to such patient populations? Does the secret sauce go with any meal? And while we want to know what's in the secret sauce, the data are compelling, so maybe it just does not matter. We look forward to seeing how this model performs in a prospective cohort to find out.

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Commentary: In analytics we trust?

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Tampa Bay Rays' left-handed pitcher Blake Snell was arguably having his best outing of the year during game 6 of the 2020 World Series. He had pitched 5-1/3 scoreless innings and recorded 9 strikeouts. To the dismay of many, the Rays' manager replaced Snell to avoid him from facing the Los Angeles Dodgers batting order for a third time (a statistical advantage for batters¹). His replacement immediately gave up 2 runs and the championship to the Dodgers.² Fans and players alike were left questioning the manager's decision, wondering what could have happened. Stories like this are common in modern Major League Baseball as teams have become heavily reliant on statistics to make in-game decisions. When such decisions fail, we are left to ponder how

CENTRAL MESSAGE

Predictive analytics could play a supportive role in the care of sick infants with complex congenital heart disease when used in conjunction with sound clinical judgment.

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well algorithms can predict complex outcomes and how heavily one should incorporate statistics into the next decision.

Identifying patients at risk for clinical deterioration in the postoperative period following surgery for congenital heart defects (CHD) continues to be a sought after, yet evasive, goal. Just like in baseball, a plethora of complex machine-learning statistical models has been proposed to accurately predict adverse outcomes in the pediatric cardiac intensive care unit (ICU).³ Some of these models rely primarily on continuously collected physiologic variables, such as the IDO₂ (inadequate oxygen delivery) index.⁴ Others, such as the Pediatric Index of Cardiac Surgical Intensive Care

FIGURE 1. Prospective studies are required to define the role of predictive models within the realm of clinical acumen.

Mortality (PICSIM), include variables such as time of admission to ICU,⁵ whereas C-CHEWS (Cardiac Children's Hospital Early Warning System) includes clinician-entered subjective scores into their analytical model.⁶ In this issue of the *Journal*, Ruiz and colleagues⁷ explore the ability of ensemble extreme grade boosting models that use machine-learning approaches to amalgamate electronic health record data to predict clinical deterioration of postoperative infants with single-ventricle or palliated complex CHD. Similar to observations with other models in comparable patient cohorts, the authors report reasonable discrimination and calibration. Their most comprehensive model predicted clinical events with an area under the receiver operating curve of 0.923 at 4 hours before the event, although its accuracy was lower at earlier time points.

Artificial intelligence approaches can assimilate a large array of repeated measures much more effectively, thereby eliminating human subjectivity and variability in pattern recognition. As demonstrated in the current study, the subjects who triggered alarms had greater heart rate and lactate levels and required more bicarbonate and epinephrine supplementation, all of which are highly intuitive and well-established predictors of poor clinical status. The model concatenates these "routine" variables into an index that provides early prediction of trends. The accurate foreknowledge of impending deterioration so gained represents an opportunity for clinicians to intervene with corrective actions that can reduce failure to rescue events.⁸ If the benefits are this obvious and choice of models this robust, why have predictive models not yet become mainstay in pediatric cardiac ICU? When the rubber hits the road, the subjective bedside evaluation and clinical judgment of the provider cannot be supplanted. Computers cannot feel a pulse, nor can they determine the perfusion status of a child's body surface. Physical examination along with a longitudinal relationship between bedside clinician and patient can capture information and alter perceptions about patient status for which statistics can never account. The current study, for

example, employed an oversimplified use of administration of any medication as a binary variable. We would argue that medication use is an intervention generated by a bedside provider who recognizes an alteration in patient status. Given that this variable was almost as predictive as the sum total of all other variables in the model, the additional predictive power of the current model becomes less obvious. And, the retrospective nature of these studies further precludes the ability to ask the crucial question if clinical decisions based on these models can actually prevent an adverse clinical outcome more often than standard of care bedside evaluation can. Lastly, few studies to date have directly compared the accuracy of the different available models.

Technology can play an important role in refining clinical management of patients following surgery for CHD. However, as the authors show in the current study, even when one uses models with high predictive power, 15% patients with adverse outcomes will have no triggers and an equal number of patients without adverse events will have false triggers. Future prospective studies are required to define the exact role of these predictive models within the realm of outstanding clinical medicine (Figure 1). Just as in baseball, analytics can help synthesize a large body of information to augment our knowledge and interpretation of the clinical situations, but they will never be able to replace sound clinical judgment.

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