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REVIEW

Quick-and-easy nutritional screening tools to detect disease-related undernutrition in hospital in- and outpatient settings: A systematic review of sensitivity and specificity

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Disease-related malnutrition;
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Systematic review

Summary
Background & aims: A valid, quick-and-easy screening tool to detect undernutrition, is an essential requisite to treat undernutrition. In order to select quick-and-easy screening tools with high analytical accuracy for the general hospital in-, and outpatient population, a systematic review at sensitivity and specificity studies were performed.
Methods: The electronic databases MEDLINE, EMBASE, CINAHL and the Cochrane Library (SR, DARE and the Central trail register) were searched. Additionally, ESPEN and ASPEN congress posters and abstracts from 2000 till 2005, reference lists and review articles, were hand-searched. There were no limitations made on language or publication date. To finally include a study there were six criteria: The study (1) determined analytical accuracy of a quick-and-easy screening tool in (2) adults with (3) the dichotomous classification: disease-related undernutrition present or absent, versus (4) an acceptable reference standard with (5) data available to abstract sensitivity and specificity. Methodological quality was formally assessed using the QUADAS (checklist for quality assessment in analytical accuracy studies) in those studies with (6) relevant sensitivity and specificity.

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Results: The search yielded 1513 citations of which finally, nine studies were included. After quality assessment, no studies for the general hospital outpatient population remained. For the general hospital inpatient population only the Short Nutritional Assessment Questionnaire (SNAQ) and the Malnutrition Screening Tool (MST) tool were studied with a high rating to the criteria specified. The analytical accuracy of the MST seemed slightly better than the SNAQ. However, the MST study had a lower QUADAS 'score' for blinding and the cut-off point of the MST for positive screening was defined post-hoc.

Conclusion: Their high applicability combined with clinically relevant sensitivity and specificity make the MST and the SNAQ the most accurate nutritional screening tools ready to implement at the general hospital inpatient population found in our systematic review.

Contents

Introduction

Disease-related undernutrition (DRU) is present in about 10% of the general outpatient population and in 25% of patients on hospital admission.[1–3] During hospital stay DRU is even found in up to 66% of patients.[4] Despite this high prevalence and overall understanding that DRU increases complications, costs and length of hospital stay,[5–8] still 50% of all hospitalised undernourished patients remain unrecognised by medical and nursing staff, and therefore untreated.[2] Data suggest that recognition of DRU at the outpatient clinic is even worse: Wilson et al.[1] describes a recognition rate of DRU in only 43% of the elderly malnourished patients and of 12% in young adult, malnourished patients. With even a lower percentage of these patients receiving appropriate nutritional treatment. To determine whether the patient is malnourished and a nutritional intervention should be started, ideally, the nutritional status should be assessed in all in- and outpatients by specialists as dieticians. However, this 'ideal', comprehensive diagnostic assessment is considered time-consuming and requires a specialist, and is thus expensive. It is also an unnecessary burden for those patients which turn out to be well nourished. For these reasons, it is desirable to have a quick-and-easy, non-invasive screening method before comprehensive diagnostic assessment takes place.[9]

Before a screening tool is considered for implementation, it ideally fulfils, next to practical applicability, a large number of criteria, as also mentioned by the ESPEN guidelines on nutritional screening,[10] such as (1) validity (well established face validity, content validity, construct validity, concurrent and predictive validity), (2) reliability (good inter-rater agreement and test–retest agreement) and (3) the tool has to be linked to specified protocols of action.[9–11] Our main interest was to select practical (e.g. quick-and-easy among untrained users) nutritional screening tools that can replace a comprehensive diagnostic nutritional assessment by specialists in all patients. Then, only after a patient is positively screened, a comprehensive diagnostic assessment has to be performed. To determine the capability of a screening tool to select the same patients as under- and well-nourished as the 'ideal' comprehensive

diagnostic assessment would, we examined the concurrent validity of nutritional screening tools. To analyse concurrent validity (further called 'analytical accuracy'), the study design has to contain an index test (e.g. quick-and-easy screening tool) versus a reference standard (e.g. concurrent criterion for DRU).[12] The comparison between index test and reference standard is expressed by the sensitivity and specificity of a tool.

The reference standards in nutritional screening studies are various because no 'golden standard' or universal accepted definition for diagnosing DRU exists. This lack of an accepted definition of DRU makes the comparison between quick-and-easy screening tools, and therefore the implementation of such tools, complex. Jones[13] identified 44 nutritional tools to detect DRU. A rank order of most accurate tools ready to implement could not be derived from the Jones paper because not all important aspects which influence bias and methodological flaws were assessed. So, although many nutritional screening tools have been developed the implementation of routine screening, necessary to offer optimal nutritional care, is for a large part hampered by the impossibility for dieticians and other caregivers, to have assess to those tool(s) that are methodologically sound, clinically relevant and practically to implement.

The aim of our study was to select and rank order, and thereby create asses to accurate quick-and-easy nutritional screening tool(s) to detect DRU (QE-ST-DRU) ready to implement. Therefore, we performed a systematic review including a formal critical appraisal of methodological study quality of analytical accuracy studies as opposed by the Cochrane Collaboration[14] combined with a-priori defined minimal criteria to define DRU and clinically relevant sensitivity and specificity.

Table 1 Search strategy February 2005.

[MeSH] terms and Text Words used to identify articles on the subject 'Analytical accuracy of screening methods to detect DRU in adults'
Patients (Undernutrition OR malnutrition OR nutrition* OR [Protein-Energy Malnutrition]) NOT (*child* OR *infant* OR *pregnant* OR *animal*)
Methodological filter sensitivity OR specificity OR valid*
Test # Screen* OR diagnos*
The topics Patients, Methodological Filter and Test were combined with AND.

#Because concurrent validation studies of Nutritional Screening Tools were not consistently categorised in diagnostic research, these text words instead of the official Medline filter for diagnostic research, were used. The free text words, screen* and diagnos* were searched because these terms were used exchangeable in articles about the nutritional screening topic.

Methods

Search strategy

To select those QE-ST-DRU with relevant analytical accuracy (sensitivity and specificity), the electronic databases MEDLINE (from 1966), EMBASE (from 1980), CINAHL (from 1982) and the Cochrane Library (SR, DARE and the Central trail register) were searched in February 2005 using medical subject headings and free text words (Table 1). There were no limitations made on language, publication date or (health care) setting. Additionally, nutritional congress proceedings from the European and American Society of Parenteral and Enteral Nutrition (ESPEN, ASPEN) from 2000 till 2005, reference lists from included studies and review articles, were hand-searched.

Inclusion criteria

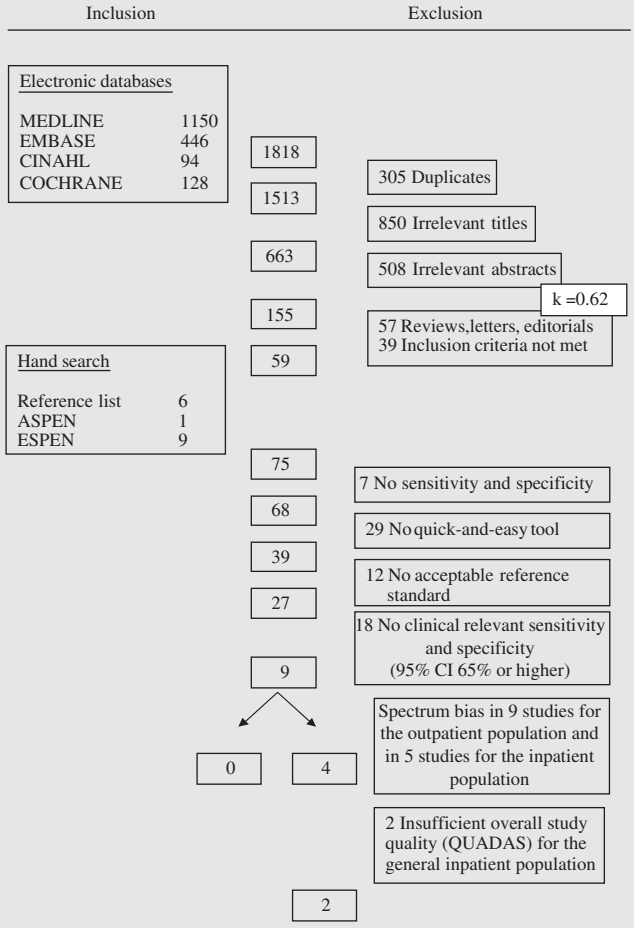
Studies were included if they met the following six criteria: (1) intention to determine diagnostic value of a method to detect DRU in (2) an adult population with (3) a dichotomous classification: DRU present or absent, and (4) data available to determine analytical accuracy (e.g. cross-tabulations or at least calculated sensitivity and specificity). Only studies with (5) a 'quick-and-easy' method versus (6) an acceptable reference standard, were finally analysed. A nutritional screening tool was defined as 'quick' if the screening result was expected to be available in <10 min. Therefore, when a screening tool contained a biochemical analysis, the tool was excluded because of a waiting time >10 min before available screening result. A tool was defined as 'easy' if a general educated nurse was expected to use the tool without special training. Tools containing physical examinations like skin folds, mid arm circumference measurements and bioelectrical impedance analysis, were defined as methods for professionals and therefore excluded. A reference standard was considered acceptable if it included at least (1) 'weight loss or another changing anthropometrics over time' and (2) 'an estimate of current body composition as BMI'. This definition of an acceptable reference standard was based on discussion with experts on the field and on the recently most relevant parameters published (BMI and unintended weight loss) capable of identifying those patients, benefiting from nutritional intervention by improved clinical outcome.[15] We stated that next to body composition at a given time, changes in time (within person variability) are necessary to correct for the wide ranges of in-between persons variability. Because there are no universally agreed methods to measure DRU, we decided to accept all methods that suggest to measure DRU with only the demand that at least (1) 'body composition' at a given time and (2) changes in 'body composition' over time, were taken into account.

Selection

Process

Selection of titles, abstracts and studies were independent by A.B. and L.V. Differences in the selection between

Table 2 Flowchart of the selection process of QE-ST-DRU studies.



A.B. and L.V. were discussed and solved by consensus. Data were abstracted from the papers by L.V. using an a-priori specified collection form for diagnostic studies.[14,16–18] Difficulties in abstracting data were discussed with the second reviewer (R.V.). To evaluate the methodological quality, H.K. and L.V. independently appraised each included paper according the QUADAS checklist designed to assess the methodological quality in screening and diagnostic research of analytical accuracy studies[19] (Appendix 1). Item 1 of the QUADAS (spectrum bias) was answered separately for the hospital in- and outpatients to account for differences at the spectrum of these populations. If essential data were missing, in the data extraction process, as well as at the methodological assessment, additional information was sought from the principal investigator of the study concerned.

Inter-rater reliability

To assess the quality of the independent selection and appraising process, the kappa statistics for agreement between reviewers at in- and exclusion of studies, and for all items of the QUADAS, were calculated (SPSS 11.0.). For calculating the kappa, the answer 'unclear' on an item of the QUADAS was recoded as a 'no'.

Analysis

All included studies were tabulated and analysed after stratification for (health care) setting, disease and age, to account for possible spectrum differences. For the proportions sensitivity and specificity, the 95% confidence intervals (CI), were computed. Anticipating on small sample sizes, the so-called 'exact' method based on binomial probabilities of Clopper and Pearson, was used.[20] If clinical and statistical homogeny studies were present, the 95% CI were also calculated after pooling these data.[21] A QE-ST-DRU was judged as clinically relevant, if the lower limit of the 95% CI was 65% or higher for sensitivity and specificity. This cut-off point is based on the fact that in current usual clinical practice (without structured screening) the recognition of DRU (e.g. sensitivity) by nurses and medical staff is only 50%.[2] Although the specificity is, in screening perspective, of less relevance to the clinical outcome of the patient,[22] the lower limit of the 95% CI of specificity, was defined to be at least 65% or higher to account for the workload of the dietician and/or to reduce the amount of over-treated patients if patients at risk of DRU are given a standard nutritional care plan without interference of the dietician as, for instance advised by the ESPEN guidelines.[10]

Table 3 All QE-ST-DRU which were compared versus an acceptable reference standard with derivable sensitivity and specificity.

First author, year		Setting	Mean age	Tool	Item (n)	Time (min)	Reference standard	Sample size	Prevalence (%)	Sensitivity (95% CI)	Specificity (95% CI)
Primary care											
Gregoire, 1999[38]	1	General Practitioner	40.0a	Adult Nutritional Screening Tool	10	<10	Standardised Nutritional Assessment by dietician: weight, WL, BMI, NI, lab, medical and social factors	92	42	67 (50–81)	77 (64–88)
Borowiak, 2003[39]	2	General Practitioner	74.1b	MNA-Short Form	6	<5	MNA<23.5	160	X	74 (X)	95 (X)
Ward, 1998[40]	3	Home Care	74.0c	Nutritional Risk Assessment Tool	9	<5	Nutritional Assessment by dietician (BMI, WL, food intake, signs and symptoms)	497	16	87 (78–94)	70 (65–74)
Secondary care: outpatient clinic											
Specific subgroups											
Ferguson, 1999[28]	4	Oncology scheduled for radiotherapy	59.9c	Malnutrition Screening Tool	2	<3	SGA (B+C)	106	11	100 (74–100)	81 (71–88)
General surgery											
Cohendy, 2001[29]	5	Elective surgery or exploration under anaesthesia	72b	MNA-Short Form	6	<5	MNA<23.5	408	32	86 (79–92)	89 (85–93)
Secondary care: inpatient clinic											
Specific subgroups											
Wolf, 2002[41]	6	Oncology (gynaeco)	56c	Malnutrition Screening Tool (Ferguson)	2	<3	SGA (B+C)	96	21	80 (56–94)	75 (64–84)
Bauer, 2002[42]	7	Oncology	57.6c	Patient-Generated SGA (Ottery)	7	<10	SGA (B+C)	71	76	98 (90–100)	82 (57–96)
Bauer, 2003[43]	8	Oncology	56.4c	Nutritional Screening Tool (MAG)	2	<3	SGA (B+C)	65	75	59 (44–73)	75 (48–93)
Thorsdottir, 2001[44]	9	COPD	73b	Screening Sheet for Malnutrition 4-point criteria (Elmore 1994)	6	<5	Nutritional Assessment by dietician: BMI, TSF, MAMC, lab, WL: 3/7<ref	34	38	69 (39–91)	90 (70–99)
	10			BMI	2	<3		34	38	54 (25–81)	95 (76–100)

Table 3 (*continued*)

First author, year		Setting	Mean age	Tool	Item (n)	Time (min)	Reference standard	Sample size	Prevalence (%)	Sensitivity (95% CI)	Specificity (95% CI)
Gossum, 2003[45]	11	Gastro-enterology	55c	Rapid Screening Tool	2	<3	SGA (C)	157	21	73 (54–87)	88 (81–93)
Martins, 2003[46]	12	Geriatric Orthopeadic-Trauma	73.5b	BMI (Beck)	2	<3	NRS 2001	137	28	76 (60–89)	76 (66–84)
General surgery and internal medicine											
Thorsdottir, 2005[47]	13		83b	WL>5% previous months	2	<3	Nutritional Assessment by dietician: BMI, TSF, MAMC, lab, WL: 3/7 <ref	60	58	49 (31–66)	100 (86–100)
	14			Screening Sheet for Malnutrition 4 point criteria (Elmore, 1994)	6	<5		60	58	89 (73–97)	60 (39–79)
	15			Simplified model (Score = BMI+15xWL−10xsurgery−6xloss of appetite<35)	4	<10		60	58	89 (73–97)	88 (69–97)
	16			BMI<20	2	<3		60	58	34 (19–52)	100 (86–100)
Thorsdottir, 1999[48]	17		56.4c	WL>5% in one; >10%in 6; 5–10% in 1–6 months	2	<3	Nutritional Assessment by dietician: BMI, TSF, MAMC, lab: 3/7<ref	82	20	64 (35–85)	87 (76–94)
	18			Screening Sheet for Malnutrition 4-point criteria (Elmore, 1994)	6	<5		82	20	69 (41–89)	91 (81–97)
	19			Screening Sheet for Malnutrition (based on Elmore, 1994)	9	<10		82	20	56 (30–80)	88 (78–95)
Oakley, 2000[30]	20		Xc	Nutritional Assessment Score	7	<5	Standardised Nutritional Assessment by dietician (Anthropometrics, WL, appetite, mental/social/ medical condition)	86	26	96 (77–100)	99 (92–100)
Murtaugh, 1995[31]	21		Xc	Rapid Screen	2	<3	Nutritional Assessment (anthropometrics, lab, diagnose, ability to chew/ swallow)	277	31	94 (87–98)	98 (95–100)
Kruizenga, 2005[32]	22		58.4c	Short Nutritional Assessment Questionnaire	3	<3	WL>5% in 1 or >10% in 6; 5–10% in 1–6 months and/or BMI<18.5	291	32	86 (77–92)	89 (84–93)
	23		60.6c					297	32	79 (69–87)	83 (77–88)
Goudge, 1998[49]	24		64c	Derby Nutritional Score	7	<5	Standardised Nutritional Assessment by dietician (WL, NI, type of diet, GI symptoms, Mobility, MAMC)	73	24	72 (47–90)	87 (76–95)
Ferguson, 1999[33]	25		57.7c	Malnutrition Screening Tool	2	<3	SGA (B+C)	408	17	93 (84–98)	93 (90–95)

Burden, 2001[25]	26		63c	Nutrition Screening Tool	7	<5	Nutritional Assessment by dietician (1/4: MAMC<15th, BMI<20, WL>10%, NI<25% of estimated average requirement)	100	64	78 (66–87)	52 (35–70)
Azad, 1999[50]	27		79b	Nutrition Screening Initiative	10	<5	Standardised Nutritional Assessment by dietician (BMI, WL, alb, risk factors as nausea or vomiting. GI disease, NI)	152	59	54 (44–65)	61 (48–73)
	28			Chandra Screening Tool	14	?		152	59	32 (23–43)	86 (74–93)
Schuetz, 2004[51]	29		62.2c	WL>10%	2	<3	SGA (B+C)	1786	26	44 (39–48)	97 (96–98)
	30			BMI<18.5	2	<3		1786	26	15 (11–18)	99 (99–100)
General internal medicine											
Stratton, 2004[26]	31		78b	Malnutrition Universal Screening Tool	4	<5	MNA-Short Form<11	86	65	66 (52–78)	97 (83–100)
Laporte, 2001[52]	32		78.9b	Simple Screening Tool	2	<5	Standardised Nutritional Assessment by 2 dieticians (BMI, WL, MAMC, TSF, lab, NI, physical exam)	72	X	75 (X)	75 (X)
Laporte, 2001[27]	33		46.4a	Simple Screening Tool	2	<5	Standardised Nutritional Assessment by 2 dieticians (BMI, WL, MAMC, TSF and lab, NI, physical exam)	54	11	33 (4–78)	81 (66–91)
	34		74.2b					57	25	79 (49–95)	77 (61–88)
pooled	33/34		60.7c					111	18	65 (41–85)	79 (69–87)
General surgery											
Acuna, 2003[53]	35	Elective surgery	34c	BMI<17	3	<3	Index Suggestive of Malnutrition (WL, %IBW, TSF, MAMC, lab)	149	12	6 (0–27)	98 (93–100)
Stratton, 2004[26]	36	Surgery (mostly gastro-intestinal)	61c	Malnutrition Universal Screening Tool	4	<5	SF-MNA<11	85	47	93 (80–98)	69 (53–82)
Tertairy care											
Visvanathan, 2004[54]	37	Rehabilitative care hospital	79.5b	Rapid screen	2	<5	Standardised Nutritional Assessment by dietician BMI<22, WL>1>7.5, risk factors and lab)	65	43	79 (63–97)	97 (78–100)
Laporte, 2001[52]	38	Nursing home	79.5b	Simple Screening Tool	2	<5	Standardised Nutritional Assessment by 2 dieticians (BMI, WL, MAMA, TSF, lab, NI, physical exam)	70	X	78 (X)	63 (X)
Laporte, 2001[27]	39	Nursing home	85.9b	Simple Screening Tool	2	<5	Standardised Nutritional Assessment by 2 dieticians (BMI, WL, MAMA, TSF, lab, NI, physical exam)	49	41	85 (62–97)	76 (56–90)

Table 3 (*continued*)

First author, year		Setting	Mean age	Tool	Item (n)	Time (min)	Reference standard	Sample size	Prevalence (%)	Sensitivity (95% CI)	Specificity (95% CI)
Borowiak, 2003[39]	40	Nursing home	78.7b	MNA-Short Form	6	<5	MNA<23.5	151	X	64 (X)	100 (X)
Mixed setting											
Rubenstein, 2001[55]	41	Community dwelling (596) and hospital geriatric inpatients (306) (Toulouse-91 database)	76.4b	MNA-Short Form	6	<5	MNA<23.5	881	35*	98 (96–99)	99 (92–100)
	42	Internal medicine (105) and home dwelling elderly (50); Toulouse-91 database	78.3b	MNA-Short Form	6	<5	MNA<23.5	142	69*	98 (93–100)	100 (97–100)
	43				6	<5	Clinical judgement by 2 physicians (anthropometrics, WL, lab, weighted 3 days food records, NI over 1 month, medical information by agreement after discussion)	142	X*	98 (X)	94 (X)

a = adults; no elderly, b = elderly, c = adults and elderly, d = all ages (inclusion criteria age), SGA = Subjective Global Assessment (Detsky), X = data not available, MAG = Malnutrition Advisory Group (BAPEN,). WL = weight loss, MNA = Mini Nutritional Assessment (Vellas), NI = nutritional index, MAMC = mid upper arm muscle area, MAMC = mid upper arm muscle circumferences, NRS = nutritional risk score, TSF = triceps skinfolds, TSF = triceps skinfolds thickness.

*Not at random selected population: prevalence DRU influenced.

For the finally included QE-ST-DRU, the positive and negative predictive values with 95% CI ('exact' method[20]) and likelihood ratios with 95% CI were computed[23] to assess the clinical relevance of the QE-ST-DRU in practice. The positive predictive value shows the percentage of patients that are really malnourished when referred to the dietician after positive screening. A relevant difference (diagnostic gain) between the positive predictive value and the prevalence (e.g. the amount of really malnourished patients if all patients were referred) is a requisite before implementing a test in practice (Bayes Theorem). The positive likelihood ratio shows the odds to be screened as malnourished in the truly malnourished patients versus the odds of being screened positive at the truly not malnourished patients (sensitivity/1−specificity).[22]

Results

Search

The search yielded initially 1513 citations omitting duplications (Table 2). Excluded were 850 irrelevant articles based on title. Of the 663 articles left, 155 abstracts were included with good agreement (kappa = 0.62).[24] After full text assessment, 57 non-research publications as reviews, letters and editorials and 39 studies who did not meet all inclusion criteria, were excluded. Fifty-nine studies remained. The hand-search resulted in 16 additional studies. During the data extraction, three studies did not describe the test characteristics at all and four studies described the test characteristics partially. For the last four studies the principal investigators were contacted to provide the missing data but this information was not returned. From the remaining 68 studies, 39 fulfilled the criteria of a QE-ST-DRU of which 27 studies included an acceptable reference standard (Table 3). See Appendix 2 for the 12 studies with no acceptable reference standards according to the criteria specified (two studies overlap and were also included within the studies with an acceptable reference standard because more than one comparison was made per research paper[22,26]).

Analysis

Analytical accuracy: sensitivity and specificity

Before excluding studies with a QE-ST-DRU presenting sensitivity and specificity with a lower limit of their 95% CI of <65%, the possibility of pooling data was determined because pooling of studies increases the precision and reduces the width of the CI. In one study (Laporte et al.[27]), it seemed justifiable to pool the results of the two subgroups, adults and elderly. The pooled results were added to Table 3 under the specific study. As no further pooling was appropriate, we continued with the selection of studies (Table 2). Only nine studies contained a QE-ST-DRU with a lower limit of the 95% CI of 65% or higher for sensitivity and specificity.

Quality assessment of analytical accuracy studies (QUADAS)

Quality assessment according to the QUADAS was performed on the nine studies (Appendix 3). No study was performed in a representative sample concerning the general outpatient population. The Malnutrition Screening Tool (MST)[28] and Mini Nutritional Assessment-Short Form (MNA-SF)[29] were applied in an outpatient clinic population but concerned respectively cancer patients receiving radiotherapy and elective preoperative elderly. For the general hospital inpatient population, four studies were performed in a representative population. The QE-ST-DRU in this studies were; the Nutritional Assessment Score (NAS),[30] the Rapid Screen (RS),[31] the Short Nutritional Assessment Questionnaire (SNAQ)[32] and the MST.[33] Taking the overall study quality into account, the NAS[30] and RS[31] studies were of insufficient quality. Not only the total QUADAS 'score' was low, but very essential parts for implementation were not described. Detailed description of selection criteria, screening tool or reference standard and explanation of withdrawals were partially missing. Also, after requesting additional information from the principal investigators this gap could not be resolved. The SNAQ study[32] had the highest methodological quality. The MST study[33] was sufficient but prone to bias as the results of the QE-ST-DRU were interpreted with knowledge of the results of the reference standard (e.g. no blinding was performed). Thus, two tool studies (three comparisons), containing the MST (Fig. 1) and the SNAQ (Fig. 2) fulfilled all minimal criteria to ensure an accurate QE-ST-DRU for the general hospital inpatient population.

As can be concluded from the kappa statistics (Appendix 3), most items of the QUADAS were agreed with good to very good inter-rater agreement.[24] The items 10 and 11 (blinding

Have you lost weight recently without trying?		
No	0	
Unsure	2	
If yes, how much weight (kg) have you lost?		
1-5	1	
6-10	2	
11-15	3	
16-20	4	
Unsure	2	
Have you been eating poorly because of decreased appetite?		
No	0	
Yes	1	
Total		..

Score of 2 or more = patient at risk of malnutrition

Figure 1 Malnutrition Screening Tool.[33]

Did you lose weight unintentionally?	
• More than 6 kg in the last 6 months	3
• More than 3 kg in the last month	2
Did you experience a decreased appetite over the last month?	1
Did you use supplemental drinks or tube feeding over the last month?	1

0 or 1 point	well nourished
2 points	moderately malnourished
3 points or more	severely malnourished

Figure 2 Short Nutritional Assessment Questionnaire.[32]

Table 4 Analytical accuracy of the MST[33] and SNAQ[32]: score cut-off point defined post hoc (A) and score cut-off point defined before study was performed (B).

Tool	Score	Reference standard	Prevalence	Sensitivity (95% CI)	Specificity (95% CI)	LR+ (95% CI)	LR− (95% CI)	PPV (95% CI)	NPV (95% CI)
MST	>1	SGA		99 (92–100)	81 (77–85)	5.22 (4.18–6.52)	0.02 (0.00–0.13)	52 (43–60)	100 (98–100)
(A)	>2	SGA	17	93 (84–98)	93 (90–95)	13.20 (8.86–19.38)	0.08 (0.03–0.18)	73 (62–82)	98 (96–99)
SNAQ	>2	WL BMI		86 (77–92)	89 (84–93)	7.74 (5.18–11.58)	0.16 (0.10–0.26)	78 (69–86)	93 (89–96)
(A)	>3	WL BMI	32	88 (80–94)	91 (86–95)	9.70 (6.21–15.16)	0.13 (0.08–0.23)	82 (74–89)	94 (90–97)
MST (B)		SGA	X	X	X	X	X	X	X
SNAQ	>2	WL BMI		79 (69–87)	83 (77–88)	4.69 (3.39–6.48)	0.25 (0.17–0.38)	69 (59–77)	89 (84–93)
(B)	>3	WL BMI	32	76 (66–84)	83 (77–88)	4.50 (3.25–6.24)	0.29 (0.20–0.42)	68 (58–77)	88 (82–92)

LR+ = postive likelihood ratio, LR− = negative likelihood ratio, PPV = positive predictive value, NPV = negative predictive value.

procedure) were judged with less agreement (fair to moderate) and the items 7 (independency index test of the reference standard) and 8 (detailed description of the index test) were primary judged with poor agreement.[24]

Diagnostic gain

When analytical accuracy of the MST with a score >2 and the SNAQ with a score >2 were compared, both in the study situation that the cut-off points of the tools were defined post-hoc,[32,33] then the analytical accuracy of the MST was only slightly better than that of the SNAQ (Table 4). Only for the SNAQ the analytical accuracy was also determined in another general hospital inpatient sample than in which the tool was developed. The analytical accuracy of the SNAQ in this cross-study was less discriminative (Table 4). However, the values of the positive and negative likelihood ratios show for the MST, as well for the SNAQ in both study situations, a moderate to strong increase of the likelihood of DRU to be present or absent (LR+ >5 and LR− <0.2).[21] The difference between the a-priori probability (prevalence) compared to the posterior probability (positive predictive value) shows a diagnostic gain of roughly 50% (Fig. 3).

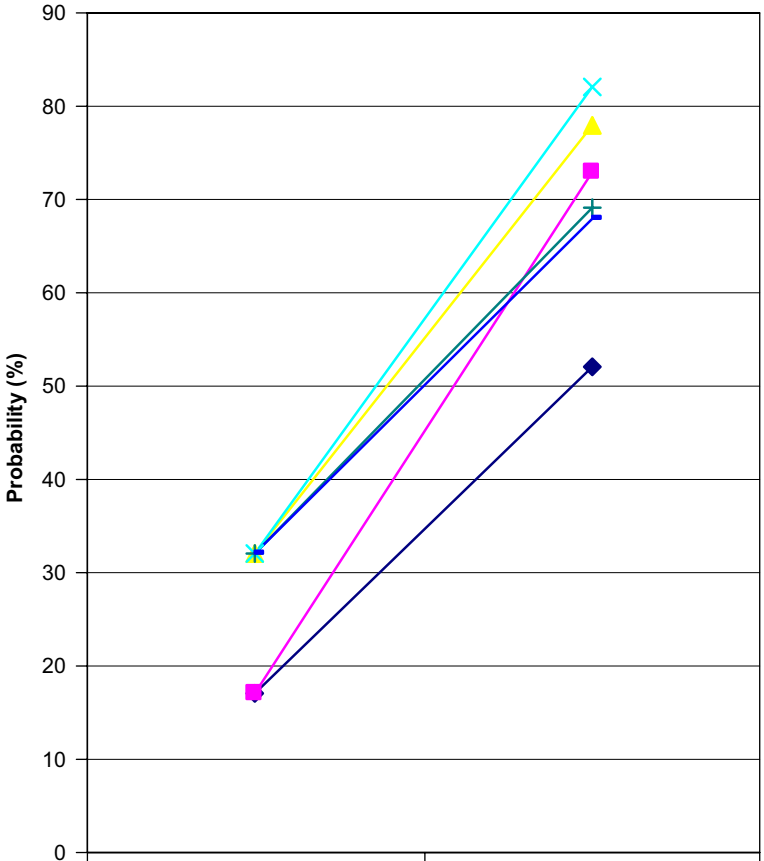
Discussion

In this systematic review, we found two QE-ST-DRU, the MST and the SNAQ, which were studied with high quality in terms of analytical accuracy. Both tools showed clinically relevant sensitivity and specificity in the general hospital inpatient population. No adequate study on a QE-ST-DRU for the general hospital outpatient population was found.

The selection process of our search was performed with good agreement between the reviewers. The comprehensive search strategy included all relevant studies also mentioned at the reviews of Jones[13] and Green and Watson.[34] Initially, we identified 39 QE-ST-DRU studies from which sensitivity and specificity could be derived. This is in contradiction to the results of Jones[13] and Green and Watson[34] who reported less than 10 studies with these data. This difference is mainly caused by the fact that in the current review also studies were included in which sensitivity and specificity were not presented by the initial authors but could be reconstructed from the data. Another reason is that QE-ST-DRU not specifically aimed to be used by nurses were included as well.

Green and Watson[34] mentioned in their review about nutritional screening tools, that quality assessment would have no additional value. This would result in many unanswered quality items because of the insufficient style of reporting by the study authors. This is not our view, we applied the QUADAS, and there were only a few items scored with 'unclear'. This was, indeed because these aspects were reported poorly (items 4, 10 and 11). In our study, the overall quality assessment was performed with good to excellent agreement. A few items were inconsistently rated by different interpretation of the QUADAS items. After discussion, the reviewers reached full consensus (Appendix 3).

The QE-ST-DRU found in our review did not correspond with the tools advised by ASPEN or ESPEN.[10,35] ASPEN opposed the Subjective Global Assessment tool. This method was not found quick-and-easy and was therefore excluded in our review. ESPEN advised the Nutritional Risk Score (NRS) for the hospital setting, the Malnutrition Universal Screening Tool (MUST) for the adult community setting and the MNA-SF specific to elderly. Our search did not include the NRS because no analytical accuracy studies of this tool were found. The MUST was initially included but did not meet the criterion of clinically relevant sensitivity and specificity (lower limit of the CI at 65% or higher). The MNA-SF was not performed at a representative population as only (frail) elderly were included in their diagnostic studies. What should be realised, when interpreting our results, is that the evaluation of analytical accuracy is limited, and only one way of assessing the clinical value of a screening tool.[21] Next to sensitivity and specificity, no other important aspects of validity such as predictive validity, i.e., that clinical outcome will improve, were directly analysed within our systematic review. Indirectly, the improvement of clinical outcome was taken into account because sensitivity and specificity are reflections of the reference standard. The reference standard was considered acceptable as the included parameters suggest to identify those patients who benefit from nutritional intervention on clinical outcome. However, the criteria used to define a reference standard as acceptable are arbitrary and involve



	Prevalence	PPV
MST>1A	17	52
MST>2A	17	73
SNAQ> 2A	32	78
SNAQ>3 A	32	82
MST>1B		
MST>2B		
SNAQ>2 B	32	69
SNAQ>3 B	32	68

Figure 3 Bayes Theorem: a-priori screening probability of being truly malnourished (prevalence) versus posterior probability of being truly malnourished after screened positive (positive predictive value).

uncertain assumptions concerning the validity of our review. Elia et al.[36] did perform a systematic review that specifically reported on clinical outcome after intervention initiated by results of screening. Unfortunately, Elia had to conclude that the overall study quality, of the finally left nine studies, was poor. Overall, the studies suggest that nutritional screening linked to a care plan, had benefit in specific conditions and specific wards or hospitals. Our idea of comparing nutritional screening tools to reference standards was intended to organise and rank order, and thereby create assess to all performed analytical accuracy studies on nutritional screening. Every dietician or caregiver can select from our results (Table 3 and Appendix 2) their own population, their own current used or preferred 'ideal' more comprehensive diagnostic assessment and check if there is a methodological sound QE-ST-DRU independent of our definitions.

Of the two tools we found, the MST suggest it has better analytical accuracy than the SNAQ. However, in the MST study more bias can be expected. The study was not only vulnerable to review bias, since there was no blinding of the reference standard, but also was the test performance only assessed in the population in which the tool was developed (no cross-validation).[18] When the SNAQ was tested in a subsequent population, the SNAQ showed a lower sensitivity and specificity which is also expected to occur for the MST. Although the SNAQ and MST seem very comparable with regard to their items, they do differ in who is referred to the dietician after being positively screened. The SNAQ score is differentiated in a score of >2 receiving energy and protein-enriched diet, and a score of >3 receiving treatment by a dietician in addition to the energy and protein-enriched diet. A score of >2 on the MST results

invariantly to a referral to the dietician. A score >1 on the MST seems comparable to a score of the SNAQ >2 which suggests that a differentiated action plan can be improvised. However, the positive predictive value of the MST decreases dramatically if a score of >1, instead of >2, is chosen for the MST. This suggests that many patients would receive unnecessary diet modifications. Besides the influence of bias and the influence off chosen cut-off points on analytical accuracy, it should be realised that sensitivity and specificity are a reflection of the chosen reference standard. The reference standard of the SNAQ and MST study were both judged as acceptable, but they do differ. To really compare the analytical accuracy, or any study result on the DRU subject, a reference standard to diagnose DRU should be universally agreed. To define QE-ST-DRU as clinically relevant, we stated that the underlimit of the 95% confidence interval of sensitivity and specificity at least should be 65% or higher. If we defined this point at 70% or 75% the results of review would be slightly different. The analytical accuracy of the cross-validation study of the SNAQ would not withhold to be clinically relevant; e.g. the underlimit of the 95% confidence interval of the sensitivity is 69%. However, the analytical accuracy of the SNAQ remains clinically relevant based on their initial study compared to the MST study. The diagnostic gain of 50% shows the clinical benefit of replacing a comprehensive diagnostic assessment by a QE-ST-DRU in reducing the workload of dieticians.

At last, it should be stressed that the tools recommended by ESPEN could be viewed as an acceptable reference standard as defined in our review. Thus, they, theoretically, are preferred above the SNAQ and the MST. But, all the ESPEN tools are considered too comprehensive to be used by nurses and medical staff as routine nutritional screening. Calculations as percentage weight loss and BMI are too time-consuming for routine use in clinical practice. In contrast, the SNAQ and the MST are very quick to fill in (<3 min) and easy to use (<3 questions without any calculations). The MUST and the NRS, containing the four items: weight loss, BMI, nutritional evaluation and disease severity, are to our opinion much more useful as reference standard to diagnose DRU in nutritional research and diagnostic assessment than as a standard screening tool.

The high applicability of the MST and the SNAQ combined with their clinically relevant sensitivity and specificity, make them the most accurate tools ready to implement at the general hospital inpatient population found in our systematic review. Next to a high qualitative analytical accuracy study, a cost-effectiveness study for the SNAQ was performed: Implementing the SNAQ protocol was cost-effective and resulted in a reduced length of hospital stay compared to a historic control group with unstructured nutritional care.[37] This improvement in clinical outcome by implementing the SNAQ protocol, together with clinically relevant sensitivity and specificity, is compelling evidence to implement this nutritional screening procedure.

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Contribution of reviewer(s)	
L.M.W. van Venrooij	Conceptualised, wrote and carried out the study, analysed the data and wrote the paper
R. de Vos	Reviewed the methodology of the protocol, reviewed the analysis and co-authored the paper
A. M.M.J Borgmeijer-Hoelen	In and excluded studies as defined in protocol independently of L.V. and reviewed the paper
H.M. Kruizenga	Carried out the methodology assessment of the included studies independently of L.V. and reviewed the paper
C.F. Jonkers-Schuitema	Reviewed the protocol and paper
B.A.J.M. de Mol	Reviewed the protocol and paper

Table A1 The QUADAS checklist: a tool for the quality assessment of studies of analytical accuracy included in systematic reviews.[19]

1. Was the spectrum of patient representative of the patients who will receive the test in practice?*
2. Were selection criteria clearly described?
3. Is the reference standard likely to correctly classify the target condition?
4. Is the time period between reference standard and index test short enough to be reasonably sure that the target condition did not change between the two tests?
5. Did the whole sample or a random selection of the sample, receive verification using a reference standard of diagnosis?
6. Did patients receive the same reference standard regardless of the index result?
7. Was the reference standard independent of the index test (i.e. the index test did not form part of the reference standard)?
8. Was the execution of the index test described in sufficient detail to permit replication of the test?
9. Was the execution of the reference standard described in sufficient detail to permit its replication?
10. Were the index test results interpreted without knowledge of the results of the reference standard?
11. Were the reference standard results interpreted without knowledge of the results of the index test?
12. Were the same clinical data available when the results were interpreted as would be available when the test is used in practice?
13. Were not interpretable/intermediate test results reported?
14. Were withdrawals from the studies explained?

*All questions are answered by yes, no or unclear.

Table A2 All QE-ST-DRU which were compared versus a non-acceptable reference standard with derivable sensitivity and specificity.

First author, year		Setting	Mean age	Tool	Item (*n*)	Time (min)	Reference standard	Sample size	Prevalence (%)	Sensitivity (95% CI)	Specificity (95% CI)
Primary care											
Secondary care: outpatient clinic											
Specific subgroups											
Ravasco, 2003[56]	6	Oncology scheduled for radiotherapy	53c	BMI < 20	2	< 3	WL > 10%	205	84	27 (20–34)	27 (13–46)
Oksa, 1991[57]	7	Nephrology scheduled for haemodialysis	Xc	BMI < 22	2	< 3	AMC < 22 cm	29	X	72 (X)	73 (X)
Secondary care: inpatient clinic											
Specific subgroups											
Ravasco, 2003[58]	8	Oncology	62.7c	Patient-Generated SGA (Ottery)	7	< 10	WL > 10%	78	X	90 (X)	95 (X)
Abayomi, 2004[59]	9	Acute psychiatric unit	39a	Nutritional Risk Tool (Reilly)	5	< 5	Subjective nurse documentation	112	42	60 (44–74)	56 (43–68)
General surgery and internal medicine											
Galvan, 2004[60]	10		54c	Prideaux Nutritional Risk Assessment	8	< 10	NRI	640	60	33 (28–38)	92 (88–95)
Elmore, 1994[61]	11		Xc	Nutritional Screening	7	< 5	Subjective assessment (history, bedside review, lab, anthropometrics)	151	31	72 (57–84)	84 (75–90)
Coenen, 2002[62]	12		51c	Screening Tool	5	< 10	NRI	282	23	62 (51–72)	70 (63–76)
Burden, 2001[25]	13		63c	Nutrition Screening Tool > 15	7	< 5	MUAC < 15th	100	35	82 (63–76)	86 (75–93)
	14						EAR < 25%		21	59 (34–78)	86 (76–93)
	15						WL > 10%		21	35 (15–57)	86 (76–93)
	16						BMI < 20		23	59 (39–80)	92 (84–97)
Apicello, 2005[63]	17		Xc	Nutrition Screening Tool	2	< 3	Nutritional assessment by dietician	145	64	63 (52–72)	100 (93–100)

Table A2 (*continued*)

First author, year		Setting	Mean age	Tool	Item (*n*)	Time (min)	Reference standard	Sample size	Prevalence (%)	Sensitivity (95% CI)	Specificity (95% CI)
Kovacevich, 1997[64]	18		56.9c	Nutrition Screening Tool	4	<5	Pre-albumin <16 mg/dl	56	23	85 (55–98)	63 (26–88)
General internal medicine											
Stratton, 2004[26]	19		44c	Malnutrition Universal Screening Tool	4	<5	MST (Ferguson)	75	29	77 (55–92)	93 (82–98)
General surgery											
Doyle, 2000[65]	20		45c	Undernutrition Risk Score	7	<5	NRI	40	41	71 (41–89)	90 (73—99)
Tertairy care											
Campillo, 2004[66]	21	Rehabilitative care hospital	69c	BMI <20	2	<3	AMC and TST	1052	13	59 (50–67)	90 (88–92)
Bryan, 1998[67]	22	Learning difficulties at rehabilitative care hospital	56c	Nutrition Screening Form	22	<10	Nutritional adequacy	35	46	75 (48–93)	95 (74–100)
	23						Weight		67	80 (56–93)	60 (28–85)
	24						Nutritional-related problems		60	95 (76–100)	71 (42–92)
Mixed settings											

a = adults; no elderly, b = elderly, c = adults and elderly, d = all ages (inclusion criteria age), X = data not available, SGA = Subjective Global Assessment (Detsky), NRI = Nutritional Risk Index (Naber) (albumin and WL), WL = weight loss, AMC = Arm muscle circumference, MUAC = Mid upper arm circumference, EAR = estimated average requirement, TST = triceps skinfold thickness.

Table A3 Quality assessment (QUADAS) of all studies in which the QE-ST-DRU has clinically relevant sensitivity and specificity and an acceptable reference standard.

First author, year		Setting	Mean age	2	3	4	5	6	7	8	9	10	11	12	13	14	Yes (2–14)	1 IPC	1 OPC
Primary care																			
Ward, 1998[40]	3	Home Care	74.0c	n	y	n	y	y	n	y	n	y	y	y	y	y	9	n	n
Secondary care: outpatient clinic																			
Specific subgroups																			
Ferguson, 1999[28]	4	Oncology scheduled for radiotherapy	59.9c	y	y	y	y	y	n	y	y	y	y	y	y	y	12	n	n
General surgery																			
Cohendy, 2001[29]	5	Elective surgery or exploration under anaesthesia	72.0b	y	y	y	y	y	n	y	y	n	n	n	y	y	10	n	n
Secondary care: inpatient clinic																			
General surgery and internal medicine																			
Thorsdottir, 2005[47]	15		83b	y	y	?	y	y	n	y	y	?	y	y	y	y	10	n	n
Oakley, 2000[30]	20		Xc	y	y	y	y	y	n	y	n	n	y	n	y	n	8	y	n
Murtaugh, 1995[31]	21		Xc	n	y	y	y	y	n	n	n	y	y	y	y	n	8	y	n
Kruizenga, 2005[32]	22		58.4c	y	y	y	y	y	n	y	y	y	y	y	y	y	12	y	n
	23		60.6c	y	y	y	y	y	n	y	y	y	y	y	y	y	12	y	n
Ferguson, 1999[33]	25		57.7c	y	y	y	y	y	n	y	y	n	y	n	y	y	10	y	n
Mixed setting																			
Rubenstein, 2001[55]	41	Community-dwelling (596) and hospital geriatric inpatients (306) (Toulouse-91 database)	76.4b	y	y	y	y	Y	n	y	y	y	y	y	y	y	12	n	n
	42	Internal medicine (105) and home-dwelling elderly (50) (Toulouse-91 database)	78.3b	y	y	y	y	Y	n	y	y	y	y	y	y	y	12	n	n
	43			y	y	y	y	Y	n	y	n	y	y	y	y	y	11	n	n
		Agreement QUADAS	Kappa	0.609	1.0	1.0	1.0	1.0	0.174	0.125	0.609	0.526	0.400	1.0	1.0	1.0		1.0	1.0

a = adults, no elderly, b = elderly, c = adults and elderly, d = all ages, ? = unclear, n = no, y = yes, X = not available, IPC = inpatient clinic, OPC = outpatient clinic.

Appendix 1

See Table A1 for further details.

Appendix 2

See Table A2 for further details.

Appendix 3

See Table A3 for further details.

References

1. Wilson MG, Vaswani S, Liu D, Morley JE, Miller DK. Prevalence and causes of undernutrition in medical outpatients. *Am J Med* 1998;**104**:56–63.
2. Kruizenga HM, Wierdsma NJ, Van Bokhorst dvdSMAE, et al. Screening of nutritional status in the Netherlands. *Clin Nutr* 2003;**22**(2):147–52.
3. Edington J, Boorman J, Durrant ER, Perkins A, Giffin CV, James R. Prevalence of malnutrition on admission to four hospitals in England. *Clin Nutr* 2000;**19**(3):191–5.
4. McWhirter JP, Pennington CR. Incidence and recognition of malnutrition in hospital. *BMJ* 1994;**308**:945–8.
5. Isabel M, Correia TD, Waitzberg DL. The impact of malnutrition on morbidity, mortality, length of stay and costs evaluated through a multivariate model analysis. *Clin Nutr* 2003;**22**(235):239.
6. Tucker HN, Miguel SG. Cost containment through nutrition intervention. *Nutr Rev* 1996;**54**(4):111–21.
7. Green CJ. Existence, causes and consequences of disease related malnutrition in the hospital and community, and financial benefits of nutritional interventions. *Clin Nutr* 1999;**18**(Suppl 2):3–28.
8. Allison JP. Malnutrition, disease and outcome. *Nutrition* 2000;**16**(7/8):590–3.
9. Streiner DL, Norman GR. *Validity. health measurements scales: a practical guide to their development and use*, 3rd ed. 2003. p. 172–93.
10. Kondrup J, Allison SP, Elia M, Vellas B, Plauth M. ESPEN guidelines for nutrition screening 2002. *Clin Nutr* 2003;**22**(4): 415–21.

11. Elia M, *Malnutrition advisory group A standing committee of BAPEN*. The 'MUST' report, Nutritional screening of adults: a multidisciplinary responsibility. 2005.
12. Bouter LM, Dongen van MCJM. Diagnostic research (Diagnostiek). *Epidemiology* (*Epidemiologisch onderzoek*), 3rd ed. 1999. p. 271–337.
13. Jones JM. The methodology of nutritional screening and assessment tools. *J Hum Nutr Diet* 2002;**15**:59–71.
14. Cochrane Collaboration. *Diagnostic reviewers' handbook*. Internet 2004, Available from: URL: 〈http://www.cohrane.org/newslett/ccnews31-lowres.pdf〉.
15. Stratton RJ, Green CJ, Elia M. *Scientific criteria for defining malnutrition. Disease-related Malnutrition: An evidence-based approach to treatment*, 1st ed. 2003. p. 1–34.
16. Irwig L, Bossuyt P, Glasziou P, Gatsonis C, Lijmer J. Designing studies to ensure that estimates of test accuracy are transferable. *BMJ* 2002;**324**:669–71.
17. Bossuyt PM, Reitsma JB, Bruns DE, et al. Towards complete and accurate reporting of studeis of diagnsotic accuracy: the STARD initiative. *BMJ* 2003;**326**(41):44.
18. Reitsma JB. *QUADAS and diagnostic reviewers' handbook*. 2005. Ref Type: Personal Communication.
19. Whiting P, Rutjes AWS, Reitsma JB, Bosuyt PMM, Kleijnen J. The development of QUADAS: a tool for the quality assessment of studies of diagnostic accuracy included in systematic reviews. *BMC Med Res Methodol* 2003;**3**(25):1–13.
20. Motulsky H. *"Exact" confidence intervals are not exactly correct*. 〈http://www.graphpad.com/articles/CIof〉 Proportion 2005.
21. Deeks JJ. Systematic reviewes in health care: systematic reviews of evaluations in diagnostic and screening tests. *BMJ* 2001;**323**:157–62.
22. Altman DG. *Diagnostic tests. Practical statistics for medical research*. 1999. p. 409–19.
23. Simel DL, Samsa GP, Matchar DB. Likelihood ratios with confidence: sample size estimation for diagnostic test studies. *J Clin Epidemiol* 1991;**44**(8):763–70.
24. Altman DG. *Inter-rater agreement. Practical statistics for medical research*. 1999. p. 403–9.
25. Burden ST, Bodey S, Bradburn YJ, et al. Validation of a nutrition screening tool: testing the reliability and validity. *J Hum Nutr Diet* 2001;**14**(4):269–75.
26. Stratton RJ, Hackston A, Longmore D, et al. Malnutrition in hospital outpatients and inpatients: prevalence, concurrent validity and ease of use of the 'malnutrition universal screening tool' ('MUST') for adults. *Br J Nutr* 2004;**92**(5):799–808.
27. Laporte M, Villalon L, Payette H. Simple nutrition screening tools for healthcare facilities: development and validity assessment. *Can J Diet Pract Res* 2001;**62**(1):26–34.
28. Ferguson ML, Bauer J, Gallagher B, Capra S, Christie DR, Mason BR. Validation of a malnutrition screening tool for patients receiving radiotherapy. *Australasian Radiol* 1999;**43**(3):325–7.
29. Cohendy R, Rubenstein LZ, Eledjam JJ. The mini nutritional assessment-short form for preoperative nutritional evaluation of elderly patients. *Aging* 2001;**13**(4):293–7.
30. Oakley C, Hill R. Nutrition assessment score validation and the implications for usage. *J Hum Nutr Diet* 2000;**13**:343–52.
31. Murtaugh MA, Dalton C, Sowa D, Ratz N, Lipson S. Validation of a rapid 2 factor screen for malnutrition against the current rush-prebyterian-St. Luke's medical center 7 factor nutritional screen. *J Am Diet Assoc A*. 1995;**33** [Ref Type: Abstract].
32. Kruizenga HM, Seidell JC, de Vet HC, Wierdsma NJ, van Bokhorst-de van der Schueren MA. Development and validation of a hospital screening tool for malnutrition: the short nutritional assessment questionnaire (SNAQ). *Clin Nutr* 2005;**24**:75–82.
33. Ferguson M, Capra S, Bauer J, Banks M. Development of a valid and reliable malnutrition screening tool for adult acute hospital patients. *Nutrition* 1999;**15**(6):458–64.
34. Green SM, Watson R. Nutritional screening and assessment tools for use by nurses: literature review. *J Adv Nurs* 2005;**50**(1):69–83.
35. A.S.P.E.N. Guidelines for the use of parenteral and enteral nutritiotn in adult and pediatric patients: part 3 nutrition assessment—adults. *J Parenteral Enteral Nutr* 2002;**26**(1):9SA–12SA.
36. Elia M, Zellipour L, Stratton RJ. To screen or not to screen for adult malnutrition. *Clin Nutr* 2005;**24**:867–84.
37. Kruizenga HM, Van Tulder MW, Seidell JC, Thijs A, Ader HJ, Van Bokhorst MAE. Effectiveness and cost-effectiveness of early screening and treatment of malnourished patients. *Am J Clin Nutr* 2005;**82**:1082–9.
38. Gregoire MJH, Chow S, Spooner GR, Cave AJ, Klemka PJ. A screening instrument to identify adults with nutritional risks in a family medicine practice. *Can J Diet Pract Res* 1999;**60**(4):205–11 [Winter (11 ref) 1999;(4):205–11].
39. Borowiak E, Kostka T. Usefulness of short (MNA-SF) and full version of the Mini Nutritional Assessment (MNA) in examining the nutritional state of older persons. *New Medicine* 2003;**6**(4):125–9.
40. Ward J, Close J, Little J, et al. Development of a screening tool for assessing risk of undernutrition in patients in the community. *J Hum Nutr Diet* 1998;**11**:323–30.
41. Wolf CA, Milde C, Stiedenroth N, Holscher C, Hollatz E, Lichtenegger W. Comparison of two screening tools for malnutrition in gynecologic cancer patients. *Clin Nutr* 2002;**88** [Ref Type: Abstract].
42. Bauer J, Capra S, Ferguson M. Use of the scored Patient-Generated Subjective Global Assessment (PG-SGA) as a nutrition assessment tool in patients with cancer. *Eur J Clin Nutr* 2002;**56**(8):779–85.
43. Bauer J, Capra S. Comparison of a malnutrition screening tool with subjective global assessment in hospitalised patients with cancer–sensitivity and specificity. *Asia Pacific J Clin Nutr* 2003;**12**(3):257–60.
44. Thorsdottir I, Gunnarsdottir I, Eriksen B. Screening method evaluated by nutritional status measurements can be used to detect malnourishment in chronic obstructive pulmonary disease. *J Am Diet Assoc* 2001;**101**(6):648–54.
45. Gossumvan A, Drumel L, Montoisy C, Arvanitaki M, Vereecken S. A rapid screening tool for detecting malnutrition. *Clin Nutr [Suppl]* 2003:S6 [Ref Type: Abstract].
46. Martins CA, Correia JR, Amaral TF. Nutritional risk screening NRS 2001 in undernutrition risk screening of hospitalised elderly. *Clin Nutr [Suppl]* 2003:S94 [Ref Type: Abstract].
47. Thorsdottir I, Jonsson PV, Asgeirsdottir AE, Hjaltadottir I, Bjornsson S, Ramel A. Fast and simple screening for nutritional status in hospitalized, elderly people. *J Hum Nutr Diet* 2005;**18**(1):53–60.
48. Thorsdottir I, Eriksen B, Eysteinsdottir S. Nutritional status at submission for dietetic services and screening for malnutrition at admission to hospital. *Clin Nutr* 1999;**18**(1):15–21.
49. Goudge DR, Williams A, Pinnington LL. Development, validity and reliability of the Derby Nutritional Score. *J Hum Nutr Diet* 1998;**11**(5):411–21.
50. Azad N, Murphy J, Amos SS, Toppan J. Nutrition survey in an elderly population following admission to a tertiary care hospital. *CMAJ* 1999;**161**(5):511–5 [Sep 7 (39 ref) 1999 September 7;(5):511–5].
51. Schuetz T, Pirlich M, Norman K, Benesch T, Kapitan M, Lochs H. Assessment of malnutrition in hospitalised patients: comparison of different methods. *Clin Nutr [Suppl]* 2004;**00**:771 [Ref Type: Abstract].

52. Laporte M, Villalon L, Thibodeau J, Payette H. Validity and reliability of simple nutrition screening tools adapted to the elderly population in healthcare facilities. *J Nutr Health Aging* 2001;**5**(4):292–4.
53. Acuna K, Portela M, Costa-Matos A, et al. Nutritional assessment of adult patients admitted to a hospital of the Amazon region. *Nutr Hosp* 2003;**18**(3):138–46.
54. Visvanathan R, Penhall R, Chapman I. Nutritional screening of older people in a sub-acute care facility in Australia and its relation to discharge outcomes. *Age Ageing* 2004;**33**(3):260–5 [May (29 ref) 2004 May;(3):260–5].
55. Rubenstein LZ, Harker JO, Salva A, Guigoz Y, Vellas B. Screening for undernutrition in geriatric practice: developing the short-form mini-nutritional assessment (MNA-SF). *J Gerontol A Biol Sci Med Sci* 2001;**56**(6):M366–72.
56. Ravasco P, Monteiro-Grillo I, Vidal PM, Camilo ME. Nutritional deterioration in cancer: the role of disease and diet. *Clin Oncol (R Coll Radiol)* 2003;**15**(8):443–50.
57. Oksa H, Ahonen K, Pasternack A, Marnela KM. Malnutrition in hemodialysis patients. *Scand J Urol Nephrol* 1991;**25**(2):157–61.
58. Ravasco P, Mourao F, Amando D, Camilo M. Searching for a nutritional screening and assessmnet tool! *Clinical nutrition/ESPEN congress*, S4–S5. 2003 [Ref Type: Abstract].
59. Abayomi J, Hackett A. Assessment of malnutrition in mental health clients: nurses' judgement vs. a nutrition risk tool. *J Adv Nurs* 2004;**45**(4):430–7.
60. Galvan O, Joannidis M, Widschwendter A, et al. Comparison of different scoring methods for assessing the nutritional status of hospitalised patients. *Wien Klin Wochenschr* 2004;**116**(17–18): 596–602.
61. Elmore MF, Wagner DR, Knoll DM, et al. Developing an effective adult nutrition screening tool for a community hospital. *J Am Diet Assoc* 1994;**94**(10):1113–8 [1121].
62. Coenen C, Bokkerink S, Achterberg van T, Naber T. Validation and reliability of a screening tool for nurses to detect a risk for malnutrition in hospital patients. *Clinical nutrition/ESPEN congress*, 88. 2002 [Ref Type: Abstract].
63. Apicello AL, McLymont V, Cox SA, Faoye OO. Effectiveness of Nutrition Screening Tool to identify patients at risk of malnutrition. *Nutr Clin Pract* 2005;**20**(1):122 [Ref Type: Abstract].
64. Kovacevich DS, Boney AR, Braunschweig CL, Perez A, Stevens M. Nutrition risk classification: a reproducible and valid tool for nurses. *Nutr Clin Pract* 1997;**12**(1):20–5.
65. Doyle MP, Barnes E, Moloney M. The evaluation of an under-nutrition risk score to be used by nursing staff in a teaching hospital to identify surgical patients at risk of malnutrition on admission: a pilot study. *J Hum Nutr Diet* 2000;**13**(6):433–41 [Dec (26 ref) 2000 December;(6):433–41].
66. Campillo B, Paillaud E, Uzan I, et al. Value of body mass index in the detection of severe malnutrition: influence of the pathology and changes in anthropometric parameters. *Clin Nutr* 2004;**23**(4):551–9.
67. Bryan F, Jones JM, Russell L. Reliability and validity of a nutrition screening tool to be used with clients with learning difficulties. *J Hum Nutr Diet* 1998;**11**(1):41–50.