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ARTICLE

# Validity of Mini Nutritional Assessment tool among an elderly population in Yeka sub-city, Addis Ababa, Ethiopia

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**Background:** The widely used nutritional assessment tool used for the elderly includes the Mini Nutritional Assessment (MNA) and Mini Nutritional Assessment–Short Form (MNA-SF) tool. These tools have not been evaluated for their validity and reliability among the elderly population of developing countries such as Ethiopia. This study aimed to evaluate the reliability and validity of the full and short form of the Mini Nutritional Assessment tool among the elderly in Ethiopia.
**Method:** We evaluated the reliability and validity of the tools using a community-based cross-sectional study among 506 elderly individuals. Accuracy, sensitivity, specificity and cut-off point were evaluated to determine the validity of both the full MNA and MNA-SF tool. Reliability was assessed using Cronbach's α coefficient. The criterion-related validity of the MNA tool was evaluated by computing the correlation between the total MNA score and anthropometric measurements. The Youden index was used to determine best cut-off points of the full MNA and MNA-SF.
**Result:** The mean MNA score was 19.9 ± 4.5. Cronbach's α value of the full MNA tool was 0.7. The overall accuracy of the full MNA was 91% (95% CI, 87.5%–94.9%). The sensitivity and specificity of the full MNA tool using an established cut-off point was 87.9% and 89.6% respectively. Youden index analysis showed that the best cut-off point to detect the malnourished and those at risk of malnutrition using the full MNA was 16 (sensitivity 90.4% and specificity 86.8%). The reliability of the MNA-SF as measured by Cronbach's α was 0.5. The overall accuracy of the MNA-SF was found to be 93% (95% CI, 0.90–0.96). By using the Youden index the best cut-off point for MNA-SF to detect malnutrition was 7.5 (sensitivity 85.7% and specificity 89%).
**Conclusion:** The full MNA tool was a valid and reliable tool to identify elderly individuals who are malnourished, at risk of malnutrition and well-nourished with modulation of cut-off points. However, the short MNA tool was valid and but not reliable in this study.

**Keywords** elderly, MNA, malnutrition, validity, reliability, sensitivity, specificity

## Introduction

The number of elderly people over the age of 60 years is growing rapidly in developing countries. By 2030, the elderly population in the developing world is projected to grow by 140%.[1] Some 15% of the world's population and 4.7% of the Ethiopian population is categorised as elderly, i.e. aged ≥ 60 years.[2,3] In the ageing and sick population, malnutrition is an important problem that has been seen in hospitals, in residential care and in the community.[4] Malnutrition is not an inevitable side effect of ageing, but many changes associated with the process of ageing can promote malnutrition. However, determining the nutritional status of the elderly is very challenging because of ageing-related changes in body anatomy, appetite, metabolism and other health problems. For instance the body mass index (BMI) may be unreliable in the presence of confounding factors such as oedema or ascites, and may not identify significant unintentional weight loss if used as a single assessment.[5]

The Mini Nutritional Assessment (MNA) tool, which was published in 1994, is a short, non-invasive, reliable and extensively evaluated nutritional assessment tool for free-living and clinically relevant elderly populations. The tool was first developed by Nestlé Institute geriatricians and tested in a variety of settings.[6] This MNA tool was recommended by the European Society for Nutrition and Metabolism for routine geriatric nutritional assessments. The MNA can be easily administered by peripheral or primary level health staff, without the need for biochemical testing or specific training in nutrition. The tool has full and short forms. The full MNA is the original version of the MNA and takes 10–15 minutes to administer.[7] It is composed of 18 questions, which are divided into four main categories: dietary assessment, subjective assessment, global assessment and anthropometric data. The short form (MNA-SF), consisting of six items, was published in 2001. All questions of the MNA-SF were derived from the full MNA. MNA-SF can be completed using calf circumference instead of BMI in cases of missing weight and height data and has a maximum of 14 points.[8,9]

Despite the simplicity and the applicability of the MNA tool to assess the nutritional status of the elderly in Ethiopia, the validity and reliability of the MNA tool has not been evaluated in Ethiopia. In light of this, we aimed to determine the criterion-related validity of the MNA tool and MNA-SF, to determine the internal consistency (reliability) of these tools among the eldersly in Yeka sub-city, Addis Ababa, Ethiopia.

## Methods and materials

### *Study setting*

The study was conducted in Addis Ababa (the capital city of Ethiopia). It is located on a well-watered plateau surrounded by hills and mountains in the geographic centre of the country. The study was conducted in Yeka sub-city, which is the largest sub-city of 10 in Addis Ababa.

### Study design and period

A community-based quantitative cross-sectional study was conducted among the community elderly. This study was conducted from March 5, 2017 to April 7, 2017. All elderly people ≥ 60 years of age and who were permanent residents (i.e. had lived for six months in the cluster) of randomly selected clusters were included in the study. The age of 60 was considered as elderly in the Ethiopian context and was the age of retirement. Elderly people with oedema and those who were severely ill were excluded from the study.

### Sample size and sampling procedure

The final sample size was determined by using a single population proportion formula. Assuming the prevalence of malnutrition at 28.3% for the elderly population,[10] a 95% confidence level, 5% margin of error and design effect 1.5, the calculated sample size was 506 elders.

A two-stage cluster-sampling technique was used to recruit study participants. Yeka sub-city was selected purposively over other sub-cities because of the larger population. A simple random sampling technique was used to select 4 districts from the total of 13 districts in the sub-city (30% of the districts in the sub-city were included as study clusters). Three clusters from each district were selected using a simple random sampling technique. The total sample size was proportionally allocated for each cluster depending on the number of households in each cluster. The study subjects from each cluster were selected by systematic sampling techniques by dividing the total households to total sample size allocated for specific clusters. Study participants of the household including rented houses selected every eighth house among the elderly population. If the selected house was closed or not available during the data collection time, the next house was considered. When there was more than one elderly person in one house, one of these was selected by simple random sampling using the lottery method.

### Data collection

Data collection was carried out using pre-tested and structured questionnaires. The full MNA tool, which comprised 18 items, was administered to the elderly people. The questionnaires were prepared in English and translated into Amharic and translated back into English by a third person to check the consistency of the language. The data were collected by three clinical nurses, three urban health extension workers and two supervisors after two days' training. The training included the objective of the study, methods like sampling techniques, a detailed description of the questionnaire, interview techniques and data cleaning.

### Mini Nutritional Assessment tool and its scoring

The full MNA score is a maximum of 30 points and classified the elderly as malnourished if they had an MNA score < 17 points, at risk of malnutrition if the score was between 17–23.5 points and well-nourished if the MNA score was ≥ 24 points. The full MNA has 18 items to be administered to the elderly, which includes: changes in dietary intake, weight loss, mobility, psychological stress or acute disease all in the past three months, dementia, BMI, lives independently, more than three prescription drugs per day, pressure sores, number of full meals per day, protein intake, intake of fruits or vegetables, fluid intake, mode of feeding, self-perceived nutritional status, self-perceived health status, mid upper-arm circumference and calf circumference. As a component of the full MNA, all anthropometric measurements (weight, height, mid upper arm circumference and calf circumference) were measured on the non-dominant arm and leg.

The short MNA has six items (changes in dietary intake, weight loss, mobility, psychological stress or acute disease all in the past three months, dementia and BMI) and all items were administered to the elderly individuals. The MNA-SF has a maximum of 14 points and they were classified as malnourished (MNA-SF < 8), at risk of malnutrition (MNA-SF 8-11) or well-nourished (MNA-SF ≥ 12).[9]

### Anthropometric measurements

#### *Height measurement*

Height was measured using a Seca 213 stadiometer (Seca, Hamburg, Germany). It was measured with the participant standing with his or her back against the measuring board, heels, buttocks, shoulders and head touching a flat upright sliding headpiece. The participants had to place legs together making the knees and ankles touch each other. Height measurement was taken at maximum inspiration and the height was recorded to the nearest 0.1 cm.

#### *Weight measurement*

Weight was measured using digital Seca scales. The scales were validated with standard weights before weighing of the study participant. The scales were placed on a hard, flat surface and participants were weighed wearing only lightweight clothing (excluding jackets, shoes and belts). Each study participant was measured twice and the average of the two measurements was recorded. In cases where the difference between the two measurements exceeded the tolerance limit the degree to which the two measurements are close, the participants were repositioned and weighed for a third time.

#### *Mid upper arm circumference (MUAC)*

MUAC was measured to the nearest 0.1 cm at the mid-point between the tip of the acromion and the olecranon process on the back of the arm while the participant held the forearm in horizontal position. The measurement was performed with the participant's arm hanging freely along the trunk using inextensible MUAC tape. Mid upper arm circumference is one item among 18 items of the MNA tool. The MUAC cut-off point levelled as: a score of 0 (MUAC < 21), a score of 0.5 (MUAC 21–23) and a score of 1 (MUAC ≥ 23) for nutritional assessment of the elderly using the MNA tool.[9]

#### *Calf circumference*

The widest calf circumference was measured between the ankle and knee to the nearest 0.1 cm using non-stretchable tape in a sitting position with the leg bent 90° at the knee and manipulated to maintain close contact with the skin without compression of underlying tissues. Calf circumference is one item among 18 items of the MNA tool. The calf circumference (CC) cut-off point levelled as: a score of 0 (CC < 31) and a score of 1 (CC ≥ 31) for nutritional assessment of the elderly using the MNA tool.[9]

#### *Body mass Index (BMI)*

BMI was calculated as bodyweight in kilograms divided by square of height in metres. Body mass index is one item among 18 items of the MNA tool. The BMI cut-off point levelled as: a score of 0 (BMI < 19 a score of), 1 (BMI 19–21), a score of 2 (BMI 21–23) and a score of 3 (BMI ≥ 23) for nutritional assessment of the elderly using the MNA tool.[9]

### Quality control

The quality of data was assured through careful design, translation and pretesting of the questionnaire. The data were monitored frequently during data collection and collected questionnaires were examined for completeness and consistency during interview by nurses and at the end of each day. The data were collected by nurses and their completeness checked by a public health officer. For the appropriateness of the designed questionnaire, pretesting of the questionnaire and translation into English language were done before the actual data-collection process.

### Data entry and statistical analysis

The data were entered using Epi-data version 3.1 (CDC, Atlanta, GA, USA), and exported to SPSS version 22.0 (IBM Corp, Armonk, NY, USA) to be cleaned and analysed.

### Reliability analysis

Internal consistency (reliability) of full the MNA and MNA-SF tool was assessed using Cronbach's α coefficient. Correlation between the total MNA score obtained and the 18 items of the MNA was calculated to estimate the reliability of the tool. Values of 0.60, 0.70 and 0.80 were considered acceptable, adequate and good respectively.[10] BMI has been found to be a useful tool in clinical and public health practice for assessing the nutritional status of adults as well as the elderly.[11] Therefore, sensitivity and specificity of the MNA tool were calculated using cross-tabulation taking into account the nutritional status of elderly individuals with the MNA score against BMI. This was done by taking the number of malnourished and well-nourished elderly people using BMI within the malnourished and well-nourished elderly people using the MNA tool.

### Validity analysis

The criterion-related validity of the tool was checked by using Pearson correlation between the total MNA score obtained and the anthropometric measurements (BMI, weight, MUAC and calf circumference).[12] The overall accuracy of the MNA tool was assessed using the area under the curve (AUC). Diagnostic accuracy of the MNA, denoted by the area under the ROC curve and ranging from 0 to1, was defined as follows: excellent >= 0.9; good 0.8–0.9, worthless 0.7–0.8, and 0.6–0.7 not good.[13] A Youden index criterion was used to define cut-off points for better sensitivity and specificity. A p-value < 0.05 was used as a cut-off point to declare the statistical significance of association.

### Ethical consideration

Ethical clearance was obtained from the Ethical Review Committee (ERC) of the School of Public Health, Addis Ababa University. All information including the objectives of the study was given to participants prior to the interview and they were asked for their willingness to participate. Informed consent was obtained from study participants prior to the interview. Those who needed intervention on their nutritional status during data collection time were counselled and referred to a health facility for proper follow-up and treatment.

## Results

### Socio-demographic characteristics of participant

A total of 506 elderly individuals participated in the study. The mean age (± SD) of the participants was 68.6 (SD = ±7.2) years. Among the 506 elderly, 259 (51.2%) were females and 247 (48.8%) males. Some 40% of those who participated in this study (201, 39.7%) do not read and write. Almost 65% (327, 64.6%) were widowed and 28.1% (127) were currently married (Table 1).

### Reliability of full MNA tool

The internal consistency of the MNA tool as measured by Cronbach's α coefficient was 0.70. Cronbach's α if an item is deleted indicates the value of Cronbach's alpha when one item from the tool was deleted. For example, in Table 2, when mobility was deleted from the tool the value of Cronbach's alpha was 0.693. Omitting BMI from the MNA items significantly lowers the Cronbach's α value, indicating the overall reliability of the tool

**Table 1:** Socio-demographic characteristics of elders in Yeka sub-city, Addis Ababa, Ethiopia, 2017 ($n = 506$)

| Variables | Frequency | Percent (%) |
|---|---|---|
| Age group in years: | | |
| 60–69 years | 311 | 61.5 |
| 70–79 years | 149 | 29.5 |
| 80 years and above | 46 | 9.0 |
| Respondents' gender: | | |
| Male | 247 | 48.8 |
| Female | 259 | 51.2 |
| Educational status: | | |
| Unable to read and write | 201 | 39.7 |
| Read and write only | 86 | 17.0 |
| Primary level completed (1–8) | 132 | 26.1 |
| Secondary and above | 87 | 17.2 |
| Marital status: | | |
| Married | 142 | 28.1 |
| Widowed | 327 | 64.6 |
| Single | 37 | 7.3 |

**Table 2:** Reliability of full MNA variables among the elderly in Yeka sub-city, Addis Ababa, Ethiopia, 2017 (Cronbach's $\alpha = 0.70$)

| MNA variables | Cronbach's α value if one MNA-SF variable deleted |
|---|---|
| Change in dietary intake in the past 3 months | 0.673 |
| Weight loss in the past 3 months | 0.672 |
| Mobility | 0.693 |
| Stress or acute disease in the past 3 months | 0.686 |
| Dementia | 0.693 |
| BMI | 0.664 |
| Lives independently | 0.691 |
| More than 3 prescription drugs per day | 0.703 |
| Pressure sores | 0.702 |
| Number of full meals per day | 0.689 |
| Protein intake | 0.687 |
| Fruit and vegetable intake | 0.695 |
| Fluid intake | 0.692 |
| Mode of feeding | 0.694 |
| Self-perceived nutritional status | 0.683 |
| Self-perceived health status | 0.691 |
| Mid arm circumference | 0.670 |
| Calf circumference | 0.675 |

(Cronbach's $\alpha = 0.664$). Conversely, deleting pressure sore and more than three prescription drugs per day increases the value of Cronbach's α to 0.702 and 0.703 respectively. Thus, avoiding inclusion of these two items from the tool would improve the overall reliability of the tool (Table 2).

A correlation analysis of the MNA items with the total MNA tool showed that BMI was strongly correlated with total MNA score ($r = 0.639$, $p < 0.001$). In contrast, pressure sore did not show any significant association with the total MNA score ($r = 0.065$, $p < 0.147$). More than three prescription drugs showed poor correlation to the total MNA score ($r = 0.097$, $p < 0.03$). All the other remaining items of the MNA showed statistically significant positive associations with the total MNA score (Table 3).

### *Validity of full MNA tool*

Criterion-related validity of the MNA tool was assessed by correlating the total MNA score to the anthropometric measurements as criteria. A significant positive correlation was observed between total MNA score and weight, CC, MUAC and BMI (Table 4). Among these, the MNA score showed higher positive correlation to weight ($r = 0.58$, $p < 0.001$) and BMI ($r = 0.57$, $p < 0.001$). Concurrent validity of the MNA tool was calculated by correlating the total MNA score and self-perceived nutritional status of participants. The MNA and self-perceived nutritional status were correlated significantly ($r = 0.43$, $p < 0.001$).

The area under the curve (AUC) was calculated and found to be 0.91 (95% CI 0.875–0.949, $p < 0.001$), which shows the overall accuracy of the MNA tool in identifying malnourished elderly people. This means that an elderly person measured with the MNA tool has 91% probability to be categorised correctly as either malnourished, at risk of malnutrition or well-nourished. According to established cut-off points, the sensitivity and specificity of the MNA tool was 87.9% and 89.6% respectively. The Youden index calculated as: Youden = J = max(sensitivity+specificity–1). By using the Youden index the best cut-off point to detect malnutrition in the present study was 16 with sensitivity and specificity of 90.4% and 86.8% respectively (Figure 1).

### *Reliability of short MNA tool*

The internal consistency of the short form MNA (MNA-SF) measured by Cronbach's α coefficient was 0.50. Omitting change in dietary intake in the past three months in the MNA-SF item lowers the Cronbach's α value to 0.424. Omitting each of the items of the MNA-SF did not push the Cronbach's α value to an acceptable level. This showed that the reliability of the MNA-SF is not acceptable (Table 5). A positive correlation was observed between the total MNA-SF score and the four items of the MNA-SF. The BMI and total score of the MNA-SF revealed a higher correlation ($r = 0.719$, $p < 0.001$) compared with others. Mobility and dementia showed weak correlations, $r = 0.399$, $p < 0.001$ and $r = 0.285$, $p < 0.001$ respectively compared with other items of the MNA-SF (Table 6).

### *Validity of the short MNA tool*

Single anthropometric measurements, weight, CC, MUAC and BMI were correlated to MNA-SF as criterion-related validity of MNA-SF tool. A significant positive correlation observed

**Table 3:** Correlation between total MNA score and 18 items of the MNA among the elderly in Yeka sub-city, Addis Ababa, Ethiopia, 2017 ($n = 506$)

| Item no. | MNA variable | r | *p*-value |
|---|---|---|---|
| 1 | Change in dietary intake in the past 3 months | 0.542 | < 0.001* |
| 2 | Weight loss in the past 3 months | 0.560 | < 0.001* |
| 3 | Mobility | 0.326 | < 0.001* |
| 4 | Stress or acute disease in the past 3 months | 0.497 | < 0.001* |
| 5 | Dementia | 0.306 | < 0.001* |
| 6 | BMI | 0.639 | < 0.001* |
| 7 | Lives independently | 0.347 | < 0.001* |
| 8 | More than 3 prescription drugs per day | 0.097 | =0.030* |
| 9 | Pressure sores | 0.065 | =0.147 |
| 10 | Number of full meals per day | 0.381 | < 0.001* |
| 11 | Protein intake | 0.359 | < 0.001* |
| 12 | Fruits and vegetable intake | 0.279 | < 0.001* |
| 13 | Fluid intake | 0.341 | < 0.001* |
| 14 | Mode of feeding | 0.341 | < 0.001* |
| 15 | Self-perceived nutritional status | 0.432 | < 0.001* |
| 16 | Self-perceived health status | 0.432 | < 0.001* |
| 17 | Mid arm circumference | 0.507 | < 0.001* |
| 18 | Calf circumference | 0.541 | < 0.001* |

MNA = Mini Nutritional Assessment, BMI = body mass index, r = Pearson correlation, * significant at $p < 0.05$.

**Table 4:** Correlation between total MNA score and anthropometric measurements of the elders in Yeka sub-city, Addis Ababa, Ethiopia, 2017 ($n = 506$)

| Criterion | Coefficients (r) | *p*-value |
|---|---|---|
| MNA $V_s$ | | |
| Weight | 0.582 | < 0.001* |
| Mid arm circumference | 0.482 | < 0.001* |
| Calf circumference | 0.565 | < 0.001* |
| BMI | 0.573 | < 0.001* |

MNA = Mini Nutritional Assessment, BMI = body mass index, r = Pearson correlation, * significant at $p < 0.05$.

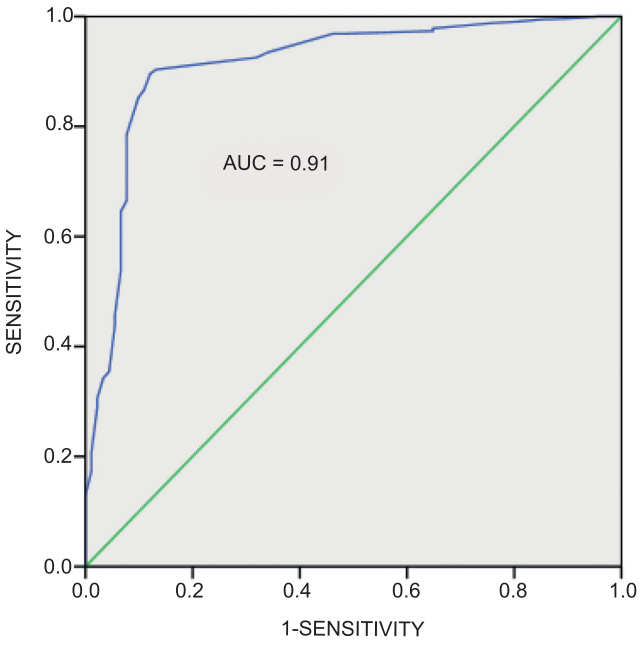


**Figure 1:** ROC curve of full MNA in predicting lower BMI (18.5 kg/m$^2$) as a marker of malnutrition in Yeka sub-city, Addis Ababa, Ethiopia, 2017 ($n = 506$).

**Table 5:** Reliability of MNA-SF among the elderly in Yeka sub-city, Addis Ababa, Ethiopia, (Cronbach's $\alpha = 0.50$), 2017 ($n = 506$)

| MNA-SF variables | Cronbach's α value if one MNA-SF variable deleted |
|---|---|
| Change in dietary intake in the past 3 months | 0.424 |
| Weight loss in the past 3 months | 0.444 |
| Mobility | 0.482 |
| Stress or acute disease in the past 3 months | 0.472 |
| Dementia | 0.505 |
| BMI | 0.409 |

MNA-SF = Mini Nutritional Assessment Short Form, BMI = body mass index.

**Table 6:** Correlation between total MNA-SF score and six items of MNA-SF among the elderly in Yeka sub-city, Addis Ababa, Ethiopia, 2017 ($n = 506$)

| Item no. | MNA variable | r | *p*-value |
|---|---|---|---|
| 1 | Change in dietary intake in the past 3 months | 0.570 | < 0.001* |
| 2 | Weight loss in the past 3 months | 0.570 | < 0.001* |
| 3 | Mobility | 0.399 | < 0.001* |
| 4 | Stress or acute disease in the past 3 months | 0.574 | < 0.001* |
| 5 | Dementia | 0.285 | < 0.001* |
| 6 | BMI | 0.719 | < 0.001* |

BMI = body mass index, MNA = Mini Nutritional Assessment, r = Pearson correlation, * significant at $p < 0.05$.

between total MNA-SF and single anthropometric measurements (Table 7). The MNA scores was strongly correlated with BMI ($r = 0.614$, $p < 0.001$) and weight ($r = 0.597$, $p < 0.001$).

The area under the curve (AUC) was calculated for the MNA-SF and found to be 0.93 (95% CI 0.901–0.958, $p < 0.001$), which shows the overall accuracy of the MNA-SF tool to identify malnourished elderly people. The total overall accuracy of the MNA-SF was found to be good according to established cut-off points; the sensitivity and specificity of the MNA tool were 85.7% and 89.7% respectively. The Youden index was calculated as: Youden = J = max(sensitivity+specificity–1). By using the Youden index the best cut-off point to detect malnutrition in the present study was 7.5, with sensitivity and specificity of 85.7% and 89% respectively (Figure 2).

## Discussion

In this study, we tried to evaluate the reliability and validity of the MNA tool among elderly people in Addis Ababa, Ethiopia.

**Table 7:** Correlation between score of total MNA-SF and anthropometric measurements of the elderly in Yeka sub-city, Addis Ababa, Ethiopia, 2017 ($n = 506$)

| Criterion | r | *p*-value |
|---|---|---|
| Weight | 0.597 | < 0.001* |
| Mid arm circumference | 0.472 | < 0.001* |
| Calf circumference | 0.543 | < 0.001* |
| BMI | 0.614 | < 0.001* |

MNA-SF = Short Mini Nutritional Assessment Tool, BMI = body mass index, r = Pearson correlation, * significant at $p < 0.05$.

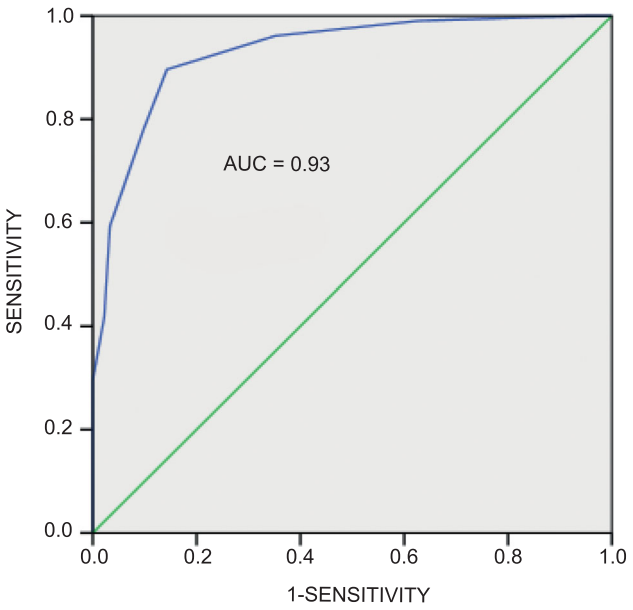


**Figure 2:** ROC curve of MNA-SF in predicting lower BMI (18.5 kg/m$^2$) as a marker of malnutrition in Yeka sub-city, Addis Ababa, Ethiopia, 2017 ($n = 506$).

The MNA tool was developed to be easy to use in identifying older people as malnourished, at risk of malnutrition or well-nourished.[14] We evaluated the internal consistency, criterion validity and overall accuracy for both the full MNA and MNA-SF tools. This study found that the reliability of the full MNA tool by Cronbach's α was 0.7, which was acceptable. This implied that the full MNA tool is reliable to assess the nutritional status of the elderly. Using a reliable tool to assess the nutritional status of elderly individuals helps to correctly identify those who are malnourished. In contrast, using an unreliable tool may result in misdiagnosis and each item of the tool measures different parameters. The reliability test measures how the items of the MNA tool were consistent, homogeneous and relatively measure the same parameter.[15] The correlation between the items of the MNA tool was positive, which showed all items that are measuring relatively correlated with each other positively. A higher value of Cronbach's α (close to 1) implies better reliability of the tool. BMI had a higher correlation to the total MNA score and removing BMI from the MNA lowered Cronbach's α value of the remaining MNA items. This shows that BMI is the most important item in the tool to assess the nutritional status of the elderly.

Regarding the reliability of full the MNA tool, deleting pressure sores and more than three prescription drugs from the full MNA tool increases the value of Cronbach's α. Pressure sores or skin ulcers commonly developed in elderly people when they spent most of their time on bed due to chronic illness.[16] Similarly, the elderly may take multiple drugs (more than three prescription drugs) if they are hospitalised or at home with follow-up. Both parameters are included to assess the nutritional status of hospitalised patients and the clinically ill elderly.[17] However, this study was conducted among the community-dwelling elderly with low prevalence of pressure sores and multiple prescription drugs. Despite this fact, many of those included in this study had no skin ulcers (pressure sores) and did not take multiple prescription drugs. As a result, poor correlation of these two parameters was observed and both showed a higher Cronbach's α if they were omitted from the tool. In

Brazil, a study conducted on validation of the MNA tool among the institutionalised elderly revealed results consistent with the present study on inter-item correlation between each item of the tool and the total MNA score. The Brazil study showed pressure sores and multiple drug prescriptions had significant correlation because the study participants were institutionalised.[18] Similarly, a significant positive correlation between total MNA score and single anthropometric measurements was observed in a study conducted in Iran, Hawassa (Ethiopia), Brazil and Nepal.[10,11,18,19]

The validity of the MNA tool depends highly on the correlation between the MNA tool and BMI, which was considered as a criterion. In the present study, strong and significant positive correlation was observed between the total MNA score and single anthropometric measurements. A high correlation between the MNA tool and BMI implies high interrelatedness of the MNA tool and BMI. The overall accuracy of the MNA tool was assessed using ROC curve and was found to be 0.91 (91%), which falls into the 'excellent' category. This finding suggests that the proportion of the MNA tool to correctly identify malnourished and well-nourished elderly individuals is 91%. This means that only 9% of the elderly individuals were identified incorrectly as malnourished or well-nourished. The larger the AUC, the better the overall performance of the MNA tool to correctly identify nutritional status of the elderly. These findings showed the MNA tool was valid and accurate to assess the nutritional status of elderly people in Ethiopia. Using an invalid tool to assess their nutritional status resulted in false categorisation of malnourished and well-nourished elderly individuals. This could have resulted in those who needed interventions being missed and well-nourished elderly individuals may have been grouped incorrectly among the malnourished. The study conducted in Hawassa found the area under the curve to indicate overall accuracy of the MNA tool to be 84%, which was lower compared with the present study.[10] The area under the curve to estimate the accuracy of the tool observed in the present study was relatively similar to the figure from the study in Spain, which was 0.88 (88%).[13]

The current study showed the sensitivity and specificity of the full MNA to be 87.9% and 89.6% respectively. This indicates the MNA tool can correctly identify true positives (87.9% of the elderly correctly identified as malnourished) and true negatives (89.6% of the elderly correctly identified as well-nourished). The original developers of the MNA reported a higher sensitivity (96%) and specificity (98%) than the current study.[17] However, in the current study sensitivity (87.9%) and specificity (89.6%) were consistent with the study conducted in Nepal.[11] Even though there was a lower specificity observed in the study conducted in Hawassa, the sensitivity observed in the current study was consistent.[10] The sensitivity and specificity of the MNA found in this study was quite similar to the study from Iran, which found 82% and 88% respectively.[19] Using the best cut-off point (MNA score 16 according to Youden index), the sensitivity increased by 2.5% and specificity decreased by 2.8%.

The overall accuracy of the MNA-SF was calculated using the ROC curve and the area under the curve (AUC) was 0.93, which falls into the 'excellent' category. The Full MNA and short MNA-SF showed relatively similar accuracy at 0.91 and 0.93 respectively. There was also strong and significant positive correlation observed between the total MNA-SF score and single anthropometric measurements, which suggest high interrelatedness of the MNA-SF tool and BMI. In the MNA-SF the reliability using Cronbach's α coefficient was found to be 0.5 and indicates that the individual items of the MNA-SF were not consistent. As the Cronbach's α coefficient value lowers, the consistency of the tool becomes low. Cronbach's alpha of less than 0.7 was not acceptable.[20] As a result, it is difficult to conclude that the MNA-SF is reliable. In this current study's findings, we can conclude that the MNA-SF tool was valid but not reliable. The MNA-SF tool may be applicable for the Ethiopian elderly to assess nutritional status with minor modification. This finding is much lower than the study conducted in Iran, with a Cronbach's α coefficient of 0.6,[19] or the finding of the full MNA's reliability in the present study.

### *Limitation and strengths of the study*

The study has its own limitations. First, dietary assessment methods were not applied and indicators for micronutrient status were not assessed for participants. Second, BMI was used as the standard marker for nutritional status for the purpose of tool validation. BMI has limited applicability in the nutritional assessment of obese individuals who are malnourished, and may underestimate malnutrition.[11] This may have influenced the result as some elderly individuals may have incorrectly been identified as malnourished or well-nourished during assessment of their nutritional status. However, as only 17 of 506 participants in the current study had a BMI $\geq 30$, it is unlikely that these findings are underestimated.

Among the strengths of this study were the inclusion of the community-dwelling elderly and the application of a simple random sampling method to recruit households. These could help to strengthen the generalisability of the results and its application to similar contexts.

## Conclusion

The current study demonstrated that the original full MNA tool was reliable and valid to identify the malnourished and those at risk of malnutrition. However, the MNA-SF was a valid but not a reliable tool to assess the nutritional status of elderly people in Yeka subcity, Addis Ababa, Ethiopia. Further research is recommended to validate the MNA tool against biochemical markers.

*Consent to participate* – Ethical approval was obtained from the Ethical Review Committee (ERC) at Addis Ababa University School of Public Health. Official letters of cooperation from ERC were obtained and given to Study selected Woreda. Prior to the interview informed consent was obtained for the study.

Information was given to the participants concerning the voluntary basis of participation and they were informed that they could stop the interview at any time if they were not comfortable. Those elderly individuals who needed interventions on their nutritional status during data collection time were counselled and referred to a health facility for proper follow-up and treatment.

*Consent for publication* – Prior to the study, written informed consent for publication was obtained from the study participants who were above 60 years.

*Availability of data and materials* – The datasets generated and/or analysed during the current study are not publicly available due to confidentiality issues but are available from the corresponding author on reasonable request.

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