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Review

An analytic appraisal of nutrition screening tools supported by original data with particular reference to age

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ABSTRACT

Objective: Controversies exist as to the suitability of various nutrition screening tools for various age groups, the incorporation of age and age-related criteria into some tools, and the procedures associated with tool selection.

Methods: Reviews of the literature and national and local datasets were used to identify the types of screening tools available for different age groups, the origins of age-related criteria, and the value of tool selection procedures based on predicting clinical outcomes.

Results: Nutrition screening can be undertaken in fetuses, children, and adults over narrow or wide age ranges, for diagnostic or prognostic purposes, with or without nutritional interventions. Certain tools can establish malnutrition risk without using any nutritional criteria, whereas others can do so only with nutritional criteria. The incorporation of age and age-specific body mass index criteria into adult screening tools can influence the prevalence and age distribution of malnutrition, but no justification is usually provided for their use. In several circumstances, age alone can predict mortality and length of hospital stay much better than screening tools. We identified various methodologic problems in nutrition screening tool selection.

Conclusions: A comparison of nutrition screening tools designed for different age groups and different purposes can be problematic. Age and screening tools incorporating risk factors that are non-modifiable or generally weakly modifiable by nutritional support (e.g., age, disease severity) may predict outcomes of disease, but they are not necessarily suitable for predicting outcomes of nutritional support. To contextualize the findings, a framework for screening tool selection is suggested that takes into account a matrix of needs.

Introduction

Screening in general can fulfill at least two roles. First, it may be helpful in identifying or predicting the risk of developing a condition and the features associated with it, such as complications, including death, resource use, and cost. Even if little can be done to prevent or treat the condition or its complications, such information may allow affected individuals and their families to put their affairs in order and to plan their futures. The information may also help health care providers or planners to allocate resources to manage the condition and insurers to design life insurance policies. Second, screening may identify individuals who are and are not likely to benefit from treatment, an issue of obvious clinical importance.

Nutrition screening tools are diverse instruments designed for use by various health care workers or members of the public (self-screening) in one or more care settings, one or more disease categories, and one or more age groups. They have also been designed to address distinct aspects of the two roles outlined earlier. Many nutrition screening tools were originally developed as diagnostic instruments (tools) for the purpose of detecting malnutrition, whereas others were developed as prognostic instruments for the purpose of predicting clinical outcomes or health care use [1]. For example, the Mini Nutritional Assessment (MNA) [2] was developed as a diagnostic instrument to establish nutritional status in the form of malnutrition rather than obesity in older (≥65 y) rather than younger people and in various care settings rather than in a single setting. Another tool, the Malnutrition Universal Screening Tool (MUST) [3], was developed to establish the need for nutritional support after establishing nutritional status, including obesity, in adults of all ages in all care settings. The Subjective Global Assessment (SGA) [4]

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was developed as a prognostic instrument (to predict clinical outcomes such as complications of disease) rather than as a diagnostic instrument, using data from observational rather than interventional studies. Similarly, the Prognostic Nutritional Index of Buzby et al. [5,6] and the Geriatric Nutritional Risk Index [7], which incorporate blood results (circulating albumin concentration), were also originally designed as prognostic instruments using data from observational studies. Comprehensive reviews on nutrition screening [8–11] include instruments that incorporate blood tests. However, many workers have pointed out the limitations of such instruments, especially in settings where blood tests are not routinely undertaken and where there is substantial delay before analysis and reporting. Conversely, this may not be a problem in clinical settings, where routine blood tests are undertaken and quickly reported on an electronic system together with other results of nutrition screening.

The tool by Wolinsky et al. [12] was primarily developed to predict health care use in older people living in the community. In contrast, the Nutritional Risk Screening–2002 (NRS-2002) [12] was developed with the aim of predicting outcomes of interventions in hospitalized patients, an important issue that is discussed later.

Given the diverse nature of nutrition screening tools, it is not surprising that they incorporate different criteria and/or apply different weightings to the same criteria. For example, the SGA, which has been described as a tool that measures "sickness" as much as nutritional status, incorporates disease stress factors and clinical manifestations of disease, e.g., ascites [13,14], which are not included in other screening tools. Certain tools can establish a malnutrition risk category without any contribution from nutritional indices, such as measurements of thinness, weight loss, and/or dietary intake. Indeed, it may be difficult for some tools to establish a malnutrition risk using only nutritional criteria, e.g., using the tool by Elmore et al. [15], which is dominated non-nutritional criteria, such as type of disease, disease severity, previous hospitalization, domicile, and age. In contrast, other nutrition screening tools can only establish a malnutrition risk category using the nutritional indices described earlier [3, 16–18] and certain tools can do both depending on the patient (e.g., [19–21]). Figure 1 suggests that the selection process should be based not only on the quality of the tool, including evidence-based criteria such as validity and reliability, but also on the matrix of needs and potential applications of the tool, some of which are used for one setting and one condition, whereas others are used for all care settings and all types of conditions. One of the important considerations concerns age. This is not only because nutrition screening can be undertaken at any age, from before birth to shortly before death, but also because some tools were developed for application over a narrow age range, whereas others were designed for use over a wide age range, sometimes spanning almost the entire age range of adults and children. However, because there have been some controversies about the choice of screening tools for specific age groups and controversies about the incorporation of age-related criteria into some of them, these issues are reviewed here, especially because they have not been critically evaluated in previous reviews [1,8–11,22–25].

Although nutrition screening tools are helpful in addressing diverse needs and have diverse applications, in clinical practice, the response to nutritional support is valued most highly [22,26]. Unfortunately, there is insufficient evidence to rank nutrition screening tools according to their ability to predict outcomes of nutritional interventions. There is concern about poor agreement between them, which suggests a risk that patients requiring nutritional support may not get it and vice versa. Most nutrition intervention studies have not used the commonly cited tools [26], no head-to-head randomized controlled trials have been undertaken, and there have been no indirect comparisons using a common denominator. In the absence of such information, clinical workers have made recommendations to the clinical community about the choice of nutrition screening tool for routine clinical practice based on their ability to predict outcomes in the absence of any specific nutritional interventions. Such studies, which are discussed later, have typically involved comparisons of commonly used or cited adult screening tools, such as the SGA, MNA, NRS-2002, and MUST; and they have involved tools with and without age components, tools designed for use in different age ranges, and tools with different body mass index (BMI) cutoff values.

Scope of the review

This review on nutrition screening aims to examine three age-related issues by:

1. identifying the spectrum of tools available for different age groups, pinpointing adult screening tools that incorporate age into their scoring systems, and examining any scientific rationale that is provided for incorporating age into such tools
2. assessing the effect of age alone in predicting clinically relevant outcomes, comparing it with the ability of nutrition screening tools to predict the same outcomes, and systematically examining methodologic issues that can influence predictive validity
3. evaluating the scientific basis and implications of incorporating different BMI thresholds for underweight into screening tools from clinical and public health perspectives.

By fulfilling these aims, we hope to achieve a better understanding of the merits and limitations of using age and different BMI cutoff values in various screening tools. The amalgamated information should help clinicians understand the clinical implications of using different screening tools, because there is no malnutrition screening tool "gold" standard and a lack of comparative data to otherwise guide them. Figure 1, which illustrates issues that need to be considered in screening tool selection, is used to put the findings into perspective.

It is beyond the scope of this review to comprehensively examine all screening tools, of which there are probably several hundred, mostly unpublished tools. We also do not aim to examine all the characteristics of screening tools, such as their acceptability by staff and patients, their reproducibility, and all aspects of their validity. The reader is referred to other reviews for a discussion of these issues [1,8–11,22–25]. The effect of nutritional support on clinical outcomes in malnourished and non-malnourished subjects identified in different ways can also be found elsewhere [22,26].

Much of the recent literature comparing screening tools has involved commonly used (MNA, NRS-2002, MUST) or cited (SGA) tools, which provide by far the richest source of information for examining certain age-related issues, such as the prediction of clinical outcomes in the absence of nutritional support. To facilitate an understanding of the issues involved, the Appendix summarizes the background to the SGA, MNA, NRS-2002, and MUST and describes their scoring systems. However, a wide range of other screening tools, whose histories are not given in

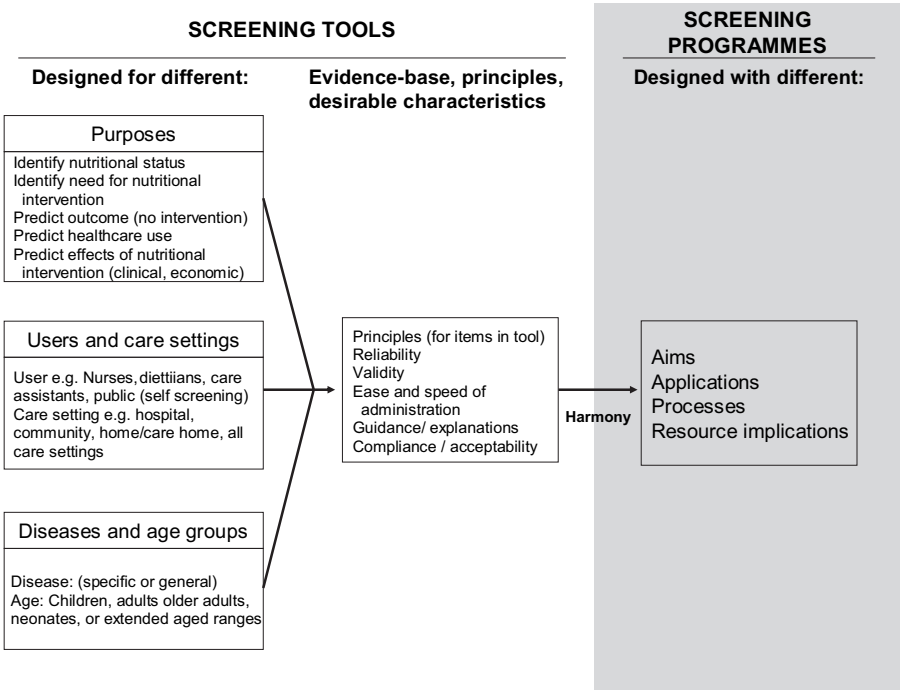

Fig. 1. A framework for screening tool selection based on the matrix of needs and quality of the tool. The screening program includes the screening test (screening tool), management, and follow-up. It is based on a modification of a previous framework by Elia and Stratton [1]. The screening test refers to the result of nutrition screening, and the screening program refers to the broader activity that includes nutrition screening, management, and follow-up.

the Appendix, are also considered, particularly those that incorporate age and different BMI cutoff points. The absence of any screening tool from this review should not be taken to imply that it is not important or not valuable for routine clinical practice.

Unlike many previous reviews, this one focuses on the nutritional and pathophysiologic principles associated with certain criteria incorporated into screening tools. It aims to provide necessary background and potential explanations on key issues, so that it can help readers to make up their own minds on controversial scientific issues and conflicting recommendations about the choice of screening tool for routine clinical practice.

Spectrum of nutrition screening tools according to stage of life and incorporation of age components into adult screening tools

Nutrition screening tools according to stage of life

Screening before birth

For the purposes of this discussion, we refer to the procedures (or toolkits) used to evaluate intrauterine growth as nutrition screening tools.

The detection of intrauterine growth retardation (IUGR) is clinically challenging because it normally occurs in pregnancies without risk factors. Nutrition screening undertaken using ultrasound aims to establish the adequacy of intrauterine growth and to identify growth retardation. This often involves estimating fetal weight using one of at least 50 published formulas. Femoral length (disproportionately decreased by IUGR), abdominal circumference (also disproportionately decreased by IUGR in association with a smaller liver), head circumference, and ratios of these circumferences have been used to identify IUGR. Measurement of femur volumes by three-dimensional ultrasonography has also been used [27]. For obvious reasons, sequential measurements are more useful than single measurements. Although there are many causes of IUGR, including constitutional and disease-related factors, which may involve chromosomal abnormalities, in many cases the placenta is small or poorly functioning so that it does not supply sufficient nutrition to the growing baby. Ultrasonography [28] can also measure pulsatility and waveforms of placental blood flow, which supplies nutrients to the fetus. Bedside palpation to detect small-for-gestational age has poor sensitivity and specificity compared with fetal imaging techniques and measurements made at birth.

Neonates

Birth weight and different anthropometric measurements, including relative segment lengths or circumferences, are frequently used to indicate the presence of malnutrition. IUGR, especially during the last trimester of pregnancy, tends to affect the head to a lesser extent than other segments of the body (disproportionate growth retardation), all of which can be measured in the neonate [29].

Children

Anthropometric measurements have been widely used to screen for malnutrition (including overnutrition) in children. These include midupper arm circumference [30], weight for age, height for age, BMI for age, and weight for height. The new World Health Organization (WHO) charts for children 0 to 4 y old are purported to reflect the optimal growth in children of all ethnic groups because of the striking similarities in results obtained from the six countries that contributed data (USA, Norway, Oman, Brazil, India, and Ghana) [31]. The charts were based on anthropometric measurements obtained from children who

were breast-fed for about 6 mo by relatively affluent, nonsmoking mothers who had experienced a healthy pregnancy. The charts, which have separate sections for preterm babies, infants 0 to 1 y old, and older children, have been widely adopted in different countries. However, in clinical practice, where decisions need to take into account the rapid changes in weight and dietary intake and disease-related factors that can change rapidly, a variety of other screening procedures have also been adopted. Numerous nutrition screening tools are available for use in children of different ages with different diseases in different care settings. However, their clinical utility remains to be evaluated. Even when considering only general purpose screening tools in the hospital setting [32–34], discrepancies between them are expected because they incorporate different criteria to detect malnutrition and different end points, which in the case of one tool [34] was to specifically identify children with more than 2% weight loss during hospitalization.

Children and adults

A few nutrition screening tools were developed for use in adults and children [19,35,36]. The Nutrition Risk Score [35], for example, incorporates items that apply to children and adults, e.g., appetite, ability to eat/retain food, and disease stress factors. The adult section of the tool requires information on weight status (BMI) and weight loss in the previous 3 mo, whereas the children's section (0–17 y) requires only information on weight status (expected weight for length). Another tool [19] requires information on children's height for age (<50th or >50th centile) and weight loss (>5% weight loss in previous month). The adult section of this tool also requires information on weight status (percentage of ideal body weight) and unintentional weight loss over one of the following periods before screening: 1 wk, 1 mo, 3 mo, and 6 mo. Establishing the most appropriate cutoff points for unintentional weight change in children of different ages can be difficult because growth rates vary considerably with age. In contrast to adults in whom weight maintenance is considered normal, failure to increase weight over as short a period as 1 mo in a rapidly growing child may represent substantial growth failure, and a 5% weight loss over the same period can be of serious concern. The particular tool under discussion [19] also incorporates scores for albumin concentrations based on cutoff points that differ between children and adults and among children of different age categories (<1, 1–5, 6–16, and ≥16 y). Some screening tools use exactly the same criteria for older children (≥15 y) and adults, including the same magnitude of unintentional weight loss (>5% body weight) [21].

Adults

Most published nutrition screening tools are for adults, and most of these are applicable to younger and older adults [8].

Older adults

A few nutrition screening tools were designed specifically for older adults, among them being the MNA, Geriatric Nutritional Risk Index [37], and the tool of Wolinsky et al. [12]. Some tools for older people were originally developed for use in hospitalized patients [38–40]. Instruments for older people may contain items such as cerebrovascular accident, Parkinson's disease [38], mental/cognitive impairment [40], and dementia [23], which contribute to the malnutrition scores, and specific anthropometric cutoff points to indicate underweight in older people [23]. Age-specific BMI cutoff points to indicate chronic protein–energy malnutrition are of considerable clinical interest and they considered near the end of this review.

After death

Nutrition screening is also undertaken after death, e.g., during postmortem examination. It generally involves the measurement of weight and length and a physical examination of the body for the presence of wasting. The wasting is typically associated with a smaller mass and often altered structure of individual organs and tissues.

Adult screening tools that incorporate age into their scoring systems

Most published adult screening tools do not include separate scores for age, but some do [15,20,21,41–44]. Table 1 presents the age at which the extra score begins to be added to their scoring systems: 45 y in one tool [41], 50 y in another tool [43], 65 y in three others [15,21,42], and ≥70 y in NRS-2002 [20]. Table 1 also suggests that the weighting for age varies between tools. With

Table 1
Examples of nutrition screening tools that incorporate age into their scoring system*

Setting and reference	Score for age	Maximum score	Risk category (suggested action)
Hospital			
McCall and Cotton (2001) [41]	≤44 y = 1, 45–64 y = 2, 65–84 y = 3, ≥85 y = 4	36	<18 = low risk (reweigh at weekly intervals), 19–27 = moderate risk (includes encouraging snacks and oral nutritional supplements), 28–36 = high risk (refer to dietitian)
Goudge et al. (1998) [42]	≥65 y = 2	28	>10 (food chart and refer to dietitian)
Doyle et al. (2000) [21]	15–64 y = 0, 65–74 y = 1, 75–84 y = 2, ≥85 y = 3	21	0–4 = low risk (weigh 1×/wk), 5–8 = moderate risk (includes use of oral supplements and referral to dietitian if no improvement), 9–21 = high risk (refer to dietitian)
Burden et al. (2001) [43]	<50 y = 1, 50–64 y = 2, 65–74 y = 3, ≥75 y = 4	28	7–9 = minimal risk (review and weigh 1×/wk), 10–14† = moderate risk (includes replacing uneaten meals with supplements, help with eating and referral to dietitian if no improvement in 3 d), ≥15 = malnourished (includes daily review and referral to dietitian)
Kondrup et al. (2003) [20]	≥70 y = 1	7	≥3 = at risk
Community hospital (and nursing home)			
Elmore et al. (1994) [15]	≥65 y = 1	22	≥6 = nutritional risk (refer to dietitian)
Community			
Gilford and Khun (1996) [44]	age not stated	unclear	unclear

* All these tools are adult tools, although the tool by Doyle et al. [21] can also be used in children ≥15 y old.

† In this tool, patients with normal gut function and desirable body weight, dietary intake, and other desirable characteristics accumulate a score, which amounts to 6 without the age effect. This means that, with the age effect, in all patients ≥75 y old cannot score less than 10, which means that they will at least qualify as being at moderate risk of malnutrition.

some instruments [41,42], age makes a relatively small contribution to the maximum score or to the threshold indicating the need for treatment, such as using oral nutritional supplements and referral to the dietitian. In contrast, other tools, such as that developed by Burden et al. [43], automatically assigns a moderate risk of malnutrition simply by the inclusion of the oldest age category (in the absence of any other abnormality); the tool developed by Doyle et al. [21] assigns a moderate risk of malnutrition in the oldest age group from the contribution of any nutritional or non-nutritional item. Using the NRS-2002, which dichotomizes the final score into <3/7 and ≥3/7, the age contribution can significantly alter the distribution between the low- and high-risk categories (a score of 2, which is not uncommon in the hospital setting, can be increased to a score of 3 by the age of the individual).

Basis for incorporating age into adult screening tools

The studies describing the screening tools listed in Table 1 have not generally explained the reason for including age into their scoring systems or the weighting applied to them. It is possible that age was included because of the belief that older people are more likely to be malnourished. However, because many screening tools use nutritional criteria to establish the nutritional risk of individual patients, including older patients, the insertion of a score for age might be considered unnecessary. In contrast, older people tend to recover from illness more slowly, take longer to mobilize, and run a greater risk of becoming dependent on others, especially when they are close to the threshold of disability [45,46]. Therefore, an argument can be put forward for recognizing the risk of malnutrition at an earlier stage in older than in younger individuals so that interventions can be put in place to prevent deterioration and the development of overt malnutrition. The incorporation of age in the NRS-2002 is discussed in some detail below, partly because the NRS-2002 is unusual in offering an explanation for including its age score, partly because an understanding of the principles that led to its development is of general scientific and clinical interest, and partly because the tool has been used as a reference standard to "judge" and also to be "judged" against malnutrition risk categories established by other tools. A further reason is that the NRS-2002 has featured in a number of studies aiming to establish a ranking order of various tools according to their ability to predict clinical outcomes. In several of the situations discussed below, age alone can be shown to be as good, if not better, a predictor of clinical outcomes (e.g., mortality) than a range of screening tools, the implications of which will be discussed shortly.

The NRS-2002 was developed with the aim of predicting responsiveness to nutritional support, mainly artificial nutritional support. It increases the total risk score of any patient ≥70 y old [20], irrespective of disease, gender, or nutritional status. The tool states, "if age ≥70 y: add 1 to total score to correct for frailty of the elderly," to produce a final score that is described as an age-adjusted score (although frailty was not defined, the reader is referred to other publications for views on this issue [47–49]). The NRS-2002 scoring system, developed according to the methodology described below, implies that a higher final score is more likely to be associated with a positive response to nutritional treatment. It implies that older age and more severe disease are more likely to be associated with a positive response to nutritional support than younger age and less severe disease, even when the degree of malnutrition is fixed. Because some of these propositions may appear counterintuitive, their origins are examined below.

The inclusion of age in the NRS-2002 appears to have originated from a retrospective analysis of 128 studies. Age and three other variables (severity of disease, use of parenteral nutrition, and impaired nutritional status) were reported to predict a positive outcome, mostly in studies of hospital inpatients, which mostly used parenteral nutrition (~56%) rather than enteral tube feeding (~20%) or oral nutrition (~24%, mainly in the form of oral nutritional supplements). The studies were divided into two groups according to whether the authors of the NRS-2002 study judged them to have at least one positive clinically relevant outcome, such as decreased mortality, complications, and hospital length of stay (LOS) or improved activities of daily living. The predictor variables were age (<70 versus ≥70 y, according to the average value obtained from each study), severity of disease, use of parenteral nutrition, and impaired nutritional status, which is influenced by weight status. However, because a heterogeneous group of 20 studies from various countries, published during the 30-y period before the NRS-2002, did not provide any concise information about weight (or other aspects of nutritional status such as height, weight, BMI, and recent weight loss), weight was subjectively established by the authors of the NRS-2002. They assigned a value of 60 kg to all studies in which they considered the population to be malnourished and 70 kg to those they considered to be non-malnourished. The following issues are noteworthy.

First, age (<70 versus ≥70 y) was reported to be an independent, significant predictor ($P = 0.019$) of clinical outcome(s) because 8 of 10 of studies in the older age group were considered to yield positive results compared with a smaller proportion in the younger age group (48/116 based on the results presented in Table 2 of the NRS-2002 study [20]). The relation was not found to be strong, because a change in the outcome of a single study (e.g., if seven instead of eight studies in the older age group had a positive outcome) would be sufficient to tip the balance from a significant to a non-significant age effect. A small stroke study ($n = 42$) in an older age group reported no significant survival advantage at 3 mo ($P = 0.127$, Fisher's exact test; $P = 0.066$, Kaplan–Meier test), but the relaxed criteria used by the authors of the NRS-2002 ($P < 0.08$) justified the inclusion of this study into the positive outcome group.

Second, the use of parenteral nutrition, which accounted for most studies in the NRS-2002 database, was found to be a highly significant independent predictor of outcome ($P = 0.001$), but, unlike age, it does not feature in the final scoring system of the currently used NRS-2002. Presumably a different model or a different set of considerations was used to establish the scoring structure of the currently used tool.

Third, from this discussion, it should be evident that the statistical procedure described in the NRS-2002 study involved a comparison of unmatched clinical trials to establish whether nutritional support in studies involving an older age group of subjects is more likely to produce a positive outcome than in studies involving a younger group of subjects with a very different case-mix of conditions and receiving different treatments (e.g., apparently four fracture femur studies in the older age group compared with none in younger age group; one parenteral nutrition study in the older age group compared with 70 in the younger age group). Although such information is of interest, it does not allow clinicians to know if nutritional support, or a particular type of support, will produce a better outcome in their patients.

Fourth, like other databases, the NRS-2002 database of 128 studies that were used to establish the age effect in the tool may merit updating, because evidence bases can change substantially

over time. For example, a Cochrane Database Systematic Review on nutritional support in patients with hip fracture [50] has recently undergone its sixth revision since its initial publication in 2000. Thirteen randomized clinical trials were published before 1998, but the number has increased to 24 in the latest review (only two involving vitamin supplements.).

In summary, from a therapeutic perspective (response to nutritional support), there appears to be generally little or no information as to why age was included in different screening tools and no information about the variable age cutoff points or the variable age weightings applied to their scoring systems. However, the presence of a score for age in some screening tools (Table 1) and not in others could influence the prevalence and distribution of malnutrition according to age and the prediction of outcomes, such as death and hospital LOS, because they are well known to be associated with age. This means that tools that include age and/or indices of disease severity in their scoring systems are expected to have an advantage over tools that do not include such items. This is simply because older people generally have a slower recovery from illness, longer hospital LOS, and greater mortality and/or morbidity than younger people. However, the extent of this advantage is likely to vary according to the distribution of age and disease severity scores within the populations studied and the weightings applied to them. Apart from some uncertainty that may arise when different sources of information are used to make general recommendations about screening tool selection for routine clinical care, the changes induced by nutritional support have not been evaluated adequately because of a lack of comparative data. The next section begins by providing the background to the use of the predictive approach for this purpose.

Predicting clinical outcomes using screening tools and age

Lack of a "gold" standard

In the absence of a nutrition screening tool that can act as a "gold" standard, information on the agreement between tools (concurrent validity) can be valuable, especially when the comparison involves tools developed for the same purpose and when no judgment is made about the superiority of one tool over another. The following are examples of tools that have been examined in this way (e.g., with the κ statistic [51–59]): the SGA, NRS-2002, MNA, MUST, Nutrition Screening Initiative, Admissions Nutrition Screening Tool, McWhirter and Pennington's tool, Undernutrition Risk Score, Nutrition Risk Score, Hickson and Hill's tool, and Ferguson's Malnutrition Screening Tool (MST), and a range of anthropometric indices, including BMI and weight loss, which are used in screening procedures alone or with other variables. However, sometimes a specific nutrition screening tool has been chosen to act as a reference or "gold" standard with which to rank a range of other tools designed for different purposes. This seems to be a risky procedure, especially because frequently no evidence is provided to support the proposition that the gold standard is superior to the alternative tools that it is "judging." The absence of such evidence, consistent with the absence of a universally accepted definition for malnutrition [3,4,26,60], can help explain why a wide range of different screening tools, typically the SGA, MNA, MUST, and NRS-2002, have not only been used as reference standards to "judge" or assess the malnutrition risk categorization of other tool(s), but they have also been "judged" against a series of alternative "reference" tools [1]. For example, one study used the SGA as the reference with which to "judge" the NRS-2002 (and other tools) employing sensitivity/specificity analysis [61], whereas in another study the NRS-2002 was used to "judge" the SGA (and other tools) employing the same type of analysis [53]. Another study used body composition measured by dual energy x-ray absorptiometry and references ranges obtained by impedance in another country to assess the "inaccuracies" of a range of screening tools, all of which performed poorly [62]. Not surprisingly, the overall information that has emerged from the investigation of all these issues has been variable, conflicting, and somewhat confusing [1].

In the absence of a generally accepted reference standard, attempts have been made to rank nutrition screening tools according to their ability to predict actual outcomes, such as death or complications of disease. Essentially these outcomes have been used as the gold standard with which to judge the value and relative value of a range of nutrition screening tools, with the aim of influencing screening tool selection in routine clinical care. However, even this predictive approach can be problematic despite being used to develop prognostic tools such as the SGA [4]. One of the reservations is that the ability of nutrition screening tools to predict outcomes without nutritional interventions is only one of many characteristics that should be taken into account in screening tool selection. Complete reliance or a disproportionately high reliance on one such criterion is likely to be risky. In this respect, it should be remembered that many tools were designed for diagnostic rather than prognostic purposes (Fig. 1). Another reservation is that a tool that is good at predicting outcomes in the absence of nutritional interventions is not necessarily good at predicting outcomes induced by nutritional interventions. Furthermore, if screening tools are to be recommended predominantly on the basis of their ability to predict clinical outcomes in the absence of nutritional interventions, they would find little use in clinical practice if another much simpler predictor can be shown to be superior at predicting the same outcome. Age alone can fulfill such a role in at least some circumstances.

Comparison of the predictive effect of nutritional indices, screening tools, and age

Predictive effect of nutritional indices and screening tools

The use of nutritional indices or nutrition screening tools (which do not involve laboratory tests) to predict mortality in the hospital has generally been modest at best. For example, when two categories of malnutrition risk (e.g., low versus high risk) have been used to predict mortality, the reported odds ratios (ORs) have generally ranged from about 1.5 to 4.0 during the hospital stay [63–67] and after discharge from the hospital (e.g., [68]), although unusually high ORs have occasionally been reported [56]. Modest ORs (typically 1.2–4.0) have also been generally reported when nutrition screening tools have been used to predict a prolonged hospital LOS (e.g., using cutoff values of $\geq$7 d [59], >8 d [53], $\geq$15 d [64], or $\geq$28 d [67]) and complications of a procedure or disease [56,64,65,67,69]. These studies have generally focused on the commonly used or cited tools described in the Appendix (MNA, NRS-2002, MUST, and SGA), but other tools such as Reilly's Nutritional Risk Score (Nutritional Risk Index [NRI]) [64,66] and Ferguson's MST have also been used in the analysis [59]. Although some studies have involved only older people [53,66,68], other studies have involved a wide range of age groups from younger to older adults [56,63,65,67,69]. However, in several circumstances, age alone, even when divided into only two categories, can yield more impressive results (higher odds ratios) than those obtained with a range of screening tools or nutritional indices.

Predictive effect of age alone

General population

Most people in developed countries die in old age. As shown in Figure 2, the mortality rates at ages 0 to ≥90 y in England and Wales can vary by 1000-fold, with a sharp absolute increase at about 65 to 70 y of age. Using national statistics from England, Wales, and the USA, it can be calculated (Fig. 3) that the OR for risk of death in adults (20–69 versus ≥70 y) is high, typically greater than 10 and sometimes greater than 20. The OR depends on the geographic location within a country, gender, and race/ethnicity. For example, using 2007 national statistics from the USA [70], the risk of death in adults ≥70 y (compared with 20–69 y) is associated with an OR of 14.988 (95% confidence interval [CI] 14.947–15.029). It is lower in American Indians and Alaskans (OR 9.995) and blacks (OR 11.052) and higher in whites (OR 15.616, 95% CI 15.569–15.663), Hispanics (OR 17.592), and Pacific Asians (OR 19.589). For the general population of England and Wales (2009; Fig. 3) the OR is also high (18.914, 95% CI 18.787–19.041), and, as in the USA, it is higher in women (OR 23.227, 95% CI 22.989–23.468) than in men (OR 16.370, 95% CI 16.224–16.518; calculated using the population and mortality statistics provided by the National Office for Statistics [71]). There is little change in the OR when the cutoff point for age is decreased from 70 to 65 y (OR 19.199) or when the age range is extended to include subjects ≥15 y (OR 20.604). When the age is restricted to ≥40 y, so that a comparison can be made between those 40 to 69 and those ≥70 y, the OR remains above 10 (12.037, 95% CI 11.954–12.121), and the values for women are higher (14.696) than for men (10.319). In contrast, analyses based on BMI categories, e.g., <20 kg/m^2 versus the referent range (typically 20–25 or 22.5–25 kg/m^2) generally yield much lower ORs (e.g., <3). Figure 4, based on data from about 900 000 subjects, mostly Caucasian [72], illustrates the effect of age categories on BMI–mortality curves. The 40-fold increase in mortality from age, a non-modifiable risk factor, is much greater that the two- to three-fold increase from BMI, a modifiable risk factor. Note that mortality rate on the *y*-axis is displayed on a semi-logarithmic scale.

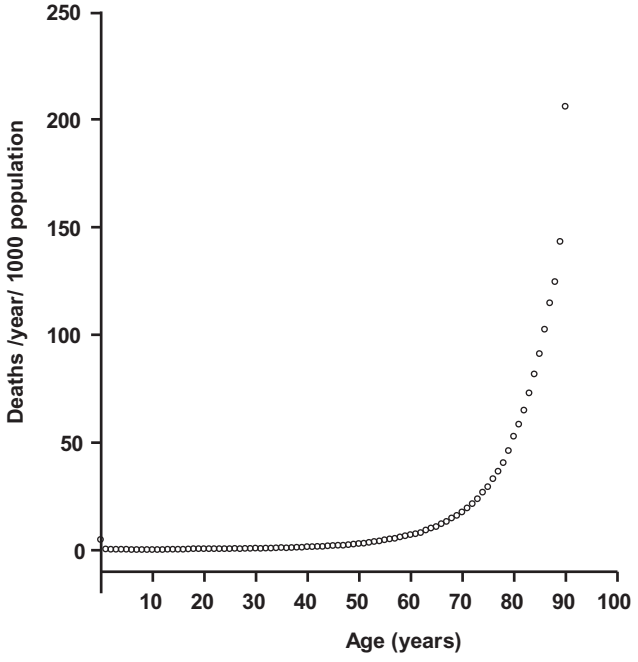

Fig. 2. Graph of mortality rate in in England and Wales according to age. The highest point represents ≥90 y of age rather than a value at a single age. Data are based on mortality statistics reported by the Office for National Statistics for 2009 [71].

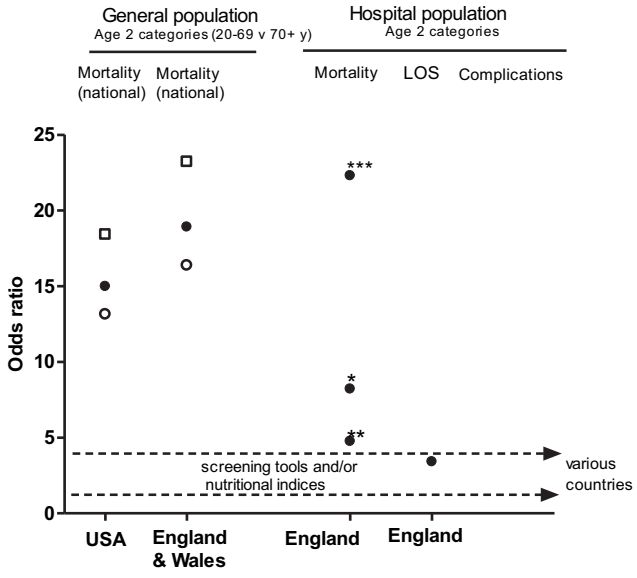

Fig. 3. The effect of age and nutritional indices/nutrition screening tools on the risk (odds ratio) of death, prolonged hospital LOS, and complications during the hospital stay. The dotted lines represent typical odds ratios reported (or calculated from published data) obtained when screening tools/nutritional indices are used to predict mortality, prolonged hospital LOS, and complications during the hospital stay. For the general population (subjects ≥20 y old), calculations for the risk of death in the USA were based on 1-y national mortality statistics for 2007 [70] and in England and Wales for 2009 [71] (solid symbols, men and women; open circles, men; open squares, women). For the hospital population, mortality calculations were based on *mortality data for England (subjects 15–54 versus ≥65 y) obtained from the Office of National Statistics for 2009 and 1-y hospital episode statistics for finished consultant episodes for 1 y (2009–2010) from the Hospital Episode Statistics for the same age groups [73] (finished consultant episodes were 1.156 times admission episodes, because each hospital admission episode may involve more than one consultant episode), **data from adults (20–69 versus 70 y) admitted to a single hospital from March 2009 through March 2010 (excluding day cases), ***data obtained from 992 adults (20–69 versus ≥70 y) participating in a nutrition screening survey in a general hospital in England. For hospital LOS, the single result is calculated from data for hospital LOS (<15 versus ≥15 d) obtained from adults (20–69 versus ≥70 y) admitted to a general hospital for 1 y (excluding day cases, n = 51 171). For complications, no new data are provided (odds ratios reported in the literature when using screening tools typically fall between the dotted lines). For further details see text. LOS, length of stay.

Hospital population

Age alone also predicts mortality and hospital LOS. Data from England, where hospital deaths account for about half of all deaths, are used to illustrate this.

Effect of age on mortality. Using national data [71,73], the risk of death in English hospitals (15–64 versus ≥65 y) can been calculated to be about 8.2 (95% CI 8.1–8.3; Fig. 3). The results vary according to region, type of hospital, and ward. For example, in a general hospital in England in which 51172 adult patients (non-day cases) ≥20 y were admitted from March 2009 through March 2010, the risk of death according to age (20–69 versus ≥70 y, overall mortality 2.55%) was associated with an OR of 4.760 (95% CI 4.144–5.089, 4.540 in men and 5.062 in women). It became lower (OR 3.496) when the age range was restricted so

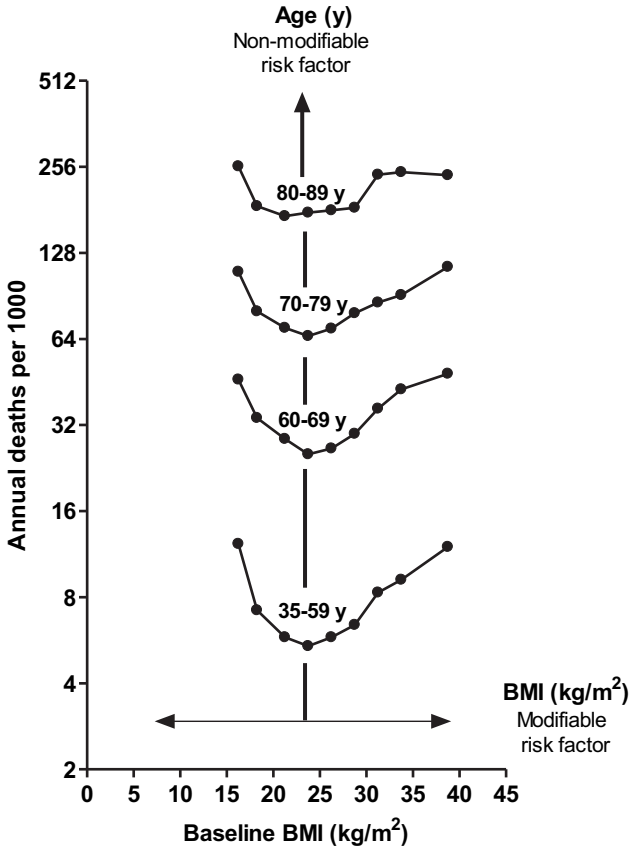

Fig. 4. BMI–all-cause mortality curves according to age categories and BMI. The effect from age, a non-modifiable risk factor, is much larger than that from BMI, a modifiable risk factor. The BMI associated with the lowest mortality is essentially the same for all age groups. The curves, depicted on a semilogarithmic scale, were constructed using numeric data provided by Whitlock et al. [72]. BMI, body mass index.

that the mortality in those 40 to 69 y old could be compared with those ≥70 y old. In contrast, a much higher OR of 22.95 (95% CI 5.433–91.485, $P < 0.00$) was found when the same age categories (20–69 versus ≥70 y) were used to predict mortality in a study of nutrition screening that included a vulnerable older group of patients and a less vulnerable younger group of patients (overall mean age 70.6 ± 19.1 y, overall mortality 7.3% among 992 subjects) distributed in various wards of the same hospital, including medical, surgical, and care wards of the elderly, but not psychiatric, maternity, or gynecology wards. The MUST, like alternative tools used in other hospitals, also predicted risk of death with a much lower OR (2.523, 95% CI 1.538–4.139, $P < 0.001$). When the two variables were used to predict mortality in the same regression model, there was little overlap between them: the independent effect of age was associated with an OR of 20.348, and the independent effect of the MUST was associated with an OR of 2.13. When the analysis was restricted to subjects ≥40 y so that the risk of death in those 40 to 69 y old could be compared with the older age group (≥70 y), the OR remained highly significant (OR 17.0, $P < 0.001$).

Effect of age on hospital LOS. Using the annual admission data ($n = 51172$) from the same hospital, it was found that age (20–69 versus ≥70 y) predicted a prolonged LOS of ≥15 d (versus <15 d) with an OR of 3.406 (95% CI 3.210–3.602), of ≥10 d (versus <10 d) with an OR of 3.144 (95% CI 3.002–3.292), and of ≥20 d (versus <20 d) with an OR of 3.430 (95% CI 3.210–3.667). The OR was 2.669 (95% CI 2.516–2.832) when the age range was lowered to compare the effects of 40 to 69 versus ≥70 y. These ORs are not as high as for hospital mortality, but they are generally as high, or higher (Fig. 3), than those obtained by a range of nutrition screening tools [59,64,65,74]. In addition, a preliminary study from Brazil reported that hospital LOS was better correlated with age (≥60 versus <60 y) than with several indices of nutritional status [75].

Implications

Four points emerge from these considerations.

First, although age can predict clinical outcomes in observational studies, especially when there is a wide age distribution within studies, it cannot do so when the population comprises individuals of the same age. Similarly, age is not expected to explain differences in mortality (or hospital LOS or complications) between the nutritional intervention and control groups when these two groups are matched for age or at least are very similar to each other, as in many randomized controlled trials. In contrast, nutritional support has been reported to produce a range of main effects in randomized control trials, including improvements in nutritional status and various clinical outcomes, such as mortality, hospital LOS, complications of disease, and functional outcomes in favor of the intervention group [22,26]. This is because, unlike age, nutritional status and dietary nutritional intake are modifiable risk factors and considered part of the causal pathway, influencing clinical and physiologic functions of the body and its tissues.

Second, observational studies do not primarily set out to examine the effects of nutritional intervention, and attempts to do so may result in erroneous conclusions. Just because a variable (e.g., age) may be good at predicting certain outcomes, it does not mean that it is also good at predicting responsiveness to a nutritional intervention (it may even be very poor at predicting such outcomes). This principle is well established within and outside the biomedical field. Therefore, when choosing a screening tool for use in clinical practice, it is necessary to consider its purpose. Is it simply to diagnose poor nutritional status? Is it to predict poor outcome? (In which case, there are simple parameters that may be able do this more effectively than the currently available screening tools.) Is it to predict responsiveness to nutritional support? Because in clinical practice, the latter is of critical importance, consideration should be given to the likelihood that this could be achieved through the use of the criteria incorporated into the scoring system of screening tools. Some tools may be strongly influenced by disease-related factors, such as disease stress factors, which are often not modifiable to any great extent by nutritional intervention, and by age, which is not at all modifiable. Such tools, especially those in which there is little input from nutritional indices, may perform well at predicting clinical outcomes in observational studies, but perhaps not so well at predicting outcomes produced by nutritional interventions. In contrast, screening tools based entirely or predominantly on factors that are modifiable by nutritional support, especially those considered to be part of the causal pathway, would be expected to predict outcomes of nutritional interventions better than tools using components that are largely non-modifiable by nutritional support. The confirmation of these suggestions in a quantitative manner needs to be established.

Third, several studies appear to have placed considerable weight on the ability of screening tools to predict outcomes without interventions, despite the more impressive effect of age alone, as suggested earlier. The results of such studies have been

variable and conflicting, at least in part because they have been based on different study designs, different methods of analysis and interpretation, and different populations receiving treatment in distinct health care systems in various countries. For example, a study in a tertiary Brazilian hospital involving medical and surgical patients ($n = 705$) reported that the NRS-2002 was generally better than the short-form MNA and MUST at predicting clinically relevant outcomes, including a very long hospital LOS (>15 d) [76]. This conclusion is based on what appears to be a largely unimpressive set of areas under the receiver operating characteristic curves (the larger the area, the better the overall prediction). For example, for a very long LOS, the values for the three tools were reported to be only 0.6508, 0.6197, and 0.6109 (out of a total maximum of 1.0000, with 0.5000 indicating the result of a useless test), although a different set of results was presented in tabular form. In any case, in a subsequent article of the same study, it was reported that the NRS-2002 was not even close to being a significant predictor of this outcome (OR 1.5, 95% CI 0.8–2.5, $P = 0.19$) [65]. This implies that all three screening tools (MNA-SF, MUST, and NRS-2002) performed poorly when predicting a very long LOS in this particular population. Perhaps more important than attempting to rank screening tools based on their generally poor overall predictive performance in that setting is the explanation for the generally unimpressive results. One possibility is that the tools were developed for use in the USA and Europe using different populations from those in a South American country, with its distinct health care system. (This is an important general issue of relevance to screening tool selection because mortality, body composition, lifestyle factors, including dietary/cultural habits, assessed using screening tool questionnaires varies between Western and non-Western populations.) In a separate study in Germany, it was reported that in a group of patients >65 y, LOS was significantly predicted by the MNA and not by the NRS-2002 (or SGA) [55], suggesting a different ranking order from the Brazilian study. Yet another ranking order can be established using the results of a study involving oncology patients in Portugal, where the observed LOS was significantly predicted by the MUST and not by the NRS-2002 (although significance was achieved after an adjustment for age and sex) or Ferguson's MST [59]. In a small surgical study [64], the Nutrition Risk Score was found to significantly predict mortality and not complications, whereas the NRS-2002 significantly predicted complications and not mortality.

Fourth, the distribution of malnutrition according to age might vary according to the type of screening tool used. Three national surveys in the UK [77–79] undertaken by the British Association for Parenteral and Enteral Nutrition (BAPEN) in collaboration with the Royal College of Nursing, the British Dietetic Association, and the National Patient Safety Agency (Department of Health) involving more than 20 000 hospital admissions examined the distribution of malnutrition according to age. They reported that the prevalence in those ≥65 y was 20% to 40% greater than for those <65 y. Similarly, a survey in the Netherlands [80], which used an unintentional weight loss greater 5% of body weight in the previous 6 mo to identify subjects at risk of malnutrition, found that elderly patients in hospitals (81%) and to a lesser extent care homes and at homes had relatively small increases in malnutrition prevalence compared with younger subjects (OR 1.36, CI 1.17–1.57). A larger and more recent cross-sectional national survey in the Netherlands [81] involving 8028 hospitalized patients with a mean age of 65.2 y used a malnutrition instrument based on BMI, weight loss, and decreased recent dietary intake. Age (categories 31–45, 45–60, 61–75, and 76–90 y) was found to have little effect on the prevalence of malnutrition (chi-square for trend = 0.06). From the reported data, it can be estimated that the prevalence in those >70 y old (or >65 y) was only about 20% higher than in those 31 to 70 y old (or 31–65 y). In contrast, a survey of German hospitals using the SGA showed a more pronounced increase in the prevalence of malnutrition with age, and another survey of Swiss hospitals [82] using the NRS-2002 yielded results from which it was possible to estimate a three-fold higher prevalence in those ≥65 y old compared with those <65 y old. Although these variable results may be due to differences in the type of diseases and type of patients admitted to hospitals in countries with distinctive health care systems, they may also depend on the type of screening tool used. In the Swiss study, the universal addition of an extra score for all those ≥70 y old would have contributed to the sharp increase in the prevalence of malnutrition in older age. The results of such studies could influence health care planners and policy makers who may allocate resources to combat malnutrition according to its distribution between age groups. However, such policy decisions should also consider the underlying principles and assumptions of the screening tools, including those related to age, as well as the purpose for which the tools were designed.

All these observation taken together suggest that there is a difficulty is selecting a general purpose screening tool based on its ability to predict clinical outcome in a specific set of circumstances, especially when the selection procedure involves observations of outcome without nutritional interventions and without considerations of differences in study designs and other methodologic problems.

Methodologic issues associated with use of screening tools to predict clinical outcomes

A wide range of potential methodologic problems can affect the results and interpretation of studies investigating the predictive validity and adequacy of procedures for nutrition screening tool selection. Some of these problems are specific to age, whereas others are more general, affecting screening tools with and without age-related criteria.

Development of a screening tool for one age group and application to another group

Care should be taken when screening tools developed and validated for use in one age group are applied to different age groups. For example, the MNA was developed for use in older people (≥65 y), so its scoring system includes items such as dementia and measurements of thinness based on thresholds (cutoff points) for calf and midupper arm circumferences deemed to be appropriate for older people, although these may not be the most appropriate values for younger people. However, the MNA has been used to screen predominantly younger groups of subjects [76,83], and it has been ranked with other screening tools according to their ability to predict clinical outcomes in observational studies involving predominantly younger subjects (<65 y) [76]. This may have underscored the value of the MNA for two reasons. First, it was developed for use in older people as a diagnostic instrument, but it has been judged according to its ability to act as a prognostic instrument. Second, it has been compared with instruments, including prognostic instruments, that were developed for use in adults of all ages. It is possible that the MNA is of value in subjects <65 y old, especially those 50 to 64 y old, but its validation in the non-elderly is required.

Adjustment for age

A study [61] administered three different screening tools to the same group of patients and then compared their ability to predict a prolonged hospital LOS (≥11 d) only after adjustment for age. However, one of the tools already incorporates a score for age (NRS-2002), producing what has been described by the authors of the NRS-2002 as an age-adjusted final score, whereas the other two do not incorporate an age score (MUST and NRI). Therefore, the age adjustment for the NRS-2002 can be regarded a second adjustment, whereas for the other two tools it can be regarded only as a single adjustment. Another study [59] also examined the ability of three screening tools to predict a prolonged LOS, one with a score for age (NRS-2002) and two without (MUST and MST). This study reported the results before and after the adjustment for age (and gender), with some subtle changes in results. The effects of such age adjustments are likely to vary with the type of tool, the age distribution of the population, and the weight assigned to age in those tools with a score for age.

Effect of altering cutoff points of predictor and outcome variables

The extent to which the scoring system of a screening tool, or individual items within screening tools, can explain outcomes such as mortality or hospital LOS may depend on how the scoring system is subdivided to produce the final malnutrition categories. Conversely, the extent to which outcome variables can be explained by predictor (explanatory) variables may depend on the way in which the outcome variable is subdivided. The following examples are used to illustrate how such manipulations can influence the results, with implications for nutrition screening tool selection.

Changing cutoff points of predictor variables. Merging categories of malnutrition risk in different ways. Malnutrition can be "defined" in different ways, even when using the same screening tool. For example, the MNA classifies subjects into three categories of nutritional status; however, in some studies, the middle category, "possible malnutrition," has been merged with the "normal nutrition" category [62], and, more commonly, it has been merged with the "malnutrition" category. This is equivalent to changing the cutoff points or threshold values for malnutrition, which could influence not only the perceived prevalence of malnutrition but also the predictive power of a tool, potentially altering its ranking order compared with other tools.

Age cutoff points and age range. The extent to which age categories predict clinical outcomes may depend on the cutoff point(s) used to establish the categories. In datasets in which there is a progressive improvement or deterioration in the outcome with age, changing the cutoff points for age may have little effect on the ORs for predicting the risk of a binary outcome variable, such as death or no death. For example, using the mortality of adults (≥20 y) in England and Wales, which progressively increases with age almost through the entire age range (Fig. 2), a series of 14 age dichotomizations from 25 to 90 y at 5-y intervals changed the OR for the risk of death only a small amount, from a little lower than 20 to a little higher than 30. However, much larger changes are expected to occur when the dichotomizations involve datasets in which the outcome variable does not change progressively with age, e.g., when the dichotomizations occur close to centrally or U-shaped distributed outcome data.

Changing cutoff points of outcome variables. Cutoff points for prolonged hospital LOS. Various studies have compared the extent to which different screening tools can predict a prolonged hospital LOS, defined in various ways by different studies, e.g., ≥7 d [59], >8 d [53], >10 d [61], >15 d [76], and ≥28 d [67]. None of these studies examined the possibility that the results and the ranking order of screening tools could be altered by changing the cutoff points for LOS. Figure 5 shows the extent to which BMI (<20 versus 20 kg/m^2), which features prominently in some tools (sometimes as the only variable), and weight loss (≥5% versus <5%), which features prominently in other tools (sometimes as the only variable) [80], can predict a prolonged hospital LOS when the cutoff value for LOS is dichotomized using a series of cutoff points that progressively increase from 6 d (50th centile) to longer than 20.5 d (95th centile). The results are based on a group of 138 patients admitted to an orthopedic ward. Using cutoff points from 10 to 17 d (long LOS) and weight loss, but not BMI, was found to significantly predict a prolonged LOS. In contrast, using cutoff points longer than 18 d (very long LOS), the ranking order reversed so that BMI, but not weight loss, was a significant predictor of a prolonged LOS. In the former situation, the OR associated with BMI was greater than that for weight loss, whereas in the latter situation, the opposite occurred. When day ≥18 was used as the cutoff point, BMI and weight loss significantly predicted LOS. In this example, weight loss was better at predicting a long LOS, whereas BMI was better at predicting very long LOS. Long and very long LOSs are relevant from clinical and economic points of view. The results shown in Figure 5 may not be typical of other datasets, and until this area is investigated more fully, it would seem reasonable to be a little cautious about coming to definitive conclusions about the relative predictive merits of different tools when a single cutoff point for hospital LOS is used, especially if the choice of cutoff point is arbitrary.

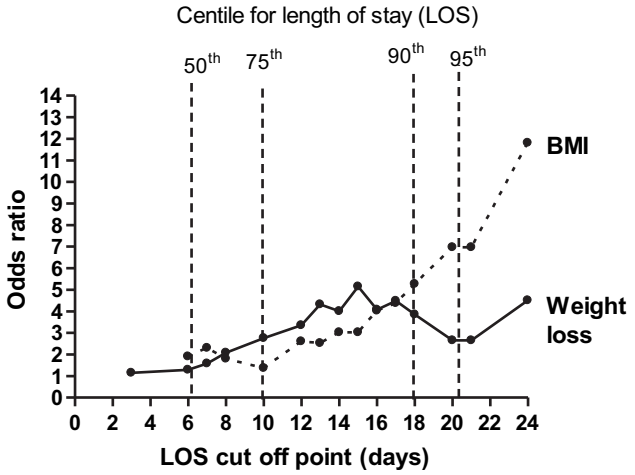

Fig. 5. Risk of longer versus shorter hospital LOS (odds ratio) according to BMI (<20 versus ≥20 kg/m^2), weight loss (<5% versus ≥5% in previous 3–6 mo), and the cutoff point used to dichotomize LOS in a group of 138 patients admitted to an orthopedic ward. Weight loss was significant only for the points shown, between the 75th and 90th centile for LOS, and BMI only for the points ≥90th centile for LOS. BMI, body mass index; LOS, length of stay.

Establishing new categories for malnutrition risk and/or omission of scores from existing screening tools. Instead of merging established categories (or scores) of malnutrition risk in different ways, some workers appear to have generated new scoring systems with more categories than in the original tool, which could influence its characteristics including its ability to predict outcomes. For example, although the NRS-2002 can

produce a score of 0 to 7, only two categories are ultimately established, one with scores <3 and the other with scores ≥3. However, one study [61] created three NRS-2002 categories (low risk = 0–1, medium risk = 3–4, and high risk = ≥5) and apparently omitted score 2, which falls between the low-risk and medium-risk groups (although it is possible that the omission was an inadvertent typographic error). Then, using binary logistic regression analysis, the investigators examined the extent to which the NRS-2002 and other tools with three risk categories predicted a prolonged hospital LOS (≥11 d). It was found that the high-risk group of all the tools (SGA, NRI, MUST, and NRS-2002) significantly predicted a prolonged LOS (NRI, OR 2.4, $P < 0.034$; MUST, OR 3.1, $P < 0.001$), but only the medium risk of the NRS-2002 significantly predicted a long LOS. It appears that the investigators concluded that overall the NRS-2002 predicted this outcome better than the other tools, including the SGA, which was paradoxically used in the same article as the reference standard for sensitivity analysis to establish misclassifications by the NRS-2002, MUST, and NRI. However, a potential problem, not commented on by the authors of this work or those citing it [76,84], concerns the procedure used to create the three NRS-2002 categories. In addition, there is at least the theoretical possibility of the omission of an intermediate score between the "no-risk" and "medium-risk" categories of a screening tool, which could also exaggerate the differences between these two categories, artificially increasing the OR in favor of that tool. The plausibility of this principle is illustrated using data obtained by a tool with a 6-point scoring system, from which two risk categories are established, one with a score of 0 and the other with a score of ≥1, as with low- and medium- plus high-risk MUST categories. These categories are used to predict mortality during hospital stay. The OR ($N = 992$, 7% death rate) was found to be 2.23 (95% CI 1.538–4.139) with the originally intended classification, increasing to 2.747 (1.610–4.687, $n = 852$) when a score of 1 was omitted from the analysis ($n = 852$) and increasing further to 3.568 (1.851–6.880, $n = 689$) when a score of 2 was also omitted from the analysis. The same principle can be demonstrated for tools with three risk categories.

The identical procedure of creating three NRS-2002 categorizes with the omission of score 2, as indicated earlier [61], has been reported in at least one other subsequent publication examining the relative merits of different screening procedures [62]. More consistent results between studies might be obtained if the tools were used as originally intended, without the omission of scores or the generation of new risk categories.

Combination of factors

The problems raised earlier about age adjustments, the creation of new risk categories (and the possible omission of a score from a tool), and use of single cutoff point for LOS (when others could have been used) may coexist [61], increasing the likelihood of multiple interactions, with unpredictable results that could influence recommendations about screening tool selection.

BMI cutoff values to establish malnutrition and influence of age

The choice of BMI cutoff points to identify underweight or overweight can have a major influence on the prevalence of these conditions. Establishing BMI cutoff points by age, gender, ethnicity, and the presence or absence of disease is a difficult task that has challenged various national and international organizations and agencies for many decades. Generic cutoff points have often been recommended, partly because of simplicity in the diagnosis, monitoring, and surveillance, and partly because the justification to use specific BMI classification systems, e.g., according to gender, disease and age, appears to have been insufficiently strong. Any justification for a specific BMI classification system needs to take into account the intended applications, such as physiologic, clinical, and public health applications, and primary end points, such as the identification of an abnormal nutritional status, the prediction of risk of death or morbidity, or the response to treatment. The issues are analogous to those already discussed in relation to screening tool selection (see also Elia and Stratton [1]). Although there are obvious limitations to the use of a single threshold to distinguish underweight from non-underweight individuals or obese from non-obese individuals, the choice has important clinical, public health, and political consequences, affecting, e.g., the perceptions about the burden of malnutrition and the resources needed to combat it.

Spectrum of BMI cutoff points

Various cutoff points from 17 to 24 kg/m^2 have been used to identify underweight in different populations including the elderly [26], but it is difficult to justify local, national, or international policies when a wide range of different principles and criteria (BMI cutoff points) are used alone or in combination with other criteria in screening tools to estimate the burden of malnutrition. However, most screening tools use BMI cutoff values from 18.5 to 20 kg/m^2 to distinguish underweight from non-underweight adults, including the elderly, and they may also use lower cutoff points so that more severe chronic protein–energy malnutrition can be identified. Most screening tools that incorporate a BMI use a cutoff value of 20 kg/m^2 [16,35,41,85–87] or 19 kg/m^2 [17,88,89] and occasionally a lower value (e.g., 18.5 kg/m^2, if there is ≤3-kg weight loss in the previous 3 mo) [16]. Some screening instruments rely on appearance [13,21,39,42,90], others record weight and/or height without specifying cutoff points [36,91–93], and yet others use a scoring system based on the percentage of ideal body weight [94–97], which is not always defined [95–97]. Most tools do not justify the choice of BMI cutoff point, although some do [3,20].

Very few nutrition screening tools use an upper BMI cutoff value >20 kg/m^2 to identify underweight. The NRS-2002 uses only the slightly higher value of 20.5 kg/m^2 for all adult age groups based on (Appendix of the NRS-2002 study [20]) the positive results obtained by a study conducted in patients with moderately severe chronic obstructive pulmonary disease (COPD) undergoing pulmonary rehabilitation [98]. Although BMI was not reported in the original study of these patients with COPD, in the depleted subjects with <90% of ideal body weight, the NRS-2002 workers estimated the BMI to be <20.5 kg/m^2, but their mean weight was 84.1% of ideal body weight (Metropolitan Life Insurance Tables), from which the mean BMI of this group can be estimated to be about 19 kg/m^2. The intervention, which involved not only nutritional supplementation (with or without anabolic steroids) but also exercise as part of the pulmonary rehabilitation program, produced significant benefits in the depleted and non-depleted groups of patients, with no significant differences between them.

The MNA uses an upper cutoff point of 23 kg/m^2 to identify a degree of malnutrition in the elderly. It also uses two other lower cutoff points so that it can assign different scores to individuals with BMIs 21 to 23, 19 to 21, and <19 kg/m^2. Little published information was found to reveal the origin of this scoring system, although those involved in its development indicated in

an early publication that a BMI <20 kg/m^2, a serum albumin <30 g/L, and a lymphocyte count >1500/mL require an intervention (nutritional support) [99]. It seems that the final MNA malnutrition risk categories were defined, or adjusted, using plasma albumin concentration [100]. Subjects were excluded from the analysis when a low serum albumin concentration was associated with a moderately increased C-reactive protein concentration (>20 mg/L), a situation that commonly exists in acutely ill hospitalized patients. Such information helps define the older population that was used to develop the MNA and its scoring system. More recent reviews about the MNA, one of which includes historical perspectives [2], provide little further insight about the choice of the BMI cutoff points.

The MNA has frequently been reported to indicate a higher prevalence of "malnutrition plus possible malnutrition" compared with other screening tools, and one of the possible explanations is that BMI values between 20 kg/m^2 (20.5 kg/m^2 in the NRS-2002) and <23 kg/m^2 contribute to the malnutrition score in the MNA but not in the other instruments. Tools may also produce widely different prevalence figures for malnutrition for other reasons, including the choice of criteria that are used to establish an overall malnutrition score and the way this score is subdivided by specific cutoff points to identify malnutrition or various degrees of malnutrition. A lower threshold for detecting the risk of malnutrition offers the opportunity of implementing preventive and early therapeutic measures, especially in older people with a decreased functional reserve. As with any other screening tool, it is necessary to consider the risk of providing unnecessary treatment in those who are well nourished.

Origins of BMI cutoff points and effect of age

Apart from the above argument, at least three other arguments have been used to support the use of a higher cutoff point to identify underweight in older people. First, at a given BMI, older people tend to have a smaller proportion of lean body mass than younger people, but the extent to which this is due to aging, inactivity, and malnutrition continues to be debated. Also debated is the extent to which the age-related decrease in lean body mass and its functions can be improved or attenuated by nutritional support compared with other forms of treatment, such as increased physical activity, including exercise, or combinations of these.

Second, people tend to shorten with age, mainly due to the compression of an osteoporotic spine. A 5-cm decrease in height from an initial height of 165 to 180 cm would increase an associated initial BMI of 20 kg/m^2 to 21.16 to 21.26 kg/m^2. The extent of height loss in adults varies [101,102], and the rate increases with age. Based on 13 studies in men, it has been estimated that the cumulative height loss between 30 and 80 y is about 5 cm, and from 11 studies in women the height loss is about 6 cm [101]. The extent of kyphosis that invalidates the use of BMI as an index of weight status in older people is unknown.

The third argument, which was particularly controversial in the 1990s [103], when the MNA was being developed, is that the nadir of the BMI–mortality curve (the BMI associated with the lowest mortality) was considered by some workers to increase progressively with age, producing an optimal BMI for older people that is up to several units higher than in young adults. A case for this was made by the National Research Council (USA) in 1989 and by the Department of Agriculture in 1990 [104]. The desirable BMI was reported to increase by 1 kg/m^2 by per decade (20–25 kg/m^2 for those 25–34 y old, increasing to 24–29 kg/m^2 for those >65 y old). Values of 24 kg/m^2 (or <22 kg/m^2) to indicate underweight [105,106] were incorporated into studies and surveys and manuals for professionals caring for older Americans [107]. However, the idea that the desirable or optimal BMI range for older people should be higher than in younger people met with some criticisms, which included a failure to adequately take into account confounding variables, such as smoking and disease. The result was that the 1995 report from the Department of Agriculture [108], unlike the previous one, did not recommend age-specific BMI ranges. Furthermore, a recent study involving about 900 000 subjects and 57 prospective studies reported that the optimal BMI for all-cause mortality was 22.5 to 25 kg/m^2 for women and men and at all age categories including those of older people [108]. Similar data emerged from another recent analysis involving 1.46 million predominantly white adults [109]. These observations argue against the use of sex- and age-specific BMI cutoff points to define chronic protein–energy nutritional status (at least for predicting all-cause mortality), irrespective of any effects of age or gender on BMI–percentage of fat relations (the relevance to nutrition screening tool selection is discussed below). The same arguments can be used in relation to race and ethnicity-specific BMI cutoff points. For example, a recent analysis of more than 1 million Asians involved in 19 cohort studies suggested that the optimal BMI range, associated with the lowest risk of death, is essentially the same in East Asian populations as in the predominantly European populations reported in previous studies. Therefore, the authors of the study strongly argued against the use of race or ethnicity-specific cutoff points [110]. This argument would still hold (at least for predicting mortality) even when acknowledging the known differences in BMI–percentage of fat relations between Caucasian and certain Asian groups, which tend to have greater percentage of body fat for a given BMI than Caucasians [111,112].

When adopting BMI classification systems, it is also important to consider the procedures used to establish them. Major classification systems aiming to predict all-cause mortality, mainly from cardiovascular disease, have generally been based on studies making observations over many years in initially "healthy" individuals (those without overt disease). The studies have also generally excluded subjects who died during "washout" periods, often lasting several years. These "washout" periods have been included in the designs of studies aiming to establish BMI–mortality curves in an attempt to decease or attenuate the effect of a pre-existing disease. Such procedures and the frequent exclusion of individuals with overt disease before the start of the observations have generated the well-known BMI–mortality curves for the general population. However, the requirements in routine clinical practice are very different because they relate to subjects with existing disease, sometimes severe disease. During hospitalization, the focus is on current events or those likely to occur in the near future as a result of the existing disease(s), rather than on the risk of risk of death from other diseases, which may develop many years later. Chronic malnutrition is also important because it adversely influences well-being, the ability to work, and different bodily functions that are relevant to clinical care. However, some of these considerations are so different from those associated with the mortality risk, mainly from cardiovascular disease, many years into the future in initially healthy individuals that care should be taken when adopting existing classifications. A brief background to one or two of the major BMI classification systems (see below) can help understand some of the clinical implications, including those related to age.

The need for a method to identify protein–energy malnutrition in adults in low- and high-income countries was a key topic at the first meeting of the International Dietary Consultancy Group (IDECG), which was held in Guatemala in 1987. A year later, a publication on behalf of the IDECG suggested a classification for chronic protein–energy malnutrition that included a BMI cutoff point of 18.5 kg/m^2 and an estimate of total energy expenditure [113]. By 1992, a simplified version was suggested, eliminating total energy expenditure, which can be difficult to measure with accuracy, and preserving the upper BMI cutoff point of 18.5 kg/m^2 [114]. During this period, the WHO together with the Food and Agricultural Organization (FAO) of the United Nations was determined to take stronger action to solve malnutrition problems throughout the world, and it selected BMI as a potentially valuable monitoring approach. The developments were summarized in a document commissioned by the FAO [115], which also reviewed a range of detrimental effects associated with increasingly severe malnutrition (marked by lower BMIs). These included behavioral changes induced by experimental malnutrition, morbidity and health status, work output, productivity, income-generating ability, socially desirable leisure activities, low birth weight, and susceptibility to infection. Several of these items are relevant to the determination of nutritional status and the use of nutritional support in clinical practice. However, by this time, Garrow's classification of obesity, which involved a normal BMI range of 20 to 25 kg/m^2, was adopted by the WHO and used in a WHO report (1990) [116]. It was based on mortality risk, which was lowest in the range of 20 to 24.9 kg/m^2, slightly increased in the range of 25 to 29.9 kg/m^2, double in the midpoint of the range of 30 to 40 kg/m^2, and incompatible with normal employment or health at >40 kg/m^2. Although this risk-based classification was not underpinned by the adverse effects of progressively severe underweight on well-being, bodily functions, or need for nutritional support, it implied that individuals with a BMI <20 kg/m^2 were underweight (at least in relation to all-cause mortality).

Over time, the various thought processes addressing different aspects of the BMI were considered together. Some of these primarily involved the effect of overweight/obesity on mortality, whereas others primarily involved the effect of underweight on a variety of outcomes including morbidity and body/tissue function in individuals in developed and developing countries. These thought processes appear to have influenced the WHO classification of weight status, which provided a broad classification system that included "underweight" (<18.5 kg/m^2), "normal weight" (18.5–24.9 kg/m^2), "overweight" (25.0–29.9 kg/m^2), "obese" (30.0–39.9 kg/m^2), and "extremely obese" (>40 kg/m^2) [117]. The new classification, which represented a modification of the previous Garrow classification, used a BMI <18.5 kg/m^2 (instead of <20 kg/m^2) to indicate underweight, in keeping with proposals that followed the IDECG meeting in Guatemala and with the FAO publication [115,118]. No age-specific BMI cutoff points were produced, despite being considered by various organizations on a number of occasions.

In the UK, various government departments including the Department of Health, have traditionally used a BMI of <20 kg/m^2 to identify underweight, and this classification was incorporated into various National Diet and Nutrition Surveys in younger [119] and older (≥65 y) [120] adults. However, the international WHO classification has influenced recent national surveys, which have adopted a cutoff point of 18.5 rather than <20 kg/m^2 to indicate underweight in adults of all age groups including the elderly. The National Institute for Health and Clinical Excellence (NICE), which produced extensive national clinical guidelines for primary and secondary care [121], identified malnutrition according to the presence of a BMI <18.5 kg/m^2, an unintentional weight loss of >10% within the previous 3 to 6 mo, or a BMI 18.5 to 20.0 kg/m^2 and an unintentional weight loss >5% within the previous 6 mo in adults of all ages (consistent with the MUST). Furthermore, the National Clinical Guideline Centre, which produces guidelines for the NICE, recommended using a BMI <20 kg/m^2 as a marker of underweight (rather than <18.5 kg/m^2) in patients with COPD (who are often older) and as a criterion for use of nutritional supplements in this patient group [122]. Workers in other countries, such as Germany, have also indicated that, according to the Deutsche Gesellschaft fur Ernahurungsmedizin, a cutoff point for diagnosing malnutrition by BMI is 20 kg/m^2 [55,123].

BMI–mortality curves in patients with established disease and effect of age

The optimal BMI thresholds to define weight status may also depend (as implied earlier) on whether the subjects are initially healthy or unhealthy, an issue that is of key clinical importance. In the previous decade, a large literature has emerged examining the effect of BMI on mortality and to a lesser extent on morbidity and resource use in patients with established disease, sometimes severe or end-stage disease. However, the relations between BMI and clinical outcomes (e.g., mortality and morbidity without nutritional interventions) are complex and conflicting. For example, after adjusting for age several epidemiologic studies suggested a better survival in overweight and/or obese individuals compared with normal-weight individuals (typically BMI 18.5–20 or 20–25 kg/m^2) and underweight individuals with a pre-existing disease, such as renal failure [124] (hemodialysis), COPD [125], heart failure [126], and cardiovascular disease [127]. Other epidemiologic studies involving infections suggested that underweight and obese individuals fare worse than normal-weight individuals [128]. Other studies also suggested that overweight/obesity is associated with significantly worse mortality and/or complications after accidental injury (M. Elia, unpublished meta-analysis), pancreatitis [129], and certain surgical procedures, such as colectomy for cancer, which has been reported to be associated with an increase in various complications [130]. In addition, obesity has been associated with increased mortality in several conditions, such as breast cancer. The optimal BMI(s) for patients with different disease(s) remains controversial for several reasons. It is not entirely clear from some of the studies whether a lower BMI causes the disease complications, including death,, or whether it has resulted from more active disease (or a combination of both). In at least some studies, adjustments for the severity of the primary disease and for other associated diseases, comorbidities, and other risk factors, such as smoking, appear to have been inadequate. In addition, overweight/obesity may induce certain symptoms and risk factors, such as hyperlipidemia and high blood pressure, which may respond to weight loss. This raises the possibility that less severe disease becomes overt at an earlier stage than in leaner individuals, making it difficult to compare different BMI groups using consistent criteria. In addition, because the studies cited are observational, it is difficult to come to definitive conclusions about the effects of nutritional interventions. It is beyond the scope of this article to review this interesting topic in detail, but it seems there is no clear consensus about the optimal BMI thresholds for predicting mortality in those with a range of established diseases. As expected, mortality in patients with established disease is strongly influenced by age, but age-specific BMI cutoff points have hardly been explored.

Conclusion

An important aspect of clinical nutrition is the identification and treatment of malnutrition, but in the absence of a universally accepted definition for malnutrition [3,4,26,60] or a universally accepted nutrition screening tool, clinical practice varies. Nutrition screening tool selection is a key issue because it reflects the start of a journey of nutritional care. The principles underpinning this journey are of fundamental importance. When the journey involves more than one care setting, e.g., between a hospital and a community or care home, the use of consistent nutrition screening criteria can facilitate care. The use of multiple screening tools with different criteria that reflect different principles, aims, and applications can cause many practical difficulties and confusion. The advantages, limitations, and pitfalls associated with screening tool selection, particularly those related to age, have been highlighted. The practice of treating one tool as a gold standard to establish a ranking order of a series of other screening tools for routine clinical use, when these other tools have been designed for different purposes, is problematic. The practice of disproportionately relying on a particular tool characteristic, such as the ability to predict clinical outcomes in the absence of nutritional interventions, can also be problematic especially if age alone can predict such outcomes more effectively, and if the primary interest is in the prediction of outcomes induced by nutritional interventions. There is a need to ensure that the screening test and the associated screening program, which includes the test, management, and follow-up within and/or between care settings, are "fit for the purpose." We have suggested a framework for doing this (Fig. 1), which takes into account a matrix of needs and the quality of the tools. Agencies and organizations making recommendations on the practice of clinical nutrition, including screening tool selection, should consider such issues before releasing guidelines, because, although guidelines can produce benefits, they also have limitations and they can have detrimental effects [131].

Acknowledgments

The authors have been involved in the development of MUST.

Appendix

Subjective Global Assessment

The SGA was developed by Detsky et al. in the 1980s [4,13,132] using clinical history and examination instead of anthropometric and laboratory measurements. It aimed to predict clinically relevant outcomes in observational studies (rather than in intervention studies). Detsky et al. (1984) [4] stated that they "converted nutritional assessment from a diagnostic instrument (i.e. measuring it against a gold standard of malnutrition) to a prognostic instrument (i.e. by measuring it against the development of certain outcomes during hospitalization)." It was understood at the time that there was no gold standard for malnutrition, and therefore clinical outcomes (e.g., complications and hospital LOS) from observational (rather than interventional) studies became the gold standard. Unlike many preceding and subsequent nutrition screening tools, the SGA included several items related to disease, such as the presence of diarrhea, ascites, disease stress factors, and other associated functional criteria related to disease, such as whether the patient was bedridden or ambulatory. By 1987 some modifications to the tool had already been made [13] (and although Detsky et al. published the SGA tool in 1994 without disease stress factors, this was probably an inadvertent omission [14]). The SGA has been shown to have predictive validity in observational studies. It was originally designed for use by clinicians relying on clinical history and examination and requiring special training.

The patient history has five components: 1) whether there was a weight change (kilograms and percentage of weight loss) in the previous 6 mo and whether the weight had increased or decreased in the previous 2 wk; 2) whether there was a change in a dietary intake (compared with normal) in which case another seven other items exist about the duration of the decreased intake, the type of diet consumed, and if starvation had occurred; 3) gastrointestinal symptoms that persisted >2 wk (none, nausea, vomiting, diarrhea, and anorexia); 4) functional capacity ranging from no dysfunction to the presence of various types and durations of dysfunction, including whether the patient is working suboptimally, ambulatory, or bedridden; and 5) disease in relation to requirements: primary diagnosis and metabolic demand (stress), no stress, low stress, moderate stress, and high stress.

The clinical examination includes an inspection for the loss of subcutaneous fat and the presence of wasting, edema, and ascites. The patients are categorized into well nourished, moderately nourished, and severely malnourished, but no care plans are provided to link with the malnutrition classification.

Mini Nutritional Assessment

The MNA was originally developed in the 1990s [99,100,133,134] from a collaborative effort among the Nestle Research Centre in Switzerland, the Centre for Internal Medicine and Clinical Gerontology in Toulouse, France, and the University of New Mexico, USA. It aimed to aid in the assessment of nutritional status of people in geriatric practice. Validation studies were carried out in elderly subjects $\geq$65 y old, and reference measurements, such as calf circumference, were specifically established in older individuals. The tool consists of 18 items, which are divided into four parts: 1) anthropometry (BMI and calf circumference and change in weight), 2) dietary assessment (food and fluid intake, ability to self-feed, consumption of two or more servings of fruit or vegetables per day, and consumption of dairy products, milk, cheese, legumes, and/or eggs), 3) self-impression of nutritional status and health, and 4) a general evaluation of lifestyle, medication, depression, or dementia. The full-form MNA (MNA-FF) has been shown to relate to different clinically relevant outcomes, such as mortality, hospital LOS, and complications in care homes and hospitals. However, it is not a rapid screening test that can easily be carried out routinely on all patients in busy clinical environments. The short-form MNA (MNA-SF) [135,136] was developed with the view of becoming a quicker, more practical tool that preserves the key characteristics of the MNA-FF, allowing a larger proportion of patients to be screened. The MNA-SF can be described as a relatively quick screening procedure, whereas the MNA-FF is probably better described as a longer, more detailed assessment procedure. When the MNA-SF indicates a risk of malnutrition (score <11), the MNA-FF must be completed [2,23]. The MNA-SF was developed [135] using the existing Toulouse database (rather than from prospective validation studies) and tested using other datasets, such as the one from New Mexico. The two forms of the MNA were developed primarily to assess "clinical nutritional status." The scoring system of the MNA-SF (maximum score 14)

differs from that of the MNA-FF (maximum score 30), so that the scores that divide "normal nutrition" from "malnutrition" and "possible malnutrition" differ between the two tools.

The establishment of the cutoff points for the MNA-FF involved the use of circulating albumin concentrations [102]. Thresholds were selected by cross-tabulations of cutoffs for albumin and MNA scores. Unlike other tools in which the risk or severity of malnutrition is reflected by a higher score, in the MNA-FF and MNA-SF, a higher score indicates "good nutrition" and a lower score indicates "possible malnutrition."

Nutritional Risk Screening–2002

This tool originated from the work of Kondrup et al. [137,138] in Denmark, and with the subsequent involvement of the European Society for Parenteral and Enteral Nutrition (ESPEN) working group, an age component to the pre-existing tool (a score for subjects ≥70 y old) was added to establish the final NRS-2002. This was published in *Clinical Nutrition*, the ESPEN journal in 2003 [139], and shortly thereafter it was followed by the publication of the ESPEN guidelines on nutrition screening by Kondrup et al. [140] (an ad hoc ESPEN working group), which promoted its use in hospitals. Unlike the MNA, which was developed for use in elderly people in and outside hospitals, and unlike the MUST, which was developed specifically for all care settings, including hospitals, the NRS-2002 was primarily developed and promoted for use in adults in the hospital setting. It aimed to establish a screening procedure that would relate to clinically relevant outcomes resulting from nutritional interventions.

The NRS-2002 has three components: 1) nutritional status, which incorporates three separate items: categories of BMI (<18.5, 18.5–20.5 [plus an additional item of impaired general condition for these two categories], and >20.5 kg/m^2), categories about weight loss (>5% in 3 mo, >5% in 2 mo, and >5% in 1 mo [∼>15% in 3 mo]), and the assessment of food intake as a proportion of the normal requirement in the preceding week (0–25%, 25–50%, 50–75%, and >75%); 2) disease severity; and 3) age, with all subjects ≥70 y being given an additional score. The total score can range from 0 to 7, with values ≥3 indicating a likelihood of benefit from nutritional intervention. The NRS-2002 is unusual among screening tools in that its scoring system was developed with the specific aim of predicting response to treatment. The tool was developed from a framework that implies, for a given degree of malnutrition, a positive response to treatment is more likely to occur in older subjects (and those with more severe disease) than in younger subjects (and those with less severe disease). The scoring structure of the tool has remained unaltered [20,24] since it was launched. Observational studies have indicated that the tool has good predictive validity (in the absence of specific nutritional intervention) with respect to mortality, complications, and hospital LOS.

MUST for adults

The MUST for adults [3] was developed in the UK by a multidisciplinary group of health care workers, which included doctors, nurses, dietitians, and scientists, and additional input from more than 30 individuals from different scientific and clinical and health care backgrounds. It was developed and validated by BAPEN and workers in the Southampton University Hospitals Trust (UK). A key driving force behind its development was the need to use the same consistent, valid, and reliable criteria to detect and manage malnutrition in all types of patients (including those who are unconscious or unable to have their weight and height measured) in all care settings (hospitals, care homes, and community settings). This would avoid possible confusion arising from the use of different screening tools and facilitate a continuity of care within and between care settings. By applying a broad range of clinical and nutritional principles, it aimed to establish a nutritional status and the need for nutrition support, which in turn would be expected to relate to the clinical outcome and response to treatment. Although the MUST was not primarily developed for use in the community, as stated in a recent review of nutrition screening in hospitals [141], some criteria had been previously included into a community tool, which differs from the MUST in many ways [142]. Most initial validity and reliability studies involving the MUST (>20 studies) were undertaken in the hospital setting before its launch in 2003, although studies in the community and care home settings had also been undertaken [3] and field tested in more than 200 centers (hospitals, care homes, and in the community) throughout the UK. The scoring structure and the method of classification of people as having a low, medium, or high risk of malnutrition have remained unchanged since its launch.

The MUST consists of three components: weight status (BMI categories <18.5, 18.5–20, and >20 kg/m^2), change in weight status (<5%, 5–10%, and >10% of body weight in previous 3–6 mo), and in the hospital setting from an acute disease effect (absence of food intake in previous 5 d or likely absence in the next 5 d). The three components can be taken to represent a journey from the past (change in weight, which could reflect the effect of a chronic disease) to the present (current weight status, BMI) and the future (unlikely to eat for the next 5 d). Objective measurements are used when possible, and more subjective measurements or surrogate measurements of height or BMI are used when necessary. In those for whom objective measurements of weight or height cannot be made, other criteria can be used, e.g., surrogate measurements of height (e.g., self-reported height or knee height/ulna length, charts provided) or BMI (midupper arm circumference). The final risk category is linked to a care plan (low risk, routine care; medium risk, observe; and high risk, treat). The guidance notes for the tool have been reviewed intermittently.

Unlike other malnutrition screening tools, the MUST was developed specifically to identify undernutrition and obesity in all care settings in adults of all ages using objective criteria whenever possible and more subjective criteria when necessary.

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