European Review for Medical and Pharmacological Sciences 2021; 25: 4037-4050

Utility of the DECAF score for predicting survival of patients with COPD: a meta-analysis of diagnostic accuracy studies

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Abstract. – OBJECTIVE: The DECAF (Dyspnea, Eosinopenia, Consolidation, Acidemia, Atrial Fibrillation) score is a widely used system for predicting the survival of patients with acute aggravation of chronic obstructive pulmonary disease (COPD). Evaluations of the predictive accuracy of DECAF have shown differing results. We performed this meta-analysis to evaluate the DECAF score as a survival predictor in patients with COPD.

MATERIALS AND METHODS: We have included the studies examining the accuracy of DECAF scoring system as index test with occurrence of events (mortality and need for invasive/non-invasive ventilation) as reference standards irrespective of the study design employed, type of participants and severity of the condition. We conducted a systematic search for all studies reporting the predictive accuracy of DECAF scores in the databases of PubMed Central, Scopus, Medline, Embase, and Cochrane from inception until September 2020. We have used the quality assessment of diagnostic accuracy studies-2 (QUADAS-2) tool to evaluate the risk of bias. We used the STATA software "midas" package to perform the meta-analysis.

RESULTS: We included 21 studies with 6429 patients. Most studies included were prospective. Most studies were conducted in the United Kingdom. Most studies used a cut-off value of the DECAF score ≥3 to predict the in-hospital or 30-day mortality and need for mechanical ventilation. All the studies used the occurrence of in-hospital/30-day mortality or patient undergoing mechanical ventilation as the reference standards. The pooled sensitivity and specificity of the DECAF score for predicting in-hospital mortality among patients with acute exacerbation of COPD were 74% (95% CI, 67%-79%) and 76% (95% CI, 68%-82%), respectively; and those for the 30-day mortality were 72% (95% CI, 59%-82%) and 83% (95% CI, 67%-93%), respectively. The overall quality of the studies in our meta-analysis was high. We found no significant publication biases as per Deek's test and funnel plot.

CONCLUSIONS: This review has certain strengths. It is the first meta-analysis assessing the predictive utility of the DECAF score for in-hospital mortality among patients with AECOPD. Most studies included were of high quality according to the QUADAS-2 tool. Despite these strengths, our review had some limitations. We found a significant between-study variability in our analysis that can limit its value for inferring or interpreting the pooled findings. The predictive accuracy of the scoring system depends on many factors such as the ethnicity of the participants or patients, the timing of the scoring system assessment, and the AECOPD severity. We could not assess the influence of these variables in our study. Despite these shortcomings, our findings provide valuable information and important implications for the clinical practice involving patients with AECOPD. We found that the DECAF score can predict in-hospital and 30-day mortalities with satisfactory sensitivity and specificity.

Key Words:
Chronic obstructive pulmonary disease, DECAF score, Meta-analysis, Validation studies.

Introduction

Chronic obstructive pulmonary disease (COPD) is a common ailment characterized by pulmonary tissue destruction and airflow limitation[1]. The Global Burden of Disease (GBD) study reported a prevalence of 251 million cases of COPD globally in 2016 with an estimated 5% of all deaths (3.17 million) being caused by COPD in 2015[2].

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An acute exacerbation of COPD (AECOPD) is recognized by worsening of respiratory signs or symptoms (like dyspnea) requiring hospitalization and intense medical management. Failing to provide adequate medical treatment can lead to life-threatening complications or even death depending on the severity of the episode[3]. AECOPD cases account for rises in the morbidity, mortality, and economic burden resulting from intensive care and hospitalizations. The clinical features of AECOPD are highly variable. Patients may present with COPD signs or symptoms that are more intense or severe than their usual ones[3].

The DECAF (dyspnea, eosinopenia, consolidation, acidemia, atrial fibrillation) score is a well-structured and widely used system for predicting the survival of patients admitted with AECOPD[4]. The predictive accuracy of the DECAF score is relatively higher than those of other similar scoring systems such as the BAP-65 (blood urea nitrogen [BUN], altered mental condition, pulse > 109/min, and age > 65 years)[5], the CURB-65 (confusion, blood urea, respiratory rate [RR], blood pressure [BP], and age ≥ 65 years)[6], the COPD and the asthma physiology score (CAPS)[7], and the APACHE II (acute physiology and chronic health evaluation)[8] risk scores for predicting mortality in patients with AECOPD. The advantages of the DECAF score over other systems lie in the simplicity of its measured variables. The DECAF can be calculated on the bedside using various routine and baseline characteristics that are easily assessed during admission. The system has consistently shown as a good predictor in various studies, and recording the DECAF score has been recommended as a part of the routine documentation process during admission (as per the COPD audit report, 2014, United Kingdom). However, no review has evaluated the utility of the scoring system in patients with AECOPD. Therefore, we designed this systematic review and meta-analysis to assess the utility of the DECAF scoring system for predicting survival in patients with AECOPD. We also assessed the utility of DECAF scoring in predicting the need for mechanical ventilation in AECOPD patients.

Materials and Methods

Eligibility Criteria

Type of studies

We have included the studies examining the accuracy of DECAF scoring system irrespective of the study design employed, type of participants and severity of the condition. The studies included also reported the sensitivity and specificity values for the DECAF scoring system or provided data to calculate them. We included only full-text articles and omitted unpublished studies or data. Case reports and studies with smaller sample size (fixed at 10 for the current review) were also excluded.

Index test

We have included the studies that used DECAF scoring system as the index test.

Reference standards

We used studies including the occurrence of events (mortality and need for invasive/non-invasive ventilation) as reference standards for assessing the accuracy of scoring system.

Outcome measure

We included studies assessing the diagnostic accuracy or utility of the DECAF score for predicting the survival or need for invasive/non-invasive ventilation.

Search Strategy

We performed a systematic and comprehensive search in the electronic databases PubMed Central, Scopus, Medline, Embase, and Cochrane Library. We used the PubMed search engine to search the PubMed Central and Medline databases. We used medical subject heading (MeSH) terms along with free-text terms to carry out the search. Examples of such terms were "DECAF Score", "Chronic Obstructive Pulmonary Disease", "COPD", "Exacerbations", "Acute Exacerbations", "Mechanical Ventilation", "Mortality", "Validation Studies", "Utility", and "Diagnostic Accuracy Studies". We used similar strategies to search other databases. We restricted the search from the time of the inception of the database until September 2020, with English language restriction. We also hand-searched the bibliographies of the retrieved full-texts to retrieve any relevant articles satisfying the eligibility criteria for our review.

Selection of Studies

During the first stage of screening, two authors (MS and GQ) independently checked the titles, keywords, and abstracts and retrieved the full-texts of the relevant articles. During the second stage of screening, two authors (MS and GQ) independently checked the retrieved full-text articles against the eligibility criteria. During the third and final stages of screening, disagreements

involving the selection process were resolved by the third author (XW).

Data Extraction

The primary author (MS) did the data extraction for relevant study characteristics and transferred the data into the STATA software (StataCorp, CollegeStation, TX, USA). We extracted the following variables during the data extraction process: author, publication year, country, study setting, study region, study design, sample size, inclusion and exclusion criteria, reference standards, mean age, true positives, true negatives, false negatives, and false positive values. We double-checked data entries by comparing the data in the study reports and those entered for our analysis.

Risk of Bias Assessment

Two authors (XW and MD) independently used the quality assessment of diagnostic accuracy studies-2 (QUADAS-2) tool to evaluate the risk of bias among the included studies[9]. The following domains were assessed using this tool: patient selection bias, conduct and interpretation of index test, reference standards, and time interval for outcome assessment. We graded the studies based on these domains as having high, low, or unclear biases based on the presence/absence of any bias.

Statistical Analysis

We used the random effects bivariate meta-analysis method to obtain the pooled diagnostic accuracy indices (sensitivity, specificity, diagnostic odds ratio [DOR], likelihood ratio of positivity [LRP], and negativity [LRN]) for the DECAF score as a predictor of mortality and the mechanical ventilation need. We graphically represented these indices using a forest plot (study-specific and pooled estimate), an LR scattergram (clinical value of DECAF score), and a Fagan plot (probability of patient mortality/mechanical ventilation need). LR scattergram has four quadrants and depending on the LRP and LRN values: the index test can fall in any one of the four quadrants: "Left upper quadrant (can be used for both confirmation and exclusion of the outcome), Left lower quadrant (exclusion of outcome only), Right upper quadrant (confirmation of outcome only) and Right lower quadrant (neither confirmation nor exclusion of the outcome)". Fagan plot helps in showing the increase in post-test probability based on the LRP and LRN values.

We calculated the area under the curve (AUC) using a summary receiver operator characteristic curve (sROC). Also, we evaluated between-study variability (heterogeneity) using chi-square test and I^2 statistics. Chi square test with p value less than 0.10 is suggestive of significant heterogeneity. I^2 statistic quantify the heterogeneity as follows: 0-25% = mild; 25-75% - moderate and > 75% = substantial heterogeneity. We graphically represented this heterogeneity using a bivariate box plot and if any studies fall outside the shaded region in the box plot, it is indicative of significant heterogeneity. We assessed publication bias using the Deek's test and drew a funnel plot to represent it graphically. P value less than 0.10 in Deek's test is indicative of significant publication bias. We performed all the analyses using the STATA software "midas" command package.

Results

Study selection

We found 1496 records through the systematic literature search. Out of these, we identified 69 relevant studies and retrieved their full-texts. We also retrieved the full-texts of four articles obtained through the manual bibliography search. Then, during the second screening stage, we selected 21 studies satisfying the eligibility criteria with 6,429 participants and analyzed their data for our review (Figure 1)[4,10-29].

Characteristics of the Included Studies

Most studies included (15 out of 21 studies) were prospective. Most were conducted in the United Kingdom (5) followed by those conducted in Egypt (3), China (3), Colombia (2), India (2), and Pakistan (2). The average age of the patients ranged from 57.5 to 79 years. In total, we assessed data from 6429 patients for the utility of DECAF score. The sample size of the studies varied from 50 to 1400. Most studies (13 out of 21) used a cut-off value of the DECAF score ≥3 to predict the in-hospital or 30-day mortality and need for mechanical ventilation. All the studies used the occurrence of in-hospital/30-day mortality or patient undergoing mechanical ventilation as the reference standards (Table I).

Risk of Bias Assessment

Figure 2 shows the risk of bias across various domains as per the results of applying the QUADAS tool. In this review, 8 out of 21 studies had high risks of patient selection bias and of conduct and interpretation of reference standards. Seven

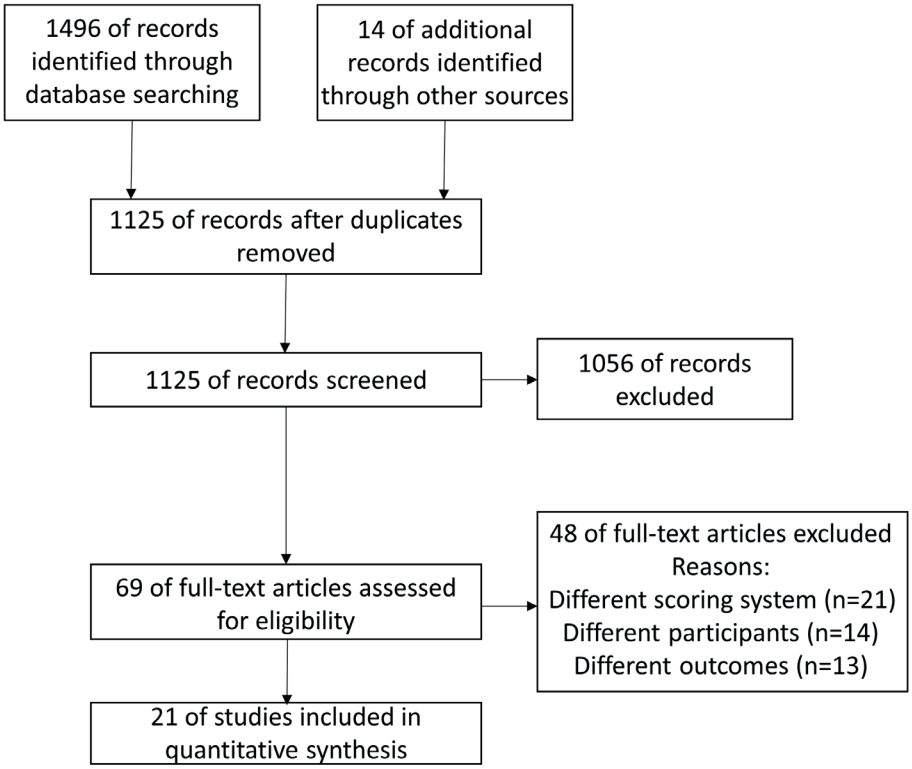

Figure 1. Search strategy diagram.

studies had high risks of bias related to the conduct and interpretation of the index test. Only two studies had high risks of bias related to the reference standards. One-third (7 out of 21) of the studies had high risks of bias in patient flow and interval between index tests and reference standards.

Prognostic Utility of DECAF score

In-hospital mortality

In total, 17 studies reported the utility of the DECAF score for predicting in-hospital mortality. The pooled sensitivity and specificity of the DECAF score for predicting in-hospital mortality among patients with AECOPD were 74% (95% CI, 67%-79%), and 76% (95% CI, 68%-82%) (Figure 3). The DOR was 9 (95% CI, 6-14), the LRP was 3.1 (95% CI, 2.3-4.1), and the LRN was 0.34 (0.27-0.43). The LR scattergram (Figure 4) shows that the LRP and LRN are in the right lower quadrant indicating that the DECAF score cannot be used for confirmation or exclusion of in-hospital mortality. The AUC was 0.80 (95% CI, 0.72-0.86) indicating a moderate predictive performance (Figure 5). Fagan's nomogram (Figure 6) showed a moderate clinical utility of the DECAF score for prediction of in-hospital mortality (positive = 28%; negative = 4%), which was significantly different from the pre-test probability (11%). We found significant between-study variability (heterogeneity) with a chi-square p-value <0.001 and an I^2 value of 95%. The heterogeneity was further confirmed by a bivariate box plot (Figure 7). Deek's test for publication bias showed a non-significant p value ($p = 0.24$) indicating the absence of publication bias. This was further confirmed by a symmetrically shaped funnel plot (Figure 8).

We performed a subgroup analysis based on the cut-offs used for predicting the in-hospital mortality. We found that 12 out of 17 studies used cut-offs ≥ 3 for assessing the prognostic utility of the DECAF score. The pooled sensitivity and specificity were 71% and 79%, respectively, with a prognostic accuracy (AUC) of 0.75. Three of the rest of the studies used an optimal cut-off of 2 and two studies used a cut-off of 4. Hence, we could not pool an estimate for these cut-offs. Subgroup analysis based on the study design did not reveal any significant difference in the sensitivity (prospective=73%; retrospective=78%) and specific-

Table I. Characteristics of the studies included (n=21).

Study No.	First author and year	Country	Study design	Sample size	Study participants	Index test and Reference Standard Assessment	Outcome	DECAF Cut-off score	Mean age (in years)
1	Ahmed et al 2020[10]	Pakistan	Cross-sectional	114	Previously diagnosed patients with COPD (before more than six months), of either sex, aged between 40 and 70 years admitted primarily with an exacerbation	**Index test**: DECAF score assessed (baseline dyspnea, eosinopenia [<0.05 x 10^3/dL], consolidation on chest X-ray, acidemia [pH <7.30], atrial fibrillation) at the time of admission **Reference standard**: In-hospital mortality assessed during the follow-up period	In-hospital mortality	3	NA
2	Bansal et al 2020[11]	India	Cross-sectional	228	Patients diagnosed as having COPD during an acute exacerbation according to the Global Initiative for COPD Criteria 2015	**Index test:** At the time of admission, the hematological, biochemical, arterial blood gas results, the presence of consolidation on chest X-ray, or of atrial fibrillation on an electrocardiogram were recorded. Based on these results, a DECAF score (index test) was calculated, and patients were classified into low, intermediate, and high risk groups for in-hospital mortality	In-hospital mortality	3	61.1
3	Bastidas et al 2018[12]	Colombia	Prospective	462	Patients who arrived at the emergency service of the hospital with a diagnosis of AECOPD	**Index test:** DECAF score calculated at the time of admission (index test), patients classified into low, intermediate, and high risk groups for in-hospital mortality **Reference standard:** Mortality assessed at the end of a 30-day follow-up period	30-day mortality	2	79
4	Bisquera et al 2018[13]	Philippines	Prospective	77	Patients with an AECOPD diagnosis	**Index test:** Laboratory and imaging tests included complete blood count, chest X-ray, arterial blood gas, and ECG. Stable-state dyspnea was assessed using the extended Medical Research Council Dyspnoea Score. The DECAF scores were recorded on admission and risk stratification was done following scoring system **Reference standard:** In-hospital mortality assessed during the follow-up period	In-hospital mortality	2	79

Table continued

Table I. ***(Continued).*** Characteristics of the studies included (n=21).

Study No.	First author and year	Country	Study design	Sample size	Study participants	Index test and Reference Standard Assessment	Outcome	DECAF Cut-off score	Mean age (in years)
5	Collier et al 2015[14]	United Kingdom	Prospective	78	Patients with an AECOPD diagnosis	**Index test:** DECAF score calculated at the time of admission (index test), patients classified into low, intermediate, and high risk groups for in-hospital mortality **Reference standard:** In-hospital mortality assessed during the follow-up period	In-hospital mortality	2	72.7
6	Echevarria et al 2015[15]	United Kingdom	Prospective	301	Primary diagnosis of pneumonic or non-pneumonic exacerbation of COPD; preadmission spirometric evidence of airflow obstruction; age ≥35 years, smoking history of ≥10 cigarette pack-years	**Index test:** DECAF indices (index test) recorded as part of the routine practice. This allowed the period of the study to be extended retrospectively to enhance recruitment. **Reference standard:** Patients followed-up to calculate the in-hospital mortality	In-hospital mortality	3	73
7	Echevarria et al 2019[16]	United Kingdom	Prospective	1400	Patients with exacerbation of COPD with preadmission obstructive spirometry, age ≥35 years, and smoking history of 10 or more cigarette pack-years	**Index test:** DECAF indices recorded as part of routine practice. For the DECAF score, 0 to 1 equates to a low in-hospital mortality risk, 2 is moderate risk, and 3 or more is high risk. **Reference standard**: Patients were followed-up to calculate the in-hospital mortality.	In-hospital mortality	3	73.1
8	Mantilla et al 2017[17]	Colombia	Prospective	462	Patients who arrived at the emergency service of the hospital with a diagnosis of AECOPD	**Index test:** DECAF score calculated at the time of admission (index test), patients classified into low, intermediate, and high risk groups for in-hospital mortality **Reference standard:** In-hospital mortality assessed during the follow-up period	In-hospital mortality	2	79

Table continued

Table I. ***(Continued).*** Characteristics of the studies included (n=21).

Study No.	First author and year	Country	Study design	Sample size	Study participants	Index test and Reference Standard Assessment	Outcome	DECAF Cut-off score	Mean age (in years)
9	Memon et al 2019[18]	Pakistan	Prospective	162	Patients 35 years or older admitted to the ICU and with a primary clinical diagnosis of acute exacerbation of COPD, spirometry consistent with airflow obstruction (FEV1/forced vital capacity <0.70), and a smoking history of ≥10 cigarette packs per year	**Index test:** DECAF score (index test) calculated as per the following domains: Dyspnea eMRCD 5a (too breathless to leave the house unassisted but independent during washing and/or dressing), or eMRCD 5b (too breathless to leave the house unassisted and requires help with washing and dressing), eosinopenia (eosinophils <0.05×109/L), consolidation, moderate or severe acidemia (pH <7.3), atrial fibrillation	In-hospital mortality	3	69
10	Nafae et al 2015[19]	Egypt	Prospective	200	Patients with an AECOPD diagnosis	**Index test:** Assessment of DECAF score (baseline dyspnea, eosinopenia [<0.05 x 10^3/dL], consolidation on chest X-ray, acidemia [pH<7.30], atrial fibrillation) **Reference standard:** Assessment of outcomes (either in-hospital death or discharge)	In-hospital mortality	3	69.3
11	Parras et al 2017[20]	Spain	Retrospective	164	Patients with an AECOPD diagnosis	**Index test:** DECAF score calculated at the time of admission (index test), patients classified into low, intermediate, and high risk groups for in-hospital mortality **Reference standard:** Patients were followed-up to calculate the in-hospital mortality	In-hospital mortality	3	76.1
12	Rabbani et al 2015[21]	United Kingdom	Retrospective	159	Patients who arrived at the emergency service of the hospital with diagnosis of AECOPD	**Index test:** DECAF score calculated at the time of admission (index test), patients classified into low, intermediate, and high risk groups for in-hospital mortality **Reference standard:** Mortality assessed at the end of a 30-day follow-up period	30-day mortality	4	72.1

Table continued

Table I. ***(Continued).*** Characteristics of the studies included (n=21).

Study No.	First author and year	Country	Study design	Sample size	Study participants	Index test and Reference Standard Assessment	Outcome	DECAF Cut-off score	Mean age (in years)
13	Sangwan et al 2017[22]	India	Prospective	50	Patients with a primary diagnosis of acute exacerbation of pulmonary disease, age ≥35 years, and smoking history of ≥10 cigarette pack-years	**Index test:** DECAF score assessed as a part of initial evaluation (eMRCD Va/Vb, eosinopenia [<0.05 × 10/L], consolidation, academia [pH <7.3], atrial fibrillation [AF]). **Reference standard:** During the in-hospital stay, the need for mechanical ventilation and the in-hospital death or discharge rates were assessed.	Prediction of need for mechanical ventilation and in-hospital mortality		Survivors – 61.2 Non-survivors – 66.6
14	Shafuddin et al 2018[23]	New Zealand	Prospective	323	Patients with primary diagnosis of an exacerbation of COPD defined as the symptoms of worsening dyspnoea, cough or sputum purulence, respiratory failure, or a change in mental status because of a COPD exacerbation	**Index test:** For the DECAF score, the presence of dyspnea, eosinopenia or eosinophilia $<0.1 \times 10^9$/L, acidemia or blood pH <7.30, and atrial fibrillation on ECG were assessed. **Reference standard:** All patients were followed up for 1 year after admission, and in-hospital, 30-day and 1-year all-cause mortality data were calculated.	In-hospital mortality		71
15	Shi et al 2017[24]	China	Retrospective	186	Patients with an AECOPD diagnosis	**Index test:** DECAF score calculated at the time of admission (index test), patients classified into low, intermediate, and high risk groups for in-hospital mortality **Reference standard:** Patients followed-up to calculate the in-hospital mortality.	In-hospital mortality	3	66.2
16	Shi et al 2019[25]	China	Prospective	112	Patients with an AECOPD diagnosis	**Index test:** DECAF score calculated at the time of admission (index test), patients classified into low, intermediate, and high risk groups for in-hospital mortality **Reference standard:** Mortality assessed at the end of a 30-day follow-up period	30-day mortality	4	77.6

Table continued

Table I. *(Continued).* Characteristics of the studies included (n=21).

Study No.	First author and year	Country	Study design	Sample size	Study participants	Index test and Reference Standard Assessment	Outcome	DECAF Cut-off score	Mean age (in years)
17	Son et al 2013[26]	Korea	Prospective	365	Consecutive patients admitted to the emergency department with exacerbations of COPD	**Index test:** DECAF score calculated at the time of recruitment **Reference standard**: Patients followed up to assess the need for mechanical ventilation and the in-hospital mortality.	Need for mechanical ventilation and in-hospital mortality	2	Survivors – 73.7 Non-survivors – 77.4
18	Steer et al 2012[4]	United Kingdom	Prospective	920	Patients with primary diagnosis of AECOPD supported by spirometric evidence of airflow obstruction (forced expiratory volume in one second (FEV1)/forced vital capacity (FVC) <0.70) when clinically stable; age ≥35 years; smoking history of $10 cigarette pack years; and admission from the primary residence	**Index test:** For the DECAF score, stable-state dyspnea was assessed using eMRCD. The first haematological, biochemical and arterial blood gas results were recorded. Included records of presence of new consolidation on a chest radiograph according to a senior physician. ECG at the time of hospital admission to confirm the presence of atrial fibrillation. **Reference standard:** Patients who died in hospital were identified from hospital records.	In-hospital mortality	3	73.1
19	Xu et al 2017[27]	China	Case-control study	302	Patients with an AECOPD diagnosis	**Index test:** DECAF score calculated at the time of admission (index test), patients classified into low, intermediate, and high risk groups for in-hospital mortality **Reference standard:** Mortality assessed at the end of a 30-day follow-up period	30-day mortality	4	75.5
20	Yousif et al 016[28]	Egypt	Prospective & Retrospective	264	Patients with an AECOPD diagnosis	**Index test:** DECAF score (index test) calculated at the time of admission, and patient classified into low, intermediate, or high risk group for in-hospital mortality **Reference standard:** Patients were followed up to calculate the in-hospital mortality.	In-hospital mortality	4	63.6
21	Zidan et al 2020[29]	Egypt	Prospective	100	Patients with primary diagnosis of AECOPD, age ≥ 25 years and pack-year of index more than 10.	**Index test**: The DECAF score required information available on the initial hospital presentation: (D) dyspnea assessment by extended modified Medical Research Council Dyspnea score (eMRCD score); CBC, (E) Eosinopenia (<0.05×109/l); chest radiograph, (C) consolidation; arterial blood gases; (A) acidemia (pH <7.3); and ECG, (F) atrial fibrillation.	Prediction of in-hospital mortality		57.5

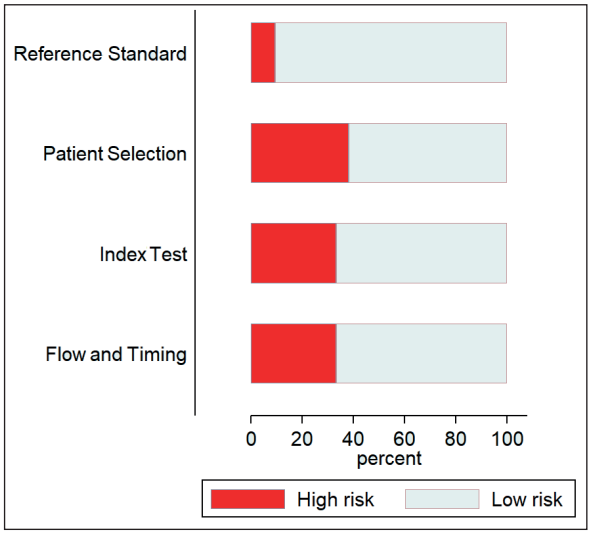

Figure 2. Quality assessment among the included studies using QUADAS-2 tool (n=11).

ity (prospective=76%; retrospective=74%) of the DECAF scoring system.

30-day mortality

Four studies have reported the prognostic utility of the DECAF score for the 30-day mortality. The pooled sensitivity and specificity of the score for predicting the 30-day mortality were 72% (95%CI, 59%-82%) and 83% (95%CI, 67%-93%), with a prognostic accuracy (AUC) at 0.77 (95%CI, 0.73=0.81).

Need for mechanical ventilation

Only two studies have assessed the utility of the DECAF score for the prediction of the need for invasive/non-invasive ventilation among patients with AECOPD. Hence, we could not provide a pooled estimate for it. However, both studies reported sensitivities and specificities higher than 80%, suggesting a high prognostic performance of the DECAF score for the requirement of mechanical ventilation.

Discussion

The DECAF scoring system is a tool used for risk stratifying of patients with AECOPD to accurately predict their risk of mortality and the need for an invasive or non-invasive mechanical ventilation. The score is usually calculated at the time of admission of the patients to the hospital. Focusing on high-risk groups and providing specific management can be helpful to prevent adverse outcomes. The DECAF can be suggested as a screening tool as it is low time-consuming and easy to calculate, and it reduces the healthcare costs by preventing life-threatening complications or even death. However, the utility of the scoring system has not been synthesized in a single meta-analysis. Hence, we conducted this review to determine the predictive performance of the DECAF score for in-hospital mortality and the need for mechanical ventilation.

During our systematic literature review, we found 21 studies reporting the utility of the DECAF score for predicting in-hospital/30-day mortality or ventilation requirements. Most were prospective studies and had low risk of bias with respect to most domains. We found that the DECAF score had moderate pooled sensitivity and specifici-

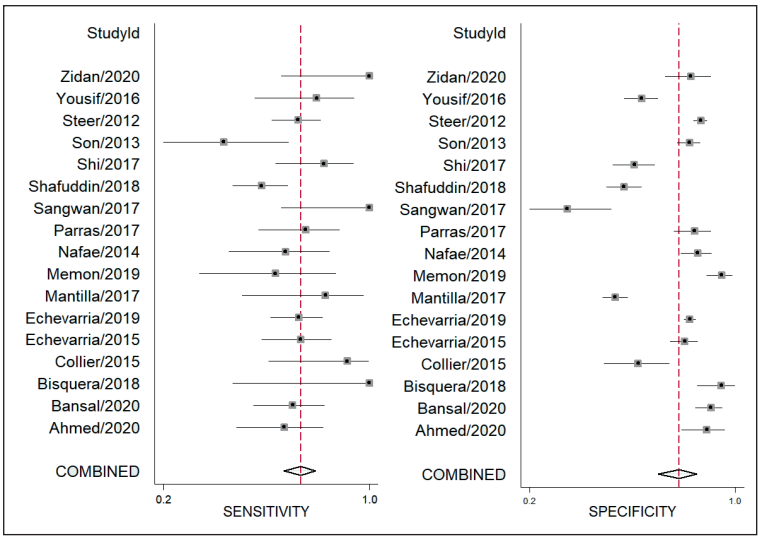

Figure 3. Forest plot showing pooled sensitivity and specificity for DECAF score.

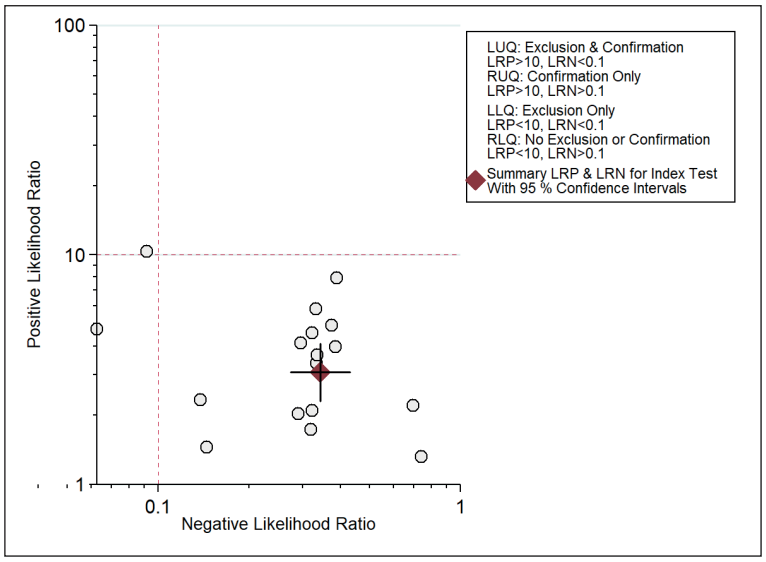

Figure 4. Likelihood scatter gram for DECAF score.

ty for predicting in-hospital mortality (74% and 76%) and 30-day mortality (72% and 83%). A review conducted by Huang et al[30] (2020) to assess the prognostic utility of the DECAF found similar accuracy parameters (sensitivity and specificity = 76%) suggesting that the DECAF scoring system is useful enough to use it as a screening tool at the time of admission to identify high-priority cases. Most studies used cut-offs ≥3 to predict the mortality among patients with AECOPD. With this cut-off for prediction of mortality, the DECAF score had a pooled sensitivity at 71% and a pooled specificity at 79% with moderate prognostic value (AUC=0.75). Further reviews should compare the prognostic performance of the DECAF score with other similar scoring systems such as APACHE-II, BAP-65, CURB-65, and CAPS. Identify the scoring system with the highest accuracy is important to issue recommendations for the clinical practice.

Other accuracy parameters also showed a moderate predictive accuracy of the DECAF score for in-hospital mortality. In the LR scattergram, LRN and LRP occupied the right lower quadrant indicating that the scoring system cannot be used for confirmation or exclusion. The clinical utility of the DECAF score looked better in the Fagan's nomogram, because it showed a significant rise in the post-DECAF score probability compared to that in the pre-DECAF score probability. Further large-scale longitudinal studies are required to check the predictive accuracy of the DECAF score for the need of invasive ventilation apparatuses as only two studies have reported this outcome. Prioritizing available healthcare resources according to patients' needs is essential in tertiary care hospitals.

Our results should be interpreted and inferred with caution considering the quality and differences in methods among the included studies, which may have influenced our summary findings. Hence, we assessed and found significant between-study variability (significantly different chi-square test and I^2 statistics). This heterogeneity can be attributed to the diverse ethnicities

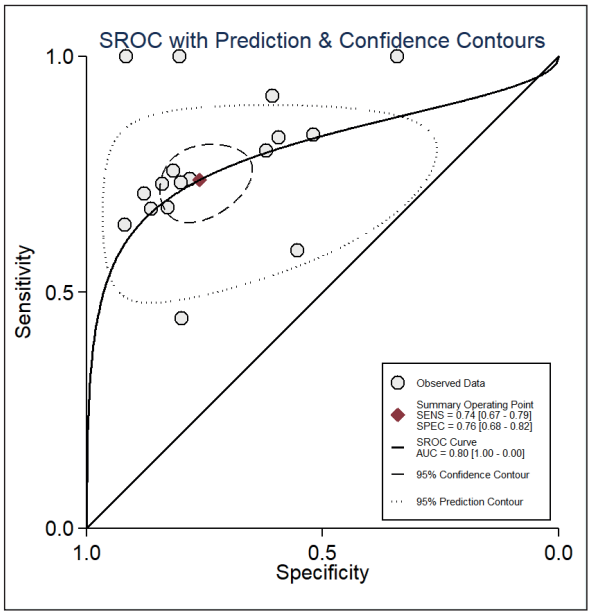

Figure 5. SROC Curve for DECAF score to predict in-hospital mortality.

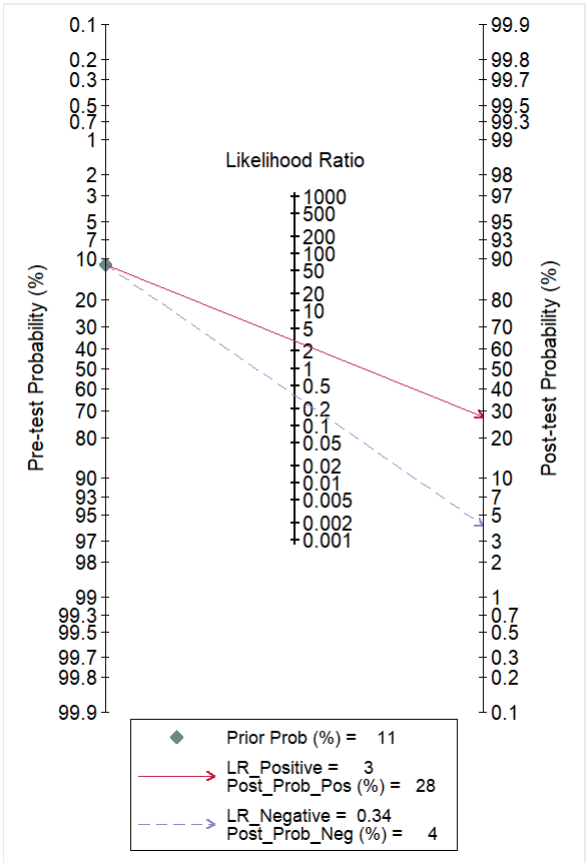

Figure 6. Fagan nomogram evaluating the overall value of the DECAF score as a predictor of in-hospital mortality.

of the study populations and to their variable risk factors and disease severity. Deek's test and a funnel plot showed a lack of publication bias amongst the studies reporting on the predictive utility of the DECAF score.

This review has certain strengths. It is the first meta-analysis assessing the predictive utility of the DECAF score for in-hospital mortality among patients with AECOPD, and it involves a large number of studies with relatively large sample sizes (21 studies with 6429 patients). Most studies included were of high quality according to the QUADAS-2 tool. We found no significant publication biases; and therefore, the credibility of the results of our meta-analysis should be high. In spite of these strengths, our review had some limitations. First, we found a significant between-study variability in our analysis that can limit its value for inferring or interpreting the pooled findings. Second, the predictive accuracy of the scoring system depends on many factors such as the ethnicity of the participants or patients, the timing of the scoring system assessment, and the AECOPD severity. We could not assess the influence of these variables in our study.

Conclusions

Despite these shortcomings, our findings provide valuable information and important implications for the clinical practice involving patients with AECOPD. Though the DECAF score showed only moderate sensitivity and specificity, we consider it an effective prognostic tool at the time of admission of patients. The role of a prognostic scoring system is to identify the patients at risk

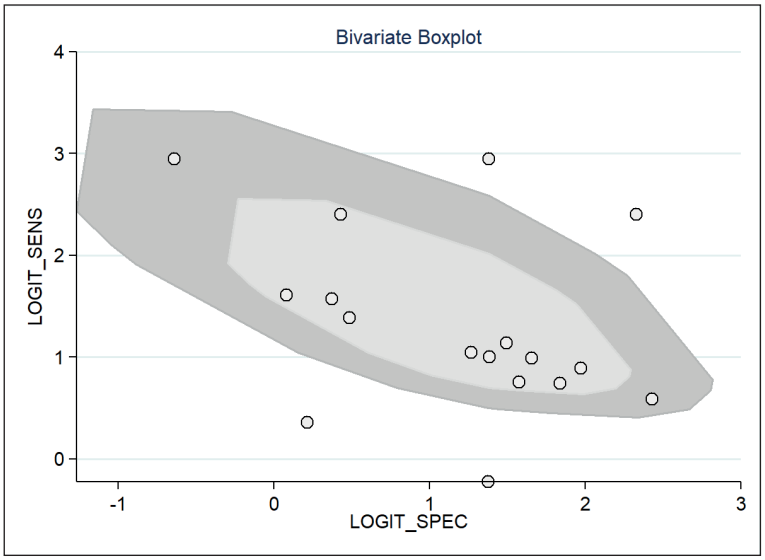

Figure 7. Bivariate boxplot of the sensitivity and specificity in the included studies.

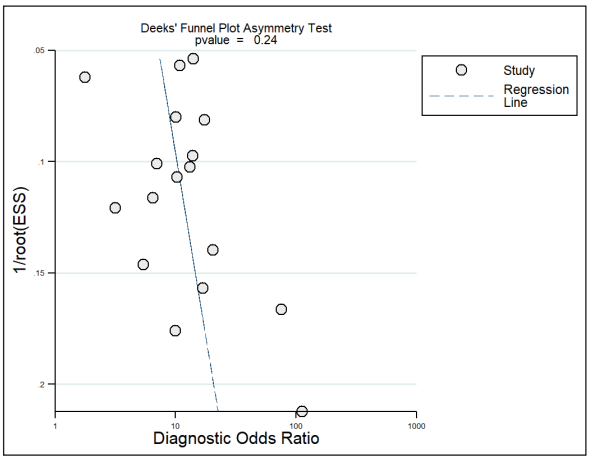

Figure 8. Funnel plot of publication biases.

of developing an outcome; thus, the system does not need to provide a high diagnostic accuracy. The DECAF score as a preliminary screening test for patient triaging can help reduce the time spent in various invasive diagnostic procedures and the healthcare costs involved in the process. Further large-scale setting-specific longitudinal studies are needed to establish the best scoring system for assessing all the patients admitted with AECOPD to tertiary care hospitals.

Funding

None.

Acknowledgements

Not applicable .

Declaration of interest statement

The authors declare that they have no competing interests.

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