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An Automated Scoring of Clinical Asthma Score: Proof of Concept and the Future Possibility

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To the Editor:

The use of high-intensity clinical data from the electronic medical record (EMR) has been getting increasingly popular, especially in intensive care medicine, where a large amount of data are continuously generated as the changing condition of patients is tracked by the minute (1, 2). However, the analysis of those data to explore a clinical causal relationship or the impact of an intervention can be particularly misleading when the severity of illness is not rigorously examined and controlled (3, 4).

The modified Wood's Clinical Asthma Score (mWCAS), generated with oxygen saturation level, presence of expiratory wheezing, inspiratory breath sounds, use of accessory muscles, and cerebral function/status (**Table 1**), is used to assess the severity of respiratory distress in children with bronchiolitis (5). An mWCAS greater than 3 is an indication of moderate-to-severe respiratory distress (6). In this study, we aimed to demonstrate a proof of concept of an algorithm to generate an automated mWCAS (A-mWCAS) for critically ill children and to validate it with manually computed mWCAS (M-mWCAS).

This retrospective study included all infants under 2 years old with a clinical diagnosis of bronchiolitis, ventilated with noninvasive neurally adjusted ventilatory assist (NIV-NAVA), in a Canadian tertiary PICU, between October 2016 and June 2018. The study was approved by the ethics committee of the Sainte-Justine Hospital. The algorithm, written with Python 3.7, was directly connected to the EMR (IntelliSpace Critical Care and Anesthesia, Version F.01; Philips, Eindhoven, The Netherlands). The first step of the developed algorithm consisted of the automatic extraction of the five main required items, as well as the Fio_2, from the EMRs of the PICU, using structured query language queries. Then, each item was given a score based on the rules listed in Table 1. This was possible because all the items were explicitly represented in the EMR in drop-down menus, except for the cerebral status. In the EMR, we have 18 different cerebral statuses in a drop-down menu. These statuses were grouped into four categories, based on Table 1, by a group of pediatric intensivists. After that, the attributed scores were added together to obtain the A-mWCAS. M-mWCAS was computed retrospectively by a clinical expert who reviewed the patients' medical charts and manually extracted the score's items in a completely independent and blind way from the automatic algorithm. Both the A-mWCAS and the M-mWCAS were therefore based on data collected by multiple clinicians (respiratory therapists or nurses), but a single "rater" (one machine vs one clinical expert) was involved in each strategy.

We included 64 infants with a median (25–75th percentile) age of 52 months (32–92 mo). Manual and automatic scores were calculated for all the included patients at eight different times from 2 hours before to 24 hours after NIV-NAVA

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TABLE 1.
Modified Wood's Clinical Asthma Score Five-Item Scoring

Item	0	0.5	1	2
Spo_2	$Spo_2 \geq 95\%$ in room air	$95\% > Spo_2 > 90\%$ in room air	$Spo_2 \geq 90\%$ with $Fio_2 > 21\%$	$Spo_2 < 90\%$ with $Fio_2 > 21\%$
Expiratory wheezing	None	Mild (+)	Moderate (++)	Marked (+++)
Inspiratory breath sounds	Normal	Slightly decreased	Decreased	Absent
Use of accessories muscles	None	Mild (+)	Moderate (++)	Maximal (+++)
Cerebral status	Normal	Agitated when disturbed	Depressed/agitated	Markedly depressed/coma

application. Scores were calculated only when all the required score elements were available. The median number of scores assessment per patient was 4 (3–5). Overall, 256 pairs of A-mWCAS and M-mWCAS were generated. Cohen kappa coefficients were applied to estimate the agreements between the two scores. The overall kappa score was 0.71 (95% CI, 0.64–0.77), in which we observed exact agreement for the 78.5% pairs and agreement with a difference in score of less than or equal to 0.5 in 96% (**Fig. 1**). The Pearson correlation coefficient was $R^2 = 0.90$. A sensitivity analysis was conducted in a subgroup of 57 patients with the same number of three ratings (total of 171 scores), with similar results: kappa score of 0.71, exact agreement in 75.4% pairs, and 95% of pairs with a difference less than 0.5.

We also examined the agreement for each score component, in which we found a very good agreement in the oxygen saturation (kappa score 0.91), the expiratory wheeze (kappa score 0.79), the inspiratory breath sounds (kappa score 0.91), and the use of accessories muscles (kappa score 0.89). However, we observed a poor agreement in the cerebral status with a kappa score of 0.51. We assumed that this stemmed from the difference in the ways of our data collection; the clinical evaluation of the cerebral status is relatively subjective and might vary among care team members (i.e., doctor, nurse, and respiratory therapist). The automated score likely decreases this variability by consistently using the same source of score (respiratory therapist). On the other hand, the clinical expert scored the cerebral status for the M-mWCAS by referring to other potentially relevant information such as the notes from the bedside nurses or physicians.

There are limitations in our study, including the small sample size, the retrospective nature of the study, and the single-center dataset. Further prospective studies are warranted to confirm the validity of this approach. Nonetheless, this first clinical report establishes the proof of concept of an algorithm to generate an automated respiratory distress score in the pediatric population. In conclusion, the A-mWCAS

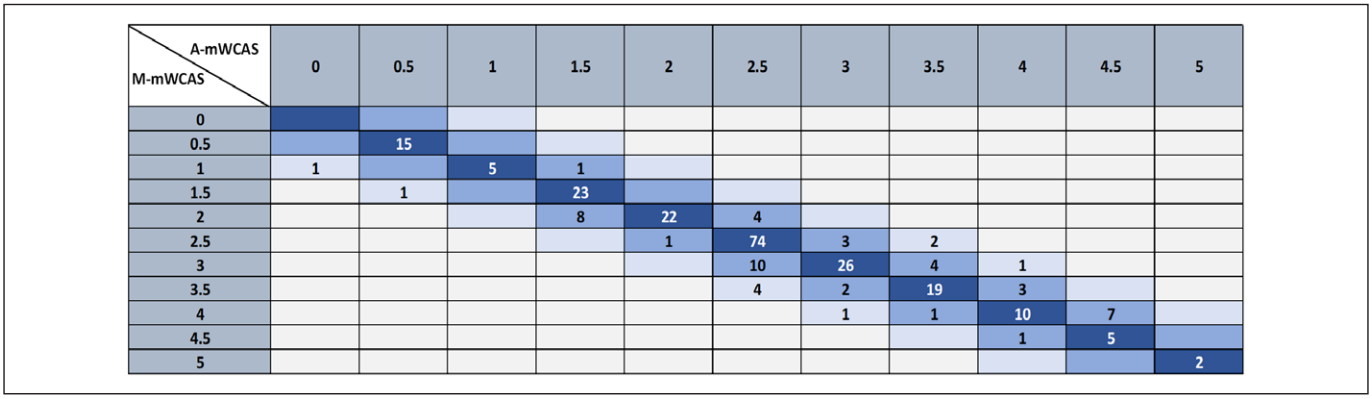

Figure 1. Agreement table showing the actual agreement between the 256 automated modified Wood's Clinical Asthma Score (mWCAS) and manually computed mWCAS.

could provide an objective, fast, robust, and reliable assessment of the severity of the respiratory distress in a large electronic database. This will be a key parameter to control when analyzing large clinical respiratory datasets. It will also be an essential real-time component in future clinical decision support systems being developed to optimize the management of children with respiratory distress.

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Dr. Lepage-Farrell and Dr. Emeriaud conceived and designed the study. Material preparation, data collection, and analyses were performed by Dr. Al-Omar, Dr. Lepage-Farrell, and Dr. Kawaguchi. The code programing was done by Dr. Al-Omar. The first draft of the article was written by Dr. Al-Omar and revised by Drs. Kawaguchi and Emeriaud. All the authors approved the final version of the submitted article.

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REFERENCES

1. Sauthier M, Jouvet P: Impact of electronic data on the development of care in critically ill children. *J Pediatr Intensive Care* 2016; 5:79–80
2. Bailly S, Meyfroidt G, Timsit JF: What's new in ICU in 2050: Big data and machine learning. *Intensive Care Med* 2018; 44:1524–1527
3. Clayton JA, McKee B, Slain KN, et al: Outcomes of children with bronchiolitis treated with high-flow nasal cannula or noninvasive positive pressure ventilation. *Pediatr Crit Care Med* 2019; 20:128–135
4. Gupta P, Green JW, Tang X, et al: Comparison of high-frequency oscillatory ventilation and conventional mechanical ventilation in pediatric respiratory failure. *JAMA Pediatr* 2014; 168:243–249
5. Duarte-Dorado DM, Madero-Orostegui DS, Rodriguez-Martinez CE, et al: Validation of a scale to assess the severity of bronchiolitis in a population of hospitalized infants. *J Asthma* 2013; 50:1056–1061
6. Milési C, Essouri S, Pouyau R, et al: High flow nasal cannula (HFNC) versus nasal continuous positive airway pressure (nCPAP) for the initial respiratory management of acute viral bronchiolitis in young infants: A multicenter randomized controlled trial (TRAMONTANE study). *Intensive Care Med* 2017; 43:209–216