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Research article

SARC-F, SARC-CalF, and SARC-F+EBM as practical predictive tools for the risk of pneumonia in patients with stable schizophrenia—a prospective study

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ABSTRACT

Objectives: Individuals diagnosed with schizophrenia have a high incidence and fatality rates due to pneumonia. Sarcopenia is a contributing factor to the development of pneumonia in patients with schizophrenia. In this study, we examine the effectiveness of three simple screening questionnaires, namely SARC-F, SARC-CalF, and SARC-F + EBM, in predicting the occurrence of pneumonia in stable patients with schizophrenia who are experiencing sarcopenia.
Design: A prospective study.
Setting: Patients with stable schizophrenia patients aged ≥50 years in two psychiatric hospitals in western China.
Methods: Medical data from patients were collected from September 1 to September 30, 2020. Data specifically from patients diagnosed with pneumonia were collected for a period of one year, from October 2020 to October 2021. Three hundred thirty-five stable schizophrenia patients, among whom 229 were males (68.36 %.), were enrolled in the prospective study. The risk of sarcopenia was evaluated using the SARC-F, SARC-CalF, and SARC-F + EBM scores, with values of ≥4, 11, and 12 indicating an elevated risk of sarcopenia. The collected data were analyzed using logistic regression analysis to establish the association between the scores of these screening tools and the risk of pneumonia in individuals with stable schizophrenia.
Results: The rate of pneumonia in stable schizophrenia individuals was 24.48 %. Among the included stable schizophrenia patients, the incidence of pneumonia in individuals with SARC-CalF scores ≥11 was higher than in those with SARC-CalF scores less than 11 (29.91 % vs 14.88 %, P = 0.002). In individuals with SARC-F + EBM scores ≥12, the pneumonia occurrence was higher than that in those with SARC-F + EBM scores less than 12 (37.33 % vs 20.77 %, P = 0.003). However, this pattern was not found in patients with stable schizophrenia who had SARC-F scores of 4 or above and less than 4. Following the implementation of logistic regression data analysis, it has been discovered that persons with SARC-CalF scores greater than or equal to 11 were at a significantly increased risk of having pneumonia compared to patients with SARC-CalF

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scores less than 11 (OR = 2.441, 95 % CI: 1.367–4.36). After adjusting the possible confounders, patients with SARC-CalF scores ≥11 had a greater danger of pneumonia (OR = 2.518, 95%CI: 1.36–4.665). As a result, it was found that individuals with SACR-F+EBM scores ≥12 were more likely to acquire pneumonia (OR = 2.273, 95%CI: 1.304–3.961) when compared to those with scores <12 (OR = 2.273, 95%CI: 1.304–3.961). The results of this study, which controlled for potential confounders, indicated that patients with SARC-F + EBM scores ≥12 were more inclined to acquire pneumonia (OR = 2.181, 95%CI: 1.182–4.026). However, in stable schizophrenia patients with SARC-F scores ≥4 and < 4, this study has not yet observed a similar pattern for pneumonia risk.

Conclusions and implications: These results demonstrate, in stable adults with schizophrenia, a relationship between pneumonia risk and SARC-F + EBM and SARC-CalF scores. It is, therefore, advised to use these scores to determine whether these patients have pneumonia, especially in hospitals that cannot diagnose sarcopenia.

1. Introduction

Pneumonia and its effects impose significant medical and financial expenses [1]. Approximately 1,591,825 patients are hospitalized with pneumonia yearly, and about 102,821 patients die during hospitalization [2]. Pneumonia in schizophrenia individuals is about 3.3 times higher than in non-schizophrenia patients [3]. Furthermore, individuals with schizophrenia experience a greater risk of adverse effects following pneumonia compared to patients who do not have schizophrenia. Therefore, patients face a higher chance of being admitted to the emergency unit and experiencing severe respiratory distress, often requiring mechanical ventilation [4]. In addition, the death rate is about seven times more frequent than in patients without schizophrenia [5]. Therefore, pneumonia among individuals diagnosed with stable schizophrenia requires more attention from healthcare professionals.

According to studies, individuals are more likely to acquire pneumonia if they have sarcopenia, are older, have a low body mass index (BMI), consume atypical antipsychotics, or have other medical conditions [6,7]. Sarcopenia is characterized by reduced muscle mass and function [8]. The disorder is usually detected by methods such as magnetic resonance imaging (MRI), computed tomography (CT), dual-energy X-ray absorptiometry, and bioelectrical impedance examination [9]. Nevertheless, these methods are subject to certain limitations, including the high equipment price, radioactivity, and increased operator demands.

As a result, it is recommended to employ targeted screening techniques, such as the SARC-F, SARC-CalF, and SARC-F + EBM scores, for the detection of sarcopenia in patients, particularly in healthcare facilities without the capability to diagnose sarcopenia [10,11]. An advantage of SARC-F is its independence from instruments and cutoff values and its resistance to the influence of age and sex. It is a simple, rapid, and efficient screening technique. Nevertheless, the study highlights that the sensitivity (41.7 %) and specificity (68.5 %) of the test are relatively low, as are the areas under the receiver operating characteristic curves (0.592) [12,13]. Barbosa-Silva et al. improved SARC-F by the inclusion of calf circumference (CC), resulting in SARC-CalF. SARC-CalF was found to improve the accuracy of sarcopenia screening, with the areas under the receiver operating characteristic curves increasing to 0.736 [12]. Similarly, Kurita et al. enhanced the foundational SARC-F framework by incorporating "EBM" (older and BMI data), resulting in the SARC-F + EBM. The test's sensitivity for detecting sarcopenia developed to 77.8 %, its specificity to 69.6 %, and its area under the receiver operating characteristic curve to 0.824 as a result of this improvement [13].

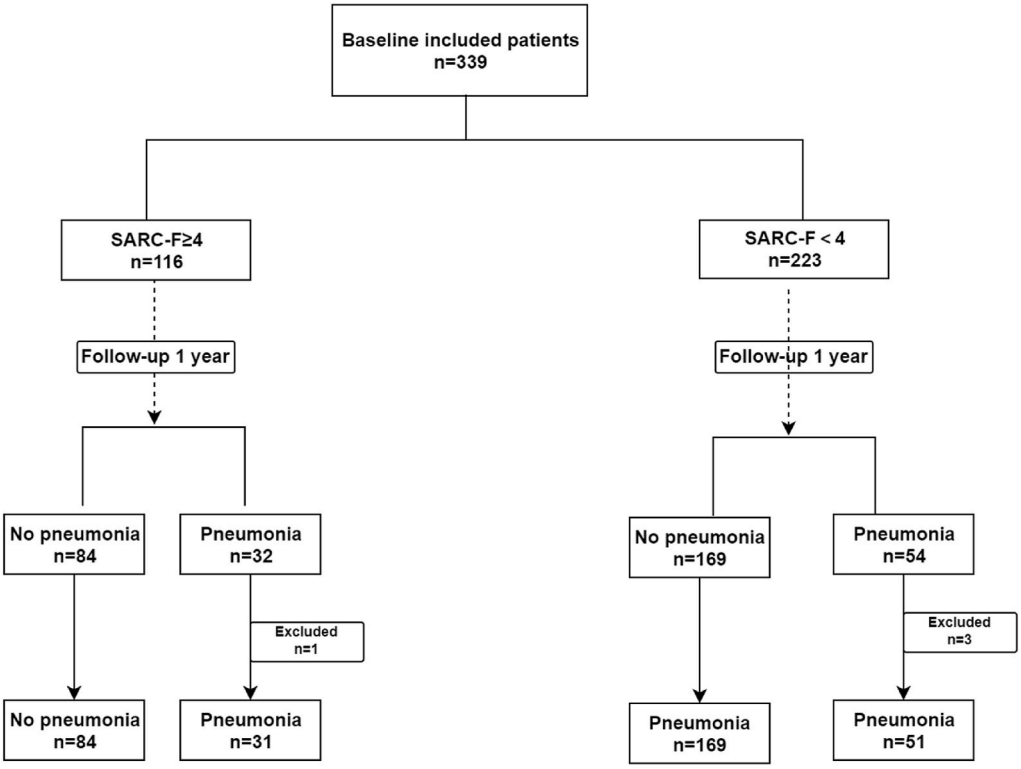
A recent study discovered that in healthy and older persons, the SARC-F scores predicted deficiencies in instrumental activities of daily living (IADL), low grip strength, decreased physical function, recent hospitalization, and death [14]. Yang et al. further proved that this score predicted a 1-year death rate among individuals from Chinese nursing homes [15]. Additional data indicated that SARC-CalF accurately predicted the probability of older individuals with Parkinson's disease being able to rise from places and ascend staircases and the occurrence of falls [16]. At the same time, Lu et al. found that this score was also an independent predictor for post-surgery impediments, extended post-surgery clinic stay, enlarged hospital costs, increased risk of 3-month readmission in gastric cancer patients, etc. [17]. Few studies have used SARC-F + EBM for the prediction of patient prognosis.

Our previous research found that SARC-F, SARC-CalF, and SARC-F + EBM were successful screening tools for sarcopenia in schizophrenia patients [11]. Irrespective of these findings, there is a lack of precise data regarding the association between these three screening modalities and the susceptibility to pneumonia in people with schizophrenia. Hence, the objective of this study was to examine the association between these screening scores and the susceptibility to pneumonia in individuals with schizophrenia. Therefore, it has been hypothesized that there is an association between SARC-F, SARC-CalF, and SARC-F + EBM and the risk of pneumonia in patients with schizophrenia.

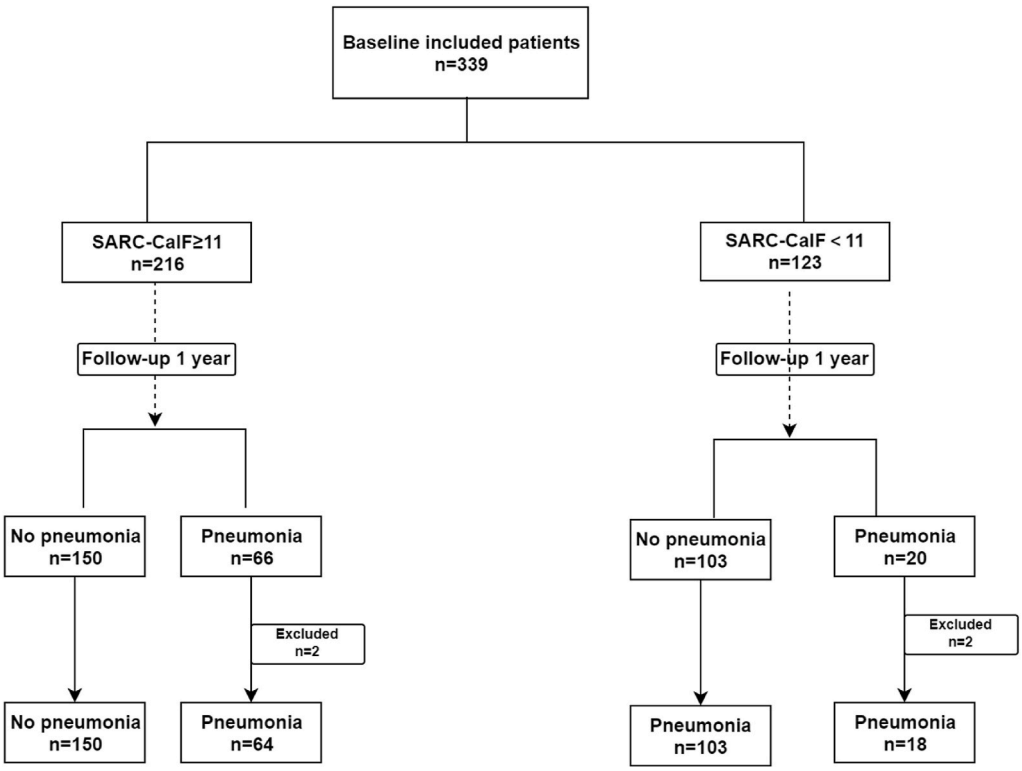
2. Research methodology

2.1. Research strategy and patient clinical characteristics

This prospective study included inpatients with stable schizophrenia who were 50 years of age or older and were receiving care from two mental health facilities in western China. The patients' medical records were gathered between September 1, 2020, and October 1, 2021, for patients diagnosed with pneumonia, respectively, within a year. A total of 335 patients with stable schizophrenia were included (Fig. 1). Inclusion and exclusion criteria were consistent with those described in our previously published studies [11].


Baseline included patients
n=339
SARC-F≥4
n=116
SARC-F < 4
n=223
Follow-up 1 year
Follow-up 1 year
No pneumonia
n=84
Pneumonia
n=32
No pneumonia
n=169
Pneumonia
n=54
Excluded
n=1
Excluded
n=3
No pneumonia
n=84
Pneumonia
n=31
Pneumonia
n=169
Pneumonia
n=51

a


Baseline included patients
n=339
SARC-CalF≥11
n=216
SARC-CalF < 11
n=123
Follow-up 1 year
Follow-up 1 year
No pneumonia
n=150
Pneumonia
n=66
No pneumonia
n=103
Pneumonia
n=20
Excluded
n=2
Excluded
n=2
No pneumonia
n=150
Pneumonia
n=64
Pneumonia
n=103
Pneumonia
n=18

b

Fig. 1. Study data include patient grouping and follow-up information on pneumonia. Note: a: Pneumonia information of patients followed according to SARC-F; b: Pneumonia information of patients followed according to SARC -CalF; c: Pneumonia information of patients followed according to SARC –F + EBM.

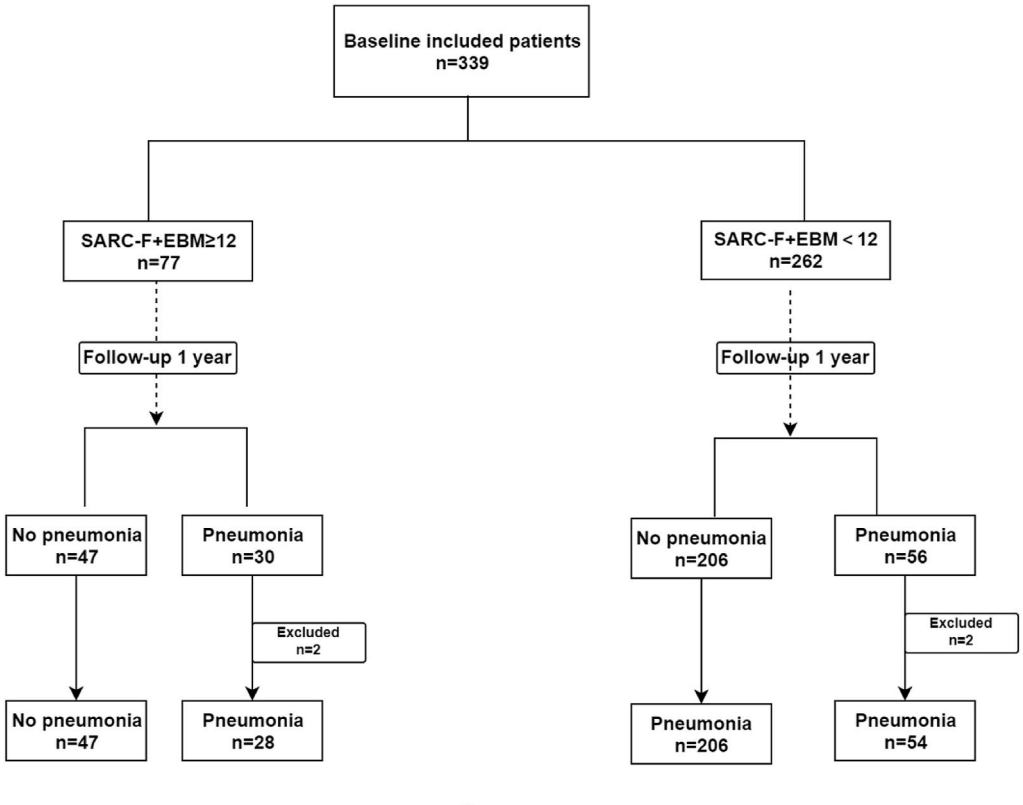


Fig. 1. (*continued*).

Specifically, the inclusion criteria are: 1. Aged 50 years or above; 2. Taking antipsychotic drugs regularly, having a stable condition for more than 6 months, and being able to cooperate with instructions and adhere to the medication plan fully. Exclusion criteria included unstable, uncooperative patients with schizophrenia or other disorders or illnesses deemed inappropriate by the investigators. During follow-up, cases were removed from the analysis if pneumonia developed within a week of a change in patient status.

The study was conducted following the Helsinki Declaration. The study received approval from the Ethics Institutional Review Board of the Zigong Medical Foundation (IRB number: 20191001) and the Psychiatric Hospital of Ziyang (IRB number: zjsjsbyy-kyxm-2019-2). All patients or their authorized representatives provided informed consent forms.

2.2. Screening tools for sarcopenia and the relevant cutoffs

Three screening tools for sarcopenia were applied, namely, SARC-F, SARC-CalF, and SARC-F + EBM. The SARC-F consists of five items, namely, muscle strength, ability to walk, ability to get up from a chair, ability to climb stairs, and the number of falls [18]. These items are scored from 0 to 2, with a total score between 0 and 10 points [18]. Data show that a score $\geq$4 indicates a risk of sarcopenia [18]. Male or female CC values $\leq$ 34 cm or $\leq$33 cm scored 10 points in the SARC-CalF questionnaire (SARC-F plus CC); any other value was considered 0 points [12]. The scores for other items were identical to those of the SARC-F [12]. The total score of the SARC-CalF questionnaire is 0–20, with an overall total of $\geq$11, indicating a risk of sarcopenia [12]. In the SARC-F + EBM questionnaire (incorporating factors such as age and BMI in the SARC-F questionnaire), 10 points were added if the patient was 75 years old or older, with 0 points representing a younger age [13]; similarly, 10 points were added if the BMI values were $\leq$21 kg/m^2 while whereas BMI $>$21 kg/m^2 scored 0 points [13]. The overall score of this tool equaled to 30 points. The scores on the other items were identical to those in the SARC-F [13]. A SARC-F + EBM score of 12 or higher suggests the presence of sarcopenia [13].

2.3. Outcome indicator

A medical professional diagnosed pneumonia and prescribed drugs, primarily antibiotics, to treat it. Only patients with pneumonia for the first-time during follow-up were included in the current study. Every patient underwent a CT scan and a chest radiograph.

Pneumonia was defined as an acute infection of the lung parenchyma, associated with acute infiltrates on chest radiograph or CT, and accompanied by the presence of two or more symptoms, such as elevated body temperature (⩾38 °C), hypothermia (<36 °C), chills, sweating, new cough, or respiratory tract change in the color of discharge, chest discomfort, or difficulty with breathing [19].

2.4. Covariates and model simulations

Data on covariates of patients diagnosed with schizophrenia who had been hospitalized for a duration exceeding 6 months was collected from the computerized system to determine the specific ward area they were assigned to. Following the specified criteria, vital medical data was acquired by direct personal interaction. These data included age, sex, weight, height, CC, and smoking and drinking history. In addition, information on all reported chronic diseases was collected, including diabetes, hypertension, coronary heart disease (CHD), chronic obstructive pulmonary disease (COPD), and hyperlipidemia, which were assessed as covariates. In addition, the Activities of Daily Living (ADL) score [20], the Patient Health Questionnaire (PHQ)-9 score for depression [21], the Short Portable Mental Status Questionnaire (SPMSQ) score for cognitive function [22], and the use of antipsychotic medication (typical antipsychotic and number of drugs), and the benzhexol and Brief Psychiatric Rating Scale (BPRS) scores were used as covariates in the study. The data collection procedure and criteria for selecting the covariates were identical to those employed in prior studies

Table 1
Characteristics of the study population.

General characteristics	No pneumonia n = 253	Pneumonia n = 82	P
Age, year, median (iqr)	65 (58,69)	65 (59,71)	0.156
Sex, n (%)			0.003
male	162 (70.74)	67 (29.26)	
female	91 (85.85)	15 (14.15)	
BMI, kg/m^2, mean (SD)	24.52 (4)	23.15 (3.89)	0.007
CC, cm, median (iqr)	33 (31,35)	32 (30, 33.63)	0.006
Smoking history, n (%)			0.042
no	187 (78.57)	51 (21.43)	
yes	66 (68.04)	31 (31.96)	
Drinking history, n (%)			0.201
no	32 (68.09)	15 (31.91)	
yes	221 (76.74)	67 (23.26)	
COPD, n (%)			<0.001
no	220 (80.88)	52 (19.12)	
yes	33 (52.38)	30 (47.62)	
Hypertension, n (%)			0.346
no	195 (76.77)	59 (23.23)	
yes	58 (71.6)	23 (28.4)	
Diabetes, n (%)			0.611
no	204 (76.12)	64 (23.88)	
yes	49 (73.13)	18 (26.87)	
CHD, n (%)			0.68
no	246 (75.69)	79 (24.31)	
yes	7 (70)	3 (30)	
Hyperlipidemia, n (%)			0.412
no	230 (76.16)	72 (23.84)	
yes	23 (69.7)	10 (30.3)	
ADL score, median (iqr)	100 (90,100)	97.5 (85,100)	0.166
PHQ-9 score, n (%)			0.004
≤4	179 (80.27)	44 (19.73)	
>4	74 (66.07)	38 (33.93)	
SPMSQ score, n (%)			0.253
0-2	85 (79.44)	22 (20.56)	
3-10	168 (73.68)	60 (26.32)	
Typical antipsychotic, n (%)			0.522
no	243 (75.23)	80 (24.77)	
yes	10 (83.33)	2 (16.67)	
Antipsychotic, n (%)			0.167
alone	222 (76.82)	67 (23.18)	
combine	31 (67.39)	15 (32.61)	
Benzhexol, n (%)			0.029
no	179 (72.47)	68 (27.53)	
yes	74 (84.09)	14 (15.91)	
Chlorpromazine equivalent dose, mg, median (iqr)	266.67 (142.86, 333.33)	222.22 (142.86, 333.33) _	0.435
BPRS score, median (iqr)	30 (26, 36)	31 (26.75, 35)	0.544

Note: BMI: body mass index; CC: calf circumference; COPD: chronic obstructive pulmonary disease; CHD: coronary heart disease; ADL: activities of daily living; PHQ-9: Patient Health Questionnaire-9; SPMSQ: Short Portable Mental Status Questionnaire; BPRS: Brief Psychiatric Rating Scale.

conducted by our research team [23]. In addition, the present study also calculated the chlorpromazine equivalent dose [24–26]. The present study also incorporated factors that had univariate p-values less than 0.05 in the adjusted model. We utilized the data to develop two models: an unadjusted Model 1 and a Model 2 that incorporated statistically validated variables in the pneumonia cohort compared to the non-pneumonia cohort. These variables, namely benzhexol, the PHQ-9 score, COPD, smoking history, and sex, were used for model correction.

2.5. Statistical analyses

This study used the SPSS v.25.0 software to compile the statistical data. The initial threshold for data significance was set at P-values less than 0.05. The results of all statistical tests are normally distributed and represented as mean and standard deviation (±SD). The Rank-sum test, Student's *t-test*, and X^2 and Pearson correlation tests were utilized to evaluate patients' medical data. The logistic regression analysis evaluated the link between SARC-F + EBM, SARC-CalF, and SARC-F and the probability of contracting pneumonia.

3. Results

This prospective study enrolled a total of 335 people who had a diagnosis of stable schizophrenia. The overall population consisted of 229 males, accounting for 68.36 %. Our study observed that out of the total number of patients with stable schizophrenia, 82 individuals had pneumonia, representing a rate of 24.48 %. The main differences between the pneumonia and non-pneumonia groups were sex, BMI, CC, smoking history, COPD, PHQ-9 score, and benzhexol. On the other hand, there was no statistical variation in factors like age, alcohol addiction, ADL score, CHD, hyperlipidemia, hypertension, diabetes, SPMSQ score, chlorpromazine equivalent dose, BPRS score, antipsychotic drugs, and their types (Table 1).

Pneumonia was more common in patients with SARC-CalF values ≥ 11 (indicating sarcopenia) in the stable schizophrenia patients than in those with values < 11 (29.91 % vs. 14.88 %, P = 0.002; Table 2). In a similar vein, people with SARC-F + EBM levels ≥12 (indicating sarcopenia) had a greater incidence of pneumonia than people with values < 12 (37.33 % vs. 20.77 %, P = 0.003; Table 2). However, no difference in pneumonia incidence was observed in stable schizophrenia individuals with SARC-F values ≥ 4 or <4 (Table 2).

A logistic regression study was conducted to investigate further the association between the three tools for screening and the likelihood of pneumonia in individuals with stable schizophrenia. It was found that individuals with SARC-CalF values ≥ 11 had a higher likelihood of pneumonia than those with SARC-CalF values < 11 (OR = 2.441, 95%CI: 1.367–4.36). The adjustment of possible confounding influences in patients with SARC-CalF ≥11 continued to provide a greater probability of pneumonia (OR = 2.518, 95%CI: 1.36–4.665). Similarly, patients with SARC-F + EBM ≥12 had a higher likelihood of developing pneumonia (OR = 2.273, 95%CI: 1.304–3.961) than those with SACR-F + EBM <12. In the implemented adjustment of possible confounding factors, patients with SARC-CalF values ≥ 12 had an elevated probability of pneumonia (OR = 2.181, 95%CI: 1.182–4.026). No association was observed between pneumonia risk and SARC-F values in stable individuals with schizophrenia, regardless of whether the values were ≥4 and < 4 (Table 3).

4. Discussion

The findings indicated that stable schizophrenia patients with SARC-F + EBM scores of 12 or higher and SARC-CalF scores of 11 or higher had an increased susceptibility to pneumonia. However, these analyses revealed no statistically significant association between SARC-F scores and the probability of developing pneumonia. The primary factor contributing to this phenomenon may be the prolonged use of antipsychotic drugs by individuals with schizophrenia. Certain drugs provide a feeling of relaxation, which may lead to subtle subjective feelings. As a result, results from a simple questionnaire could be misleading. Objective factors such as age, BMI, and CC must be added to predict these individuals' adverse outcomes (pneumonia). Other investigations have shown that patients with COPD who had relatively low CC levels had worse clinical outcomes. These included increased mortality, lower quality of life scores, more severe or frequently occurring exacerbations, etc. [27]. Some studies reported that CC predicted health complications like accidental falls and hospital readmissions in elderly patients with depression [28]. In other published reports, age was a significant

Table 2
Univariate analysis of SARC-F, SARC-CalF, SARC-F + EBM and pneumonia.

Variable	No pneumonia (n = 253)	Pneumonia (n = 82)	P
SARC-F score, n (%)			0.445
<4	169 (76.82)	51 (23.18)	
≥4	84 (73.04)	31 (26.96)	
SARC-CalF score, n (%)			0.002
<11	103 (85.12)	18 (14.88)	
≥11	150 (70.09)	64 (29.91)	
SARC-F + EBM score, n (%)			0.003
<12	206 (79.23)	54 (20.77)	
≥12	47 (62.67)	28 (37.33)	

Table 3
Association between SARC-F, SARC-CalF, SARC-F + EBM and pneumonia.

Variable	Model 1		Model 2	
	P-value	OR (95 % *CI*)	P-value	OR (95 % *CI*)
SARC-F				
SARC-F score<4	–	1	–	1
SARC-F score≥4	0.446	1.223 (0.729–2.052)	0.797	1.077 (0.614–1.887)
SARC-CalF				
SARC-CalF<11	–	1	–	1
SARC-CalF≥11	0.003	2.441 (1.367–4.36)	0.003	2.518 (1.36–4.665)
SARC-F + EBM				
SACR-F + EBM<12	–	1	–	1
SARC-F + EBM≥12	0.004	2.273 (1.304–3.961)	0.013	2.181 (1.182–4.026)

Note.
Model 1: a non-adjusted model.
Model2: adjusting for sex, smoking history, COPD, PHQ-9 score, benzhexol.

predictor of pneumonia among inpatients from nursing homes [29] and community-acquired pneumonia [30]. It was also found that a low BMI indicated a higher probability of developing pneumonia after craniotomy [31] and predicting community-acquired pneumonia [32]. The studies above demonstrate an association between CC, age, and BMI and unfavorable clinical outcomes. Thus, it has been hypothesized that this is why the SARC- CalF and SARC-F + EBM values in our study accurately predicted the occurrence of pneumonia in stable schizophrenia patients, whereas the SARC-F value did not.

In this study, 24.48 % of patients with schizophrenia developed pneumonia, which is higher than that reported in other studies (4.6–10.26 %) [6,33,34]. There are other potential explanations for this disparity. The participants in our research with schizophrenia were aged 50 years and above, leading to a higher median age of around 65 years for the study population. Conversely, in the remaining three trials, the subjects' average age varied from 40.62 to 52.3 years old. Pneumonia is recognized to be influenced by age as a distinct risk factor [30]. Second, our study was conducted on long-term hospitalized schizophrenia patients, while the other three studies were not conducted on long-term hospitalized schizophrenia patients. Patients living in healthcare facilities are at significantly increased risk of developing pneumonia [35]. Finally, this research included a limited sample size of 335 individuals, potentially introducing sampling bias. The sample sizes in the remaining three investigations were in the thousands, which may be another limitation of this study.

The strength of this study is the discovery of the role of SARC-CalF and SARC-F + EBM in predicting the risk of pneumonia in patients with stable schizophrenia. Prior to this, these two scales were mostly used for older people. SARC-CalF and SARC-F + EBM are simple, fast, cheap, and non-invasive scale assessments. They have definite clinical value for mental health institutions with limited equipment and are also very beneficial in reducing the cost of medical examinations for patients.

There are certain limitations in our prospective study. Initially, the cohort consisted of a relatively limited number of individuals, specifically patients diagnosed with schizophrenia residing in Western China. Specifically, the study had inadequate pneumonia patients who were assessed using the SARC-F score (with a power value of only 0.12). The power values for SARC-CalF and SARC-F + EBM were 0.92 and 0.77, respectively. Therefore, it is necessary to confirm the findings of this study regarding the SARC-F score by conducting studies with larger sample sizes. Second, the period for follow-up was relatively short. These limitations resulted in fewer data and insufficient clinical information from those patients who died. The last hindered any investigation of the association between the three screening tools and death probability in these individuals. Lastly, age as a screening parameter for identifying the risk of pneumonia in adults with stable schizophrenia could not be further implicated due to the small number of patients included.

5. Conclusions and Implications

The present study demonstrated that two screening tools, SARC-CalF and SARC-F + EBM, were associated with pneumonia probability among stable schizophrenia individuals. In patients with stable schizophrenia, however, there was no association between the SARC-F score and the incidence of pneumonia. Hence, in hospitals that cannot detect sarcopenia, we recommend using the SARC-CalF and SARC-F + EBM scores to assess the risk of pneumonia in these patients.

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Sponsor's role

The sponsors did not participant in the design, methods, data collection, analysis, or in the preparation of this manuscript.

Availability of data and materials

The datasets generated and analyzed during the current study are not publicly available due to this is a database that has a lot of important information, and we are applying some important projects based on this. However, the dataset is now available from the corresponding author upon reasonable request.

CRediT authorship contribution statement

Sha Huang: Writing – original draft, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Ming Chen:** Writing – original draft, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization. **Tian Zhu:** Writing – review & editing, Methodology, Investigation, Data curation, Conceptualization. **Xiuping Lei:** Writing – review & editing, Methodology, Investigation, Data curation, Conceptualization. **Qiuxia Li:** Writing – review & editing, Methodology, Investigation, Data curation, Conceptualization. **Youguo Tan:** Writing – review & editing, Investigation, Conceptualization. **Xiaoyan Chen:** Writing – review & editing, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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