

Modified Tal Score: Validated score for prediction of bronchiolitis severity

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Abstract

Objective: To further validate the use of the Modified Tal Score (MTS), a clinical tool for assessing bronchiolitis severity, by physicians with varying experience and training levels, and to determine the ability of the MTS to predict bronchiolitis severity.

Methods: This prospective cohort study included infants of <12 months of age who were diagnosed with bronchiolitis and assessed via MTS. We calculated the intra-class correlation coefficient (ICC) among four groups of raters: group 1, board-certified pediatric pulmonologists; group 2, board-certified pediatricians; group 3, senior pediatric residents; and group 4, junior pediatric residents. Clinical outcomes were determined as length of oxygen support and length of stay (LOS). We assessed MTS's prediction of these outcomes. Relative risk (RR) for clinical severity was calculated via a Generalized Linear Model.

Results: Twenty-four physicians recorded a total of 600 scores for 50 infants (average age 5 ± 3 months; 56% male). The ICC values with group 1 as a reference were 0.92, 0.87, and 0.83, for groups 2, 3, and 4, respectively ($P < 0.001$). RR for oxygen support required was; 1.33 (CI 1.12-1.57), 1.26 (1.1-1.46), 1.26 (1.06-1.5), and 1.21 (0.93-1.58) for groups 1, 2, 3, and 4, respectively. RR for LOS was; 1.15 (CI 0.97-1.37), 1.19 (1.03-1.38), 1.18 (1.0-1.39), and 1.18 (0.93-1.51) for groups 1, 2, 3, and 4, respectively.

Conclusion: The MTS is a simple and valid scoring system for evaluating infants with acute bronchiolitis, among different physician groups. The first score upon admission is a fair predictor of oxygen requirement at 48 h, and LOS at 72 h.

KEYWORDS

bronchiolitis severity scoring

1 | INTRODUCTION

Acute bronchiolitis (AB) is a major cause of morbidity among infants below 1 year of age,¹⁻⁴ with respiratory syncytial virus (RSV) being the

most common causative pathogen.⁵ While the majority of affected infants have mild symptoms and can be managed as outpatients, AB-related hospital admissions have increased over the past two decades.^{3,6}

It is difficult to assess the severity of acute bronchiolitis using laboratory tests or pulmonary function testing in the pediatric population, thus, several different scoring systems are being used, including the Tal score,⁷ Modified Tal score (MTS),⁸ Lowell score,⁹

Abbreviations: AB, Acute bronchiolitis; aROC, Area under receiver operating characteristic; ICC, Intra-class correlation coefficient; LOS, Length of hospital stay; MTS, Modified Tal score; RR, Relative Risk; RSV, Respiratory syncytial virus; SpO₂, Oxygen saturation measured on a pulse oximeter.

Wang score,¹⁰ and Liu score.¹¹ Many different scoring systems causes inhomogeneity in clinical researches and practical clinics, therefore, there exists a need for a unique and uniform clinical scoring system worldwide, so data is comparable between sites and within different groups of healthcare providers. Systematic evaluation reveals that most of the scores have limited validity, and they have varying levels of complexity.¹² Complex clinical scores are time consuming to apply, and are often poorly reproducible and unsuitable for routine clinical use. McCallum et al⁸ reviewed the available scoring systems and identified the MTS as the most clinically appropriate and easy to use. They concluded that the MTS is repeatable and can be reliably used in research and clinical practice, although it did not predict the requirement for oxygen support within 24 h. Duarte-Dorado et al¹³ assessed the use of the modified Wood's Clinical Asthma score¹⁴ and the Modified Tal score by two physicians, and concluded that the MTS is valid in terms of inter-rater agreement, practicality, and ease of use.

The primary aim of the present study was to further validate the MTS, concentrating on inter-rater reliability and internal consistency within specific physician groups, different in their experience and qualification. The secondary aim was to evaluate the usefulness of the MTS for predicting disease severity, estimated based on length of oxygen requirement and by LOS.

2 | METHODS

2.1 | Study design and population

We performed a prospective cohort study of infants with AB admitted to Soroka University Medical Center between November 2014 and February 2015. This institute is a tertiary hospital with a catchment population of 750 000. The children's hospital includes 210 beds, with approximately 400 admissions annually, due to AB. Inclusion criteria were age <12 months and clinical diagnosis of bronchiolitis. Exclusion criteria were previous admission/s due to a wheezing episode, chromosomal abnormality, or chronic heart or lung disease. It was a convenience sample and collected data included; patient demographics, risk factors for asthma, number of days with respiratory symptoms prior to the admission, treatment received prior to and during hospitalization, length of oxygen requirement, and length of hospital stay. Nasal wash

was performed for viral detection, using polymerase chain reaction (PCR). For each participating infant, at least one parent gave their signed informed consent before enrollment and the study was approved by the Soroka University Medical Center Ethics Committee (No. 268-14).

2.2 | Clinical assessment

Bronchiolitis severity was assessed twice daily, at 9 am and 3 pm, using the MTS^{7,8} (Table 1). Scoring was performed by four groups of physicians: group 1, certified pediatric pulmonologists; group 2, certified pediatricians; group 3, senior pediatric residents; and group 4, junior pediatric residents. Each patient was scored independently by 2-6 raters, representing 2-4 groups, within a 60-min timeframe. Raters were blinded to the assessments of other raters, and to the patient's medical history, current medical treatments, and length of hospitalization. Each physician performed the evaluation independently and immediately submitted the evaluation form to the research coordinator.

The MTS comprises four specific components: respiratory rate; accessory muscle use; degree of wheezing or crackles (which is often more common); and room-air arterial O₂ saturation (SpO₂) which replaced "cyanosis" in the original Tal score.⁹ Each component is scored between 0 and 3 points, providing a total score of 0-12 points. Respiratory rate was counted over 30 s and then multiplied by two. Accessory muscle use was defined as non/ mild/moderate or severe and scored 0/1/2 or 3, respectively. The degree of wheezing or crackles was defined as non/ during expiration/during inspiration and expiration or heard without stethoscope, and scored between 0 to 3, correspondingly. Before measuring SpO₂, the infant was placed in room air for 5 minutes, and the physician made sure the infant was calm and that saturation had been steady for at least 30 s. According to the level of oxygen saturation in room-air, the patient was scored 0, 1, 2, or 3 for O₂ saturation ≥95%, 92-94%, 90-91%, and ≤89%, respectively. If SpO₂ was ≤89%, oxygen was immediately provided to the patient and he or she was scored three points for the SpO₂ component. AB was defined as either mild (total score ≤ 5), moderate (score between 6 and 10), or severe (score ≥ 11). Oxygen was discontinued when room air saturation was ≥90%. Patients were discharged when two conditions were fulfilled: discontinuation of oxygen and senior doctor approval (satisfactory feeding and resolution of respiratory distress).

TABLE 1 Modified Tal score^{7,8}

Score	Modified Tal score				
	Respiratory rate (breaths/min)		Wheezing/Crackles	O ₂ Saturation (room air)	Accessory respiratory muscle utilization
	Age <6 months	Age ≥6 months			
0	≤40	≤30	None	≥95	None (no chest in-drawing)
1	41-55	31-45	Expiration only	92-94	+ Presence of mild intercostal in-drawing
2	56-70	46-60	Expiration and inspiration with stethoscope only	90-91	++ Moderate amount of intercostal in-drawing
3	≥71	≥61	Expiration and inspiration without stethoscope	≤89	+++ Moderate or marked intercostal in-drawing, with present of head bobbing or tracheal tug

2.3 | Statistical analysis

Continuous variables are presented as mean \pm SD or as median and interquartile range (IQR) according to their distribution, while categorical data are presented as percentages. The intra-class correlation coefficient (ICC) was determined to assess score reliability and the extent of agreement between the four groups of raters. We designed a Linear Mixed Model, containing fixed and random effects, to calculate the agreement via ICC between the four groups of raters, standardized for multiple score determinations per patient. We constructed a Bland-Altman plot to graphically illustrate and describe the agreement between the four groups of raters, with group 1 (pediatric pulmonologists) set as reference (Figure 1A-1C). A Bland-Altman approach using the average measurements method depicts the overall per patient agreement between group 1 and each of the other groups of raters, accounting for repeated measurements within the same patient. Each mark represents a patient with multiple score measurements, the larger the mark the greater amount of scoring events took place per that specific patient (eg, longer hospitalization).

TABLE 2 Population characteristics

Demographic characteristics	
Male sex, n (%)	28 (56%)
Age (months)	Mean age \pm SD: 5 \pm 3, Median age (IQR): 4.5 (2-7)
Ethnicity, n (%)	Jewish: 13 (26%), Bedouin: 37 (74%)
Gestational age, mean \pm SD	39 weeks \pm 2 days
Day of illness at admission (days), mean \pm SD	5 \pm 2
Clinical characteristics	
First Score by Group 1, median (IQR)	7 (5-8)
First Score by Group 2, median (IQR)	6.5 (5-8)
First Score by Group 3, median (IQR)	6 (4-8)
First Score by Group 4, median (IQR)	6.5 (4.5-8)
RSV positive nasal wash, n (%)	39/48 (81%)
Non-RSV positive nasal wash, n (%)	6/48 (13%)
Oxygen support treatment, n (%)	44 (88%)
Antibiotic treatment, n (%)	26 (52%)
Systemic steroidal treatment, n (%)	13 (26%)
Inhaled bronchodilators, n (%)	29 (58%)
Clinical outcomes	
Length of oxygen support (hours), median (IQR)	47.5 (15-79)
Length of stay in hospital (hours), median (IQR)	79 (46-115)

The higher the agreement upon the MTS between the two groups, the closer the mark is to the zero line on the Y-axis.

Spearman's correlation coefficient was determined to assess the correlation between the first score determined by each group of raters and the infant's disease severity, which was manifested in oxygen requirement time (hours) and LOS (hours). A Generalized Linear Model (GLM) was performed using negative binomial regression to show the relative risk (RR) of a patient with a higher MTS to have a more severe extent of the clinical outcome. Negative binomial regression was chosen due to the distribution of the clinical manifestations.

Clinical outcomes of interest were determined as oxygen requirement \geq 48 h, and LOS \geq 72 h. These outcomes were chosen to provide a practical reference points for physicians assessing the severity of children with AB. We built a receiver operating characteristic (ROC) curve to illustrate the ability of the MTS to diagnose these clinical outcomes. The ROC curve plots the true positive rate (also known as sensitivity) against the false positive rate (also known as 1-specificity). The area under the curve (AUC) was calculated to assess the probability of the score to properly classify a child with AB in relation with the clinical outcomes, in opposed to a randomly chosen classification. In this test, a value of 1 means perfect classification and a value of 0.5 would mean the rank of a randomly chosen classification. Statistical significance was set at $P < 0.05$ (two-sided). Data were analyzed using IBM SPSS Statistics Data Editor version 20 and MedCalc version 15.6 software.

3 | RESULTS

3.1 | Population characteristics

This study, held between November 2014 and February 2015, enrolled 50 infants. The mean age of the population was 5 \pm 3 months, 56% were males and approximately two-thirds were of non-Jewish (Bedouin) ethnicity (Table 2). Nasal wash for viral detection was available in 48 subjects, 39/48 (81%) tested positive for RSV, three subjects had a negative routine viral panel and the rest had non-RSV respiratory viruses. The subjects had exhibited respiratory symptoms for an average of 5 days (\pm 2 days) prior to hospital admission. During hospitalization, 44/50 patients (88%) required oxygen support, 29/50 (58%) were treated with bronchodilators, 13/50 (26%) were treated with systemic steroids and 26/50 (52%) were treated with antibiotics due to suspected secondary bacterial infection: 12 (24%) subjects were diagnosed with pneumonia in chest X-ray, 7 (14%) with acute otitis media, five underwent sepsis work up and were treated empirically until sterile cultures, and two had urinary tract infection.

3.2 | MTS and agreement between groups

A total of 600 MTS scores were obtained on 21 treated measuring events, by a total of 24 physicians. The median first MTS for each patient was 7 (IQR 5-8) as assessed by group 1, 6.5 (5-8) by group 2, 6 (4-8) by group 3, and 6 (4-8) by group 4. Overall, the scores determined by group 1 (pediatric pulmonologist) showed significant agreement

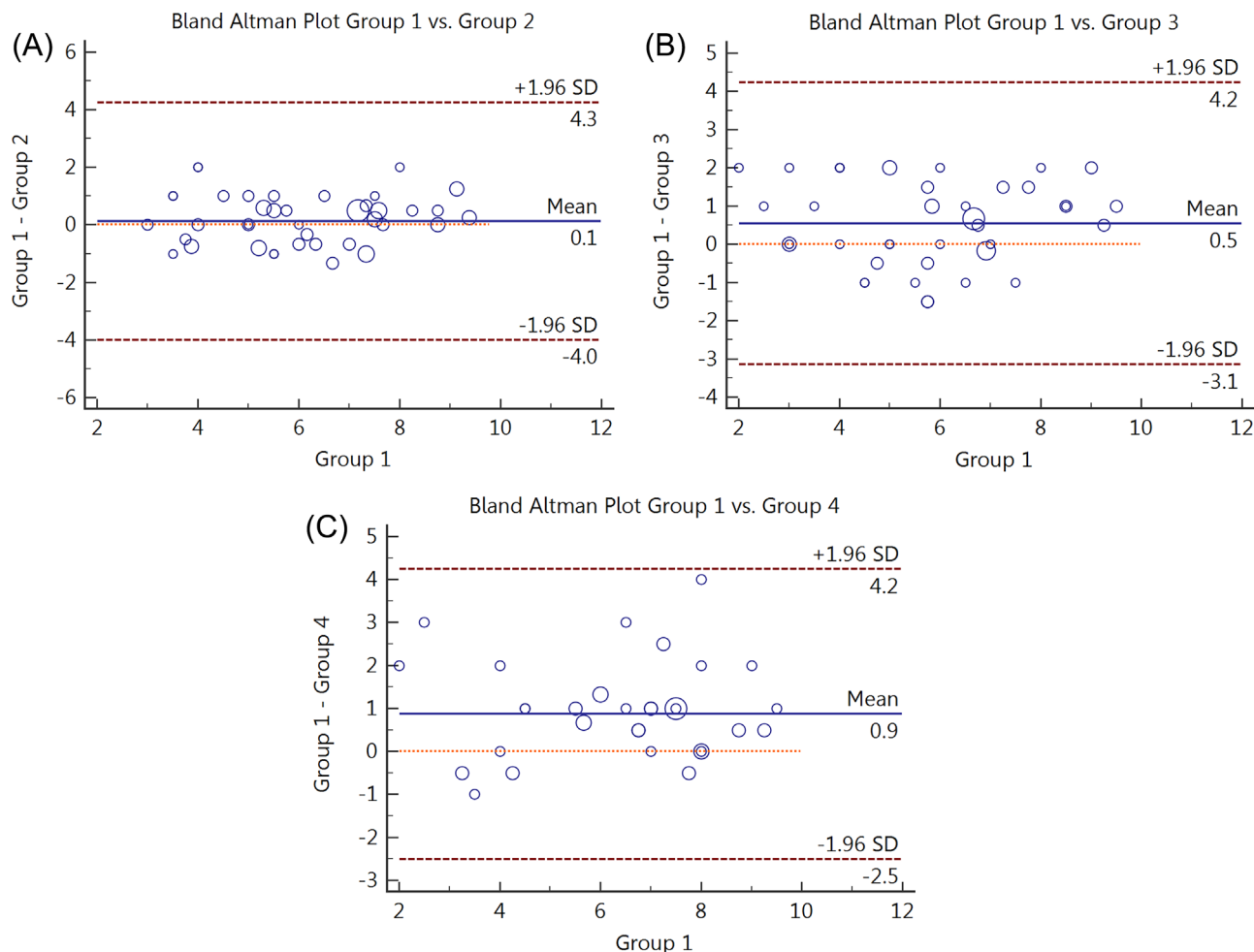


FIGURE 1 Bland-Altman Plots for the agreement between group 1 and group 2 (Figure 1A), between group 1 and group 3, (Figure 1B) and between group 1 and group 4 (Figure 1C). A: Each mark represents a patient with multiple score measurements; the larger the mark the greater amount of scoring events took place per that specific patient. The higher the agreement upon the MTS between the two groups, the closer the mark is to the zero line on the Y-axis. Mean disagreement is 0.1, 0.5 and 0.9 MTS points between group 1 and group 2, 3 and 4, respectively.

with the scores determined by group 2 (ICC 0.92; $P < 0.001$), 3 (cells ICC 0.87; $P < 0.001$), and 4 (ICC 0.83; $P < 0.001$). Using mixed models containing mixed and random effects, and standardized for multiple score measurements per patient, group 1 showed significant agreement with group 2 (ICC 0.86; $P < 0.001$) and group 3 (ICC 0.84; $P = 0.05$), and a non-significant agreement with group 4 (ICC 0.89; $P = 0.2$) (Table 3). A Bland-Altman Plot was used to graphically illustrate the agreement between group 1 and groups 2, 3, and 4 individually (Figure 1A-1C). The means of disagreement between group 1 and groups 2, 3, and 4 were 0.1, 0.5, and 0.9 score points, respectively. The maximal average disagreement per patient was two points of the total score for group 1 versus 2 and for group 1 versus 3, and four points of the total score for group 1 versus 4.

3.3 | MTS and clinical outcomes

Primary clinical outcomes regarded Oxygen support and LOS. Oxygen support was required for a median time of 47 h (IQR: 15-79), and the median LOS was 79 h (IQR: 46-115).

First, we assessed the correlation between the first score given to a patient and the degree of the severity of their disease. The correlation coefficient (ρ) for the length of O_2 support was 0.62 ($P < 0.001$), 0.50 ($P = 0.001$), 0.48 ($P = 0.006$), and 0.37 ($P = 0.06$), for groups 1, 2, 3, and 4, respectively. The correlation coefficient (ρ) for LOS was 0.48 ($P = 0.008$), 0.55 ($P < 0.001$), 0.52 ($P = 0.003$), and 0.50 ($P = 0.01$), for groups 1, 2, 3, and 4, respectively. Second, we evaluated the ability of the first score to predict the extent of that severity. Results of the negative binomial regression model for the prediction of the duration of oxygen support required by the first score were RR 1.33 (CI 1.12-1.57), 1.26 (1.1-1.46), 1.26 (1.06-1.5), and 1.21 (0.93-1.58) for groups 1, 2, 3, and 4, respectively. For the prediction of LOS by the first score RR were 1.15 (CI 0.97-1.37), 1.19 (1.03-1.38), 1.18 (1.0-1.39), and 1.18 (0.93-1.51) for groups 1, 2, 3, and 4, respectively.

Receiver operating characteristic (ROC) curve to illustrate the ability of the MTS to diagnose these clinical outcomes displayed an AUC for oxygen support requirement ≥ 48 h; 0.855 ($P < 0.001$) for group 1, 0.786 ($P = 0.002$) for group 2, 0.784 ($P = 0.007$) for group 3, and 0.679 ($P = 0.126$) for group 4. The AUC for LOS ≥ 72 h; 0.757

TABLE 3 Intra-class correlations coefficient between groups of score givers

	Number of valid scoring events (% within total)	Intra-class Correlations Coefficient	P-value
All scores estimated individually			
Group 1 vs Group 2	115 (54%)	0.92	<0.001
Group 1 vs Group 3	70 (33%)	0.87	<0.001
Group 1 vs Group 4	54 (25.5%)	0.83	<0.001
Multiple measurements per patient			
Group 1 vs Group 2	115 (54%)	0.86	<0.001
Group 1 vs Group 3	70 (33%)	0.84	0.05
Group 1 vs Group 4	54 (25.5%)	0.89	0.2

Intra-class correlations coefficient analysis is shown first for all scores individually and second via a generalized mixed model standardized for multiple measurements per each patient.

($P = 0.012$) for group 1, 0.82 ($P = 0.011$) for group 2, 0.723 ($P = 0.034$) for group 3, and 0.609 ($P = 0.350$) for group 4. No patient with an MTS <5 required oxygen support for ≥ 48 h, while 72% of patients who scored an MTS of 9–10, required oxygen support for ≥ 48 h.

4 | DISCUSSION

The present study results showed that the MTS had high internal validity and reliability when used by physicians with various training levels to assess AB in hospitalized infants. In previous studies, bronchiolitis or asthma severity scores have been determined by nurses,⁸ respiratory therapists,¹¹ or by two physicians.¹³ Balaguer et al¹⁵ recently attempted to validate the bronchiolitis score of Sant Joan De Deu when used by two physicians. However, the Sant Joan De Deu score is a complex scoring system comprising six parameters with stratification for different age groups, which is difficult for untrained physicians to use.

In contrast to previous studies, our present investigation included 24 physicians who recorded a total of 600 bedside clinical scores, within a limited timeframe. To our knowledge, this is the first report on a comparison between physicians that varied in training and experience. We demonstrated good correlation between the scores reported by first-year residents and experienced pulmonologists using the MTS. We speculate that the significant ICC values between the different groups are largely the result of the two objective score components; room-air SpO₂ and respiratory rate. These objective components showed some between-group differences, possibly due to fluctuations within the 1-h time period for score measurements. The other two score components are subjective; auscultatory findings and respiratory effort, which naturally showed greater variability. We further emphasize the simplicity and feasibility of the MTS, which takes less than five minute to perform and can be

applied by physicians in different settings, from clinics to intensive care units, without any previous training.

Previous publications have reported that clinical score could not predict oxygen support requirement.⁸ In contrast, here we demonstrated that the first MTS showed a good correlation with two major clinical outcomes: oxygen requirement and LOS. Corneli and coworkers examined potential predictors of hospital admission and LOS after emergency department evaluation for bronchiolitis in 598 infants (in 20 emergency departments). They found that initial SpO₂ at the ER was the only tested parameter that predicted hospital admission and longer LOS.¹⁶ Our present data showed that MTS upon admission, with all its components, could predict fairly LOS. We believe that the main difference between these studies is that our study was performed in a single center, while the earlier study was performed in 20 different emergency departments. We speculate that the assessment was likely not performed in exactly the same manner in all 20 centers, leading to inconsistency.

The ability of the MTS to predict LOS and the duration of oxygen requirement is of great value. This may facilitate communication between families and medical staff, enabling medical staff to use the MTS to predict the expected length of hospitalization with some certainty. We speculate that the MTS can predict oxygen requirement with greater certainty than the LOS, because the later depends on different parameters. Many patients were discharged several hours after weaning from oxygen, sometimes up to 18 h later, for a variety of reasons—including both medical needs, such as requirements for intravenous fluids or intravenous antibiotics, and non-medical needs, such as transport issues or religious restrictions. However, the MTS could reasonably predict the need for oxygen support at 48 h and the length of hospitalization at 72 h.

The present study has several limitations, including the relatively small number of enrolled patients, and the single-center design. Focusing on the study population, we had high percent of antibiotic treatment (52%), more than half is due to secondary pneumonia. The high rate of suspected pneumonia is probably related to the department policy of routine X-ray in a case of acute bronchiolitis, which may cause over-diagnosis of atelectasis as a segmental infiltration/ pneumonia. We also reported a high rate of treatment with bronchodilators (52%) and systemic steroids (26%). One of the common practices in our department is to give one bronchodilators inhalation and reevaluate the infant for improvement. If there is an improvement, we treat with inhalations of bronchodilators as a symptomatic treatment. Regarding the use of systemic steroids, 32% of the subjects had first degree family member with asthma, which may cause the physician to think of first wheezing episode in a child with hyper reactive airway disease instead of AB and add systemic steroids to the treatment. It is not the common practice in acute bronchiolitis, but it is open for consideration.

Further limitation is that all of the raters were pediatricians; therefore, our findings may not be generalized to other caregivers, such as general physicians, nurses, and respiratory therapists. However, as the MTS can be easily used with minimal previous training, we speculate that other caregivers can use it with no further training.

In summary, we conclude that the MTS is a simple, reliable, and valid scoring system for evaluating infants with acute bronchiolitis, showing high inter-rater correlation among physicians with various training levels. Moreover, the MTS showed good ability to predict oxygen requirement and length of hospitalization. The MTS can be reliably used as an outcome in research, and as an end-point for various medical decisions, such as criteria for admission or discharge. Additional studies are needed to evaluate MTS use by other types of caregivers, and in larger number of patients in multiple centers, which will better represent the general population.

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CONFLICT OF INTEREST

The authors declare that they have no financial competing interests.

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