to join an outpatient therapeutic program meant to improve nutrition levels (40).

MSTs also show inconsistencies when considering anthropometric factors across different groups of children. Tadesse et al., use population-based survey methodology to study a study group of 4,297 children in Ethiopia (40). The authors reported that MUAC classified many more children as wasted than when WHZ was used. Specifically, MUAC detected wasting in 10.5% of participants, while the WHZ detected wasting in only 5.4% (40). The MUAC method also classifies severe wasting more in girls than in boys (40). Compared to the WHZ method, the MUAC also diagnoses more younger children, between the ages of 6-23 months, as severely wasted (40). However, some overlapping results were also evident. In both the WHZ and MUAC, 23.5% of boys, 8.9% of girls, 20.6% of young children, and 14.3% of older children fulfilled the basic criteria for severe wasting (40). The study shows that the two diagnostic tools can be inconsistent when considering factors such as age and gender.

2.7.4 Screening for Malnutrition in Developed Countries

A number of malnutrition screening tools (MSTs) have been developed over the years to measure paediatric malnutrition risk in developed countries, and these were accompanied by guidelines that help practitioners identify and measure child malnutrition (4). Since their development, these tools have been adapted and validated in many different populations and settings (4). For a screening tool to be considered effective and useful in a clinical setting, nurses and other health practitioners need to be able to administer MSTs quickly, safely, and effectively, without the requirement for healthcare workers to have expert-level knowledge of nutrition (23).

Screening tools should be both practical and valid, presenting concurrent results when compared to other tests (34). Results also need to be scientifically replicable (34). Sensitivity, specificity, and reliability are all important attributes of valid screening tools.

Sensitive tools can minimize false negatives and for this reason, sensitivity may be more important than specificity because even if a child gets a false positive, they can be given a detailed nutritional assessment, which is preferred in cases where malnutrition remains undetected (34).

2.8 Conclusions

Malnutrition impacts LOS, mortality, morbidity, and increases infection risks, and yet not all nutrition risks are equal from patient-to-patient and from one clinical environment to another. Nutritional screenings are complicated further by the range of illnesses or non-illness related factors that a paediatric patient may experience (32). For malnutrition not related directly to illnesses, treatment should not be as complicated, but in the case of persistent malnutrition, due to complications, for instance, from extended hospital stays, the lack of clarity about nutritional cut-offs and definitions of malnutrition evident among different MSTs may lead to further complications or negative clinical outcomes (32).

Healthcare workers, clinicians, and nurses play an important role in the process, in terms of both administering MSTs and monitoring paediatric patients in hospitals. More often than not, nurses are the group who are more likely to complete malnutrition screening.

With proper training and strong diagnostics tools, nurses can help identify children experiencing malnutrition or those who may be at risk of malnutrition (32). Professional use of a strong MST enables nurses to quickly determine if a child shows symptoms of nutritional deficiencies. Some of these tools, such as STRONGkids, do not require any anthropometric measurements, relying solely on physical observations of paediatric patients, along with a few questions for caregivers about a child’s medical history and any recent dietary changes (24). Other tools, such as PYMS and STAMP, require height, weight, and age measurements, yet these routine assessments do not usually take long and may be part of routine admission protocols (17, 26). Nurses can use MSTs to document and report data for paediatricians to analyse. If high malnutrition risk is detected, paediatricians can then refer the case to a registered paediatric dietitian (32). Diagnosing malnutrition early on can reduce the risk of adverse short-term health outcomes, potentially limiting LOS, and, early detection can improve long-term outcomes, enabling paediatric patients to avoid delayed cognitive or behavioural functions, morbidity, or, in the worst-case scenario, mortality (8, 50).

2.9 Aim

The thesis aims to conduct a systematic review of the literature to analyse the strengths and limitations of some of the most common MSTs so that nurses will better understand how and why MSTs are used and what issues may arise in the process. This will allow paediatric nurses in acute settings to better understand how to care for high-priority patients, save time for dietitians, and create suggestions on those tools that are better for various backgrounds in the context of patient types.

2.10 Research Objectives

1. To determine whether malnutrition screening tools used in the identified studies are a valid and reliable method for identifying the risk of paediatric malnutrition
2. Identify whether the study evaluates the efficiency of the malnutrition screening tools used by nurses
3. To determine the criteria is used to refer to a dietitian by nurses

Chapter 3: Methods

A systematic review of the literature was conducted to evaluate the use of malnutrition screening tools (MSTs) used by nurses to assess paediatric patients in acute hospital settings. All the articles selected for initial review were published between the years 2010 and 2019. The articles were reviewed using recommended guidelines from the Cochrane Handbook for Systematic Reviews of Intervention, which establishes a detailed methodology for reviewing the literature concerning healthcare interventions (41). The Cochrane method guides reviewers through the process of planning, searching, and selecting studies, collecting, evaluating risks of bias during the assessment, methods of statistical analysis, grading studies, and interpreting results.

3.1. Protocol registration

The protocol for this study was registered with PROSPERO (registration number: CRD42021240080), an international database that registers systematic reviews in the social sciences. This process avoids duplication of studies and registration enables a permanent record to be established for systematic reviews so that future researchers can verify them to ensure that research is distinct and not redundant.

3.2. Database and search strategy

A broad literature search was conducted in September of 2020. Prior to embarking on the search, a comprehensive search strategy was developed with the support of the University of Auckland FMGS librarian via a Zoom meeting, in order to identify which databases were appropriate for conducting such a search. The following databases were utilized for the literature search: MEDLINE, LILACS, PubMed, Scopus, Embase, the Cochrane Library, and CINAHL. **Figure 1** shows a more detailed outline of the Embase search terms and diagrams the search strategy employed. This was then adapted for use with the other databases.

Search terms included words relating to malnutrition screening tools, and terms commonly used in a paediatric and acute inpatient setting. Search results were then limited to “human” studies and to “All Child 0-18”. The reference lists from the identified articles were considered and relevant articles were selected that were not identified in the database search.

1.	Malnutrition OR Undernutrition OR Undernourish* OR Malnourish
2.	Tool* OR Assessment tool* OR Screen* tool* OR Nutrition assessment OR Nutrition screening tool*
3.	Nurse*
4.	Child* OR Paediatric* OR Infant OR Premature OR Baby OR Babies OR Immature OR Newborn* OR New-born* OR New born* OR Neonate OR Kid* OR Adolescent*
5.	Hospital* OR Acute care OR Critical care OR Hospitalised children OR Hospitalised paediatric* OR Hospitalised infant OR Hospitalised baby OR Hospitalised neonatal* OR Hospitalised kid*)
6.	1 and 2 and 3 and 4 and 5 and 6
7.	Limit Search Results to "Human" and "All child 0-18"

Figure 1: Embase Search Strategy for Systematic Review: Search Period 2000 to 2020.

3.3. Inclusion and exclusion criteria

Publications were included if they met the following criteria:

- Assessed malnutrition
- Studies were of children between 0-18 years of age
- Studies must be conducted on children in a hospital or acute care setting
- Malnutrition screening tools must be used by nurses, not patients or other health care professionals e.g. paediatricians or dietitians

Journal articles were excluded from the review if any of the following applied to them:

- Studies involved healthy children
- Participants were outside the identified age range of 0 to 18 years old
- Malnutrition screening was not performed by nurses
- Tools were used that did not assess or screen for malnutrition

The Type of studies included were either observation cohorts or randomised control trials.

3.4. Selection of studies

The initial search of the literature excluded validation studies of malnutrition screening tools. However, this significantly limited the number of eligible studies (n= 2). Therefore, we expanded the search criteria to include validation studies, where results were available for malnutrition screening (n=30). The review includes original articles that have used malnutrition screening tools that were administered by nurses on paediatric patients in acute hospital settings.

Two independent reviewers (YR and AL) conducted a title and abstract analysis. A third reviewer (CW) resolved disagreements or conflicts that arose in the choices. The following steps were carried out by (YR and AL):

1. Identification of the articles in the databases
2. Deletion of the duplicate articles by using the EndNote program
3. Initial selection by title and abstract reading
4. Modification of inclusion criteria to include ‘validated studies’
5. Further searches based on references pages of selected articles and grey literature

3.5. Full-text review and data extraction

Of the articles reviewed, fifteen met the inclusion criteria. However, ten articles did not specify whether nurses in the acute setting conducted malnutrition screening in patients 0-18 years of age. To obtain this information, YR sent emails to all authors requesting further information and clarification regarding the administration of the malnutritional screening tool referred to in the publication. Six authors replied and provided the requested information. Three of these confirmed that nurses were responsible for the malnutrition screening of paediatric patients while the other three stated that the study team (i.e. dietitian or paediatrician) was responsible for screening. One further email was sent to the outstanding four authors that had not acknowledged our original request for further information. However, no response was received.

Eight studies met the inclusion criteria and went forward for full-text review and data extraction. Data were extracted from each study and entered into a summary table (**Table 1**). The table includes details of authors, the date of publication, the country where research was conducted, the study design, the malnutrition screening tool used, sample size, participant age range, and a summary of the outcomes.

The extraction and systematisation of the results were conducted in Microsoft Excel and Word. The results were organised in reference to the specific purposes: (1) to know the malnutritional risk of the paediatric in the acute setting; (2) to know the referral criteria to a registered dietitian; (3) to understand the association of nutritional risk assessed by nurses and workload of dietitians; (4) to focus on the barriers of the tools used by nurses; (5) to examine what criteria is used to refer onto a dietitian.

3.6. Quality of the included studies

To assess the methodological quality of the chosen studies, a modified version of the Quality Assessment of Diagnostic Accuracy Studies (QUADAS) was used (Table 2). QUADAS is recommended by the Cochrane Handbook and is an evidence-based tool designed to assess the quality of diagnostic accuracy studies included in systematic reviews. In this review, the authors used eleven items phrased as questions designed to determine whether bias, variability, and quality of information are present. These questions are applied to each article giving a ‘yes’ or ‘no’ answer in each category. A high-quality study will have a positive evaluation in at least eight out of eleven of these QUADAS items (41).

Chapter 4 Results

4.1. Search Results

Figure 2 shows a flow chart representing the systematic review. Initially, 119 studies were identified after searching four databases (PubMed, Medline, LILACS, and SCIELO). Fifty studies were identified from a manual search of other sources (e.g., reference lists, Google Scholar, and grey literature). Nineteen articles were excluded as they were duplicates. Of the 137 remaining references, 107 were excluded after the title and abstract screening. This left thirty studies for full-text review. A further twenty-two articles were excluded, leaving us with eight studies that went on for data extraction.

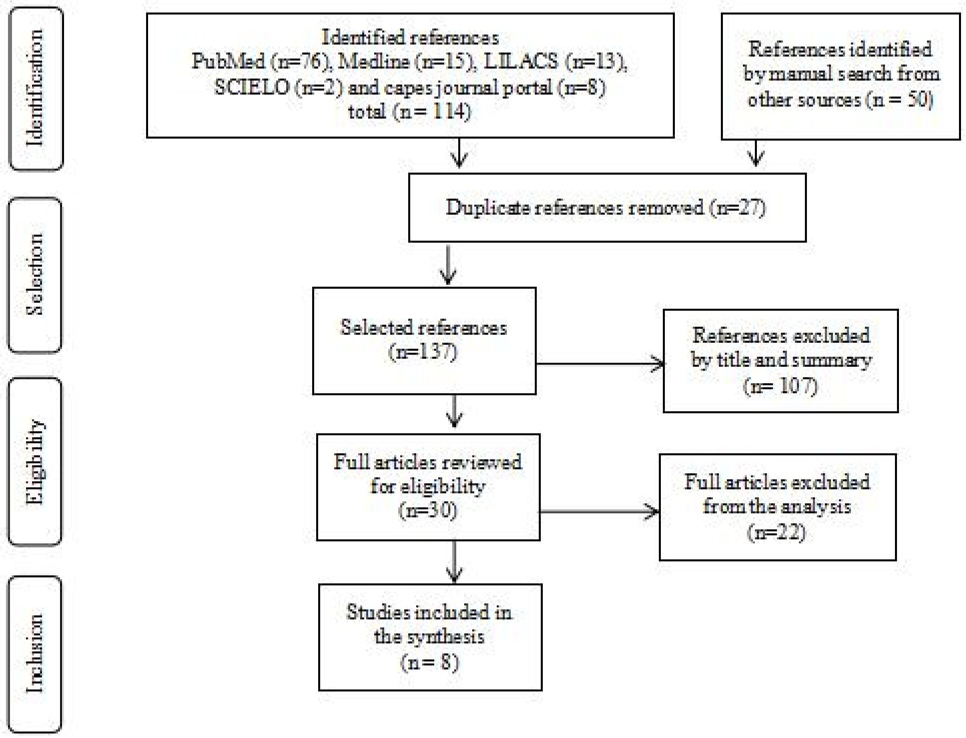

Figure 2. Flowchart of article selection for the systematic review, according to the Cochrane Collaboration model.

4.2. Screening Tools Identified

Five paediatric malnutrition screening tools were identified in the eight included studies that had been validated in clinical settings (42,53,29,50,28,32,46). These were:

- Paediatric Yorkhill Malnutrition Score (PYMS): Collects anthropometric measurements, consists of four elements, including BMI, changes in nutritional intake, history of weight loss, and severity of underlying disease on nutritional status (42). PYMS requires training from nurses and a sufficient level of expertise to perform data calculations (43).

- Screening Tool for the Assessment of Malnutrition in Paediatrics (STAMP): Collects anthropometric measurements immediately upon admission, including data on weight-for-age, reported weight loss, appetite change, weight-for-height, nutritional risk of disease (42). STAMP involves a three-step assessment.
- Screening Tool for Risk on Nutritional Status and Growth (STRONGkids): Does not collect anthropometric measures, as it relies mostly on visual inspection of body habitus when children are admitted into clinical settings (44). It consists of collecting four data sets, including a subjective clinical assessment, high-risk disease assessment, nutritional intake assessment, and weight loss assessment (42). Although designed for paediatricians to complete two parts of the assessment, it has become standard practice for nurses to complete the entire STRONG kids screening process (45).
- Paediatric Nutrition Screening Tool (PNST): Does not collect anthropometric measurements or information about past medical conditions (42). PNST consists of four screening questions to assess for nutrition, including (i.) Has the child unintentionally lost weight lately? (ii.) Has the child had poor weight gain over the last few months? (iii.) Has the child been eating/feeding less in the last few weeks? (iv.) Is the child obviously underweight?
- Subjective Global Nutrition Assessment (SGNA) is not considered a screening tool as much as an assessment tool and is usually applied after a nutritional screening tool has been administered (46). SGNA classifies patients into three groups based on level of malnutrition (Group A for well-nourished children, Group B for moderate or suspected malnutrition, and Group C for severely malnourished). SGNA involves collecting information on patients' medical history, including weight loss, gastrointestinal and functional impairments, dietary intake change, and data from a physical examination, including measurements of muscle wasting, ankle oedema, loss of subcutaneous fat, sacral oedema, and ascites (46).

PYMS, STAMP, and STRONGkids all take into account the effect of disease and current nutritional intake (42). STRONGkids and PNST do not collect anthropometric measurements as do STAMP and PYMS. STRONGkids, PYMS, and PNST consider weight loss, but STAMP does not. PNRS considers pain as an additional component (42).

4.3. Characteristics of the Included Studies

The characteristics of the eight studies that met inclusion criteria in this systematic literature review are presented in Table 1. The country of origin where the studies took place varied. Three studies were conducted in the U.K. (42), one was conducted in New Zealand (47), one in Mexico (44), one in Canada (23), one in Israel (43), and one in Spain (48). The Mexican and New Zealand studies used STRONGKids, although Salvador Ortiz-Gutierrez et al. adapted STRONGkids into the Spanish version from the original tool, translating the language and adapting it for use in a Spanish setting (44). Alterations from the original to the Spanish version included making slight changes to the format of the questionnaire. The Spanish version included a dichotomous answer area, added a section to tally the points, and included a risk classification traffic light section that delineates how much risk is present within each point scale (44).

The sample sizes varied across the studies, ranging from 51 to 1,571 participants. The age of participants ranged from as low as one month in five of the studies (10,50,45,46,32) to six months in one study (48), to one-year-old in two of the studies (42,53). Conversely, one study used participants up to fifteen years old (45), three studies used participants up to sixteen years old (42,51,50), three studies used participants up to seventeen years old (32,29,46) and one study used participants as old as thirty (48).

Most of the studies included in this review share similar clinic settings. While all the research took place in some form of hospital or medical facility, two studies took place in tertiary medical centres (46,45). In one study, 83% of the participants were admitted under the care of medical teams while another 36% were admitted under the care of surgical teams (47). The studies also grouped participants according to low-risk, medium-risk, and high-risk categories. Three of the studies classified LOS as less than twenty-four hours (28,50,32,46) while two studies had a median LOS of three days (45,32), one averaged 2.76 days (47), and one lasted, on average, four days (44). Finally, anthropometric measures were taken in all eight of the included studies (42,51,29,50,28,32,45,46). In tools that do not collect anthropometric measures, like STRONGkids and PNST, anthropometric measures were taken to show the validity of the tools being tested as a reference standard. In one study, anthropometric measurements were collected through SGNA as a reference standard to determine the concurrent validity of both STRONGkids and PNST (45).

Table 1: Main characteristics of studies, frequency of nutrition risk according to categories of Malnutrition screening tools and outcomes of interest in health

Author (year)	Country	Study design	Tool	Sample size	Age	Place of study	LR	MR	HR	Outcomes
Gerasimidis et al. (2010)	UK	Validation study to compare nutritional outcomes to other tools	PYMS	2174 patients admitted, 1571 successfully screened (72.3%)	1-16 years old	Two hospitals RHSC: Four paediatric wards (Three medical, one surgical) DGH: General paediatric ward	220 LR		27	Over the 4-months pilot phase The study aimed to test how PYMS would perform in clinical practice when used by non-specialist nurses. PYMS identified half those children diagnosed by a full assessment at high risk, an acceptable result given the limitation of the tool and the fact that the children would not have been identified otherwise.
Gerasimidis et al. (2011)	UK	Validation of feasibility and implementation of PYMS in clinical practice	PYMS	1571 patients	1-16 years	Two hospitals and five pilot wards TPH: 3 medical wards and 1 surgical wards DGH: General paediatric ward	1266	147	158	The study was meant to test the feasibility of administering PYMS in a clinical setting over a period, measuring rate of implementation, but also compared PYMS data with deeper nutritional analysis. Those deemed at high risk of malnutrition were referred to dieticians, a higher proportion in TPHs compared to DGH. Dieticians felt PYMS overestimated risk. The PYMS had high completion rates, indicating its feasibility in clinical setting, but greater application was evident for older children compared to infants. Rates decreased as time went

										on, indicating that implementation necessitates managerial support and supervision.
Wong et al. (2013)	UK	Validation of STAMP in paediatric spinal cord injured patients in tertiary SCI centre	STAMP	51	1-18 years old	Tertiary SCI centre	18 MR		12	Study compares STAMP to other screening tools to validate test. STAMP shows moderate agreement with dietetic assessments (83.3% sensitivity; 66.7% specificity). Shows comparable results compared to PNSTs.
Moeeni et al. [] (2014)	NZ	Validation of feasibility of STRONGkids	The STRONGkids	162	1 month-17 years odl	General medical and surgical hospital, secondary level paediatric care department, tertiary care facilities Surgical (17%) and medical (83%) paediatric wards	54	91	17	STRONGkids was capable of identifying majority of hospitalised patients at risk (86%) both with nurses or a paediatrician, proving its reliability. The study estimates that 10% of total children admitted are undernourished.
Ortíz-Gutiérrez, et al. (2018)	Mexico	Validation of STRONGkids screening tool among paediatric patients	The STRONGkids	400	1 month-16 years old Median age: 5.5 years	Surgical and medical facilities and paediatric wards	200 LR	100 MR	100 HR	Using standard references to evaluate malnutrition risk, the authors observed substantial agreement, and that STRONGkids shows a high level of consistency even when used by different staff members, and good reproducibility. STRONGkids was found to be more sensitive than specific, and is a good screening tool.

Carter et al. (2019)	Canada	Validation and comparative study of multiple screening tools	The STRONGkids	154	1 month to 17 years; Median age: 5.7 years	General hospital with surgery and medicine units	44	87	25	STRONGkids had a poor specificity, suggesting a high level of false positive, compared to SGNA, a validated test, used as a standard of comparison. PNST had poor sensitivity, identifying 58% of those at risk. PNST performed better in specialty medical population, those with underlying conditions. Neither tool missed a severely malnourished child.
			PNST				89	42	25	
			SGNA				109	38	7	
Marderfeld et al. (2019)	Israel	Validation of STAM in hospitalised paediatric patients	STAMP	60	1 month to 17 years; Mean (SD) age = 7.8±4.7 years	A tertiary medical centre specializing in Internal medicine with surgical medicine wards	12	21	27	STAMP performed well compared to full nutritional assessment by registered dietician, and is recommended as a screening tool. The tool did not increase knowledge of nutrition among staff.
Moreno et al. (2019)	Spain	Prospective	STAMP	200	1 month-15 years Median age = 15.8 months	Tertiary care hospital with a general paediatrics ward	7	96	96	The study found that nearly 48% of total children were of high risk of malnutrition, and patients had longer LOS. Children with underlying disease at higher risk.

Total 8

4.4. Bias, Variability, and Quality of Information

Table 2 shows a QUADAS chart, indicating the results of the methodological quality evaluation of each study included in this systematic review. The QUADAS is a commonly used tool for assessing the quality of diagnostic accuracy of research studies in systematic reviews and is recommended by the Cochrane Handbook. Every study had an option of marking yes, no, or unclear to each of the eleven items. To be considered a high-quality study, a study must score at least eight out of the eleven items, to assess bias, variability, and quality of information.

Based on these criteria, all eight studies could be classified as high-quality. In particular, the studies by Moeeni et al. (47), Ortiz-Gutierrez et al. (44), and Carter et al. (23) met all eleven criteria, including representative spectrum, which serves to assess whether the spectrum of patients was representative of the patients who will receive the test in practice, had an acceptable delay between tests, considered whether the time between the reference standard and index test is short enough, ensured that the target condition is consistent between two tests (33) and those acceptable reference standards were met. Most of the studies used anthropometric measures as a reference standard while one study used SGNA as a reference standard (45), but SGNA is based on anthropometric data. Anthropometric data, as well as growth charts, are considered traditional forms of measurement to screen for chronic undernutrition (48). For example, the WHO's anthropometric growth chart is a common reference standard (4). However, taken alone, these tools do not account for malnutrition and they are time-consuming for nurses, which is why nutritional screening tools in the form of quick administering questionnaires were adopted. It is also why SGNA was developed. Rather than being a quick screening tool that takes between five to ten minutes to complete, SGNA is a comprehensive nutritional assessment developed by Secker and Jeejeebhoy (48). But SGNA is technically an assessment method rather than a reference standard (4).

Three of the eight studies did not meet the criteria that consider whether reference standards were independent of index tests (42,50,45). In other words, in these three studies, the index test was not formed as part of the reference standard. It was not clearly ascertained if two of the studies met the criteria for relevant clinical information, as this data could not be located upon review of the articles (42,28). In one research study, it was difficult to determine the reported non-interpretable results as the information could not be explicitly found (43).

Table 2. Results of the methodological quality evaluation of each study included in the systematic review, according to the QUADAS.
√, Yes; ×, NO;?, Unclear.

	Representative spectrum	Acceptable reference standard	Acceptable delay between tests	Partial verification avoided	Differential verification avoided	Incorporation avoided	Independent index test results	Independent reference standard results	Relevant clinical information	Non-interpretable results reported	Explained withdrawals
Gerasimidis et al. (2010)	√	√	√	√	√	√	√	√	√	√	√
Gerasimidis et al. (2011)	√	√	√	√	√	√	√	√	√	√	√
Wong et al. (2013)	√	√	√	√	√	√	√	√	√	√	√
Moeeni et al. (2014)	√	√	√	√	√	√	√	√	√	√	√
Ortiz-Gutierrez, et al. (2018)	√	√	√	√	√	√	√	√	√	√	√
Carter et al. (2019)	√	√	√	√	√	√	√	√	√	√	√
Marderfeld et al. (2019)	√	√	√	√	√	√	√	√	√	?	√
Moreno et al. (2019)	√	√	√	√	√	√	√	×	√	√	√

4.5. Summary of Findings

A systematic review of studies identified 150 potential articles that met the initial inclusion criteria. Subsequent exclusion narrowed the articles to forty for full-text review. Of these forty studies, eight studies were identified and used for data extraction. Five paediatric malnutrition screening tools were identified in these studies that were validated in clinical settings (42,49,29,44,28,32,45,46). The screening tools were: Paediatric Yorkhill Malnutrition Score (PYMS), Screening Tool for the Assessment of Malnutrition in Paediatrics (STAMP), Screening Tool for Risk on Nutritional Status and Growth (STRONGkids), Paediatric Nutrition Screening Tool (PNST), and the Subjective Global Nutrition Assessment (SGNA). While the country of origin and the sample sizes varied across the eight studies, most shared similar clinic settings (hospitals or medical facilities), with only two studies taking place in tertiary medical centres (46, 45). It is important to note that three of the eight studies did not meet the criteria to identify whether reference standards were independent of index tests (42, 45). However, three studies met all eleven criteria (10, 45, 44). Overall, using the QUADAS tool, all eight studies were classified as high-quality and allowed the characteristics of each malnutrition screening tool to be analysed.

Chapter 5: Discussion

This thesis set out to look at malnutrition screening tools used in paediatric populations and better understand the extent to which malnutrition screening tools can be used to greater effect among paediatric nurses. Understanding some of the complications of existing universal assessments can inform a better perspective on the extent to which these standards need to be changed to be more inclusive and effective overall.

The main findings from the systematic review were MSTs are critical instruments for gathering observational and anthropometric data on patients, and yet a number of factors may complicate these assessments, and little agreement has been established about which nutritional assessment tool is the most practical, efficacious, or accurate (4). Finding a gold standard MST may neither be practical, or possible, as Klanjsek et al. conclude that validation results indicate that nutritional screening tools perform best when designed for specialized groups of patients experiencing specific conditions (4). There is a lack of general consensus about which MST is best for general clinical applications and validations of these tests are based on different reference standards, such as SGNA, anthropometry, WHO's child growth standards, and others. The MSTs outlined in this research vary and each have strengths and weaknesses. Given the challenges involved in choosing an appropriate MST, it is important that health care facilities account for capabilities and needs, and, if multiple MSTs are necessary and hospitals have the budget, personnel, and facilities. Health care administrators may find value in using complementary screening and assessment tools to account for the varying circumstances and the needs of paediatric patients in institutional settings. Some MSTs require anthropometric measurements upon admission, such as PYMS, STAMP, while others rely more on physical observations of patients, or questions, such as STRONGkids and PNST, and are more subjective and dependent on the competency level of health care practitioners. Other assessments, such as SGNA, are meant to complement initial MSTs. Decisions about what tool to use may depend on complex factors and constraints within each health care centre.

5.1. Summary of Findings from the Systematic Literature Review

The findings from the systematic literature review show that five paediatric malnutrition screening tools were commonly used in acute care hospital settings by nurses. All of these tools (STAMP, PYMS, STRONGkids, SGNA, and PNST) have strengths and limitations that were highlighted by the review. The Paediatric Yorkhill Malnutrition Score (PYMS) and the Screening Tool for the Assessment of Malnutrition in Paediatrics (STAMP) measure and consider anthropometric measures, and strengths and weaknesses are evident in both of these MSTs, although this largely depends on the clinical situation and the needs of the paediatric patients. Both PYMS and STAMP are recognised for giving more complete assessments compared to other assessment tools such as STRONGkids and PNST (52). Comparing PYMS and STAMP, PYMS performs at higher levels in terms of both specificity and sensitivity, when compared to anthropometric measurement, most notably BMI and TSFT (triceps skinfold thickness) (4, 55). Both Klanjsek et al. (4) and Katsagoni et al. (52) recommend using PYMS in clinical settings for paediatric patients without chronic conditions. However, because of its high sensitivity, PYMS has a tendency to overpredict positive cases. Thus, it is widely recommended that a more comprehensive dietary and nutritional assessment is administered once a patient is identified as being malnourished (4). Overall, PYMS exhibits the superior capability to STAMP in terms of its versatility, as PYMS performed well in paediatric and surgical care settings, adding value if a health care facility wishes to invest in only one MST. However, Moreno et al. contend that STAMP is a better measure of severity and is a stronger indicator of LOS (45).

Some researchers have challenged the viability of MST tools such as PYMS and STAMP, arguing that the use of screening tools alone is insufficient to address nutritional issues that arise from increased hospital stays or complications from illnesses and that current tools are inadequate to improve outcomes (32). Furthermore, neither PYMS nor STAMP are suitable for assessing nutritional risks stemming from overnutrition and obesity and are only marginally better for determining undernourishment in patients, according to Thomas et al. (53).

Compared to MSTs that rely on anthropometric measurements, assessment tools such as STRONGkids and PNST are more subjective and arguably less accurate, but these types of MSTs also have value. Carter et al. found STRONGkids only had a 35% specificity rate, and PNST shows a low sensitivity rate, at 58% (23). Neither tool is particularly accurate when using standard nutritional cut-off rates. While STRONGkids was developed to be administered by junior physicians and paediatricians, it has become widely used in clinical practice because it has proven to be reliable when nursing staff administers the assessment and is not solely dependent on specialized expertise. Both STRONGkids and PNST can assess the risk of malnutrition in patients in approximately five minutes, whereas STAMP, because of its anthropometric measurements, takes closer to fifteen minutes on average to administer. PNST is meant to work in conjunction with a more in-depth assessment once risk is identified. PNST detects the risk of malnutrition upon admission to the hospital and SGNA provides a more detailed nutritional analysis (55). SGNA is more sensitive and accurate, and yet PNST has been shown to have a sensitivity of 72.06% and a specificity of 75.00% compared with SGNA the reference method.

Both STRONGKids and PNST have some advantages in clinical settings, as they are both quick and simple assessments that do not require tremendous levels of specialization, and yet PNST does not consider the influences of underlying disease or illnesses as much as STRONGkids (56). STRONGkids has been investigated more thoroughly than PNST and shown to have a better correlation with anthropometric measures and is thought to generally perform the best of the two (23).

Overall, the results of the review indicate the most commonly used MSTs and highlight how and why they are effective. The initial literature review indicated that these five paediatric MSTs were common, but also made reference to other less common MSTs such as PNSS, iNews, PNRT, and PNRS. In this way, the present study corroborates with previous findings that indicate the most frequently used MSTs in paediatric patients are PNST, STAMP, PYMS, and STRONGkids. In addition, the present study also refines existing findings by collecting data related to these MSTs in a way that allows their various strengths and limitations to be analysed and compared.

Additionally, the findings from the systematic review also corroborate with the literature review's conclusions that STRONGkids is a MST widely used in clinical settings, but the systematic review has also further revealed that this tool is generally thought to also perform well even though it is more subjective than some of the other MSTs. A contradiction occurs between the literature review and the systematic review on the comparison between STAMP and PYMS. The former indicated that STAMP is widely used and is efficient. The systematic review, however, indicated that PYMS was more versatile and sensitive than STAMP. Overall, even the discrepancies between these studies highlight the challenges that stem from attempting to meet the needs of a varied paediatric population with MSTs.

While it is clear that MSTs have value in acute care facilities, no general agreement has been determined about what methods and standards are best, which tool is most universally appropriate, or even if it is necessary to find a gold standard that can be applied to all health care facilities. Further research needs to pursue confounding issues of how to assess chronically ill patients, how to detect and address nutritional imbalances in obese children, and how to overcome endemic shortcomings of budget, time, and skill-level in hospitals around the world, as tests that are less objective require clearer judgement and those MSTs relying on biometric and anthropometric data require stronger scientific analysis. Simple, cheap, and easy tools may not provide accurate results and these tools should not replace stronger nutritional assessments. Furthermore, without reliable and detailed nutritional data upon admission, paediatricians, dietitians and nurses may fail to adequately monitor and treat paediatric patients suffering from malnourishment while in hospital care.

Assessing the risks of malnutrition in paediatric patients in a clinical setting is essential, given that the illness or trauma that precipitates hospital admission can be associated with or influenced by the malnutrition, and also because hospitalization often leads to declines in nutrition levels. Hospitalised children are at risk of malnutrition even if they were well-nourished upon arrival, and therefore, it is critical that health care facilities screen paediatric patients to detect for risk and continue to monitor nutrition levels if patients are hospitalised (58). Malnutrition has a significant impact on both prognosis and LOS, and on health care costs, which can cause issues not only for hospitals but families, as it increases financial burdens (58). Strictly in terms of paediatric health, however, hospitalised children often suffer from weight loss, underscoring the importance of preventing malnutrition. The process starts immediately upon admission, and MSTs are considered an expedient method to assess incoming patients that do not overburden the medical staff. However, as discussed, while many MSTs exist, arguably none are ideal for every situation and condition (32).

Hospitals and health care clinics around the world have distinct constraints, capacities, and abilities to administer MSTs. Particularly in rural hospitals in the developing world, or in medium-sized urban centres, expertise, equipment and resources may not be available to properly and comprehensively assess incoming paediatric patients, despite the fact that in many cases, children in the developing world may generally be at greater risk than children in the developed world, as malnutrition is considered a double burden in developing countries (59). Undernutrition can impact individuals, families, and the well-being of low-income and middle-income countries, in terms of health and economics. At the same time, health care centres in the developing world may lack qualified and skilled paediatricians and dietitians, and even nurses may not be as qualified as those in developed countries where rigorous training programs are a prerequisite for employment. Therefore, countries, where children are of the greatest risk of malnutrition may have underfunded or understaffed health care facilities, necessitating a simple, cost-effective, and easy-to-use MST that does not require specialized expertise.

In some situations, simple, cheap, and easy-to-use MST may be more practical even if they are less sensitive, specific, or reliable. In the absence of a capable MST that fulfils all three of these criteria, health care practitioners should evaluate which of these tools is best for the unique situation. The most practical and least skill-intensive MSTs, such as STRONGkids and PNST, lacking in anthropometric measures, may not be as accurate or detailed in terms of providing information to dietitians and paediatricians. PYMS, STAMP, and SGNA rely on greater levels of expertise, and while this is not to suggest that paediatricians and dietitians in the developing world are less skilled than those in the developed world, overall, hospitals in the developing world may not have as many qualified and skilled personnel on hand that can conduct the data-based anthroponomy. Skilled paediatricians and dietitians may experience greater demand on time and resources and hospitals may need to delegate to MST diagnosis process to less specialized nurses and medical staff.

While the developing world has a great need for a standardised nutritional assessment that can identify at-risk patients, most often nutritional assessments that are done are inadequate, and it would require extensive training and stronger nutritional programs to implement many of the MSTs discussed in this review, some of which require equipment and specialized expertise. In some cases, in local hospitals, such as in the Bagamoyo District Hospital in Tanzania, health and well-being depend to a degree on community-based interventions (11). Health education may not be prioritised in some regions, which is also a problem in the developed world, but health care facilities in developing countries often fail to consistently gather basic anthropometric data from incoming patients. The lack of anthropometric data presents a problem in places like Pakistan, a country that suffers from some of the highest child malnutrition rates in the world (60). While hospitals will commonly employ a rapid nutritional assessment approach, such as measuring MUAC or skinfold thickness, or may even administer a haemoglobin test, these quick and easy indicators are better to assess risk in emergency situations and are less comprehensive as tools to diagnose malnutrition and suggest nutritional interventions (60). Most health care systems in the developing world are comprised of independent hospitals and clinics, and some, as in the case of Pakistan, do not keep consistent, accurate records of patients, particularly in rural, poverty-stricken, and underserved areas. Any MST that is implemented in areas with underserviced health care systems would also need to train health care workers to administer them; Otherwise, the nutritional assessment tools will be less effective.

Although MSTs may be available and implemented into routine health care protocols, questions arise about how these nutritional screening tools are used or should be used, especially in acute settings, and concerns have also arisen about how effective these tools are in improving nutritional knowledge about patients among the medical staff (46, 53). Most of the current tools assess risks that arise from the current illness yet neglect chronic risks. The MSTs discussed in this review are also better at detecting undernourished patients than the overweight/obese. While tools are geared for short-term assessments, monitoring, and interventions, during the hospital stay, the tools do little in terms of improving longer-term health and nutrition outcomes (53). Simply because an established MST is utilized in the hospital does not necessarily mean that it is used correctly or that the information translates to correct interventions. Marderfeld et al. found that malnutrition awareness did not significantly change for medical staff before and after STAMP interventions, indicating that MSTs may inadequately inform medical personnel, or that the tools become so ubiquitous within standard hospital routines, practice, and procedures that results are not taken seriously or examined in sufficient depth or detail (46).

The prevalence of obesity in developed countries is a growing problem, although not exclusive to the industrialized world, and yet the most common and widely utilized MSTs are calibrated to detect levels of undernutrition and are less capable of assessing nutritional imbalances and deficiencies in overweight/ obese paediatric patients (32). Nutritional risk scores do not currently account for malnutrition stemming from obesity, although in some clinical settings, overweight patients account for up to 37.3% of the total inpatient population, and 17.3% are considered obese (32). Practitioners need to be aware that overweight and obese children are at risk of micronutrient and vitamin deficiencies from improper diet and imbalanced nutritional intake. Overweight and obese children are more likely to have chronic conditions like asthma or diabetes and thus are at increased risk of hospitalisation (61). Once admitted, overweight or obese children commonly need more therapy and experience longer LOS in hospitals (61). Despite these comorbidities, increased risks, and medical complications due to hospitalizations, the MSTs commonly used for nutritional screenings are formation inadequate to assess these children properly (61).

While developed countries may have modernized health care facilities, better training programs, diverse resources, and a greater level of expertise, many paediatric health complications challenge the efficacy of the most used MSTs. For instance, illnesses like cholestasis, reduced bile, and flow, leads to deficient concentrations of bile acids in the intestines, and biliary substances get retained in the blood and liver. Cholestasis is a condition more commonly found in neonates and infants, but if left untreated, it can lead to cholestatic liver diseases (CCLD). One of the most common complications of CCLD is malnutrition, significantly increased risks of morbidity and mortality in paediatric patients. However, it is difficult to detect the proportion of malnutrition this condition causes. It is recommended that children being treated for CCLD have a clinical nutritional evaluation and intervention, and these assessments necessitate a more thorough examination than inpatient MSTs afford.

Despite the limitations of the most accepted MSTs such as PYMS, STAMP, STRONGkids, PNST, and SGNA, and given that none are acknowledged as a gold standard that can be applied universally across clinical settings, they have become invaluable to paediatric health care providers, both in the developed and developing world. At a minimum, the tools provide some functional way to identify at-risk patients and can be utilized on a schedule, to measure common indicators of malnutrition and to monitor inpatients while they are hospitalised. Paediatric patients diagnosed as at-risk can then be referred to dietitians and paediatricians who can further investigate deficiencies and nutritional imbalances, developing interventions that can lead to improved health outcomes. While the MSTs themselves are only meant to screen at-risk paediatric patients, using practical indicators, many of which a non-specialized nurse can administer, it is commonly accepted that MSTs are an important feature of any competent paediatric acute care facility.

Growing awareness is emerging today about the consequences of neglecting malnutrition assessments in paediatric patients in acute settings, and the general inadequacies in the way that hospitals diagnose hospitalised patients (62). McCauley et al. point out startling deficiencies evident in addressing malnutrition (62). Estimates indicate that between twenty to fifty percent of all hospitalised patients are at risk of malnutrition worldwide. Even in the United States, with its modern health care facilities, trained medical professionals, and diverse tools and resources, as few as five to eight percent of all inpatients receive a documented diagnosis of malnutrition during hospital stays. For chronically ill paediatric patients, the numbers are worse, as the diagnostic rate is estimated at only around three percent (22). Such low diagnostic rates among hospitalised patients indicates severe shortcomings in hospital protocols, widespread underdiagnosis, and general neglect of the importance of malnutrition in clinical settings (62).

The consequences of malnutrition are known to be severe, as hospitalised patients are more prone to become malnourished in hospitals and this can lead to increased risk of infections, diminished wound healing capabilities, stressed organs, complications from comorbidities, exacerbated health conditions, longer LOSs, and increased occurrences of hospital readmissions.

For children with chronic disease, malnutrition is of particular concern, given that they may have increased caloric needs, altered nutrient utilization capabilities, limited existing nutrients because of fluid status or variable feeding tolerance, and they may suffer from malabsorption. Diagnosis can also be complicated by chronic disease because of altered fluid status and other factors impacting anthropometric measures (63). Chronic diseases such as cystic fibrosis, liver, kidney, or congenital heart disease can disrupt nutritional status and make children more prone to malnutrition. Larson-Nath et al. argue that nutritional status for paediatric chronic disease is difficult to assess because it is complex, rendering standard anthropometric assessments inadequate to accurately diagnose malnutrition (63).

Although an array of malnutritional assessment tools are available, the most widely used are those mentioned in this review, others are in various stages of development and phases of validation, and yet, for one reason or another, hospitals routinely fail to properly diagnose paediatric patients who are at risk of malnutrition, although the health and financial consequences are fairly clear in the literature (64). Questions concerning persistent inadequacies and failures in administering MSTs in clinical care facilities might indicate that modern hospitals fail to prioritise nutrition, or that the lack of consensus regarding what MST to use contributes to the problem. Administrative neglect or budgetary concerns may be to blame for these inadequacies, but these are questions for future research. Perhaps a combination of factors leads to poor diagnostic rates in the acute clinical settings. More work must be done on systemic, technological, and programmatic levels to improve outcomes.

In the absence of a strong MST, it is difficult for dietitians and paediatric specialists to address the heterogenous needs of paediatric patients. While MSTs are imperfect instruments and often lead to practitioners overlooking more subtle and differentiated nutritional needs, such malnutrition assessments are helpful as preventive measures, often identifying children at risk of nutritional deficiencies. MSTs can be important instruments in paediatric acute care settings where hospitalised children are admitted for various ailments and come from different social and environmental contexts. Initial screenings, complemented by ongoing nutritional monitoring and interventions, may help prevent compliments that arise from malnutrition during hospital stays. Of those reviewed, PYMS appears to be superior for those MSTs that require anthropometric measures, although the development of the automated EHR-STAMP assessment may ultimately be of more practical use in modern health care systems that are becoming digitally interconnected. PNST, used in conjunction with the SGNA assessment, may be superior to STRONGkids in terms of ultimately providing stronger nutritional results, but both the non-anthropometric-based tests remain subjective at the diagnostic levels.

Administrating reliable and validated MST, and getting accurate assessments, can greatly improve the work of dietitians. After health professionals administe an MST, and gather strong data, these results can be referred to paediatricians or registered dietitians, who can develop proper interventions to improve nutrition levels and health. Interventions may include creating individualized nutrition plans that can be administered in hospitals or recommended to caregivers. Every paediatric patient will have unique conditions and personal histories, thus, accurate results from MSTs can support dietitians as they consider supplements, formula fortifications, feeding tubes, or dietary recommendations. In the absence of reliable and accurate results, it can be difficult for paediatricians or dietitians to give referrals and it may also be hard for nurses to monitor the health outcomes of patients during hospital stays.

5.2. Strengths and limitations of this review

5.2.1 Limitations:

While interpreting this study’s findings, it is important to also note the limitations that may exist.

One of the main limitations is the other factors that might contribute to the issues of malnutrition that are cultural, economic, or environmental in nature and exist beyond the scope of assessment. Much of the literature is focused on the strengths of the various assessments in the context of the facilities in which they are administered. This is a limitation because even beyond the facility-related considerations of the assessments, it is important to consider some of the other circumstances that may contribute to the challenges of choosing one assessment over another. Another limitation of the literature is that there is little mention of the extent to which western facilities have begun addressing this issue. Inclusion of this information in the literature could denote solutions that might inform options in developing areas of the world. Overall, while the issue being analysed is specific to a certain subset of assessments, understanding some of the larger environmental narratives surrounding the issue could help inform more targeted solutions regarding this issue. One of the other main limitations is that the available resources are limited. Only eight eligible studies were included. Furthermore, the background and study design also vary among the studies making it harder to compare, and therefore the accuracy of the result can be affected.

5.2.2 Strengths

This study also has strengths in its use of the Cochrane method to conduct a rigorous systematic review of the literature to evaluate the use of MSTs used to assess paediatric patients in acute hospital settings. Another strength of this study is the consideration given to each assessment, breaking down the nuances of each to provide an informed perspective on why existing approaches are not necessarily working. The study is comprehensive in its understanding of the shortcomings of the healthcare facilities discussed throughout, owing to the fact that many of the failures surrounding these assessments have to do with failures at the institutional level. Finally, the literature analysed for the purposes of this study represents a comprehensive take on issues of malnutrition and thus provides a rich amalgamation of information from which to mine analysis for conclusions and potential solutions.

5.3. Future implications and recommendations

Future studies in MSTs for use in paediatric patients could further investigate the screening complications that arise from obesity and chronic illness in order to find best practices or tools more suited to children with these conditions.

As uncovered by the research, budget shortcomings can also impact effective malnutrition screening. Additional research is needed to understand the correlations between budget and effective screening.

This study found that certain MSTs can mitigate malnutrition risks, but it has also been noted that stronger organisational commitment must also accompany the use of these tools. Further research may reveal an organisational approach that can be used to ensure that nutrition is prioritised in acute care settings.

Chapter 6: Conclusion

The objective of this study has been to assess and review the most common MSTs used in the identified studies to determine whether these tools are a reliable method for identifying the risk of paediatric malnutrition. In addition, this study aimed to determine the criteria used to refer onto a dietitian by the nurse and whether the identified studies evaluate the efficiency of the MSTs used by nurses. Although a range of MST have been developed since the mid-1990s, and MSTs have become more commonly used in health care centres and hospitals in the developed world, this research indicates that they are less frequently used in the developing world, where, arguably, they may be of great value in terms of helping to rectify public health problems associated with malnutrition.

This review considered a wider range of MSTs, some of which have not been fully validated or remain exclusive to specific countries and are not more widely utilized. Of the five selected for a more comprehensive review, some rely on anthropometric data and others on subjective physical observation and questionnaires. The argument has been that ideally, a more thorough nutritional analysis, using biometric data to assess nutritional levels, is preferred, and yet constraints exist in clinical practice. Many of these constraints were addressed, such as lack of qualified medical staff and specialized knowledge, costs, demands of time, and general neglect of nutrition in clinical practices around the world. MST is neither fool-proof nor substantial alone, and concern has arisen in the medical community that these quick and easy tests have become a substitute for more comprehensive nutritional assessments. However, given the demands on health care centres, MSTs have proven to be valuable as a way to identify children who may be at greater risk of malnutrition when they are admitted to hospitals, and thus, should be considered valuable even though they may not ultimately be perfect. Stronger MSTs may help to mitigate risks associated with malnutrition but these tools must also accompany stronger organisational commitment and greater prioritisation of the value of nutrition in acute care settings.

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