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ORIGINAL ARTICLE

Accuracy of Quick Covid-19 Severity Index and Brescia-Covid Respiratory Severity Scale in Predicting ICU Admission and Mortality

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Abstract

The usefulness of risk screening tools in triaging and predicting likelihood of adverse outcomes of COVID-19 patients at first point of contact, would prevent overestimation or underestimation of severity risk in COVID pneumonia. BCRSS algorithm, a dynamic risk predictor, that uses clinical parameters of patient to assess need for escalating levels of respiratory support(Non-invasive ventilation, intubation, proning) to suggest treatment recommendations. Quick COVID-19 Severity Index (qCSI) is based on 3 variables (nasal cannula flow rate, respiratory rate, minimum documented pulse oximetry). To compare prognostic performance of BCRSS and qCSI-scores of hospitalized patients diagnosed with COVID-19. This is a Retrospective record-based study conducted at a tertiary hospital in Karnataka among COVID-19 patients. Patient's clinical severity grade classification was done according to standard guidelines by Government of India. BCRSS and qCSI scores were calculated using baseline clinical information of patients. Statistical analysis used were Chi-squared test, regression analysis and ROC curve. The study results showed that out of 363 patients, majority of patients with high qCSI risk score of 3 and those with high BCRSS risk score of 4 were found to have high rates of ICU admissions and in-hospital deaths (66.9% and 44.4% for qCSI-3; 34.6% and 1.9% for BCRSS-4). With every unit increase in qCSI and BCRSS scores, there were 2.68 and 1.58 times more risk of fatality respectively. ROC curves for qCSI and BCRSS scales showed high area under curve:qCSI(AUC:0.761) and BCRSS(AUC:0.760), to predict in-hospital fatality. The study has shown that both qCSI and BCRSS scoring models have good results for predicting probabilities of ICU admissions and in-hospital mortality of COVID-19 patients.

Key Messages: These risk prediction models, if applied during the initial clinical assessment stage, could help in better triaging, risk prediction, better treatment of COVID-19 patients.

Keywords: Quick COVID-19 Severity Index; Brescia-COVID Respiratory Severity Scale; in-hospital mortality; COVID-19; ICU admission

Introduction

Corona virus disease 2019 (COVID-19) pandemic has severe consequences in terms of exponentially high cases, disruption of health care system, imbalance in the 'demand and supply' chain of essential medical facilities, increased morbidity and mortality, particularly in the younger and middle-aged population [1–4]. Developing countries like India experienced more catastrophic outcomes particularly in the second COVID-19 wave, due to limited and pre-existing inequitably distributed health-care infrastructure fighting against a very high healthcare demand across all the socioeconomic spectrum. India alone has reported 33million confirmed COVID cases and 4.4 lakh deaths as on 8th Sept, 2021 [5].There were also challenges to health care professionals in terms of triaging, risk prediction and disposition [1,6,7].

It has been a welcome development with the launch of global vaccination drive. India, the largest democracy of the world is undertaking the largest vaccination drive, having administered a total of 756.3million vaccine doses, 1st dose for 573.8 million people and 2nd dose for 182.47 million people, as on 14th September 2021 [8].

With the backdrop of the looming threat of emergence of multiple SARS-COV-2 variants, the global medical community is closely monitoring four most important variants of concern (VOC) such as Alpha(B.1.1.7), Beta (B.1.351), Gamma(P.1) and Delta(B.1.617.2) [9].As like any other pandemics, the world might witness more subsequent pandemic waves, either more severe or milder versions, with varying intensity and durations of pandemic. Amidst such probabilities of new waves of pandemic, India like any other country has to be prepared for managing further waves of illness, that could go on for months or years to come by ensuring good preparation of healthcare systems for efficient resource allocation during the pandemic [7,10,11].

As experienced in the 2nd wave, exponentially high number of new COVID-19 cases, had led to overburdening on India's healthcare system, causing a dearth of medical oxygen, hospital beds, and other essentialities for the COVID-19 patients [7,10–12]. Limited number of emergency department beds and intensive care unit beds, high pressures to meet the rising demand of these facilities during pandemics can only be handled by efficient triaging, risk prediction and diagnostic workup and disposition. The risk screening tools in triaging and predicting the likelihood of adverse outcomes of COVID-19 patients at the first point of contact, would prevent overestimation or underestimation of severity risk in COVID pneumonia, that could potentially harm the patients due to suboptimal decisions regarding the clinical management [4,13,14].

Various risk models have been developed for this purpose. Among which, two of them have gained particular interest [2,4]. The BCRSS algorithm (Brescia-COVID Respiratory Severity Scale) is a dynamic risk predictor, that uses the clinical parameters of patient to assess the need for escalating levels of respiratory support (non-invasive ventilation, intubation, proning) to suggest treatment recommendations. It also allows clinicians to more closely monitor patients nearing a critical action point (eg, Level 3–possibly nearing the need for intubation) [2]. Quick COVID-19 Severity Index (qCSI), on the other hand, is evaluated into 4 risk classes by a 12-point system

(0-3 low risk, 4-6 low-intermediate risk, 7-9 high-intermediate risk, and ≥10 high risk) based on 3 variables (nasal cannula flow rate, respiratory rate, and minimum documented pulse oximetry)[2]. Sufficient validation studies of these risk prediction models, for clinical prognoses in different patient populations, have not yet been performed[3].The aim of this study was to compare the prognostic performance of the BCRSS and the qCSI scores of hospitalized patients diagnosed with COVID-19.

Subjects and Methods

This retrospective record-based study was undertaken after obtaining institutional ethics committee clearance to review and publish information collected from in-patient medical records of COVID-19 patients treated at Basaveshwara Medical College & Hospital. Data was collected from all consecutive COVID-19 patients aged ≥ 18 years, treated on in-patient basis in the hospital, during the study period of April 2021 to July 2021. A confirmed case of COVID-19 was defined as a positive test result of reverse transcriptase polymerase chain reaction (RT-PCR) assay of a nasopharyngeal specimen. Patients who got discharged against medical advice, or referred to higher centre were excluded from the study.

Patient's clinical severity grade classification was done according to the clinical guidance for management of adult COVID-19 patients by AIIMS/ ICMR-COVID-19 National Task Force/ Joint Monitoring Group (Dte.GHS), Ministry of Health & Family Welfare, Government of India.[15] The clinical severity grades were defined as: **Mild disease:** Upper respiratory tract symptoms (and/or fever) without shortness of breath or hypoxia; SpO2: ≥93%; **Moderate disease:** Any one of: 1. Respiratory rate > 24/min, breathlessness 2. SpO2: 90% to < 93% on room air; **Severe disease:** Any one of: 1. Respiratory rate >30/min, breathlessness 2. SpO2 < 90% on room air[15].

Clinical severity scoring systems: BCRSS, and qCSI scores were calculated using baseline clinical information of patients, collected retrospectively from their respective medical records, from 1st day of admission. Although, BCRSS prediction rule is a dynamic scoring system, that needs frequent reassessment and rescoring after interventions, in the present study, BCRSS is utilized as a screening tool to assist physicians during initial clinical assessment. The first phase of the BCRSS algorithm was analysed in this study, similar to the study conducted by Rodriguez-nava G., et al in Illinois, United States[3].

As this is a retrospective study, the response to the question: patient wheezing or unable to speak in full sentences while at rest/with minimal effort – was replaced with patient reporting shortness of breath. Other parameters of BCRSS score such as respiratory rate >22, oxygen saturation (SpO2) <90%, and repeat chest X-ray with significant worsening (defined as bilateral or diffuse infiltrates) were noted. Patients were classified into five risk strata based on these risk factors[16] . The qCSI is a 12-point scale considers bedside available information of: nasal cannula flow rate, respiratory rate and minimum documented pulse oximetry. The patients were then assigned to four risk strata (0–3) based on the following scores: 0–3 low risk, 4–6 low intermediate risk, 7–9 high-intermediate risk, and 10 high risk[2].

Outcome variables: The primary outcome was in-hospital mortality and the secondary outcome was ICU admission. For the primary outcome, patients discharged were considered survivors.

Statistical analysis

Data were compiled in Microsoft excel worksheet and analysed using the Statistical Package for the Social Sciences (SPSS) version 16 (SPSS Inc., Released 2007. SPSS for Windows, version 16.0. SPSS Inc., Chicago, Illinois, USA). All characteristics were summarized descriptively. For continuous variables, assessment of the normality of data was performed by Kolmogorov Smirnov test. Variables with normal distribution were described in terms of summary statistics of N, mean, standard deviation about the arithmetic mean. Categorical variables are presented as number (percentage). Binary logistic regression analysis was applied to find the odd's ratios for every score of qCSI and BCRSS indices in predicting rates of ICU admission and in-hospital fatality. Receiver operator characteristic curves were obtained using EZR software (version 1.53, Oct 15, 2020; Saitama Medical Center, Jichi Medical University, Saitama, Japan), which is a graphical user interface for R (The R Foundation for Statistical Computing, Vienna, Austria)[17].The Youden index, defined as (sensitivity + specificity) -1, was calculated at each cutoff. The cutoff point with highest Youden index was reported[18]. The discriminatory power of each score was assessed by calculating the area under each ROC curve by applying the Hanley–McNeil test. Associations with p-value of less than 0.05 were considered to be statistically significant[19].

Results

A total of 363 patients were included in the study. Majority of patients were male (64.2%). Average age of patients was 50.2 ± 16.2 years. A 37.5% of patients had at-least one comorbidity. Most common co-morbid condition was diabetes mellitus (26.4%) followed by hypertension (17.9%). As per COVID-19 adult clinical severity grade classification of AIIMS/ ICMR-COVID-19 MOHFW guidelines, 14.6% of patients had mild disease, 33.9% had moderate grade disease and 51.5% had severe grade disease. A total of 187 (51.5%) patients received intensive care treatment and a total of 92 (25.3%) fatalities were documented. (Table 1)

*Clinical severity grade classified according to clinical guidance for management of adult COVID-19 patients by

Table 1. Baseline characteristics of patients with COVID-19

Characteristics	Total N (%)
Age (years) (Mean ± SD)	50.17 ± 16.2
Sex	
Male	233 (64.2%)
Female	130 (35.8%)
SpO2 (%) (Mean ± SD)	85.07 ± 11.9
Duration of hospital stay (days) (Mean ± SD)	8.15 ± 4.7
Clinical Severity Grade*	
Mild	53 (14.6%)
Moderate	123 (33.9%)
Severe	187 (51.5%)
Comorbidities	
Any 1 comorbid condition present	136 (37.5%)
Absent	227 (62.5%)
Diabetes mellitus	96 (26.4%)
Hypertension	65 (17.9%)
Number of Comorbid conditions	
Absent	227 (62.5%)
1	86 (23.7%)
2	42 (11.6%)
>2	8 (2.2%)
ICU Admissions	187 (51.5%)
Clinical Outcomes	
Survivor	271 (74.7%)
Death	92 (25.3%)
Total	363 (100.0%)

*Clinical severity grade classified according to clinical guidance for management of adult COVID-19 patients by AIIMS/ ICMR-COVID-19National Task Force/JointMonitoring Group (Dte.GHS), MOHFW, GOI [15]

AIIMS/ ICMR-COVID-19 National Task Force/
Joint Monitoring Group (Dte.GHS), MOHFW, GOI [15]

Table 2 describes the distribution of ICU admission and in-hospital fatality of COVID-19 patients according to qCSI and BCRSS indices scores.

A majority of patients with high qCSI risk score of 3 were found to have high rates of ICU admissions and in-hospital deaths (66.9% and 44.4% respectively) compared to patients with low qCSI risk score of 0 (34.6% and 1.9% respectively). Accordingly, a majority of patients with high BCRSS risk score of 4 were found to have high rates of ICU admissions and in-hospital deaths (91.7% and 100% respectively) compared to patients with low BCRSS risk score of 0 (25.8% and 8.5% respectively).

The logistic regression analysis showed that, with every unit increase in the score of qCSI and BCRSS, there were 2.68 and 1.58 times more risk of fatality respectively. And with every unit increase in the scores of qCSI and BCRSS, there were 1.15 and 1.46 times more risk of ICU admissions respectively, and these associations were found to be statistically significant.

Table 3 depicts the sensitivity, specificity to predict ICU admission rate for qCSI and BCRSS scores at every score. The cutooff score was determined based on highest Youden index. Accordingly, to predict ICU admissions rates for qCSI score, highest Youden index was at cutoff score of ≥3 (sensitivity: 61.5%; specificity: 66.1%). And for BCRSS score, highest Youden index was at cutoff score of ≥ 3 (sensitivity: 65.2%; specificity: 66.1%). Hence, qCSI score of ≥3 showed high specificity (66.1%) whereas BCRSS score showed high sensitivity (65.2%) at cut-off of ≥3, to predict ICU admission rates.

Table 4 shows the sensitivity, specificity to predict in-hospital fatality rates forqCSI and BCRSS indices at every score. The cutooff score was determined based on highest Youden index. Accordingly, to predict fatal outcome for qCSI score, highest Youden index was at cutoff score of ≥3 (sensitivity: 84.8%; specificity: 66.1%). And for BCRSS score, highest Youden index was at cutoff score of ≥ 3 (sensitivity: 88.0%; specificity: 60.9%).

Thus, high sensitivity was found with both qCSI and BCRSS indices (84.8% and 88.0% respectively at cutoff score of ≥3) to predict in-hospital fatality. Whereas qCSI score had higher specificity of 66.1% to predict in-hospital fatality.

The ROC curves for ICU admission and in-hospital fatality for both qCSI and BCRSS scales were applied. (Figures 1 and 2). High area under the curve were found for both risk scoring systems: qCSI (AUC 0.761) and BCRSS (AUC 0.760), to predict in-hospital fatality. Accordingly, to predict ICU admission rates, higher area under the curve were found for both risk scoring systems: qCSI (AUC 0.654) and BCRSS (AUC 0.666). However, the discriminatory power for ICU admission or in-hospital fatality were not statistically different between the qCSI score and the BCRSS prediction rule (p>0.05)

Discussion

The present retrospective study was conducted at a tertiary care teaching hospital of central Karnataka, including the medical case records of 363 COVID-19 patients treated on in-patient basis during the second wave of COVID-19 pandemic. The study evaluated the predictive performance of two important 'COVID-19 risk prediction models in assessing in-hospital mortality and intensive care ward admissions [2,16].

Table 2. Distribution of ICU admission and In-hospital fatality rates across the clinical severity risk indices (Outcome: ICU Admission: N= 187; Death N=92)

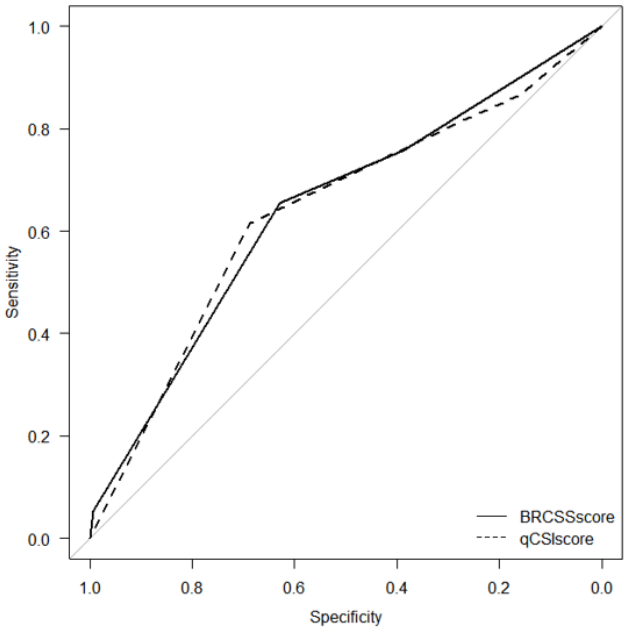
qCSI Index	ICU Admissions		In-hospital Deaths		Total N (%)
	Admitted to ICU n (%)	Not admitted to ICU n (%)	Death n (%)	Survivor n (%)	
0 (Low Risk)	18 (34.6%)	34 (65.4%)	1 (1.9%)	51 (98.1%)	52 (100.0%)
1 (Low Intermediate Risk)	11(36.7%)	19 (63.3%)	1 (3.3%)	29 (96.7%)	30 (100.0%)
2 (High Intermediate Risk)	39 (37.9%)	64 (62.1%)	11 (10.7%)	92 (89.3%)	103 (100.0%)
3 (High Risk)	119 (66.9%)	59 (33.1%)	79 (44.4%)	99 (55.6%)	178 (100.0%)
Logistic regression analysis	**OR: 1.15; p < 0.001**		**OR: 2.68; p<0.001**		
BCRSS Index	**ICU Admissions**		**In-hospital Deaths**		**Total N (%)**
	Admitted to ICU n (%)	**Not admitted to ICU n (%)**	**Death n (%)**	**Survivor n (%)**	
0	38 (25.8%)	68 (64.2%)	9 (8.5%)	97 (91.5%)	106 (100.0%)
1	12(20.8%)	27 (69.2%)	0 (0.0%)	39 (100.0%)	39 (100.0%)
2	11(37.9%)	18 (62.1%)	2 (6.9%)	27 (93.1%)	29 (100.0%)
3	115(65.0%)	62 (35.0%)	69 (39.0%)	108 (61.0%)	177 (100.0%)
4	11(91.7%)	01 (8.3%)	12 (100.0%)	**0** (0.0%)	12 (100.0%)
Logistic regression analysis	**OR: 1.46; p < 0.001**		**OR: 1.58 p<0.001**		

Table 3. Sensitivity, Specificity forqCSI and BRCSS scores in predicting ICU admission (Outcome: ICU Admission; N=187)

COVID severity scores	ICU admission prediction			Youden Index
	Cut-off Value	Sensitivity % (95% CI)	Specificity % (95% CI)	
qCSI	≥0	100 (0.9805 -1.0000)	0 (0.0000 - 0.0207)	1.0000
	≥1	86.6 (0.8090 - 0.9116)	18.82 (0.1084 - 0.2217)	1.0254
	≥2	81.3 (0.7494 - 0.8660)	29.5 (0.2136 - 0.3508)	1.0912
	≥3	**61.5 (0.5412 - 0.6851)**	**66.1 (0.6134 - 0.7551)**	**1.3025**
BCRSS	≥0	100 (0.9805 - 1.0000	0.0 (0.0000 - 0.0207)	0.0000
	≥1	75.9 (0.6916 - 0.8187)	38.6 (0.3141- 0.4626)	0.1457
	≥2	65.8 (0.5850 - 0.7254)	62.5 (0.5490 - 0.6967)	0.2828
	≥3	**65.2 (0.5795 - 0.7204)**	**63.1% (0.5548 - 0.7021)**	**0.2831**
	≥4	5.4 (0.0259 - 0.0961)	99.4 (0.9688 - 0.9999)	0.0478

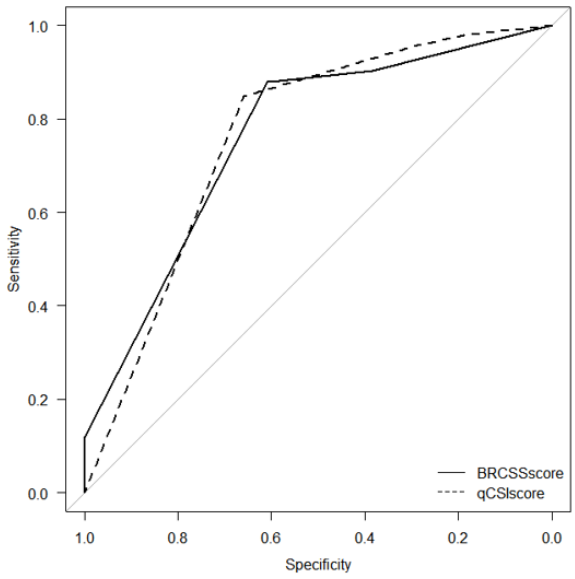
Table 4. Sensitivity, Specificity forqCSI and BRCSS scores in predicting in-hospital fatality (Outcome: Death; N=92)

COVID severity scores	Mortality Prediction (N=92)			Youden Index
	Cut-off Value	Sensitivity % (95% CI)	Specificity % (95% CI)	
qCSI Score	≥0	100 (0.9607-1.0000)	0 (0.0000-0.0135)	0.0000
	≥1	97.83 (0.9237 – 0.9974)	18.82 (0.1434 - 0.2399)	0.1655
	≥2	95.7 (0.8924 - 0.9880)	29.5 (0.2416 - 0.3534)	0.2517
	≥3	**84.8 (0.7579 - 0.9142)**	**66.1 (0.6008 - 0.7167)**	**0.5083**
BRCSS Score	≥0	100 (0.9607 1.0000)	0.0 (0.0000 - 0.0135)	0.0000
	≥1	90.2 (0.8224 0.9543)	38.4 (0.3256-0.4445)	1.2859
	≥2	88.0 (0.7961 0.9388)	60.2 (0.5405-0.6602)	1.4819
	≥3	**88.0 (0.7961- 0.9388)**	**60.9% (0.5480-0.6673)**	**1.4893**
	≥4	12.0 0.0612 0.2039	100 (0.9865-1.0000)	1.1196



Risk Score	Area under the curve	95% CI
q CSI	0.654	0.598-0.711
BCRSS	0.666	0.610-0.721

Fig 1. ROC Curves for prediction of ICU Admission for qCSI and BCRSS score



Risk Score	Area under the curve	95% CI
q CSI	0.761	0.710-0.812
BCRSS	0.760	0.704-0.817

Fig 2. ROC Curves for prediction of mortality for qCSI and BCRSS score

The average age of patients was 50±16years, majority were males (64.2%), about half of patients had severe grade illness (51.5%) and one-third of patients had moderate grade illness (33.9%)[15]. Comorbid conditions were present in 37.5% patients. Although Diabetes mellitus (26.4%) and hypertension (17.9%) were the two most common conditions found in the present study, which is comparable with studies conducted elsewhere, our study found that diabetes mellitus was (26.4%) was the major comorbid condition, followed by hypertension (17.9%)[1,2,4,20].Whereas, most of the other studies have reported that hypertension was leading comorbidity among COVID-19 patients[1,2,4,20].(Table 1)

In the present study, more than half of total patients (51.5%) were treated in intensive care wards and overall in-hospital fatality was 25%. (Table 1) Wide variations in ICU admissions as well as in-hospital mortality rates have been reported in studies conducted elsewhere. The in-hospital death rates have varied from 5% to 78%[21–25]. Reasons for variations in ICU admissions could be due to world-wide differences in the availability of intensive care facilities and the differences in in-hospital mortality rates could be due to age groups and gender differences, variations in proportion of associated comorbidities, different

differences in associated comorbidities (that impact immunity), SARS-COV-2 variants, differences in testing and treating strategies[20].

In the present study, the prognostic performance of both qCSI and BCRSS clinical risk models for predicting ICU admission and in-hospital mortality, revealed that for COVID-19 patients, every unit rise in the scores resulted in rise in the odds of ICU admission (qCSI: 1.15 & BCRSS: 1.46) and in-hospital morality (qCSI: 2.68 & BCRSS:1.58) (Table 2). Similar results are found in studies conducted by Rodriguez-Nava G. et al and Rohat AK. et. al.[3,4].

In our study, prediction of ICU admission by qCSI and BCRSS risk models were found to be 0.666 and 0.654 respectively. Whereas, the AUC of qCSI and BCRSS to predict ICU admissions in study conducted by Rohat K et al., were 0.851 and 0.842 respectively and in study conducted by Rodriguez-Nava G et al were 0.761 and 0.735 respectively[3,4].

In our study, prediction of in-hospital mortality by both qCSI and BCRSS risk models were found to be good with AUC of 0.761 and 0.760 respectively. The AUC of qCSI and BCRSS to predict in-hospital mortality in study conducted by Rohat AK et al., were 0.851and 0.842 respectively and in study conducted by Rodriguez-Nava G et al were 0.847 and 0.804 respectively[3,4].

In our study, the sensitivity and specificity of qCSI in predicting ICU admissions were found to be 61.5% 66.1% respectively. And that for BCRSS were found to be 65.2 and 63.1 respectively. In study conducted by Rohat AK et al, for qCSI had 83.5% sensitivity and 84.0% specificity, whereas BCRSS had 97.8% sensitivity and 59.2% specificity.[4] Rodriguez-Nava G et al, found that for qCSI there was 69.39% sensitivity and 75.81% specificity, whereas for BCRSS, it was 64.29% sensitivity and 73.95% specificity[3].

In our study, the sensitivity and specificity of qCSI in predicting in-hospital mortalitiy were found to be 84.8% and 66.1% respectively. And sensitivity and specificity for BCRSS model, sensitivity and specificity were 88.0% and 60.9% respectively. In study conducted by Rohat AK et al, for qCSI had 94.9% sensitivity and 73.8% specificity, whereas BCRSS had 94.9% sensitivity and 59.9% specificity.[4] Rodriguez-Nava G et al, found that for qCSI there was 58.4% sensitivity and 72.2% specificity, whereas for BCRSS, it was 54.46% sensitivity and 72.73% specificity[3].

Conclusion

The present study has shown that both qCSI and BCRSS scoring models have showed good results for predicting the probabilities of ICU admissions and in-hospital mortality of COVID-19 patients. These risk prediction models, if applied during the initial clinical assessment stage, could help in better triaging, risk prediction, better treatment of COVID-19 patients.

Limitations of the study

As this was a single centre, retrospective study utilizing the available in-patient medical case records, further prospective studies across the socio-geographic gradients, are required to support these study findings.

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