

*Review*

# Nutritional risk screening tools for elderly patients with COVID-19: a systematic review

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**Abstract:** Coronavirus disease 2019 (COVID-19) is associated with high risk of malnutrition, primarily in elderly people; assessing nutritional risk using appropriate screening tools is critical. This systematic review identified applicable tools and assessed their measurement properties. Literature was searched in the MEDLINE, Embase, and LILACS databases. Four studies conducted in China met the eligibility criteria. Sample sizes ranged from six to 182, and participants' ages from 65 to 87 years. Seven nutritional screening and assessment tools were used: the Nutritional Risk Screening 2002 (NRS-2002), Mini Nutritional Assessment (MNA), MNA-short form (MNA-sf), Malnutrition Universal Screening Tool (MUST), Nutritional Risk Index (NRI), Geriatric NRI (GNRI), and modified Nutrition Risk in the Critically ill (mNUTRIC) score. Nutritional risk was identified in 27.5% to 100% of participants. The NRS-2002, MNA, MNA-sf, NRI, and MUST demonstrated high sensitivity; the MUST had better specificity. The MNA and MUST demonstrated better criterion validity. The MNA-sf demonstrated better predictive validity for poor appetite and weight loss; the NRS-2002 demonstrated better predictive validity for prolonged hospitalization. mNUTRIC score demonstrated good predictive validity for hospital mortality. Most instruments demonstrate high sensitivity for identifying nutritional risk, but none are acknowledged as the best for nutritional screening in elderly COVID-19 patients.

**Keywords:** nutritional screening; nutritional risk; nutritional assessment; malnutrition; elderly; COVID-19; coronavirus

## 1. Introduction

Disease caused by the novel coronavirus 2019 (COVID-19) is currently the most serious public health issue on several continents [1]. Older age (over 65 years) has been associated with more severe disease and worse prognoses [2,3]. Factors such as the presence of comorbidities, greater propensity for systemic organ dysfunction, and poor nutritional status can contribute to the heightened risk of clinical complications in elderly patients with COVID-19 [4].

The course of COVID-19 presents with one severe inflammatory condition characterized by the involvement of proinflammatory cytokines [5]. Thus, adequate nutrition can contribute to a better immune system response and a more favorable prognosis [6–8].

There is no gold standard for identifying nutritional risk or malnutrition. In most cases, nutritional risk is researched via screening tools, typically applied by nutritionists, doctors, or other professionals, preceding a full nutritional assessment [9,10]. Tools such as the Mini Nutritional Assessment-short form (MNA-sf) [11,12], the Geriatric Nutrition Risk Index (GNRI) [13], the Nutritional Risk Screening 2002 (NRS-2002) [14], the Malnutrition Universal Screening Tool (MUST) [15], the Nutritional Risk Index (NRI) [16], the Short Nutritional Assessment Questionnaire (SNAQ) [17], and Nutrition Risk in the Critically Ill (NUTRIC) scores [18] are practical and inexpensive to apply and can predict clinical outcomes [9]. Nutritional assessment instruments, such as the Global Assessment Subjective (SGA) and the Mini Nutritional Assessment (MNA), also assess biochemical and laboratory parameters and clinical and dietetical factors [9,10].

The MNA [19,20], MNA-sf [11,12,21], GNRI [13,21], MUST [15,21], and NRI [16,21] were developed specifically to identify nutritional risk or malnutrition in elderly patients. However, some other instruments are also used for nutritional risk assessment in elderly patients, such as the SGA [21,22], NRS-2002 [14,21], SNAQ [17,23], and NUTRIC score [18,24].

Several studies have recorded a high prevalence of nutritional risk and malnutrition in the population over 65 years old, especially those who are hospitalized [25,26]. Researchers have thus noted the need to assess nutritional risk among elderly patients with COVID-19 [27]. However, to our knowledge, no systematic review has yet been published of the nutritional screening instruments that could be used to identify nutritional risk in elderly patients with COVID-19. Therefore, the present study aims to identify the screening instruments that can be used to assess nutritional risk in elderly patients with COVID-19, and to clarify their measurement properties.

## **2. Materials and Methods**

This systematic review included studies published in any language between November 2019 and July 2020, and was prepared following the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [28]. The systematic review protocol is registered in PROSPERO (CRD42020186866).

### *2.1. Eligibility Criteria*

Observational, comparative, or validation studies that used nutritional screening instruments to identify nutritional risk in patients over 65 years of age with COVID-19 were considered eligible for inclusion. Review articles were excluded.

### *2.2. Databases and Search Strategy*

The literature search was conducted on July 3, 2020, using the Medical Literature Analysis and Retrieval System Online database (MEDLINE, via PubMed), the Excerpta Medica Database (Embase), and the Latin American and Caribbean Health Sciences Literature (LILACS) database using a combination of the following descriptors and their synonyms: "nutrition risk," "nutritional risk," "nutritional screening," "nutrition screening," "nutritional assessment," "nutritional index," "Geriatric Nutrition Risk Index," "Mini Nutritional Assessment," "Subjective Global Assessment," "Nutritional Risk Screening tool 2002," "Malnutrition Universal Screening Tool," "Nutritional Risk Index," "Short Nutritional Assessment Questionnaire," "Nutrition Risk in Critically Ill score," and "COVID-19." Supplementary Table S1 presents the search strategy used in each database.

### *2.3. Screening and Selection of Studies*

Two researchers independently (DS and SL) screened the studies. Initially, titles and abstracts were read. The full text of selected articles was then analyzed to confirm fulfillment of the study's eligibility criteria.

### *2.4. Data Extraction*

The following data was extracted from the selected articles: authorship; country and period of research; type of study; number, age, and sex of participants; criteria used to diagnose COVID-19; nutritional screening instrument used; properties of the nutritional screening instrument used (sensitivity, specificity, criterion validity, predictive validity); and participants' nutritional risk information.

## 2.5. Evaluation of Studies' Methodological Quality and Instruments' Properties

The Newcastle-Ottawa scale was used to assess the methodological quality of retrospective studies [29], applying the modified version [30] to assess cross-sectional studies. The scale consists of eight questions; all are rated up to one star each, except for the question about comparability, which can be rated up to two stars. The modified version for cross-sectional studies consists of seven questions rated up to one star each, except those on questions on comparability and outcome, which can be rated up to two stars. Total scores for both versions can reach a maximum of nine stars. To assess case series studies, the instrument proposed by Murad et al. [31] was employed.

The nutritional screening instruments' properties were evaluated according to the Quality Assessment of Diagnostic Accuracy Studies (QUADAS) criteria [32], which assess four domains: patient selection, instrument testing, reference standard and flow, and time of administration. The answers to the questions in each domain can be used to identify instrument's the risk of bias and applicability [32].

## 2.6. Narrative Summary of Results

One narrative summary of the nutritional screening tools used to identify nutritional risk in elderly patients with COVID-19 was conducted. Descriptive analysis was performed to synthesize the data on the instruments' properties.

The instruments' sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were evaluated. Sensitivity refers to the instrument's ability to accurately identify individuals at nutritional risk (true positive [TP] / true positive [TP] + false negative [FN]) [33]. Specificity refers to the instrument's ability to accurately identify well-nourished individuals (without malnutrition) as having no nutritional risk (true negative [TN] / true negative [TN] + false positive [FP]) [33].

PPV indicates the proportion of subjects who tested positive for nutritional risk and were actually at risk (true positive results; TP / TP + FP). NPV indicates to the proportion of subjects who tested negative for nutritional risk and were actually without risk (true negative results; TN / TN + FN) [34,35]. Sensitivity, specificity, PPV, and NPV were calculated based on the studies' true positive, true negative, false positive, and false negative results. Statistical analysis, including calculation of 95% confidence intervals (CIs), was performed using RevMan (Review Manager) version 5.3. Sensitivity and specificity levels of over 80% were classified as good; levels above 50% and up to 80% were classified as weak, and levels below 50% were classified as poor [36].

Criterion or construct validity of the nutritional screening instrument was analyzed for studies that compared the nutritional screening results with a reference criterion, according to the parameter or criterion used for comparison. Because no gold standard has been defined for diagnosis of nutritional risk [25,37], the methods or criteria suggested by Schueren et al. [36] were considered appropriate for analysis of criterion validity: nutritional assessment and anthropometry, objective assessment by a professional, or comparison with another nutritional screening tool of reference (e.g., the MNA or SGA).

Construct validity was analyzed for studies that compared the nutritional screening results with reference standards considered to have less validity, which have differences in comparison with nutritional screening instruments [9,36,38]. Evaluation was conducted of the relationship between the problem diagnosis (nutritional risk) and related variables not included in the instrument, for example by analyzing in comparison to other nutritional screening instruments, such as the MNA-sf, MUST, NRS-2002, NRI, or modified NUTRIC (mNUTRIC) score, or the results of laboratory tests, including albumin, pre-albumin, creatinine, and total lymphocyte count (TLC) [39].

Predictive validity, referring to the screening tool’s ability to predict clinical outcomes, was assessed according to cutoff points of the area under the curve (AUC). When analyzing predictive validity, higher AUC results indicate greater ability to predict an outcome. In this study, the discriminative power of AUC was defined according to the traditional academic point system: 90 to 100 (Excellent), 80 to 90 (Good), 70 to 80 (Weak), 60 to 70 (Poor), and 60 or below (Failure) [40]. This classification has been used in previous studies validating nutritional screening instruments [41,42].

Considering the number and heterogeneity of the studies included in this review, meta-analysis of the prevalence of nutritional risk or malnutrition was not possible.

3. Results

The initial database search retrieved 101 records; 13 duplicate studies were removed. Of the 88 remaining articles, which were analyzed by reading the title and abstract, five were selected for full-text review. Of these, four studies [43-46], all conducted in China, met the criteria for inclusion in the study: two retrospective cohort studies [43,46], a cross-sectional study [44], and a case series study [45]. Figure 1 shows the study selection flowchart.

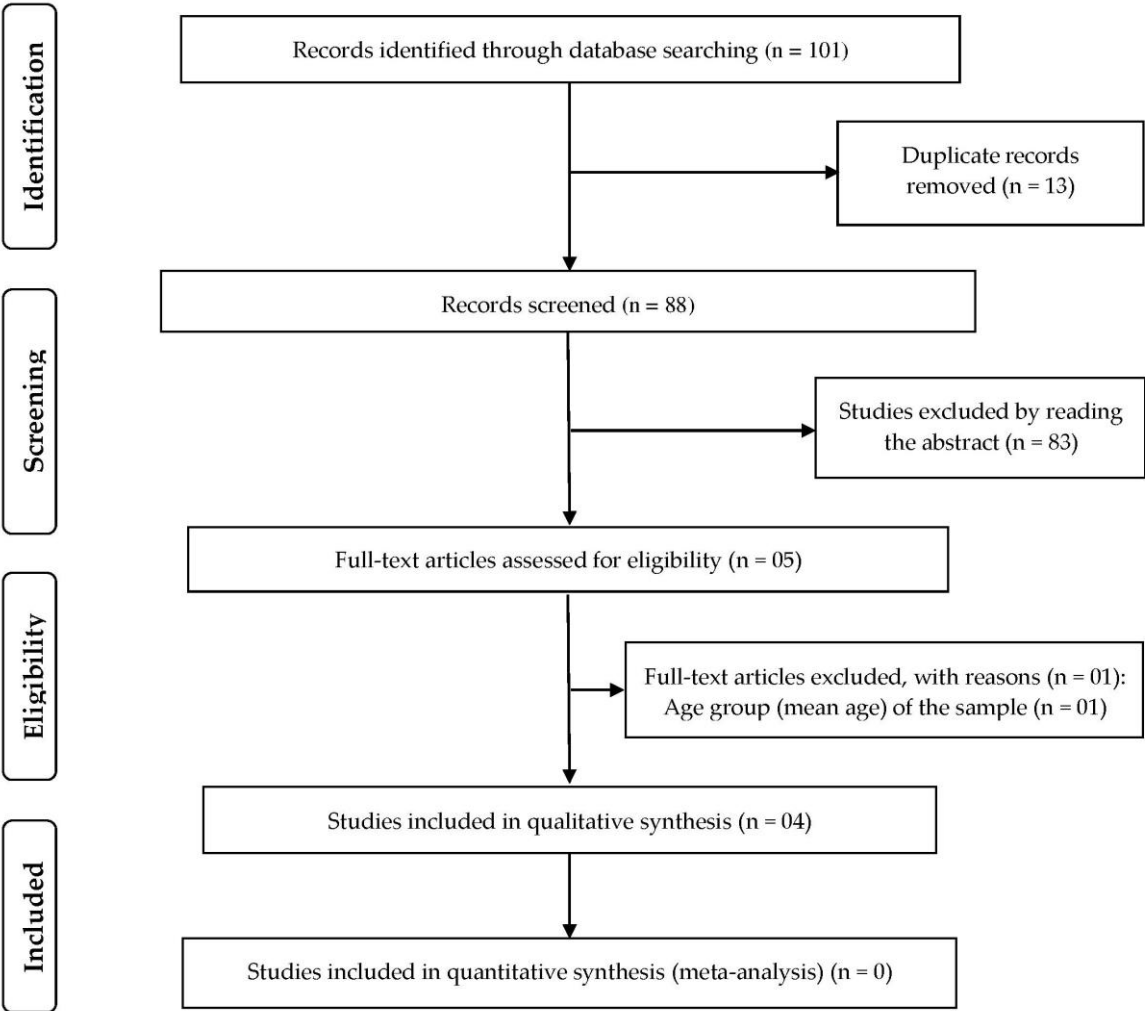


Figure 1. PRISMA flow chart for selection of studies.

Methodological Quality of Studies

The studies evaluated according to the Newcastle-Ottawa scale showed good methodological quality, with total scores of seven stars. The case series study also showed good methodological quality. Of the five questions applicable to this study, four were scored. Table 1 presents the assessment of methodological quality according to study type.

Table 1. Methodological quality of included studies (n = 04)

Cohort – Newcastle-Ottawa Scale								
		Selection			Comparability		Outcome	
Quality criteria	1. Representativeness of the exposed cohort	2. Selection of the non exposed cohort	3. Ascertainment of exposure	4. Demonstration that outcome of interest was not present at start of study	1. Comparability of cohorts on the basis of the design or analysis	1. Assessment of outcome	2. Was follow-up long enough for outcomes to occur	3. Adequacy of follow up of cohorts
Liu et al, 2020 [46]	*		*		**	*	*	*
Zhang et al., 2020 [43]	*		*		**	*	*	*
Cross-sectional – Newcastle-Ottawa Scale								
		Selection			Comparability		Outcome	
Quality criteria	1. Representativeness of the sample	2. Sample size	3. Ascertainment of exposure	4. Non-respondents	1. The subjects in different outcome groups are comparable, based on the study design or analysis. Confounding factors are controlled.	1. Assessment of outcome	2. Statistical test	
Li et al, 2020 [44]	*		*		**	**	*	
Case series – Murad et al. (2018)								
		Selection		Ascertainment		Causality		Reporting
Quality criteria	1. Does the patient(s) represent(s) the whole	2. Was the exposure	3. Was the outcome	4. Were other alternative	5. Was there a challenge/	6. Was there a	7. Was follow-up	8. Is the case(s) described with sufficient details to

	experience of the investigator (centre) or is the selection method unclear to the extent that other patients with similar presentation may not have been reported?	adequately ascertained?	adequately ascertained?	causes that may explain the observation ruled out?	rechallenge phenomenon?	dose–response effect?	long enough for outcomes to occur?	allow other investigators to replicate the research or to allow practitioners make inferences related to their own practice?
Yuan et al., 2020 [45]		*	*	NA	NA	NA	*	*

*Notes.* For case series, items 4, 5 and 6 are mostly relevant to cases of adverse drug events.

The studies' quality with respect to the nutritional screening instruments employed was evaluated according to the QUADAS criteria. With respect to selection of participants, three studies [44-46] were at high risk of bias, as they did not perform random or consecutive sampling; one was at low risk of bias [43]. Additionally, the study by Yuan et al. [45] did not report data on the nutritional risk of two patients.

Low risk of bias was observed in all the studies with respect to evaluation of the nutritional screening results (index test domain) [43-46], as they defined a cut-off point for the diagnosis of nutritional risk. Two studies compared between the diagnosis of nutritional risk and patients' body mass index (BMI) [44-46], but it was clear that this did not interfere in the diagnosis of patients' nutritional risk.

Two studies [44-46] compared diagnoses of nutritional risk to other nutritional screening tools as well as BMI. In these studies, a low risk of bias was identified with respect to the reference standards used, and for the sequence and timing of the comparisons. Although BMI may not be one of the best indicators of nutritional risk when used alone, the study authors adequately addressed the limitations of using BMI to identify nutritional risk or malnutrition, as well as the limitations regarding BMI's predictive validity. Table 2 presents the evaluation of the studies' quality with respect to the instruments used.

**Table 2.** Methodological quality evaluation of each study included in the systematic review, according to QUADAS (n = 04).

Domain	Item	Liu et al., 2020 [46]	Li et al., 2020 [44]	Yuan et al., 2020 [45]	Zhang et al., 2020 [43]
Patient selection	Was a consecutive or random sample of patients enrolled?	No	No	No	Yes
	Signalling questions (yes/ no/ unclear)				
	Was a case-control design avoided?	Yes	Yes	Yes	Yes
	Did the study avoid inappropriate exclusions?	Yes	Yes	No	Yes
	Risk of bias: High/ low/ unclear	High	High	High	Low
	Concerns regarding applicability: High/ low/ unclear	Low	Low	Low	Low
Index Test	Were the index test results interpreted without knowledge of the results of the reference standard?	Unclear	-	-	-
	Signalling questions (yes/ no/ unclear)				
	If a threshold was used, was it pre-specified?	Yes	Yes	Yes	Yes
	Risk of bias: High/ low/ unclear	Low	Low	Low	Low
	Concerns regarding applicability: High/ low/ unclear	Low	Low	Low	Low
	Are there concerns that the index test, its conduct, or interpretation				



	low/ unclear	differ from the review question?					
<b>Reference standard</b>	<b>Signalling questions (yes/ no/ unclear)</b>	Is the reference standard likely to correctly classify the target condition?	Yes	Yes	-	-	
		Were the reference standard results interpreted without knowledge of the results of the index test?	Unclear	Unclear	-	-	
	<b>Risk of bias: High/ low/ unclear</b>	Could the reference standard, its conduct, or its interpretation have introduced bias?	Low	Low	-	-	
		Concerns regarding applicability: High/ low/ unclear	Low	Low	-	-	
<b>Flow and timing</b>	<b>Signalling questions (yes/ no/ unclear)</b>	Was there an appropriate interval between index test(s) and reference standard?	Yes	Yes	-	-	
		Did all patients receive a reference standard?	Yes	Yes	-	-	
		Did all patients receive the same reference standard?	Yes	Yes	-	-	
		Were all patients included in the analysis?	Yes	Yes	-	-	
	<b>Risk of bias: High/ low/ unclear</b>	Could the patient flow have introduced bias?	Low	Low	-	-	

### Participants' Characteristics

The number of participants in each study ranged from six [45] to 182 [44], and ages ranged from 65 [4446] to 87 years [46]. Three studies included more women than men [44-46]. Table 3 illustrates the characteristics of the participants and instruments used in each study.

**Table 3.** Characteristics of participants included in the studies (n = 04)

Author	Country	Design	n	Age group (years)	Sex	Nutritional screening tool	Nutritional risk
Liu et al., 2020 [46]	China	Retrospective cohort	141	65 a 87	Women: 73. Men: 68	NRS-2002 - NR: score $\geq 3$ (out of a maximum of 6); MNA-sf - NR: score $< 12$ (out of a maximum of 14); MUST - NR:	NRS-2002: 120 (85.1%); MNA-sf: 109 (77.3%); MUST: 58 (41.1%); NRI: 101



						score ≥2 (out of a maximum of 6);	(60.4%).
						NRI - SNR: score <83.5 and no NR> 100.	
Li et al., 2020 [44]	China	Cross-sectional	182	Average age of 68.5 years old	Women: 117. Man: 65.	MNA: No malnutrition 24; Risk of malnutrition: 17-23.5; Malnutrition 17.	No nutritional risk / malnutrition: 36 (19.8%); Risk of malnutrition: 50 (27.5%); Malnutrition: 96 (52.7%).
Yuan et al., 2020 [45]	China	Case series	6 <sup>1</sup>	65 a 71	Women: 4. Man: 2.	GNRI: High NR: score <82 - cut-off point used to diagnose nutritional risk in the study; Moderate NR: score from 82 to <92; Low NR: score from 92 to ≤98; No risk: score> 98.	4 (100%).
Zhang et al., 2020 [43]	China	Retrospective cohort	136	Average age 69 years	Women: 50 (37%) Man: 86 (63%)	mNUTRIC score High NR ≥ 5. Low NR < 5.	High NR: 83 (61.0%). Low NR: 53 (39.0%).

Abbreviations: GNRI, Geriatric Nutritional Risk Index; MNA, Mini Nutritional Assessment; MNA-sf, Mini Nutritional Assessment-short form; MUST, Malnutrition Universal Screening Tool; NRI, Nutritional Risk Index; NRS-2002, Nutritional Risk Screening tool 2002; NUTRIC score, modified Nutrition Risk in the Critically ill (mNUTRIC) score; RN, nutritional risk; SRN, Severe nutritional risk. <sup>1</sup>For four participants, data on nutritional risk were provided.

Li et al. [44] diagnosed COVID-19 according to a positive reverse-transcriptase polymerase chain reaction (RT-PCR) test for SARS-CoV-2. Liu et al. [46] diagnosed and classified COVID-19 using a combination of several criteria, including history of epidemiological exposure; characteristic symptoms of COVID-19, such as fever, cough, and gastrointestinal symptoms; laboratory tests with changes in lymphocyte count and number of white blood cells; changes in pulmonary imaging tests; and a positive RT-PCR test result for SARS-CoV-2 using respiratory or blood specimens.

Yuan et al. [45] used only RT-PCR test results to diagnose COVID-19 in two patients, PCR-RT test results and history of epidemiological exposure in two other patients, and a combination of clinical, epidemiological, and laboratory test information for the final two patients.

Zhang et al. [43] diagnosed and clinically classified COVID-19 according to the *Guidance for Coronavirus Disease 2019* (6th edition) published by the National Health Commission of China, which includes criteria related to the RT-PCR test and the characteristic symptoms of COVID-19.

#### *Nutritional Screening Instruments Used to Identify Nutritional Risk*

The studies used various nutritional screening tools to identify nutritional risk in elderly people with COVID-19. Liu et al. [46] used four different instruments: the NRS-2002, MNA-sf, MUST, and NRI. Cut-off scores for diagnosis of nutritional risk were  $\geq 3$  points for the NRS-2002 (out of 6) [14],  $<12$  for the MNA-sf (out of 14) [11,12],  $\geq 2$  for the MUST (out of 6) [15], and  $<83.5$  for the NRI (severe risk of malnutrition; a score of  $> 100$  indicates no risk) [16].

Li et al. [44] used the full version of the MNA to assess the nutritional risk, with three classifications: no risk of malnutrition ( $\geq 24$  points), risk of malnutrition (17–23.5 points), and malnutrition ( $< 17$  points). Yuan et al. [45] used the GNRI, with four categories: high risk, the cut-off point used to diagnose nutritional risk ( $< 82$  points); moderate risk (82–91 points); low risk (92–98 points), and no risk ( $> 98$  points). Zhang et al. [43] used mNUTRIC scores with two categories: high nutritional risk ( $\geq 5$  points) and low nutritional risk ( $< 5$  points). Table 3 illustrates the cut-off points for each instrument.

#### *Nutritional Risk in Elderly Patients with COVID-19*

Based on the various instruments applied, the prevalence rates of nutritional risk in Liu et al.'s study [46] were 85.1% (NRS-2002), 77.3% (MNA-sf), 60.4% (NRI), and 41.1% (MUST) [46]. Li et al. found that 50 patients (27.5%) were at risk of malnutrition and 96 (52.7%) were malnourished [44]. Based on mNUTRIC scores, Zhang et al. found that 61% of patients had a high nutritional risk [43]. All four participants with reported GNRI evaluation data were classified by Yuan et al. as at high nutritional risk [45].

#### *Association between Comorbidities and Nutritional Risk*

Li et al. found that diabetes mellitus was associated with higher nutritional risk and malnutrition (odds ratio [OR]: 2.12, 95% CI: 1.92–3.21) [44]. Liu et al. found no significant associations between arterial hypertension, vascular and cerebrovascular diseases, and nutritional risk [46]. Zhang et al. found no significant associations between nutritional risk and hypertension, diabetes, cardiovascular disease, malignancy, chronic obstructive pulmonary disease, chronic kidney disease, liver cirrhosis, or immunopathy [43].

#### *Sensitivity, Specificity, and Criterion Validity of Nutritional Screening Instruments*

Liu et al. [46] compared diagnoses of nutritional risk between the different instruments and with cut-off points of BMI. Compared to the cut-off points for BMI, all the instruments (NRS-2002, MNA-sf, MUST, and NRI) demonstrated 100% sensitivity. Between the instruments, only the MUST showed a sensitivity of less than 50% compared to the NRS-2002.

Only the MUST showed better specificity compared to BMI (62%). Between the instruments, good specificity was identified for the MUST vs. the NRS-2002 (95%), the MUST vs. the NRI (88%), the MNA-sf vs. the NRS-2002 (86%), and the MNA-sf vs. the MUST (97%).

The NRS-2002 was the only instrument to present an NPV above 80% compared to BMI, the MUST, and the NRI. All instruments had a PPV below 13% when compared to BMI. The GNRI demonstrated a PPV of 25%.

The MNA showed weak criterion validity, demonstrating a significant correlation with BMI, calf circumference, albumin, and TLC but no correlation with tricipital skinfold thickness and arm circumference. The MUST, NRS-2002, MNA-sf, and NRI all showed poor criterion validity compared to BMI. The GNRI demonstrated poor construct validity when compared to TLC. mNUTRIC score demonstrated poor construct validity, having a significant correlation with TLC and creatinine but no correlation with albumin and pre-albumin levels. Table 4 reports the diagnostic performance of the nutritional screening and assessment instruments included in this review.

**Table 4.** Diagnostic performance of Nutritional Screening Tools identifying older patients with COVID-19 at nutritional risk or With malnutrition.

Author	Screening tool	Reference standard	TP	FP	FN	TN	Sensitivity (95%CI)	Specificity (95% CI)	PPV (%)	NPV (%)	Other analysis
Liu et al., 2020 [46]	NRS-2002	BMI	7	113	0	21	100 (59 to 100)	16 (10 to 23)	5.8	100	-
Liu et al., 2020 [46]	NRS-2002	MUST	57	63	1	20	98 (91 to 100)	24(15 to 35)	47.5	95.2	-
Liu et al., 2020 [46]	NRS-2002	MNA-sf	102	18	7	14	94 (87 to 97)	44 (26 to 62)	85.0	66.7	-
Liu et al., 2020 [46]	NRS-2002	NRI	98	22	3	18	97 (92 to 99)	45 (29 to 62)	81.7	85.7	-
Liu et al., 2020 [46]	MUST	BMI	7	51	0	83	100 (59 to 100)	62 (53 to 70)	12.1	100	-
Liu et al., 2020 [46]	MUST	NRS-2002	57	1	63	20	47 (38 to 57)	95 (76 to 100)	98.3	24.1	-
Liu et al., 2020 [46]	MUST	MNA-sf	57	52	1	31	98 (91 to 100)	37 (27 to 49)	52.3	96.9	-
Liu et al., 2020 [46]	MUST	NRI	53	5	48	35	52 (42 to 63)	88 (73 to 96)	91.4	42.2	-
Liu et al., 2020 [46]	MNA-sf	BMI	7	102	0	32	100 (59 to 100)	24 (17 to 32)	6.4	100	-
Liu et al., 2020 [46]	MNA-sf	NRI	86	23	15	17	85 (77 to 91)	42 (27 to 59)	78.9	53.1	-
Liu et al., 2020 [46]	MNA-sf	NRS-2002	102	3	22	18	82 (74 to 99)	86 (64 to 97)	97.1	45.0	-

Liu et al., 2020 [46]	MNA-sf	MUST	57	1	52	31	52 (43 to 62)	97 (84 to 100)	98.3	37.4	-
Liu et al., 2020 [46]	NRI	BMI	7	94	0	40	100 (59 to 100)	30 (22 to 38)	6.9	100	-
Liu et al., 2020 [46]	NRI	MNA-sf	86	15	23	17	79 (70 to 86)	53 (35 to 71)	85.2	42.5	-
Liu et al., 2020 [46]	NRI	NRS-2002	98	3	22	18	82 (74 to 88)	86 (64 to 97)	97.0	45.0	-
Liu et al., 2020 [46]	NRI	MUST	53	48	35	5	60 (49 to 61)	9 (3 to 21)	52.5	12.5	-
Li et al., 2020 [44]	MNA	BMI	-	-	-	-	-	-	-	-	BMI (kg/m <sup>2</sup> ) – No malnutrition: 25.6 ± 3.0; risk of malnutrition: 23.3 ± 3.4 kg/m <sup>2</sup> ; malnutrition: 21.1 ± 3.6 kg/m <sup>2</sup> . F or X <sup>2</sup> value: 4.106, p = 0.035.
Li et al., 2020 [44]	MNA	Calf circumference (cm)	-	-	-	-	-	-	-	-	Calf circumference (cm) – No malnutrition: 33.4 ± 5.6; risk of malnutrition: 31.2 ± 4.8; malnutrition: 28.7 ± 5.7, F or X <sup>2</sup> value: 2.518, p = 0.047.
Li et al., 2020 [44]	MNA	Albumin (g/L)	-	-	-	-	-	-	-	-	Albumin (g/L) – No malnutrition: 38.5 ± 4.2; risk of malnutrition: 30.1 ± 6.4; malnutrition: 25.7 ± 5.3, F or X <sup>2</sup> value: 10.217, p < 0.001.
Li et al., 2020 [44]	MNA	TLC	-	-	-	-	-	-	-	-	TLC – No malnutrition: 1.7 ± 0.52; risk of malnutrition: 1.2 ± 0.43, malnutrition: 0.9 ± 0.38, F or X <sup>2</sup> value: 11.237, p < 0.001.
Li et al., 2020 [44]	MNA	TSFT (mm)	-	-	-	-	-	-	-	-	TSFT (mm) – No malnutrition: 16.8 ± 7.2; risk of malnutrition: 15.7 ± 6.9; malnutrition: 14.9 ± 7.3, F or X <sup>2</sup> value: 1.632, p = 0.126.
Li et al.,	MNA	MAC (cm)	-	-	-	-	-	-	-	-	MAC (cm) – No malnutrition: 28.7 ± 2.8; risk of malnutrition:

2020 [44]												27.6 ± 3.3; malnutrition: 26.5 ± 3.2, F or X <sup>2</sup> value: 2.679, p = 0.379.
Yuan et al., 2020	GNRI	TLC	-	-	-	-	-	-	-	-	-	Of the four patients at nutritional risk, one had low TCL levels and three had normal levels.
[45]												
Zhang et al., 2020	NUTRIC score	Albumin (g/L)	-	-	-	-	-	-	-	-	-	High NR group (n = 83): 29 g/L (25 - 32). Low NR group (n = 53): 30 g/L (28 - 32), p = 0.107.
[43]												
Zhang et al., 2020	NUTRIC score	Prealbumin (g/L)	-	-	-	-	-	-	-	-	-	High NR group (n = 83): 82 g/L (80-122). Low NR group (n = 53): 95 (80-128) g/L, p = 0.281.
[43]												
Zhang et al., 2020	NUTRIC score	TLC	-	-	-	-	-	-	-	-	-	High NR group (n = 83): 0.5 10 <sup>9</sup> /L (0.3-0.7). Low NR group (n = 53): 0.6 10 <sup>9</sup> /L (0.4-0.9), p = 0.007.
[43]												
Zhang et al., 2020	NUTRIC score	Creatinine (mmol/L)	-	-	-	-	-	-	-	-	-	High NR group (n = 83): 90 (65-144) mmol/L. Low NR group (n = 53): 67 (54-85) mmol/L, p < 0.001.
[43]												

*Abbreviations:* BMI, Body Mass Index; FN, False negative; FP, False positive; GNRI, Geriatric Nutritional Risk Index; MAC, Mid-arm circumference (cm); MNA, Mini Nutritional Assessment; MNA-sf, Mini Nutritional Assessment-short form; MUST, Malnutrition Universal Screening Tool; NR, Nutritional risk, NRI, Nutritional Risk Index; NRS-2002, Nutritional Risk Screening tool 2002; TLC, Total Lymphocyte Count; TN, True negative; TP, True positive; TSFT, Triceps skin-fold thickness (mm).

*Predictive Validity of Screening and Nutritional Assessment Instruments*

In the study by Liu et al. [46], patients with nutritional risk according to the NRS-2002, MNA-sf, and NRI exhibited longer hospitalization, worse disease, worse appetite, and greater weight change than patients without nutritional risk. Diagnosis of nutritional risk according to the MUST predicted worse appetite and weight change, but not of worsening disease or prolonged hospitalization.

Zhang et al. [43] found that mNUTRIC score predicted complications in the ICU such as acute respiratory distress syndrome (ARDS), shock, acute myocardial injury, secondary infection, and death in the ICU after 28 days of hospitalization, but did not predict acute liver dysfunction, embolization/thrombosis, acute kidney injury, or pneumothorax.

The NRS-2002 had poor predictive validity for patients' length of hospital stay and poor validity for hospital expenses, decreased appetite, and weight loss of more than 2.6 kg. The MNA-sf had good predictive validity for changes in appetite and weight, but weak predictive validity for length of hospital stay, and failure for hospital expenses. The MUST had good predictive validity for weight change and poor predictive validity for appetite change. The NRI demonstrated poor predictive validity for all analyzed outcomes. mNUTRIC scores showed good predictive validity for complications in the ICU such as ARDS, shock, acute myocardial injury, secondary infection, and ICU mortality after 28 days of hospitalization. Table 5 presents the analysis of the predictive validity of the nutritional screening instruments included in this review.



1 **Table 5.** Predictive validity of various tools used to evaluate nutritional risk or malnutrition in older patients with COVID-19.

Author	NST	Length of stay (LOS)	Appetite change	Weight change	Hospital expenses	Complications	Mortality
Liu et al., 2020 [46]	NRS-2002	Nutritional risk predicted longer LOS; OR (95% CI): 0.102 (0.042–0.250), $p = 0.000$ ; AUC for LOS > 30 days (95% CI): 0.724 (0.640–0.808), $p = 0.000$ . <b>Rating: Weak.</b>	Nutritional risk predicted change in appetite; OR (95% CI) for no change: 11.179 (3.881–32.169), $p = 0.000$ ; AUC for poor appetite (95% CI): 0.670 (0.586–0.747), $p = 0.014$ . <b>Rating: Poor.</b>	Nutritional risk predicted weight change; OR (95% CI): 0.128 (0.047–0.350), $p = 0.000$ ; AUC for weight change > 2.6 kg (95% CI): 0.613 (0.528–0.694), $p = 0.000$ . <b>Rating: Poor.</b>	Nutritional risk predicted higher hospital expenses (¥); OR (95% CI): 0.131 (0.054–0.313), $p = 0.000$ ; AUC for hospital expenses > ¥56,163 (95% CI): 0.667 (0.583–0.744), $p = 0.000$ . <b>Rating: Poor.</b>	Nutritional risk predicted greater disease severity; OR (95% CI): 0.095 (0.031–0.292), $p = 0.000$ . <b>Rating: Poor.</b>	-
Liu et al., 2020 [46]	MNA-sf	Nutritional risk predicted longer LOS; OR (95% CI): 0.401 (0.198–0.813), $p = 0.011$ ; AUC for LOS > 30 days (95% CI): 0.602 (0.304–0.492), $p = 0.032$ . <b>Rating: Poor.</b>	Nutritional risk predicted change in appetite; OR (95% CI) for no change: 40.731 (13.681–121.389), $p = 0.000$ ; AUC for poor appetite (95% CI): 0.868 (0.801–0.919), $p = 0.000$ . <b>Rating: Good.</b>	Nutritional risk predicted weight change; OR (95% CI): 0.085 (0.035–0.206), $p = 0.000$ ; AUC for weight change > 2.6 kg (95% CI): 0.895 (0.832–0.940), $p = 0.000$ . <b>Rating: Good.</b>	Nutritional risk predicted higher hospital expenses (¥); OR (95% CI): 0.436 (0.216–0.880), $p = 0.021$ ; AUC for hospital expenses > ¥56,163 (95% CI): 0.597 (0.511–0.679), $p = 0.063$ . <b>Rating: Failure.</b>	Nutritional risk predicted greater disease severity; OR (95% CI): 0.632 (0.289–1.382), $p = 0.250$ . <b>Rating: Poor.</b>	-
Liu et al., 2020 [46]	MUST	Nutritional risk did not predict longer LOS; OR (95% CI): 0.722 (0.391–1.334), $p = 0.298$ ; non-significant AUC for LOS > 30 days (95% CI): 0.506 (0.421–0.591), $p = 0.887$ . <b>Rating: Poor.</b>	Nutritional risk predicted change in appetite; OR (95% CI) for no change: 2.866 (1.449–5.669), $p = 0.002$ ; AUC for poor appetite (95% CI): 0.614 (0.528–0.694), $p = 0.009$ . <b>Rating: Poor.</b>	Nutritional risk predicted weight change; OR (95% CI): 0.009 (0.003–0.026), $p = 0.000$ ; AUC for weight change > 2.6 kg (95% CI): 0.887 (0.823–0.934), $p = 0.000$ . <b>Rating: Good.</b>	Nutritional risk did not predict higher hospital expenses (¥); OR (95% CI): 0.599 (0.323–1.109), $p = 0.103$ ; non-significant AUC for hospital expenses > ¥56,163 (95% CI): 0.516 (0.430–0.601), $p = 0.735$ . <b>Rating: Failure.</b>	Nutritional risk did not predict greater disease severity OR (95% CI): 1.367 (0.688–2.718), $p = 0.372$ . <b>Rating: Failure.</b>	-
Liu et al., 2020	NRI	Nutritional risk predicted longer LOS; OR (95% CI): 0.261	Nutritional risk predicted change in appetite; OR (95% CI)	Nutritional risk predicted weight change; OR (95% CI):	Nutritional risk predicted higher hospital expenses (¥); OR (95%	Nutritional risk predicted greater disease severity; OR (95% CI): 0.367 (0.173–0.776),	-

[46]	(0.133–0.513), $p = 0.000$ ; AUC for LOS > 30 days (95% CI): 0.664 (–0.579 to 0.741), $p = 0.000$ . <b>Rating: Poor.</b>	for no change: 2.768 (1.363–5.618). $p = 0.005$ ; AUC for poor appetite (95% CI): 0.629 (0.544–0.709), $p = 0.014$ . <b>Rating: Poor.</b>	0.182 (0.087–0.378), $p = 0.000$ ; AUC for weight change > 2.6 kg (95% CI): 0.697 (0.614–0.772), $p = 0.000$ . <b>Rating: Poor.</b>	CI): 0.199 (0.100–0.397), $p = 0.000$ ; AUC for hospital expenses > ¥56,163 (95% CI): 0.621 (0.535–0.701), $p = 0.019$ . <b>Rating: Poor.</b>	$p = 0.009$ .	
Zhang et al., 2020 [43]	mNUTRIC score				Nutritional risk correlated with complications during ICU stay: ARDS ( $p < 0.001$ ), shock ( $p < 0.001$ ), acute myocardial injury ( $p = 0.002$ ), and secondary infection ( $p = 0.002$ ). <b>Rating: Good.</b> No correlation with acute liver dysfunction ( $p = 0.820$ ), acute kidney injury ( $p = 0.172$ ), embolization/thrombosis ( $p = 0.281$ ), or pneumothorax ( $p = 0.856$ ).	Nutritional risk correlated with death in the ICU after 28 days ( $p < 0.001$ ). <b>Rating: Good.</b>

Abbreviations: ARDS, acute respiratory distress syndrome; COVID-19, coronavirus disease 2019; ICU, intensive care unit; MNA-sf, Mini Nutritional Assessment-short form; mNUTRIC, modified Nutrition Risk in the Critically Ill; MUST, Malnutrition Universal Screening Tool; NRI, Nutritional Risk Index; NRS-2002, Nutritional Risk Screening 2002; NST, nutritional screening tool.

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#### 4. Discussion

To our knowledge, this is the first systematic review to verify the nutritional screening tools used to identify nutritional risk in elderly patients with COVID-19. Seven different instruments were used in the included studies: the NRS-2002, MNA, MNA-sf, NRI, GNRI, MUST, and mNUTRIC score. The NRS-2002, MNA, MNA-sf, NRI, and MUST showed high sensitivity, and the MUST demonstrated better specificity. The MNA and the MUST showed better criterion validity. Thus, the instruments evaluated in this review can be considered useful for assessing nutritional risk in the elderly. Although the majority (except the MUST) demonstrated low specificity, they showed high sensitivity and/or good predictive validity.

High sensitivity to identify risk is an important aspect and the preferable criterion for selecting a screening instrument when tools with high sensitivity and specificity are not available [47,48]. This is justified considering that a false positive diagnosis of nutritional risk can be reassessed later. Additionally, high sensitivity in early identification of nutritional risk is essential for directing individualized nutritional management with a focus on recovering the patient's nutritional status [47,48]. The NRS-2002 was the only instrument to demonstrate a sensitivity of 100% compared to BMI and of greater than 90% compared to three other nutritional screening instruments (the MNA-sf, MUST, and NRI).

Different nutritional screening instruments identified different prevalence rates of nutritional risk. Liu et al. [46] found a prevalence of 85.1% using the NRS-2002, but only 41.1% using the MUST. Previous studies have also reported overestimation by the NRS-2002 in identifying nutritional risk in elderly individuals [21,49]. For example, Poulia et al. [21] found that the NRS-2002 showed greater sensitivity (99%) and less specificity (6.1%) when identifying nutritional risk in elderly patients compared to the NRI, GNRI, MNA-sf, MUST, and SGA.

The evaluation criteria of the NRS-2002 and MUST can explain the wide difference in the prevalence of nutritional risk they report in elderly patients with COVID-19. The NRS-2002 consists of two domains, nutritional score and disease severity score. In the disease severity score domain, patients with severe pneumonia who are not in the ICU receive a score of 2 points (out of 3) [14]. The Multinational Consensus Statement from the Fleischner Society reports that patients with moderate and severe clinical conditions can present significant lung dysfunction or damage [50]. Chen et al. [51] have reported that 43.6% of elderly patients with COVID-19 had severe conditions at hospital admission, and 43.6% were critical cases. Likewise, in a study that evaluated 24 COVID-19 patients in critical condition, all were admitted to the ICU with hypoxemic respiratory failure and with 75% requiring mechanical ventilation [52]. The severe respiratory condition of most patients hospitalized with COVID-19 may favor higher scores in terms of disease severity (2 or 3 points). This, in turn, can affect the NRS-2002's identification of nutritional risk in these patients. This can be seen in a study by Zhao et al. [53], which included 371 young adult and elderly patients with COVID-19 in severe and critical condition. Disease severity was scored as 2 points for 99% of the patients in severe condition (307 of 310) and 3 points (the maximum) for 100% (61) of the patients in critical condition.

In the nutritional score domain of the NRS-2002, patients receive 1 point if they demonstrate weight loss greater than 5% in the last three months, or food intake between 50% and 75% of nutritional needs (from a maximum score of 3). These conditions are common among elderly patients with COVID-19, which may explain the impact of this domain in characterizing nutritional risk (score  $\geq 3$ ) according to the NRS-2002 [14]. For elderly patients over 70, an additional point is awarded for weight loss of more than 5% in the last three months or food intake between 50% and 75% of nutritional needs, leading to a diagnosis of nutritional risk [14].

The MUST, in contrast, has three domains: BMI, weight loss, and consequences of disease severity. Inclusion of BMI as a parameter for classifying nutritional risk may represent limited applicability of this nutritional screening instrument for hospitalized elderly patients; it is difficult to measure weight and height, needed to calculate BMI, in bedridden patients [9,54]. Furthermore, there are still limitations in the accuracy and precision of the weight and height estimation equations used for nutritional assessment among elderly individuals [55].

The MUST is assigned a point in the BMI domain for people with a BMI less than 20 kg/m<sup>2</sup>. Several studies have reported a high prevalence of overweight and obesity among patients with COVID-19, with few elderly patients having low weight [56,57]. In a study including 37 patients with a mean age over 60 years, 23 were overweight (BMI > 24.9 kg/m<sup>2</sup>), 13 were adequate weight (BMI between 18.5 and 24.9 kg/m<sup>2</sup>), and only one was underweight (BMI < 18.5 kg/m<sup>2</sup>) [57]. Because the MUST is applied on admission and weight loss is more visible during hospitalization, it could be that few patients meet this criterion [58]. Furthermore, the MUST's low BMI cut-off point may not be adequate to identify nutritional risk related to weight loss in elderly patients, because the optimal BMI is higher in this population than the optimum proposed for young adults [9].

In the weight loss domain, points are only awarded if weight loss is between 5% and 10% in the last three to six months. This criterion can also be difficult to identify in some patients with COVID-19, considering that many times, the patient does not know how to provide this information, or the records are not available on the patient's admission. Furthermore, COVID-19 can worsen very quickly in elderly patients [59]. Wang et al. [59] found that elderly Chinese with COVID-19 showed rapid disease progression, with an average duration of 11.5 days from first symptoms to death. Thus, weight loss above 5% may not occur before hospital admission.

The disease severity domain is assigned 2 points for patients with a drastic reduction of food consumption or inability to eat on more than five days. Chen et al. [51] found that 9.1% of elderly patients with COVID-19 experienced anorexia. Thus, this area could be assigned a low score before these symptoms are present and severe enough to fulfill the criterion.

mNUTRIC scores showed poor construct validity when compared to albumin, pre-albumin, creatinine, and TLC levels. Despite disagreement among researchers on the use of these laboratory parameters to assess the validity of nutritional screening instruments, some studies have reported them to associate with the diagnosis of nutritional risk [60,61], and other systematic reviews have used them for the analysis of construct validity [9,36,38]. These parameters are also included in some instruments, such as CONUT [62], the Nutrition Screening Equation [63], the GNRI [13], and the NRI [16].

These laboratory parameters are influenced by several factors, including inflammation and acute disease [64–67]. Zhang et al. [43] recorded low concentrations of albumin, pre-albumin, and TLC in patients with both high and low nutritional risk. This may have been because the mNUTRIC score is an instrument for critically ill patients, and a severe inflammatory condition is recorded for patients with COVID-19 in this context [68,69].

Many authors question the validity of albumin as an indicator of nutritional status because it has a half-life of 20 days [70,71], whereas other researchers consider this half-life applicable under normal physiological conditions. In cases of disease, including infection, the half-life of albumin can be reduced [72,73]. Thus, analysis of albumin concentrations requires caution, especially in patients with COVID-19 who have been administered corticosteroids, which can further modify albumin concentrations [74,75].

The prevalence of nutritional risk was high in all studies, ranging from 27.5% [44] to 100% [45]. Only one study evaluated actual malnutrition, identifying a prevalence of 52.7% [44]. These prevalence rates are higher than those recorded in previous literature regarding hospitalized elderly patients [20,23], including Chinese [76]. A previous systematic review identified a 22.0% prevalence of malnutrition in hospitalized elderly patients based on the MNA [20]. In contrast, Li et al. [44], who also used the MNA, identified a 52.7% prevalence of malnutrition in elderly patients with COVID-19, in addition to 27.5% prevalence of nutritional risk. Another previous study involving 339 elderly people in Nepal identified a 49.6% prevalence of nutritional risk and a 24.8% prevalence of malnutrition [77].

Using the NRS-2002, Liu et al. [46] identified an 85.1% prevalence of nutritional risk among elderly patients with COVID-19. This is higher than the prevalence recorded by Zhang et al. [78], who also used the NRS-2002, but in a study that included 536 hospitalized patients with different diseases. Another study using the NRS-2002, included 114 Chinese with gastric cancer, a clinical condition that leads to severe catabolism, identified a 70.1% prevalence of nutritional risk [76], and a

systematic review including studies of European patients hospitalized for various diseases found a prevalence of 41.5% [23].

COVID-19 is a disease characterized by the development of pneumonia, particularly in patients in moderate to severe clinical condition [79,80]. Malnutrition is both a risk factor [81] and a consequence [82] of pneumonia. The high prevalence of dysphagia in elderly patients with pneumonia may be one reason this disease is included as one of the criteria for a higher score in the domains related to worsening disease. This may favor identification of high nutritional risk or malnutrition in elderly patients infected with COVID-19 [83,84]. Furthermore, gastrointestinal symptoms such as vomiting and diarrhea [85,86] and loss of taste (ageusia) and smell (anosmia) have been reported in patients with COVID-19 [87–89]. Gastrointestinal symptoms generally result in deterioration of intestinal permeability, harmful changes in intestinal microbiota, and low food consumption [90,91]. This may also favor identification of nutritional risk in elderly patients with COVID-19, as most nutritional screening instruments establish reduced food consumption as an evaluation criterion.

In COVID-19 pneumonia, fever (defined as a body temperature above 38° C) is a frequent symptom [92]. Metabolic demand is estimated to increase by 10% to 13% with each 1° C increase in body temperature [93]. These symptoms, which are characteristic of acute clinical disease conditions, are accounted for in the nutritional risk screening instruments and must also be considered when determining the nutritional management of patients with COVID-19. To avoid greater energy-protein depletion, particularly in patients with COVID-19 not receiving mechanical ventilation, adequate calculation of nutritional needs must precede dietary intervention, accounting for nutritional risk assessed by means of these instruments [94,95]. For patients in the ICU on mechanical ventilation, the European Society for Clinical Nutrition and Metabolism (ESPEN) recommends offering low-calorie nutrition, not to exceed 70% of energy needs [96,97].

Li et al. [44], who evaluated the association between comorbidities and nutritional risk [43,46], found an association between diabetes mellitus and nutritional risk. No significant associations were identified with other comorbidities analyzed in the studies. Diabetes mellitus is associated with greater nutritional risk in the elderly population in general [98]. Paris et al. [99] identified a 39.1% prevalence of nutritional risk in elderly hospitalized patients with diabetes, and a 21.2% prevalence of malnutrition. Diabetes mellitus is also a risk factor for COVID-19 progression and worse prognosis [100,101]. Thus, particular focus should be directed toward the nutritional screening process of hospitalized elderly COVID-19 patients with comorbid diabetes mellitus, many of whom may also be obese, another risk factor for worsening the disease [102,103]. In a systematic review, 38 of the 44 studies reported a prevalence of obesity above 38% in hospitalized patients with an average age between 50 and 70 years and diabetes mellitus [104].

Accordingly, considering BMI alone or as the primary criterion in nutritional screening may neglect or underestimate nutritional risk among COVID-19 patients with a high BMI [105]. In the study by Liu et al. [46], for example, overweight patients were diagnosed with nutritional risk according to the NRS-2002, MUST, MNA- sf, and NRI. This highlights the importance of using nutritional screening tools to identify nutritional risk in elderly patients with COVID-19, regardless of BMI. Considering that both diabetes and nutritional risk relate to worsening progression of COVID-19, it is important that personalized nutritional therapy for elderly patients with COVID-19 consider all these factors [27,59,96].

Liu et al. [46] found that a diagnosis of nutritional risk using the NRS-2002, NRI, and MNA-sf predicted longer hospital stays, worse disease, worse appetite, and greater weight change, as compared to no nutritional risk. mNUTRIC score predicted complications in the ICU such as ARDS, shock, acute myocardial injury, secondary infection, and mortality after 28 days of hospitalization. The good predictive validity of the mNUTRIC score for ICU complications can be explained by the fact that this instrument was developed to screen for nutritional risk in critically ill patients, with a focus on identifying clinical complications related to nutritional risk [18,106]. Thus, the good predictive validity of mNUTRIC scores can contribute to better monitoring of patients' prognosis and more effective treatment by the health team.



The predictive validity of the screening instruments was weak or poor for other factors, except for the MNA-sf, which showed good predictive validity for poor appetite and weight change, and the mNUTRIC score, which showed good predictive validity for mortality in the ICU after 28 days of hospitalization. A diagnosis of nutritional risk according to the MUST predicted only poor appetite and weight change. This may be related to the evaluation criteria of this instrument, which include changes in body weight and appetite (reduction of food consumption) as important factors. Several previous studies have also reported on the predictive validity of nutritional screening instruments for various clinical outcomes [107–109]; for example, Rabito et al. [110] found that a diagnosis of nutritional risk according to the NRS-2002, MUST, and SGA predicted longer hospital stays.

In addition to assessing elderly patients' nutritional risk upon hospital admission and during treatment of COVID-19, follow-up after improvement or recovery the disease with remission of pneumonia is necessary. A study including 50 young and elderly adult patients in a hospital unit and in rehabilitation after recovery from COVID-19 identified that 45% were at high nutritional risk and 26% were at moderate risk, according to MUST criteria [111].

During the COVID-19 pandemic, with the adoption of physical distancing measures, situations may arise that require new approaches to nutritional screening of elderly patients who have recovered from the disease. For countries in which telemedicine is authorized, nutritional screening can be conducted at a distance. To this end, Krznarić et al. [112] proposed a simple and practical protocol for assessing malnutrition in adult and elderly patients. The Remote Malnutrition App (R-MAPP) includes assessment of nutritional risk with MUST adaptation and can be used in primary health care settings.

This systematic review presents the strengths and weaknesses of various instruments used to assess nutritional risk in elderly patients with COVID-19. However, some limitations must be considered. First, all the included studies were conducted in China. Caution is required when extrapolating the results to other populations. Second, the sample sizes in the four studies were small, and selection was not random or consecutive. Third, there was no standardization among the studies regarding the gold standard diagnostic criterion for COVID-19 (RT-PCR test). Finally, because the studies were not prospective and controlled, confusion and selection biases may have influenced the results and there is no way to infer causality regarding the diagnosis of COVID-19 and nutritional risk or malnutrition.

## 5. Conclusions

Nutritional risk was highly prevalent among elderly patients with COVID-19 regardless of the nutritional screening tool applied. The NRS-2002, MNA, MNA-sf, NRI, and MUST showed high sensitivity, but only the MUST demonstrated better specificity compared to BMI. Of the various instruments used in the studies, the MNA and MUST presented the best criterion validity. The MNA-sf had the best predictive validity for poor appetite and weight loss over 2.6 kg, and the NRS-2002 had the best predictive validity for the length of hospital stay. mNUTRIC score had good predictive validity for complications in the ICU such as ARDS, shock, acute myocardial injury, secondary infection, and mortality after 28 days of hospitalization.

Considering their convenience, low cost, and good ability to predict clinical outcomes, nutritional screening and assessment tools can contribute to the early diagnosis of patients with greater nutritional risk. Because nutritional risk is a modifiable factor that can be reduced or controlled with early, individualized nutritional therapy, identifying risk using instruments with adequate sensitivity can help prevent worsening disease and improve patients' prognoses.

**Supplementary Materials:** The following are available online at [www.mdpi.com/xxx/s1](http://www.mdpi.com/xxx/s1), Table S1: Detailed Search Strategy for Systematic Review.

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