The use of scoring systems during COVID-19

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Healthcare services worldwide are challenged by the novel COVID-19 crisis. As of 18 October 2021, >240 million cases and 4.88 million deaths have been reported worldwide to the World Health Organization, which is an indication of the increase in healthcare services work overload. Scoring systems are standardised methods for the evaluation of presenting symptoms, radiological images and laboratory specimens to assist in disease diagnosis or treatment. This article explores the most common scoring systems in clinical practice, and acknowledges challenges in both the clinical application and validation of scoring systems, particularly in the context of new diseases such as COVID-19.

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The COVID-19 pandemic has affected triage, resource allocation, risk stratification and many clinical practices. As of 18 October 2021, >240 million cases and 4.88 million deaths have been reported worldwide.[1] Adequate categorisation and scoring of risk are important for diagnosis, prognosis, clinical decision-making and disease management, particularly in the current global healthcare crisis. Scoring systems for critical care were introduced in the 1980s, and are now used in all diagnostic areas of medicine.[2] These are standardised methods for the evaluation of presenting symptoms, radiological images and laboratory specimens. Several score models have been developed to establish not only severity of disease but also patient response to therapies, to identify patients at risk and to predict outcomes for patients, including the risk of death and the length of hospital stay. Scoring systems also act as an audit tool for evaluating performance over time.[2]

The ideal scoring system has routinely recordable variables, is well calibrated, shows discrimination, is applicable in multiple countries or health systems or in groups of patients and predicts status and quality of life of patients. Comorbidities, organisational aspects and a common language for discussion should be considered.[3]

Scoring systems can be quantitative, semi-quantitative or qualitative. The classification of common scoring systems used in clinical settings, along with their advantages and limitations, is depicted in Table 1.[4-37]

With most scores, problems remain in their calculation and in the interpretation of results.[2] Physiological derangement that is self-limiting or quickly treatable can mislead the scoring of the patient by generating high severity scores.[3] For several clinical conditions, there is a lack of an established and accessible gold standard. Where pathology and interventions are based on evolving research and emerging clinical observations, as in the context of COVID-19, it becomes important to stratify test results and clinical and radiological features, and validate these scores. Scoring systems may lead to incorrect interpretation of the score where there is limited validation or data.[3]

Validation of scoring systems

A scoring system consists of a numerical value, such as a number assigned to disease severity, and a probability model. An example is the equation giving the probability of having a disease. The latter enables the score to be used for group comparisons to enable decision-making by assessing various factors.[2,3]

An accurate scoring model should be calculated with specific beta coefficients. The transformation of the score into a probability of, for example, mortality uses a logistic regression equation. Furthermore, the ideal model should be well validated, calibrated and discriminated.[2,4]

Validity, as the quality of being real or correct, evaluates the performance of the prediction model by testing the dataset that was used for model development. Typically, large datasets produce more reliable models.[2,4] In the case of COVID-19, there is no established gold standard, and a rapidly changing situation provides challenges in the validation of scoring systems. Clinical observations and a combination of established scoring systems may therefore be used.

Table 1. Summary of common clinical scoring systems listing their advantages and limitations

Classification of scoring systems	Example	Reference	Department	Advantages	Limitations
Anatomical scoring	Abbreviated injury score (AIS)	Greenspan *et al.*[5]	Emergency	Provides a standard numerical scale of ranking and comparing injuries	Non-linear correlation with the risk of mortality in multiple traumas
	Injury severity score (ISS)	Linn[6]	ICU, emergency	Provides platform for trauma data registry Used for trauma management research	Inadequate ISS results in severe multiple injuries in the same anatomical region in addition to the injury score Scores less than expected for penetrating injuries Dependence on angiography or MRI in some cases
	New injury severity score (NISS)	Eid and Abu-Zidan[7]	ICU, emergency	Differentiates mortality and poor outcome	Does not include a specific body region
	Penetrating abdominal trauma index (PATI)	Moore *et al.*[8] Aldemir *et al.*[9]	General surgery	Measures injury severity in abdominal trauma in order to assist the surgeon in categorising patients at risk of developing complications Assists surgeons in decision-making techniques for repairing intra-abdominal organs according to severity score	Limitations are those of the observational study type, as no experimental groups can be established
	International Classification of Diseases Injury Severity Scale (ICISS)	Turner *et al.*[10]	ICU	Predicts trauma patient outcomes	Unstable in terms of predictive performance
	Rapid emergency medical score (REMS)	Kennedy *et al.*[11]	Emergency medicine	Identifies high-risk mortality patients and enables the physicians to develop a proper care plan	Does not differentiate between injury types, which are known factors in predicting mortality
	Trauma mortality prediction model (TMPM-ICD9)	Lemeshow *et al.*[12]	Emergency	Uses information routinely collected by clinicians for administrative reasons No additional labour or expenses required	Does not code for burn diagnoses, requiring that patients with only burn diagnoses be excluded
Therapeutic weighted score	Therapeutic intervention scoring system (TISS)	Muehler *et al.*[13]	ICU	Easily applicable method for measurement of workload in the ICU ICU management control	Limitations in detecting some determinants of the nursing workload
Organ-specific scoring	Sequential organ failure assessment (SOFA) score	Singer *et al.*[14]	ICU	Assesses the acute morbidity of critical illness at a population level and has been widely validated as a tool for this purpose across a range of healthcare settings and environments	Designed to look at populations and not individual patients, it cannot accurately predict which patients will survive when the mortality rate is high

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Table 1. (continued) Summary of common clinical scoring systems listing their advantages and limitations

Classification of scoring systems	Example	Reference	Department	Advantages	Limitations
Organ-specific scoring (continued)	Multiple organ dysfunction score (MODS)	Cook *et al.*[15]	ICU	Measures severity of organ failure, correlates strongly with ultimate risk for ICU and in-hospital mortality and has been shown to reflect the progression of organ dysfunction when measured sequentially	Not designed to predict outcome
	Logarithm of the odds (LODS)	Le Gall *et al.*[16]	ICU	It can easily extend to multiple classes (multinomial regression) and a natural probabilistic view of class predictions	Assumption of linearity between the dependent variable and the independent variables
Physiological assessment	Acute physiology and chronic health evaluation (APACHE)	Knaus *et al.*[17] Knaus *et al.*[18] Knaus *et al.*[19]	ICU	Includes data from any period during first 24 hours in ICU	Therapeutic bias Lead time bias Historical bias
	Simplified acute physiology score (SAPS)	Metnitz *et al.*[20]	ICU	Assesses the severity of disease in ICUs	Fails to predict long-term mortality
	Revised trauma score (RTS)	Alvarez *et al.*[21]	ICU, emergency	Distinguishes between mortality and survival It is one of the more common scores aimed at measuring the functional consequences of an injury	Not practical in field Underestimates the severity of head injury
	Emergency trauma score (EMTRAS)	Raum *et al.*[22]	ICU, emergency	Assesses mortality risk in adult patients with trauma Uses parameters that are available within 30 minutes of a patient presenting to the ED Does not require a knowledge of anatomical injuries, and accurately predicts mortality	Predicted mortality was systematically too high compared with actual mortality in patients with low-to-medium expected risk
	Portsmouth physiological and operative severity score for enumeration of mortality and morbidity (P-POSSUM)	Copeland *et al.*[23] Prytherch *et al.*[24]	Surgery	Predicts the mortality in high-risk patients	Accurate tool for this high-risk population and it is not possible to safely extrapolate its use to low-risk patients
	COVID-19 scoring for prognosis: COVID-19 scoring system (CSS); COVID-19 acuity (CoVA) score	Shang *et al.*[25] Altschul *et al.*[26] Sun *et al.*[27]	Medicine, emergency	Useful for predicting in-hospital mortality and complications, and it could help clinicians to identify high-risk patients with a poor prognosis	Continuously changing parameters

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Classification of scoring systems	Example	Reference	Department	Advantages	Limitations
Physiological assessment (continued)	COVID-19 disease severity and management	Zhang *et al.*[28]	Medicine, emergency, ICU	Predicts severity of disease Uses clinical parameters collected on the first day of presentation to hospital Could assist clinicians to administer different therapy strategies at a very early stage	Affected by continuously changing parameters defining COVID-19
	Intermountain Chronic Disease Risk Score (ICHRON)	May *et al.*[29]	Research, public health	Highly predictive of 3-year chronic disease diagnosis in an internal validation	Cannot measure quality of the lifestyle risk factors
Simple scales	Glasgow coma score (GCS)	Teasdale and Jennett[30]	Medicine, ICU, emergency, surgery	Easy to perform It can be used to indicated a depth of coma at which one's airway reflexes are likely to become unreliable	It is inadequate to assess higher cortical functions or brainstem reflexes The eye score is unreliable if the eyes are damaged
	COVID-19 scoring for diagnosis	Allam[31]	Emergency, medicine	Rapid screening for COVID-19 No biomarkers required	Continuously changing clinical parameters Patient reporting and attendance at clinics Asymptomatic patients
	COVID-19 risk stratification: rapid scores (modified early warning score (MEWS), rapid emergency medicine score (REMS)); age, blood pressure, clinical features, duration of transient ischaemic attack, and presence of diabetes (ABCD) score	Hu *et al.*[32] Salunke *et al.*[33]	Emergency medicine, ICU	To identify high-risk patients for risk stratification	Influenced by continuously changing clinical parameters
	Chronic disease score for risk stratification and prognosis (M-CDS)	Iommi *et al.*[34]	Emergency, medicine	Used for population risk stratification, for risk-adjustment in association studies and to predict the individual risk of death	Lack of information on lifestyle, social and economic characteristics and the presence of bias related to their observational nature

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Classification of scoring systems	Example	Reference	Department	Advantages	Limitations
Simples scales (continued)	The CDC Worksite Health ScoreCard (CDC)	Roemer *et al.*[35]	Employers, Department of Health, worksite-based clinics, occupational health	Yes/no scorecard to assess how evidence-based health-promotion strategies are implemented at a worksite to prevent heart disease, stroke and related health conditions Assesses work-based disease prevention programmes Prioritises health topics and resources	Response bias Multiple-component questions may confuse response Uncertainty around decision process to answer yes/no Potential response fatigue (long questions)
Disease-specific scoring	Ranson criteria	Ranson *et al.*[36]	Surgery	For diagnosing pancreatitis and mortality	Valid only at 48 hours after onset and not at any other time during the disease The threshold for an abnormal value depends on whether the pancreatitis is caused by alcohol or gallstones
	Model for end-stage liver disease (MELD)	Wiesner *et al.*[37]	Medicine, surgery	Minimised ceiling effect Limited effect on post-liver transplant mortality Inclusion of renal dysfunction	Medical urgency score Less convenient to use at the bedside Exclusion of complications of cirrhosis

ICU = intensive care unit; MRI = magnetic resonance imaging; ICU = intensive care unit; ED = emergency department.

Calibration evaluates the concordance between the estimated probabilities of the factor being assessed by the model and the actual factor experienced by the patient. Discrimination refers to the ability of the model to distinguish patients who, for example, either have or do not have the disease. Measures of discrimination include sensitivity, specificity, false positive predictive value, false negative predictive value, positive predictive power, area under the receiver operating characteristic (AUROC) curve, misclassification rate and concordance. Sensitivity and specificity are often preferred for application in clinical practice. Estimates of sensitivity and specificity vary widely, especially in populations with high co-infections or comorbidities.

The AUROC is calculated as the area under the ROC.[38] The ROC shows the trade-off between true positive rate (TPR) and false positive rate (FPR) across different decision thresholds. The AUROC is thus a performance measurement for classification models at various threshold settings. The AUROC provides information about the classification model's ability to discriminate between diseased (positive) and non-diseased (negative) cases. An AUROC of 0.8 means that the model has good discriminatory ability: 80% of the time, the model will correctly assign a higher absolute risk to a randomly selected patient with an event than to a randomly selected patient without an event.[38]

Evaluation of the clinical relevance of a scoring system is based not only on the AUROC, but also on the expected clinical use associated with that AUROC.[2,39] The key clinical question that should be asked is what harm will be provoked by not treating a patient, compared with overtreating one? These estimations should be applied to the values of positive and negative predictive values associated with different points on the AUROC.[39]

Scoring systems in clinical practice during COVID-19

Scoring systems have been proposed, with some in review, for COVID-19 diagnosis, prognosis, disease severity and management, and to identify high-risk patients for risk stratification.[4] Clinical guidance for clinicians was developed for managing COVID-19 in low-resource settings according to the World Health Organization guidelines for basic emergency care course and severe acute respiratory illness. In settings with limited resources, or countries with highly vulnerable populations, these tools can mainly assist in clinical management.[40] A critical appraisal of systematic reviews performed by the Oxford COVID-19 evidence service team for the Centre for Evidence-Based Medicine[41] found no current reliable clinical model or scoring system to predict outcomes or inform decisions regarding hospital admission for patients in the community with COVID-19.

The risks associated with acquiring COVID-19 increase significantly with age and underlying comorbidities. Hypertension, cardiovascular diseases and diabetes are the most common comorbidities seen in COVID-19 patients across the world.[42]

COVID-19 risk increases by 80% in patients with hypertension, 50% in cancer and diabetic patients, 100% in congestive heart failure, and 300% in patients suffering from chronic kidney diseases.[42] In terms of reducing risk and addressing comorbidities among healthcare workers, the Centers for Disease Control and Prevention (CDC) scorecard[35] may be applied to assess interventions for reducing heart disease and stroke in employees. The Intermountain Chronic Disease Risk Score (ICHRON)[29] can also be used for predicting the development of chronic disease within 3 years. In addition, the COVID-19 Acuity (COVA) score[26,27] as an outpatient screening tool, and the modified chronic disease scores (M-CDS) for infectious diseases or chronic disease prevention,[34] can be used in screening outpatients to identify those at risk, or to predict adverse outcomes related to COVID-19 infection.

These scoring systems can form part of guidelines using symptom- or test-based approaches in establishing the safety of healthcare workers to return to work after self-isolation for potential COVID-19 exposure,[43] to plan health promotion to prevent infection[26,27,35] and to identify undiagnosed conditions in healthcare workers to reduce risk for infection.[34] Scoring systems still need to be used alongside a wider clinical assessment of the individual, and in the context of changes over time.[4]

Conclusion

Scoring systems are widely used in clinical practice. Reliable scores should be validated and calibrated and show discrimination. An overall limitation is that scoring systems are based on statistical models of recorded patient variables that may vary across clinical or resource-limited settings. In the context of COVID-19, scoring systems may help in diagnosis, predicting the severity of disease and identifying those at risk. The challenge with COVID-19 scores is the rapidly changing situation. Therefore, a combination of scores alongside clinical assessment needs to be applied. Advancement in clinical practice and research outcomes will influence the development of scoring systems, including their application in disease prevention.

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