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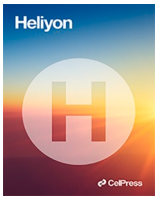

Research article

Albumin-dNLR score could be an etiological criterion to determine inflammation burden for GLIM in medical inpatients over 70 years old: A multicenter retrospective study

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ABSTRACT

Aim: To validate the role of the albumin-derived neutrophil-to-lymphocyte (ALB-dNLR) score in diagnosing malnutrition in medical inpatients over 70 years old.
Methods: This is a retrospective cross-sectional study involving 7 departments from 14 Chinese hospitals. The ALB-dNLR score was calculated, and outcomes between groups with positive and negative ALB-dNLR scores were compared after propensity score matching (PSM). Afterwards, the outcomes were compared between the groups receiving nutrition support and those not receiving support among malnourished patients diagnosed using the Global Leadership Initiative Malnutrition (GLIM) criteria after PSM.
Results: Out of 10,184 cases, 6165 were eligible. 2200 cases were in the positive ALB-dNLR score group. After PSM, 1458 pairs were analyzed, showing lower in-hospital mortality (0.8 % vs. 2.1 %, $p = 0.005$) and a lower nosocomial infection rate (5.9 % vs. 11.0 %, $p < 0.001$) in the negative ALB-dNLR score group. In malnourished patients, 259 pairs were analyzed after PSM. It showed better outcomes in mortality (0.8 % vs. 3.5 %, $p = 0.033$), nosocomial infection rate (5.4 % vs. 15.4 %, $p < 0.001$), length of stay (LOS) (13.8 ± 10.3 vs. 18.4 ± 14.1, $p < 0.001$), and total hospital cost (3315.3 ± 2946.4 vs. 4795.3 ± 4198.2, $p < 0.001$) in the support group. In malnourished patients with ALB-dNLR score as the sole etiological criterion, 94 pairs were calculated. It showed better outcomes in mortality (0.0 % vs. 6.4 %, $p = 0.029$), nosocomial infection rate (7.4 % vs. 18.1 %, $p = 0.029$), LOS (13.7 ± 8.3 vs. 19.8 ± 15.2, $p = 0.001$), and total hospital cost (3379.3 ± 2955.6 vs. 4471.2 ± 4782.4, $p = 0.029$) in the support group.
Conclusions: The ALB-dNLR score was validated to predict in-hospital mortality in medical inpatients over 70 years old. Malnutrition patients diagnosed by the GLIM criteria and using the ALB-dNLR score might benefit from nutrition support.

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1. Introduction

With the increase in the aging population worldwide, geriatric diseases have become a significant burden on public health. Elderly hospitalized patients have a high rate of comorbidity, which impacts their nutritional status and outcomes [1,2]. Furthermore, nutritional risk and malnutrition are independent risk factors that lead to a worse prognosis. Researchers are dedicated to discovering high-level evidence and establishing standardized strategies for nutritional evaluation and intervention for elderly patients [3]. In 2019, Professor Philipp Schuetz and his colleagues published the EFFORT study and a series of studies by reanalyzing the EFFORT database [4]. In these high-quality studies, the authors demonstrated the effectiveness of nutrition support in malnourished patients from various perspectives. They emphasized that nutritional screening, assessment, and personalized interventions should be integrated into daily clinical practice and multimodal treatment in hospitals worldwide [5].

Disease-related malnutrition (DRM) has replaced starvation-related malnutrition as the primary cause of malnutrition in clinical practice [6]. The core of DRM is systemic inflammation caused by the original disease and its comorbidities, which may result in inadequate nutrient intake and weight loss. Before the Global Leadership Initiative on Malnutrition (GLIM) criteria, there were no clear definitions and diagnostic criteria for malnutrition [7]. While GLIM provides a unified diagnostic framework, it also offers a vast space for research and continuous updates [8].

For inflammation assessment, C-reactive protein (CRP) was the most commonly used marker [9]. In China, however, it is not a routine test after admission [10]. Counts of neutrophils and lymphocytes are available for all patients, which can indicate acute and chronic inflammation. Albumin is a routine test that relates to both inflammatory and nutritional status. The albumin-derived neutrophil-to-lymphocyte ratio (ALB-dNLR) is a combination of albumin and complete blood count, which has been validated in some studies [11]. In this study, our aim was to calculate and validate the ALB-dNLR score. Subsequently, we intended to incorporate it into the GLIM criteria and assess the significance of GLIM-defined malnutrition in guiding nutrition support for medical malnutrition inpatients over 70 years old in China.

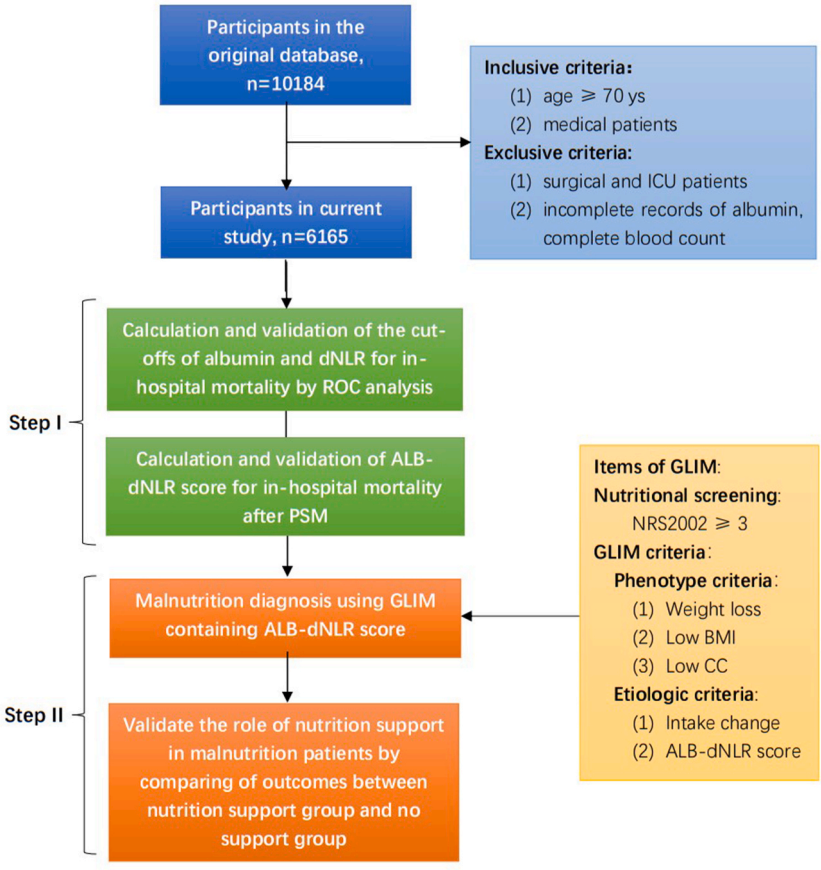

Fig. 1. Flowchart of the study.

2. Materials & methods

2.1. Participants

The Geriatric Study Group of the Chinese Society of Parenteral and Enteral Nutrition (CSPEN) conducted a prospective multicenter investigation of the nutritional status in non-ICU elderly patients in seven departments from 14 major Chinese hospitals from March 2012 to May 2012. The original inclusive criteria were: (1) age ≥65 years old, (2) hospitalized overnight, (3) not receiving emergency surgery, (4) conscious, and (5) willing to cooperate with the researchers and sign informed consent. Based on this database, we selected patients to participate in this study who met the previous criteria and new inclusion criteria, including: (1) age ≥70 years old, (2) patients from the internal medicine department, (3) complete records of albumin and complete blood count, and (4) a length of stay exceeding 48 h. All data extraction and analysis were conducted by the authors listed, who were involved in establishing the original prospective database. The present study adhered to the STROBE guidelines for a cross-sectional study.

2.2. Study design

This is a secondary retrospective study of a dataset. we did the analyses in two steps which are shown in Fig. 1.

2.2.1. Step I - calculation and validation of ALB-dNLR score

We calculated dNLR using the following formula as previously reported: neutrophil count/(leukocyte count - neutrophil count) [12]. Receiver operating characteristic (ROC) analysis was used to determine the cutoff values of serum albumin and dNLR [13]. The ALB-dNLR score was classified into three levels: a score of 2 indicated both low albumin and high dNLR; a score of 1 indicated either of the two abnormalities, and a score of 0 indicated a high albumin level and low dNLR [14]. In some references published in the last two years, the high ALB-dNLR group included only patients with a score of 2, while the low ALB-dNLR group included patients with scores of 1 and 0 [11,15,16]. However, we divided the patients into two groups based on the ALB-dNLR score classification. An ALB-dNLR score of 2 or 1 was defined as the ALB-dNLR score positive group, which was considered to have high or moderate inflammation. An ALB-dNLR score of 0 was defined as the ALB-dNLR score negative group, which was considered to have mild or no inflammation. The reason for the different way of grouping is that in many published papers, both albumin and dNLR are independently related to systemic inflammation [12,17,18]. Either of them becomes abnormal and may be treated as inflammation. In the diagnosis of malnutrition using GLIM, one of the criteria is to assess the body's inflammation status. Therefore, solely relying on an ALB-dNLR score of 2 may overlook patients with inflammation whose ALB-dNLR score is 1. In our study, the ALB-dNLR score positive group included scores of 1 and 2. Subsequently, we compared the outcomes between these two groups after propensity score matching (PSM) and validated the significance of the ALB-dNLR score through logistic regression analysis.

2.2.2. Step II - validation of GLIM using ALB-dNLR score

We used the Nutritional Risk Screening 2002 (NRS2002) as the screening tool to determine the nutritional risk, and the patients who meet these criteria would undergo nutrition assessment by GLIM [7,19]. The GLIM criteria consist of three components in phenotypic criteria and two components in etiologic criteria. It is necessary to fulfill at least one component in each part to diagnose malnutrition. In phenotypic criteria, a weight loss of more than 5 % within the last 6 months was considered positive. BMI was retrieved from the original database. Calf circumference (CC) was used to assess muscle atrophy, as per our previous study [20]. In etiologic criteria, less than 50 % of the requirements lasting more than 1 week, or any reduction for more than 2 weeks, were considered positive. For disease burden or inflammation, we utilized the ALB-dNLR score validated in this study as the inflammation marker instead of diagnosis, which is deemed to be highly subjective and variable. Then we validated the effect of GLIM-defined malnutrition using the ALB-dNLR score on in-hospital mortality through logistic regression analysis.

To assess the effectiveness of GLIM in guiding treatment, we categorized malnourished patients into two groups: a nutrition support group and a no support group. We then compared the outcomes between these two groups after performing PSM. The original database was established prospectively in 2012, and a relatively consistent definition of nutrition support was applied across all hospitals that contributed data, based on the ESPEN guidelines at that time. Parenteral nutrition is defined as the intravenous administration of a combination of amino acids, glucose, and fats that meet the recommendations of the guidelines. Enteral nutrition includes both oral nutrition supplements and tube feeding [21,22].

2.3. Clinical characteristics and outcomes

Basal data contained age, sex, complete blood count, serum test containing albumin and liver function, nutrition support after admission, and diagnosis. All blood tests were done within 72 h after admission. We use dichotomy to separate diagnoses: benign and malignant. The anthropometric parameters included height, weight, body mass index (BMI), and CC. Clinical outcomes included in-hospital mortality, nosocomial infection rate, length of hospital stay (LOS), and total hospital cost. Since the original database was multicentered and there was missing data in the recruited cases. According to the inclusive criteria, we deleted all patients without complete records of albumin and complete blood counts. In the eligible 6165 cases, based on the items we analyzed in this study, 89 (1.4 %) cases of CC, 41 (0.7 %) cases of ALT, and 139 (2.3 %) cases of total in-hospital cost were missed, which were too small to influence the calculation of the whole data. We used the mean completer for the missing data imputation.

2.4. Propensity score matching

We applied propensity score matching (PSM) to guarantee the balance between the study and control groups. The matching variables were all basal characteristics that were significantly different between groups, including age, sex, BMI, CC, Hgb, ALT, diagnosis, and nutrition support. Binary logistic regression with selected variables was used to generate continuous propensity scores from 0 to 1. Patients were matched by a matching ratio of 1:1 based on the propensity score with a standard caliper width of 0.02 [23].

2.5. Statistical analysis

The original data were input by two staff to ensure accuracy. IBM SPSS Statistics (Ver. 26.0, IBM Corp., Armonk, NY, United States) was used to do the statistical analysis. Continuous data were compared by the Student's unpaired *t*-test. Categorical data were tested by the Fisher exact test or chi-square test. The cut-off values were calculated by maximizing the sensitivity and specificity using Youden's index, and the areas under the receiver operating characteristic (ROC) curves were compared. Uni- and multivariate logistic regression analyses were conducted to evaluate the relationship between risk factors and in-hospital mortality, and the results were expressed utilizing an odds ratio (OR) with 95 % confidence intervals (CI). We defined the risk factors in our published study [20]. P value less than 0.05 meant statistically significant.

2.6. Ethics

The original study was approved by the ethics committee of Beijing Hospital (approve number: LLKYPJ2012002A), and written informed consent was obtained before the investigation from every participant, and the consent contained information that the data might be used for subsequent studies. And the Declaration of Helsinki and good clinical practice standards were applied and complied with.

3. Results

3.1. Basal characteristics

There were 10184 cases in the original database and 6165 were selected according to inclusive and exclusive criteria. According to geographical distribution, 2655 (43.1 %) cases were from East China, 1827 (29.6 %) were from North and Northeast China, 946 (15.3 %) were from Southwest China, 371 (6.0 %) were from South China, 205 (3.3 %) were from Middle China, and 161 (2.6 %) were from Northwest China. The average age was 78.0 ± 5.7 years old with a range of 70.0–112.0 and 3750 (60.8 %) cases were male. Cancer patients accounted for 15.6 % (961/6165) who received adjuvant or supportive therapy but not terminal palliative care. Benign chronic disease patients accounted for the rest 84,4 % and they were from the internal medicine departments of respiration, cardiology, GI tract, nephrology, and neurology. The prevalence of nutritional risk determined by NRS 2002 was 52.3 % (3225/6165).

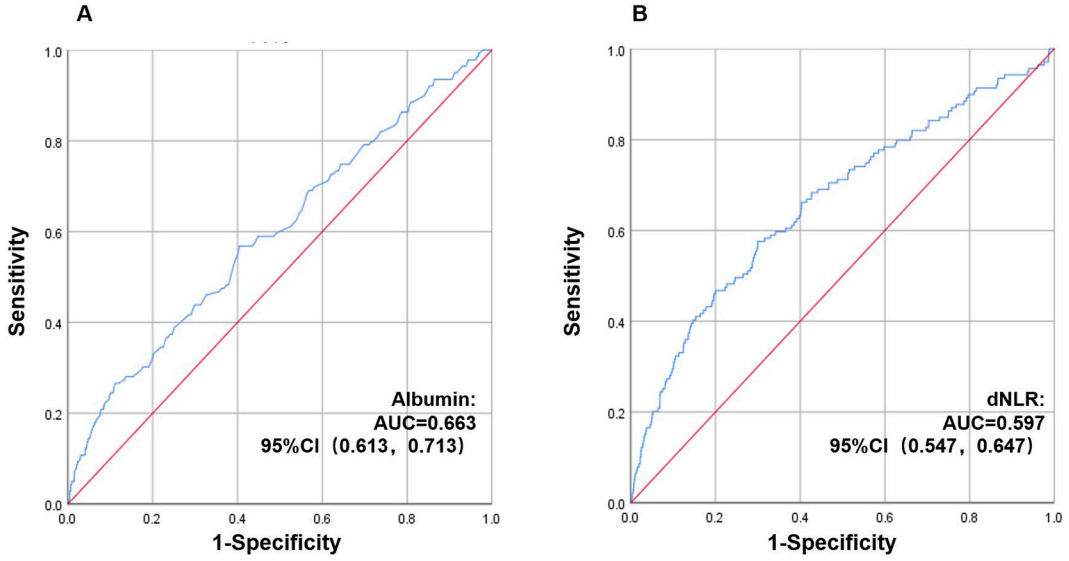

Fig. 2. Receiver operating characteristic (ROC) analysis of albumin and dNLR for in-hospital mortality. A. ROC curve of albumin; B. ROC curve of dNLR.

3.2. Step I -study of ALB-dNLR score

3.2.1. Cutoff of dNLR and ALB

By ROC analysis, the optimal cutoff value of albumin was 36.0 g/L, and the area under the curve (AUC) was 0.663 for in-hospital mortality (2.3 %, 139/6165) with the 95%CI(0.613,0.713), the sensitivity was 0.568, the specificity was 0.595, the Youden's index was 0.163, and p-value < 0.001(Fig. 2A). And 40.8 %(2517/6165) cases were lower than this cut-off. The cutoff value of dNLR was 3.67 (AUC, 0.597) in-hospital mortality with the 95%CI(0.547,0.647), the sensitivity was 0.576, the specificity was 0.700, the Youden's index was 0.276, and p-value < 0.001(Fig. 2B). And 30.5 % (1880/6165) reached the criterion. Thus, we calculated the ALB-dNLR score. 64.3 % (3965/6165) got 0 scores, 18.4 % (1136/6165) got 1 score and 17.3 % (1064/6165) got 2 scores. Then the patients were divided into ALB-dNLR score positive (2 and 1) and negative groups. The clinical characteristics of the two groups are summarized in Table 1.

3.2.2. ALB-dNLR score and mortality

From Table 1, we can see the imbalance of original basal data between ALB-dNLR score positive and negative groups. Then we did PSM to make the groups comparable. After PSM, 1458 pairs were compared with statistically lower In-hospital mortality (2.1 % vs. 0.8 %, $p = 0.005$) and lower nosocomial infection rate (11.0 % vs. 5.9 %, $p < 0.001$) in the negative ALB-dNLR score group.

Fig. 3 displayed the uni- (Fig. 3A) and multivariate (Fig. 3B) analyses which showed that age [OR = 2.387, 95 %CI (1.139–5.001), p = 0.021], calf circumference [OR = 0.363, 95 %CI (0.208–0.635), p < 0.001], ALB-dNLR score [OR = 2.406, 95 %CI (1.463–3.957), p = 0.001] were proved to be independent poor prognostic factors of in-hospital mortality and nutrition support was a protective factor [OR = 0.259, 95 %CI (0.157–0.429), p < 0.001].

3.3. Step II – study of GLIM-defined malnutrition

3.3.1. Basal data and mortality

Diagnosed by GLIM criteria, the prevalence of malnutrition was 28.3 % (1747/6165). The average age was 78.2 ± 5.9 years old with a range of 70.0–100.0 and 1088 (62.3 %) cases were male. 13.2 % (230/1747) were cancer patients. Then we divided the patients into nutrition support and no-support groups. The clinical characteristics of the two groups are summarized in Table 2.

Fig. 4 displayed the uni- (Fig. 4A) and multivariate (Fig. 4B) analyses to assess the effect of GLIM-defined malnutrition using ALB-dNLR score on in-hospital mortality in malnutrition patients, which showed that age [OR = 1.837, 95 %CI (1.051–3.211), p = 0.033] and GLIM-defined malnutrition [OR = 1.207, 95 %CI (1.009–1.443), p = 0.039] were proved to be independent poor prognostic

Table 1
Basal data and outcome comparisons between ALB-dNLR score positive and negative groups in all patients.

Variables	Before PSM		P	After PSM		P
	ALB-dNLR score positive group (n = 2200)	ALB-dNLR score negative group (n = 3965)		ALB-dNLR score positive group (n = 1458)	ALB-dNLR score negative group (n = 1458)	
Basal data						
Age, mean (SD), year	78.5 (5.8)	77.7 (5.6)	< 0.001	77.9 (5.6)	77.8 (5.7)	0.811
Sex, male, n (%)	1412 (64.2)	2338 (59.0)	< 0.001	931 (63.9)	899 (61.7)	0.220
BMI, mean (SD), kg/m^2	22.4 (3.9)	23.6 (3.7)	< 0.001	22.6 (3.8)	22.9 (3.9)	0.968
CC, mean (SD), cm	30.8 (4.1)	32.4 (3.7)	< 0.001	31.5 (3.8)	31.6 (3.7)	0.851
Haemoglobin, mean (SD), g/L	116.3 (23.2)	124.9 (18.3)	< 0.001	119.0 (21.4)	119.5 (19.3)	0.489
ALT, mean (SD), U/L	30.0 (79.5)	21.1 (32.2)	< 0.001	26.2 (35.8)	25.0 (48.8)	0.448
Diagnosis, cancer, n (%)	331 (15.0)	630 (15.9)	0.448	257 (17.6)	164 (18.1)	0.735
Nutrition support, n (%)	777 (35.3)	803 (20.3)	< 0.001	395 (27.1)	383 (26.3)	0.615
Outcomes						
In-hospital mortality, n (%)	91 (4.1)	48 (1.2)	< 0.001	30 (2.1)	12 (0.8)	0.005
nosocomial infection, n (%)	328 (14.9)	312 (7.9)	< 0.001	161 (11.0)	86 (5.9)	< 0.001
Length of stay, mean (SD), day	15.2 (10.1)	14.2 (10.3)	< 0.001	14.3 (9.3)	14.2 (10.6)	0.885
Total in-hospital cost, mean (SD), USD	4000.6 (3876.0)	3731.0 (3800.4)	< 0.001	3745.6 (3555.3)	3776.5 (3826.3)	0.824

PSM: prosperity score matching: SD: standard deviation; BMI: body mass index; WBC: white blood cell; ALT: alanine transaminase; USD: United States dollar.

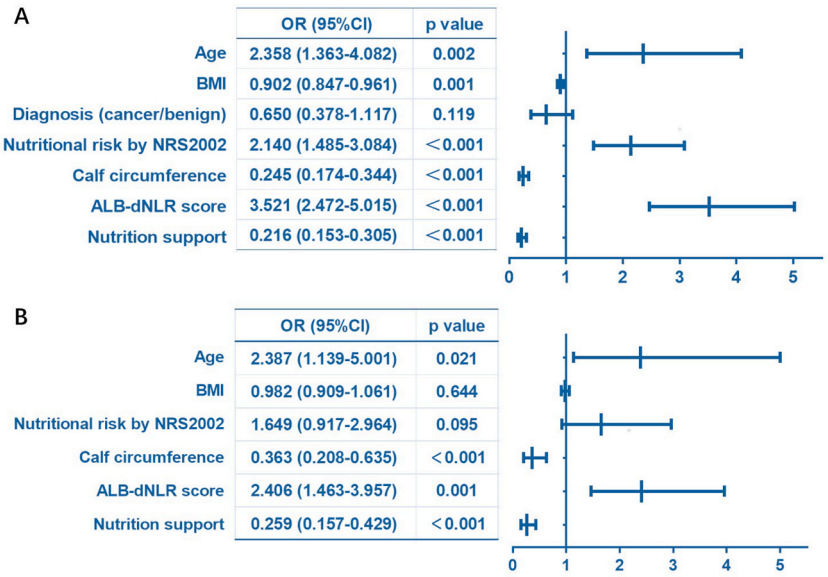

Fig. 3. Regression analysis for in-hospital mortality in all patients. A. univariate analysis; B. multivariate analysis.

Table 2
Basal data and outcome comparisons between nutrition support and no support groups in malnutrition patients.

Variables	Before PSM		P	After PSM		P
	Nutrition support group (n = 445)	No support group (n = 1302)		Nutrition support group (n = 259)	No support group (n = 259)	
Basal datarowhead						
Age, mean (SD), year	79.4 (6.6)	77.8 (5.5)	< 0.001	78.1 (5.4)	78.2 (6.3)	0.736
Sex, male, n (%)	278 (62.5)	810 (62.2)	0.922	158 (61.0)	161 (62.2)	0.786
BMI, mean (SD), kg/m2	22.3 (3.7)	23.7 (3.8)	< 0.001	22.5 (3.7)	22.4 (3.7)	0.895
CC, mean (SD), cm	30.1 (4.2)	32.5 (3.7)	< 0.001	31.1 (3.6)	31.0 (3.9)	0.735
Haemoglobin, mean (SD), g/L	115.8 (22.3)	125.4 (18.3)	< 0.001	119.5 (19.1)	118.7 (21.9)	0.652
WBC, mean (SD), × 109/L	7.6 (3.8)	6.6 (2.5)	< 0.001	7.0 (3.0)	6.9 (3.2)	0.930
ALT, mean (SD), U/L	26.7 (54.9)	20.7 (32.2)	0.031	21.8 (30.0)	28.4 (64.0)	0.135
Albumin, mean (SD), g/L	35.3 (5.9)	39.8 (6.0)	0.000	35.7 (4.8)	35.9 (5.1)	0.767
Diagnosis, cancer, n (%)	102 (23.0)	128 (9.9)	< 0.001	76 (29.3)	75 (29.0)	0.923
Outcomesrowhead						
In-hospital mortality, n (%)	34 (7.6)	29 (2.2)	< 0.001	2 (0.8)	9 (3.5)	0.033
nosocomial infection, n (%)	98 (22.0)	81 (6.2)	< 0.001	14 (5.4)	40 (15.4)	< 0.001
Length of stay, mean (SD), day	19.8 (15.4)	14.4 (10.8)	< 0.001	13.8 (10.3)	18.4 (14.1)	< 0.001
Total in-hospital cost, mean (SD), USD	4989.0 (4194.2)	3429.3 (3327.4)	< 0.001	3315.3 (2946.4)	4795.3 (4198.2)	< 0.001

PSM: prosperity score matching: SD: standard deviation; BMI: body mass index; WBC: white blood cell; ALT: alanine transaminase; USD: United States dollar.

factors of in-hospital mortality and nutrition support was a protective factor [OR = 0.25948, 95 %CI (0.173–0.357), p < 0.001].

3.3.2. Nutrition support in malnutrition

Since the baseline characteristics were not comparable between the nutrition support and no support groups in malnourished patients, we utilized Propensity Score Matching (PSM) to balance the baseline data (Table 2). After propensity score matching (PSM), 259 pairs were compared, revealing statistically lower in-hospital mortality (0.8 % vs. 3.5 %, p = 0.033), a lower nosocomial infection rate (5.4 % vs. 15.4 %, p < 0.001), a shorter length of stay (13.8 ± 10.3 vs. 18.4 ± 14.1, p < 0.001), and lower total in-hospital costs

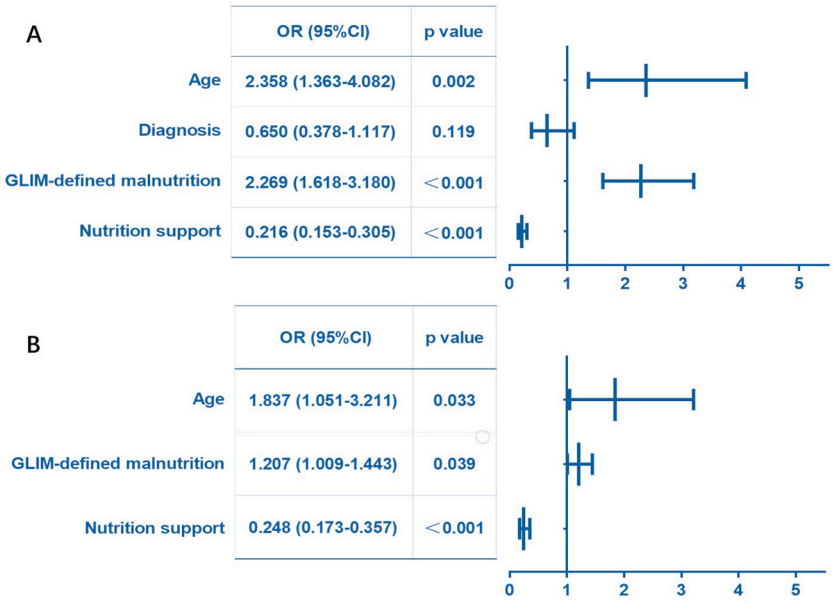

Fig. 4. Regression analysis for in-hospital mortality in GLIM-defined malnutrition patients. A. univariate analysis; B. multivariate analysis.

(3315.3 ± 2946.4 vs. 4795.3 ± 4198.2, $p < 0.001$) in the nutrition support group.

3.3.3. Nutrition support in ALB-dNLR score defined malnutrition

To further validate the significance of the ALB-dNLR score, we analyzed the data of malnutrition patients defined by GLIM, where the ALB-dNLR score was the sole criterion used to assess the burden of inflammation. We compared the outcomes between patients receiving nutrition support and those without support. 577 cases were included, and 94 pairs were calculated after propensity score matching (PSM). Table 3 displays the results indicating that nutrition support may lead to statistically lower in-hospital mortality (0.0 % vs. 6.4 %, $p = 0.029$), a lower nosocomial infection rate (7.4 % vs. 18.1 %, $p = 0.029$), a shorter length of stay (13.7 ± 8.3 vs. 19.8 ± 15.2, $p = 0.001$), and lower total in-hospital costs (3379.3 ± 2955.6 vs. 4471.2 ± 3782.4, $p = 0.029$).

4. Discussion

The ALB-dNLR score is a new parameter used to evaluate inflammation. It has been validated in several recent studies and is associated with higher mortality rates, cancer prognosis, and sensitivity to anticancer treatments [11,15,16]. In our study, the ALB-dNLR score has been validated as a reliable predictor of mortality in medical inpatients over 70 years old.

The GLIM criteria is a new diagnostic tool for malnutrition published in 2019. Numerous studies have been published to validate different populations using various methods and combinations of criteria. The ideal assessment tool we need should be simple (easy to learn and conduct), available (no need for a complex instrument or process), time-saving, economical, and clinically validated [24]. Based on our experience and the literature, there are some questions that require discussion.

GLIM criteria consist of five criteria. The most common modified criteria include weight loss, low BMI, and reduced intake, all of which are objective measures that can be easily assessed [25,26]. The other two criteria, muscle mass reduction and inflammation, lack unified measurement methods and cut-off values, which are the focus of controversy and are often omitted [27,28]. In a scoping review of 79 studies on inflammation, two-thirds of the studies reported inflammation based on disease burden and diagnosis, which are subjective and challenging to reach a consensus on [7]. For example, in a study of COPD, all patients were considered to have inflammation burden even though they were considered stable according to the inclusive criteria [29]. In another study of patients awaiting liver transplantation, the authors used Child-Pugh or MELD scores to determine inflammation burden. However, the GLIM criteria were found to be inadequate for diagnosing malnutrition [30]. So, objective and quantifiable criteria are urgently needed. In that scoping review, only one-fourth used inflammation biomarkers [7]. The most commonly used biomarker was CRP. IL-6 and IGF-1 were also helpful, but they are not widely accessible [31]. In China, CRP is not routinely tested after admission. Therefore, some Chinese researchers utilize white blood cells and their relative parameters like NLR and PLR [32]. Albumin has been proven to be an inflammation biomarker and also a traditional marker of nutritional status, but its sole use remains controversial [17,18]. In this study, after validating the ALB-dNLR ratio, we utilized it as an inflammation criterion in the GLIM criteria for diagnosing malnutrition.

In clinical practice, the true role of diagnostic criteria is not only to predict outcomes but also to guide nutrition support therapy [33]. From 2010 to the present study, a series of studies conducted by the Nutritional Risk – Undernutrition – Support – Outcomes – Cost/effectiveness ratio (NUSOC) Multicenter Data Sharing Cooperative Group from the Chinese Society of Parenteral and Enteral Nutrition (CSPEN), founded by Professor Zhuming Jiang, focused on the correlation study and risk analysis between malnutrition and

Table 3
Basal data and outcome comparisons between nutrition support and no support groups in malnutrition patients with ALB-dNLR positive score.

Variables	Before PSM		P	After PSM		P
	Nutrition support group (n = 375)	No support group (n = 202)		Nutrition support group (n = 94)	No support group (n = 94)	
Basal datarowhead						
Age, mean (SD), year	78.2 (5.4)	79.7 (6.6)	0.005	77.7 (5.6)	78.5 (6.2)	0.302
Sex, male, n (%)	245 (65.3)	128 (63.4)	0.637	55 (58.5)	58 (61.7)	0.655
BMI, mean (SD), kg/m2	22.9 (3.9)	21.6 (4.1)	0.003	22.3 (4.4)	22.1 (4.1)	0.755
CC, mean (SD), cm	31.8 (3.7)	29.3 (4.5)	< 0.001	30.7 (3.6)	30.6 (4.2)	0.863
Haemoglobin, mean (SD), g/L	121.1 (21.2)	110.9 (24.4)	< 0.001	115.6 (19.8)	115.9 (24.1)	0.939
WBC, mean (SD), × 109/L	8.4 (3.3)	9.5 (4.6)	0.002	8.5 (3.6)	8.9 (4.2)	0.492
ALT, mean (SD), U/L	23.3 (40.2)	30.1 (66.5)	0.191	25.6 (42.6)	37.3 (91.9)	0.265
Albumin, mean (SD), g/L	34.6 (5.2)	32.2 (5.3)	< 0.001	32.9 (5.0)	33.1 (5.2)	0.806
Diagnosis, cancer, n (%)	28 (7.5)	37 (18.4)	< 0.001	18 (19.1)	15 (16.0)	0.565
Outcomesrowhead						
In-hospital mortality, n (%)	14 (3.7)	20 (9.9)	0.003	0 (0.0)	6 (6.4)	0.029
nosocomial infection, n (%)	38 (10.1)	49 (24.3)	< 0.001	7 (7.4)	17 (18.1)	0.029
Length of stay, mean (SD), day	13.5 (9.2)	20.5 (15.7)	< 0.001	13.7 (8.3)	19.8 (15.2)	0.001
Total in-hospital cost, mean (SD), USD	3291.1 (3104.0)	4913.9 (3822.8)	< 0.001	3379.3 (2955.6)	4471.2 (3782.4)	0.029

PSM: prosperity score matching: SD: standard deviation; BMI: body mass index; CC: calf circumference; WBC: white blood cell; ALT: alanine transaminase; USD: United States dollar.

adverse outcomes. Malnutrition patients were divided into nutrition support and no support groups, and outcomes were compared between these two groups to validate the value of nutrition support [26,34–36]. In the series of EFFORT studies, Professor Philipp Schuetz and colleagues conducted similar research to ours and clarified that the primary goal of nutritional diagnosis is to predict which patients are likely to benefit from nutritional therapy [25,37]. Our results indicate that the ALB-dNLR ratio can predict in-hospital mortality and assist in identifying malnourished patients who may benefit from nutritional interventions.

According to the recent systematic review and our literature search, this study represents the first comprehensive analysis aimed at identifying and validating an inflammation biomarker for potential use in the GLIM etiologic criteria, particularly in the elderly [8]. However, several limitations exist. First, we only studied the ALB-dNLR score. Other parameters such as CRP and prognostic index may also be useful and require further investigation. Secondly, as this is a secondary analysis of a prospective database established twelve years ago, we were unable to account for all potential confounding variables in our analysis. Third, the database was department-based. In the future, disease-specific study designs should be considered as they may provide a more comprehensive overview.

5. Conclusions

By conducting this multicenter retrospective study, the ALB-dNLR score was validated for predicting in-hospital mortality in medical inpatients over 70 years old. Additionally, it could serve as an etiological criterion for determining the inflammation burden for GLIM. Malnourished patients diagnosed by the Global Leadership Initiative on Malnutrition (GLIM) criteria using the Albumin-derived Neutrophil-to-Lymphocyte Ratio (ALB-dNLR) score might benefit from nutrition support.

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Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

CRediT authorship contribution statement

Jingyong Xu: Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Yifu Hu:** Writing – review & editing, Software, Formal analysis, Data curation. **Lijuan Wang:** Writing – review & editing, Software, Investigation, Formal analysis, Data curation. **Pengxue**

Li: Writing – review & editing, Software, Formal analysis, Data curation. **Mingwei Zhu:** Writing – review & editing, Methodology, Investigation, Data curation, Conceptualization. **Jinghai Song:** Writing – review & editing, Supervision, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Junmin Wei:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, 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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