# VALIDATION OF THE MINI NUTRITIONAL ASSESSMENT SHORT-FORM (MNA®-SF): A PRACTICAL TOOL FOR IDENTIFICATION OF NUTRITIONAL STATUS

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**Abstract:** *Objective:* To validate a revision of the Mini Nutritional Assessment short-form (MNA®-SF) against the full MNA, a standard tool for nutritional evaluation. *Methods:* A literature search identified studies that used the MNA for nutritional screening in geriatric patients. The contacted authors submitted original datasets that were merged into a single database. Various combinations of the questions on the current MNA-SF were tested using this database through combination analysis and ROC based derivation of classification thresholds. *Results:* Twenty-seven datasets (n=6257 participants) were initially processed from which twelve were used in the current analysis on a sample of 2032 study participants (mean age 82.3y) with complete information on all MNA items. The original MNA-SF was a combination of six questions from the full MNA. A revised MNA-SF included calf circumference (CC) substituted for BMI performed equally well. A revised three-category scoring classification for this revised MNA-SF, using BMI and/or CC, had good sensitivity compared to the full MNA. *Conclusion:* The newly revised MNA-SF is a valid nutritional screening tool applicable to geriatric health care professionals with the option of using CC when BMI cannot be calculated. This revised MNA-SF increases the applicability of this rapid screening tool in clinical practice through the inclusion of a "malnourished" category.

**Key words:** Mini Nutritional Assessment, short-form, weight, body mass index, calf circumference, elderly.

## Introduction

The Mini Nutritional Assessment (MNA®) is a short, valid nutritional screening tool for free-living and clinically relevant elderly populations (1, 2). The MNA contains geriatric-specific assessment questions related to nutritional and health conditions, independence, quality of life, cognition, mobility and subjective health (3). The MNA is recommended for routine geriatric assessments by the European Society for Clinical Nutrition and Metabolism (ESPEN) (4). The MNA is easily completed within 10 to 15 minutes time (1, 2), but the MNA is used infrequently in some acute care settings due in part to the time needed to complete it (3, 5). To reduce this short time burden further, Rubenstein and colleagues developed a six question MNA short-form (MNA-SF) by identifying a subset of questions from the full MNA that had high sensitivity, specificity and correlation to the full MNA (5). This original MNA-SF identifies elderly individuals as well nourished or at risk of malnutrition so that the full MNA is needed only if a patient is classified as at risk. The diagnostic accuracy of this original MNA-SF in identifying the elderly as well nourished is comparable to the full MNA, and it can be a valid time saving alternative.

The clinical utility of the MNA and MNA-SF is challenged by several short screening tools such as the Malnutrition Universal Screening Tool (MUST) (6), the Short Nutritional Assessment Questionnaire (SNAQ) (7) and the Nutritional Risk Screening 2002 (NRS) (8). The merits of these short screening tools have been discussed previously (9), but these short, rapid screens are specifically not designed for clinical use in geriatric medicine. However they are frequently applied to some elderly patients because they are short, quick and easy to use.

Many nutritional and geriatric assessment/screening tools require the body mass index (BMI) including the full MNA. In some clinical and free living settings, measuring weight and height for the BMI can be time-consuming particularly in bedridden and immobile elderly patients. Also, in some Asian and African populations, weight and thus BMI are not common health measures (10). Calf circumference (CC) and mid-arm circumference (MAC) are possible alternatives to BMI because they can be taken easily with a tape measure, and they are also part of the full MNA (11). With the exception of a nutrition screening tool for South African elderly that includes only MAC (10), there are no screening instruments for the elderly

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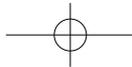
that include circumferences instead of BMI.

The aim of the present study was to revise the MNA-SF developed by Rubenstein and colleagues almost a decade ago. A revision of the MNA-SF is warranted in the light of changing demographics among elderly populations and the clinical demands of geriatric health care professionals. This revision addressed the following points: (I) Is the current MNA-SF still valid? (II) Is it useful for a revised MNA-SF to classify patients into three nutritional risk categories (well-nourished, at risk, and malnourished) as the full MNA? (III) Can an alternative measurement to BMI be used in a revised MNA-SF?

## Methods

### *Database setup*

The present study is a pooled analysis of recent, previously collected data as shown in Figure 1. Due to changing population demographics, studies published before the year 2000 were not considered. There were no language restrictions, and several investigators were known to members of the study group. Studies with data on the full MNA and the MNA-SF were accepted. Some datasets were revised before transmission to increase comprehensibility (e.g. translation into English) or to meet advisory board or ethics committee regulations on data transfer or additional information or clarification after data transmission. Each dataset was reviewed by two members of the study group (RC and KMJ) to assure data quality.

### Figure 1
Flow diagram of data collection
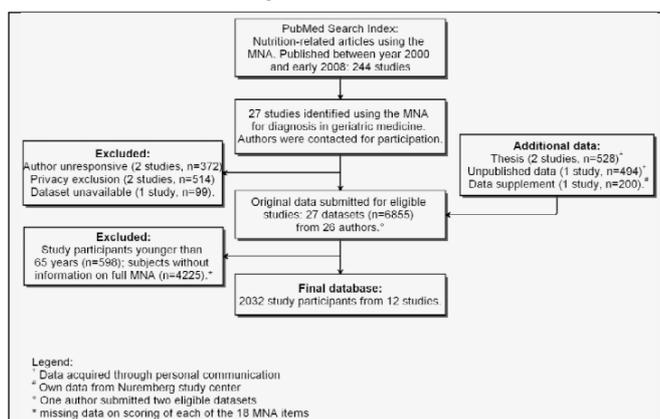


### *Revision of the MNA-SF*

Revision of the MNA-SF was based on the following conditions: the questions on "self view of nutritional status" and "self view of health status" in the full MNA were not included (as in Rubenstein's approach) due to a high number (>20 %) of "don't know" answers (5). Only one anthropometric measurement (BMI, MAC or CC) was included in a revision to avoid time-consuming measurements and to retain an appropriate balance between body measurements and general and dietary assessment status (12). The MNA-SF variation

scores were compared against scores of the full MNA. Table 1 presents a list of the questions by item included in the original MNA-SF and the full MNA.

### *Statistical analysis*

Possible versions of the revised MNA-SF were created by calculating all possible combinations of six questions from the full MNA, and these versions of the revised MNA-SF were evaluated against the full MNA. The versions with more than one anthropometric measure were discarded. The score for each MNA-SF version was calculated using the original weight of each of the included questions. These scores were correlated with the corresponding full MNA scores using Spearman's correlation coefficients. Sensitivity, specificity and the Youden-index were calculated using a dichotomized categorization of the full MNA classified as "well nourished" vs. "at risk of malnutrition/malnourished". The version of the MNA-SF were ranked according to the highest correlation coefficient and diagnostic measures, primarily sensitivity, and a Youden index (sensitivity+specificity-1) of at least 0.7 indicated good overall diagnostic accuracy.

In order to have a three-classification scoring system for the revised MNA-SF rather than the current two classifications of the original MNA-SF, receiver operating characteristic (ROC) analyses were conducted with the upper cut-point optimized for sensitivity by comparison of the revised MNA-SF with the full MNA dichotomized as "well-nourished" vs. "at risk/malnourished". The lower cut-point was optimized for specificity by comparing the revised MNA-SF with the dichotomized full MNA as "well-nourished/ at risk" vs. "malnourished". The revised MNA-SF with CC or MAC was compared to the BMI-MNA-SF by Pearson's correlation coefficient the MNA total score. The MNA-SF with either CC or MAC and the highest correlation coefficients were used as potential substitute for the BMI-MNA-SF, and another revised MNA-SF version that had no anthropometric variable. The performance of the CC-MNA-SF and MAC-MNA-SF against the full MNA is presented in bubble plots with the two respective cut-points as reference lines. Cross-tabulation of MNA-SF with full MNA in a corresponding 3x3 contingency table determined the agreement between the revised MNA-SF and the full MNA. These findings were quantified as the percentage of correct classifications. Statistical analysis was performed using SAS version 9.2 (SAS Institute, Cary, NC, USA). Graphics for ROC analyses were created with R 2.8.1 (R Foundation for Statistical Computing, Vienna, Austria).

## Results

### *Database content*

Twenty-seven datasets containing information on 6257 participants 65 years of age and older were submitted for initial consideration (one unpublished) (13-38). Only twelve of these datasets were selected for analysis because they contained answers for all of the eighteen questions on the full MNA. This
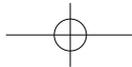
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**Table 1**
List of Full MNA Questions

| Item | Item description | Full Question | Max. score | | |
|------|------------------|---------------|------------|---|---|
| A | Appetite loss | Has food intake declined over the past 3 months due to loss of appetite, digestive problems, chewing or swallowing difficulties? | 2 | M N | |
| B | Weight loss | Weight loss during the last 3 months? | 3 | A | |
| C | Mobility | Mobility problems? | 2 | - | |
| D | Stress/acute disease | Have you suffered psychological stress or acute disease in the past 3 months? | 2 | S | |
| E | Dementia/depression | Neuropsychological problems? | 2 | F | |
| F | BMI | Body mass index in kg/m² | 3 | | |
| G | Living situation | Do you live independently (not in a nursing home or hospital)? | 1 | | F |
| H | Drugs | Do you take more than 3 prescription drugs per day? | 1 | | U |
| I | Skin lesions | Pressure sores or skin ulcers? | 1 | | L |
| J | Full meals | How many full meals do you eat daily? | 2 | | L |
| K | Protein intake | Selected consumption markers for protein intake (milk, cheese, yogurt, legumes, eggs, meat, fish, poultry) | 1 | | M |
| L | Fruits, vegetables | Do you consume more than two servings of fruits and vegetables per day? | 1 | | N |
| M | Fluid intake | How much fluid is consumed per day? | 1 | | A |
| N | Mode of feeding | Mode of feeding? | 2 | | |
| O | Nutritional status | How do you consider your nutritional status? | 2 | | |
| P | Health status | In comparison with other people of the same age, how do you consider your health status? | 2 | | |
| Q | MAC | Mid-arm circumference in cm | 1 | | |
| R | CC | Calf circumference in cm | 1 | | |

Result categories of MNA-SF: ≥12 points: normal – not at risk; ≤ 11 points: possible malnutrition. Result categories of full MNA: 24-30 points: well-nourished; 17-23.5 points: at risk of malnutrition; 0-16.5 points: malnourished

subset of datasets included 2032 study participants, 1535 women and 497 men where the mean age was 83.1±8.1 years (men 81.6±8.3 years, women 83.6±8.0 years). Of these 2032 participants, 1346 were living in nursing homes, 490 in the community, 127 in hospitals and 65 in geriatric rehabilitation facilities. These twelve datasets were from Germany (13, 14, 15, 16), Sweden (17, 18), Spain (19), Italy (20), The Netherlands (21), Australia (22), Japan (23), and South Africa (24).

### *Rankings of versions of the revised MNA-SF in comparison to the full MNA*

Table 2 presents the highest ranking coefficients for the possible revised MNA-SF compared to the full MNA using sensitivity as the primary ranking criterion. The original MNA-SF had the second-highest ranking and had nearly the same sensitivity and specificity and identical Youden-index as the best performing revised MNA-SF that included the original MNA-SF questions but with "mode of feeding" replacing "appetite loss."

### *Determination of three nutritional classifications for the revised MNA-SF*

The ROC curves for two cut-points are shown in Figure 2. The upper cut-point at a score of eleven demonstrated a sensitivity of 89.3% and a specificity of 81.8%, with the area under the curve being 0.94. The lower cut-point at a score of eight had a sensitivity of 85.2% and a specificity of 94.3%, with the area under the curve being 0.97. Figure 3 graphically

presents the correlation between the revised MNA-SF and full MNA scores as a bubble plot. The revised MNA-SF has the three classifications that are the same as for the full MNA: 0 – 7 points: malnourished; 8 – 11 points: at risk of malnutrition; or 12 – 14 points: well-nourished.

**Table 2**
Top ten revised versions of the MNA-SF compared to the full MNA (ranked for highest sensitivity; only combinations with Youden-Index ≥0.7 shown)

| Rank | Items | Sensitivity | Specificity | Spearman's correlation with full MNA | Youden-Index |
|------|-------|-------------|-------------|--------------------------------------|--------------|
| 1 | B-C-D-E-F-N | 0.90 | 0.81 | 0.90 | 0.71 |
| 2 | A-B-C-D-E-F Original MNA-SF | 0.89 | 0.82 | 0.90 | 0.71 |
| 3 | B-C-D-E-F-L | 0.89 | 0.81 | 0.90 | 0.70 |
| 4 | B-C-D-E-F-J | 0.89 | 0.82 | 0.89 | 0.71 |
| 5 | B-C-D-E-F-K | 0.88 | 0.83 | 0.89 | 0.71 |
| 6 | B-C-D-E-F-I | 0.88 | 0.83 | 0.89 | 0.71 |
| 7 | B-C-D-E-F-M | 0.87 | 0.83 | 0.89 | 0.70 |
| 8 | B-C-D-E-N-R | 0.86 | 0.84 | 0.86 | 0.70 |
| 9 | A-B-C-D-E-R | 0.85 | 0.84 | 0.86 | 0.70 |
| 10 | A-B-C-E-F-L | 0.85 | 0.85 | 0.88 | 0.70 |

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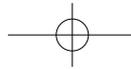
**Figure 2**
ROC curves for determination of upper (above) and lower (below) cut-point for the original MNA-SF



one cut-point were compared (s. table 2), and the number of correct classifications was lower at 77.5% after calculation of the second cut-point using the methods described above.

**Figure 3**
Bubble-plot of revised MNA-SF against full MNA. Vertical bars represent short-form cut-points; horizontal bars represent full MNA cut-points
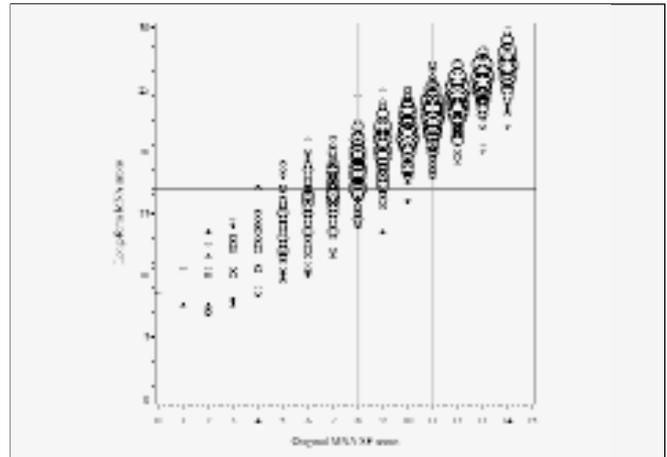


**Table 3**
Top ten revised versions of the MNA-SF without BMI compared to the full MNA (ranked for highest sensitivity)

| Rank | Items | Sensitivity | Specificity | Spearman's correlation with full MNA | Youden-Index |
|---|---|---|---|---|---|
| 1 | A-B-C-E-H-R | 0.88 | 0.78 | 0.84 | 0.66 |
| 2 | B-C-D-E-M-R | 0.88 | 0.80 | 0.85 | 0.68 |
| 3 | B-C-E-H-J-R | 0.87 | 0.79 | 0.81 | 0.66 |
| 4 | A-B-C-D-E-M | 0.86 | 0.80 | 0.83 | 0.67 |
| 5 | B-C-D-E-N-R | 0.86 | 0.84 | 0.86 | 0.70 |
| 6 | B-C-D-E-L-R | 0.86 | 0.83 | 0.86 | 0.69 |
| 7 | A-B-C-D-E-R | | | | |
| „ | CC-MNA-SF" | 0.85 | 0.84 | 0.86 | 0.70 |
| 8 | A-B-C-D-E-N | 0.85 | 0.83 | 0.85 | 0.67 |
| 9 | B-C-D-E-L-N | 0.85 | 0.82 | 0.84 | 0.66 |
| 10 | A-B-C-D-E-L | 0.84 | 0.83 | 0.83 | 0.67 |

Cross-tabulation of the revised MNA-SF (with three classifications) against the full MNA revealed that 1623 out of 2032 cases (79.9%) were classified correctly. No participant classified as "malnourished" by the full MNA was classified as "well-nourished" by the MNA-SF and vice versa. In 409 cases, participants were misclassified by one category, and in 220 of these 409 cases (53.8%) the revised MNA-SF classified participants in a lower category (i.e. "at risk" or "malnourished") than the full MNA. In 189 of these 409 cases (46.2%), the MNA-SF classified participants in a higher category (i.e. "well-nourished" or "at risk") than the full MNA. Although the highest ranking item combination (with "mode of feeding" replacing "appetite loss") offered slightly higher sensitivity than the MNA-SF when short-form variations with

***Revision of the MNA-SF using CC instead of BMI***

The full MNA contains two anthropometric parameters in addition to BMI, mid-arm circumference (MAC) and the calf circumference (CC). Pearson's correlation coefficients between the revised MNA-SF with MAC or CC and the full MNA were 0.37 (CI 0.33-0.41) and 0.47 (CI 0.44-0.50), respectively. Combination analysis revealed that the CC-MNA-SF had the highest ranking of 4290 possible MNA-SF versions without BMI when ranked for highest sensitivity (table 3). With regard to the Youden-index, the CC-MNA-SF was one of the two revised MNA-SF versions with a value ≥0.7 indicating good diagnostic accuracy. The ranking of the revised MNA-SF with MAC instead of BMI was twelfth (sensitivity 0.84, specificity
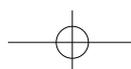
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0.82, Youden-index 0.66, not shown in table 3). In order to have a total score of 14 points as the original MNA-SF, scoring for the CC in the revised MNA-SF was changed from one point to three points. The upper cut-point at a score of eleven had a sensitivity of 90.2% and a specificity of 76.2%, with an area under the curve of 0.93. The lower cut-point at a score of eight had a sensitivity of 88.3% and a specificity of 87.1%, with an area under the curve of 0.95 (ROC curves not shown). The bubble-plot between the CC-MNA-SF and the full MNA is shown in Figure 4.

**Figure 4**
Bubble-plot of CC-MNA-SF against the full MNA. Vertical bars represent short-form cut-points; horizontal bars represent full cut-points
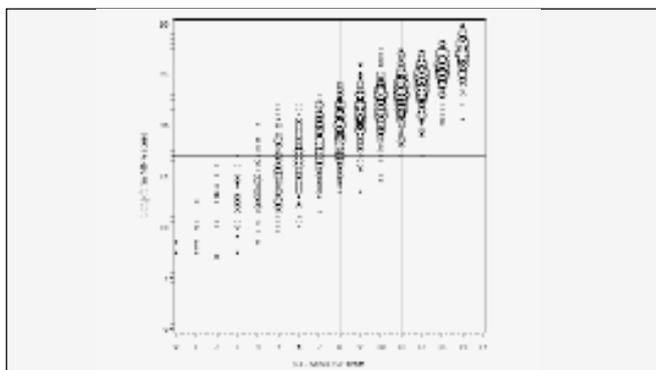


Cross-tabulation of the CC-MNA-SF with the full MNA demonstrated that 1482 of 2032 cases (72.9%) were classified correctly. No participant classified as "malnourished" by the full MNA was classified as "well-nourished" by the CC-MNA-SF and vice versa. In 550 cases, participants were misclassified by one category. In 382 of these 550 cases (69.5%) the CC-MNA-SF classified participants in a lower category (i.e. "at risk" or "malnourished") than the full MNA. In 168 of these 550 cases (30.5%) the CC-MNA-SF classified participants in a higher category (i.e. "well-nourished" or "at risk") than the full MNA.

### Application of the MNA-SF

Figure 5 presents the newly revised MNA-SF incorporating the modifications described above. This revised MNA-SF is available for use among the elderly and copies can be found on www.mna-elderly.com. The first five questions of the revised MNA-SF are unchanged for the original MNA-SF, but the sixth question can either be BMI or CC depending on the ability of taking these measurements. The total score and nutritional classifications of this revised MNA-SF are identical to the original MNA-SF and the full MNA.

**Figure 5**
The Newly Revised MNA-SF



### Discussion

### Validation of the revised MNA-SF

The present study used twenty-seven large international datasets to revise the MNA-SF for practical use in geriatric care settings. This revision was based on the original development and validation study of the MNA-SF, published by Rubenstein and colleagues in 2001 (5). In addition, two anthropometric measures were added to the general and dietary assessment. In selecting questions for inclusion in the original MNA-SF, Rubenstein determined correlations of the MNA-SF score against the full MNA score. Sensitivity, specificity and diagnostic accuracy were calculated based on a "gold standard" which was the physician's evaluation of nutritional status adopted from the initial MNA dataset collected in Toulouse in

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1991 (12). The final original MNA-SF included the six questions with highest correlation.

In the present study, combination analysis was used that systematically optimizes the desired variable (here sensitivity) by identification of an optimal combination of questions, to test more than 5500 possible versions of the revised MNA-SF. Sensitivity was selected as the primary criterion because it is essential for screening. The combination of questions on "weight loss", "mobility", "stress/ acute disease", "dementia/ depression", "BMI" and "mode of feeding" had the highest ranking and a marginally higher sensitivity than the original MNA-SF, but the specificity, correlation and Youden-index between the original and revised MNA-SF were identical. This small gain in sensitivity did not warrant changing the original MNA-SF. This confirms that the original MNA-SF is valid and compares well against the full MNA instrument.

The inclusion of a second cut-point produced a three classification scoring system for the revised MNA-SF because of the large number of participants with MNA-SF assessments classified as "at risk for malnutrition" (i.e. ≤11 points in original MNA-SF; 66% of participants in current subset). This classification indicates the need to complete the full MNA and increases the time required for a nutritional assessment. The MNA-SF cannot distinguish clearly between those elderly "at risk" and those "malnourished" because of the large proportion of these classifications. It is less problematic for the MNA-SF to misclassify elderly individuals as "at risk" or "malnourished" than with the full MNA, than if the misclassification incorrectly classified a nutritionally compromised person as being well nourished, who does thereby not receive adequate monitoring and follow-up. The original MNA-SF classified 90.7% of participants correctly or at least "unharmfully" incorrect. Accordingly, only 9.3% of the whole study population were incorrectly classified as well nourished when they were not. However, when the screening process is regularly repeated every three to twelve months, as recommended depending on an elderly person's health condition, the chance of an incorrect misclassification is minimized (39, 40, 41).

Calculating BMI requires measuring weight and height that are often unavailable in bedridden patients and in some populations; therefore, it was supplemented by using CC, which was identified as a better parameter than MAC. In addition, CC is a specific indicator for sarcopenia and showed also a good correlation with serum albumin and BMI (42, 43, 44). Use of CC as substitute for BMI has been suggested before by Bonnefoy et al. (44). Combination analysis confirmed that replacing BMI with CC maintained the largest congruence between the revised MNA-SF with BMI and the MNA-SF with CC. Identical scoring to the original MNA-SF indicated that the revised CC-MNA-SF is a clinically useful alternative. However, this necessitated the CC be re-scored from one point to three points.

The revised MNA-SF is an easier way to evaluate older patients who cannot stand or cannot be weighed. In cognitively impaired individuals, it has recently been shown that both the MNA-SF and the full MNA have good reliability, with the assistance of either a caregiver or proxy (13). We propose that this revised MNA-SF is applicable to virtually any older person, even those who are bedridden or demented who were previously excluded from nutritional screening initiatives. The three-category CC-MNA-SF classification has a slightly lower number of correct classifications as compared to the original MNA-SF but 91.7% of the study population were classified correctly or at least "unharmfully" misclassified, leaving only 8.3% misclassified with potential harm. To facilitate the practical application of the revised MNA-SF with the use of the two alternative anthropometric measurements both options are listed on the revised MNA-SF. This provides a clear choice according to availability or possibility of measuring either or both of these body measurement parameters.

### Strengths and limitations of the database

A strength of this study is the large sample of older participants and the varied clinical and community settings from which they were drawn. This supports our findings that the MNA-SF is valid in clinical and community-dwelling assessments of the elderly. The data subsets also contained data from Asian, Australian and African study participants, and this broadens the utility of the MNA-SF beyond Europe. This lack of homogeneity across the samples also explains why we observed lower values for sensitivity and specificity of the original MNA-SF in this revalidation as compared to the report by Rubenstein on only 155 participants from geriatric acute care and community settings in Toulouse, France (1, 5). It is recommended that further studies are required to test the validity of the revised MNA-SF in hospitalized elderly and those in recuperative care. Another limitation of the present study is that measurement- standardisation could not be assumed, and it is unknown whether nutrition screenings in these data were performed by physicians, nurses, dietitians, nutritionists, technical research staff or even with the help of a third party e.g. wife, husband, child, caregiver, legal proxy. Considerable differences in MNA scores can occur depending on how and by whom the MNA is completed (13).

### Conclusion

Using a large database of elderly participants from various settings and countries, we have demonstrated that the original MNA-SF is a valid and sensitive rapid nutrition screen instrument, and that it compares well with the full MNA. A revised three-category scoring of the MNA-SF is introduced with an additional classification of "malnourished" that the original MNA-SF lacked. This revision now allows the newly revised MNA-SF to be a stand-alone nutritional assessment screening tool for the elderly. A further strength of this newly revised MNA-SF is that it allows the use of either BMI or calf circumference, enabling its application in immobile individuals or in circumstances where weight and height cannot be measured such as in resource-poor settings. These

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modifications further reduce the time required for a nutritional assessment with the MNA-SF in routine nutrition screening in geriatric care.

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