

Prediction of hospital outcome in emergency medical admissions using modified early warning score (MEWS): Indian experience

Mini Bhatnagar¹, Nikita Sirohi², Aruna Bhagat Dubey²

Departments of ¹General Medicine and ²Medicine, MMIMSR, Mullana, Haryana, India

ABSTRACT

Objective: To evaluate the applicability of modified early warning (MEWS) Score for prediction of hospital outcomes of medical emergency patients. **Design:** Prospective hospital based observational study. **Setting:** A tertiary care level medicine emergency unit in a medical college of North India. **Study Population:** 300 Patients admitted in medicine emergency. **Method:** Patients of both sexes of age more than 18 years who were admitted in medical emergency unit at MMIMSR, Ambala were evaluated. Patients who were in cardiac arrest at arrival and those who died within the first 24 hours were excluded and 300 patients were included. Modified Early Warning Score based on physiological parameters was recorded at admission for each patient and monitored over the next 24 hours in the emergency unit. Hospital outcome of the patient in terms of mortality, need for critical care, prolonged stay and uneventful discharge were recorded and correlated with MEWS scores over the first 24 hours in the emergency unit. Receiver Operating Characteristic (ROC) curves was generated to evaluate the utility of MEWS as a tool to predict patient outcome in medical emergency setting. **Result:** Of the 300 patients studied, the mean age of patients was 49 years, and the majority of the patients were male (61%). A MEWS Score of >5 at 24 hours of admission was associated significantly with in-hospital mortality of patients ($p < 0.0001$). The ROC (Receiver Operator Characteristic) curve revealed that in those patients who had a 24 hours MEWS ≥ 5 , the area under curve was (AUC) = 0.9. (95% CI: 0.95-0.98). Thus, MEWS was an effective predictor of in hospital mortality with sensitivity (78%) and specificity (94%). **Conclusion:** MEWS, a scoring system based on easily recordable physiological parameters can be used as an effective tool to triage and monitor patients in medical emergency units, to identify patients who are at greater risk of clinical deterioration and need close monitoring or early transfer for critical care or other timely interventions. Thus, application of MEWS in medical emergency units can be a useful tool to improve patient care, ensure optimal utilization of resources and prevent inappropriate discharge or neglect of sick patients.

Keywords: MEWS, outcome, prediction

Background

Emergency services all over the world suffer from increasing workload and India, being a highly populated country is no exception. Increasing patient footfall, a wide spectrum of clinical scenarios, rising patient expectations, lack of trained

manpower, escalating financial cost of healthcare and the current COVID-19 pandemic pose a significant strain on the emergency department and sometimes result in unsavory experiences for medical staff.

Triage systems, originally developed in 1800 s in France during wartime situations to cope with mass trauma involve sorting patients into immediate, urgent and non-urgent categories so that the most sick ones are attended to as a priority as well and to identify those who are vulnerable to deteriorate and thus need to shift to critical care

Address for correspondence: Dr. Mini Bhatnagar,
930, Sector 40 A, Chandigarh - 160 036, India.
E-mail: drshyamini@yahoo.com

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areas. Triage is based on the observation that clinical deterioration of admitted patients is frequently preceded by decline of physiological parameters, which if identified in a timely manner may lead to appropriate interventions and thus improve patient survival.^[1,2]

Early Warning Scores (EWS) are simple scoring systems based on change in physiological parameters like heart rate, respiratory rate, systolic blood pressure, oxygen saturation, temperature, and level of consciousness. These parameters can be recorded by nursing staff and other medical personnel and used as track and trigger systems for triage and monitoring of patients, to identify periarrest situations or clinical deterioration well in time to organize appropriate response thereby improving patient outcomes.^[3-6] EWS are widely applied by clinical teams in medical and surgical specialties throughout the developed world but applicability at the point of admission of medical emergencies in India has not been evaluated.^[5-12] The Modified Early Warning Score (MEWS) is one such simple tool which was originally developed by Morgan, Wright *et al.*,^[13] it was later modified for use by hospital staff. The patient's clinical observations can be recorded by junior doctors or nursing staff periodically and documented on the (MEWS) observation chart which may be color coded for convenience. These observations include temperature (°C), Pulse rate (beats per minute), Systolic blood pressure (mm Hg), Respiratory rate (beats per minute) and level of consciousness according to AVPU score. Each physiological parameter is assigned a score which is zero if it is within physiological range and values above or below range are assigned a score between 1 and 5 [Table 1]. If the aggregate MEWS score exceeds a predetermined value (usually > 5), an appropriate response can be instituted. Serial MEWS monitoring over time may predict clinical deterioration of medical as well as surgical patients.^[12,14-18]

This study aims to assess whether the MEWS can be used in medical emergency units in resource limited settings such as India, as a tool to predict clinical deterioration for timely intervention.

Procedure

This hospital based, prospective observational study was conducted in a medical college of north India between May and August of 2018. Ethical and institutional permissions were

obtained prior to commencement. Patients admitted in medical emergency were screened using MEWS keeping in mind the inclusion and exclusion criteria. Patients were then monitored over the next 24 hours using MEWS modified by Subbe *et al.*^[16] Patients who did not complete 24 hours of observation period due to death or discharge were excluded and a total of 300 patients, a sample size estimated using the standard formula described by Kirkwood *et al.*^[19] were enlisted for study at the end of this period. Informed consent was taken from enrolled patients.

Inclusion criteria

1. Age more than 18 yrs attending medical emergencies at MMIMSR.

Exclusion criteria

1. Patients who already had cardiac arrest at the time of arrival to hospital.
2. Patients who died within 24 hours of admission and could not complete the period of observation.

The course of the patient in hospital and outcome was recorded in terms of in hospital mortality, transfer to ICU, requirement of mechanical ventilation or NIV, requirement of renal replacement therapy in the form of dialysis, Length of hospital stay >7 days or transfer to general ward and discharge <7 days.

Based on MEWS scores recorded in emergency the patients were divided into 2 groups, one with MEWS =/< 5 and another with MEWS > 5. The study then attempted to assess whether MEWS score in ED can be used to prognosticate about the course of illness and hospital outcome of the patient.

Laboratory investigations including hemoglobin, total leukocyte count, serum creatinine, serum sodium, and potassium carried out in Emergency department were also correlated with in hospital outcome of the patient.

Statistical analysis

Data was analyzed and described in terms of range; mean ± standard deviation, median, frequencies (number of cases) and relative frequencies (percentages). For comparing categorical data, Chi square (χ^2) test was performed and appropriate statistics performed when the expected frequency was less than 5. Sensitivity, specificity, positive and negative predictive values and accuracy of method and its confidence interval (95% CI) was also calculated. A probability value (p value) of less than 0.05 was considered statistically significant. Statistical calculations were done using SPSS 20 (Statistical Package for the Social Science).

Observations and Results

The mean age of the patients was 49 ± 13.29 years. 53.7% were in the age group of 41–60 years. There were 183 (61%) males and 117 (39%) females. The mean age of males was 49.55 ± 12 years

Table 1: Standard mews score used in study (Subbe *et al.*)

	Score						
	3	2	1	0	1	2	3
Systolic blood pressure	<70	71-80	81-100	101-199	-	>200	-
Heart rate	-	<40	41-50	51-100	101-110	111-129	>130
Respiratory rate	-	<9	-	9-14	15-20	21-29	>30
Fever	-	<35.0	-	35-38.4	-	>38.5	-
AVPU	-	-	-	A	V	P	U
AVPU=Alert/verbal/painful/unresponsive							

and of females 48.16 ± 14 years. Of the 300 patients studied, 68 (22.7%) were suffering from diabetes mellitus, 59 (19.7%) were hypertensive, 50 (16.7%) had anemia and 48 (16%) had chronic kidney disease, 39 (13%) patients suffered from heart failure. The majority of had multisystem co-morbidities.

At the time of admission 243 (81%) patients had MEWS ≤ 5 while 57 (19%) had MEWS > 5 [Table 2]. After 24 hours of emergency management 258 (86%) patients had MEWS score ≤ 5 while 42 (14%) patients had MEWS > 5 . Their hospital course was followed and 32 (10.7%) patients died in hospital. 268 patients were discharged among whom 168 (56%) survived after a complicated course with ICU admission, mechanical ventilation, dialysis or prolonged hospital stay of > 7 days, while 100 (33.3%) were discharged without any such intervention within 7 days [Table 3].

Table 2: Distribution of patients in medical emergency according to MEWS at 0 and 24 h

MEWS	No of patients 0 h	%	No of patients 24 h	%
≤ 5	236	78.6	258	86
> 5	64	21.3	42	14
Total	300	100	300	100

Table 3: Hospital outcome of medical emergency patients Out of 300 patients 32 (10.7%) died in hospital

Hospital outcome	No of patients	%
Died	32	10.7
Survived		
1) complicated stay	168	56
2) uncomplicated stay	100	33.3
Total	300	100

Out of remaining 268 patients, 168 (56%) required ICU admission or mechanical ventilation or dialysis or had prolong hospital stay (> 7 days) and 100 (33.3%) were discharged without any such intervention within 7 days

Table 4: Association of clinical profile with outcome- on correlating the comorbidities with outcome, statistical significant difference was found ($P < 0.05$)

	Outcome			P
	Death	Alive	Total	
HTN	3 (9.4%)	56 (20.9%)	59 (19.7%)	0.159
DM2	1 (3.1%)	67 (25%)	68 (22.7%)	0.003
ACS	5 (15.6%)	11 (4.1%)	16 (5.3%)	0.019
CKD	3 (9.4%)	45 (16.8%)	48 (16%)	0.442
Stroke	2 (6.3%)	8 (3%)	10 (3.3%)	0.290
Cardiogenic shock	4 (12.5%)	15 (5.6%)	19 (6.3%)	0.131
Heart failure	5 (15.6%)	34 (12.7%)	39 (13%)	0.584
Seizure	2 (6.3%)	8 (3%)	10 (3.3%)	0.290
CAD	4 (12.5%)	31 (11.6%)	35 (11.7%)	0.776
Anemia	4 (12.5%)	46 (17.2%)	50 (16.7%)	0.622
Sepsis	3 (9.4%)	10 (3.7%)	13 (4.3%)	0.150
COPD	7 (21.9%)	18 (6.7%)	25 (8.3%)	0.010
Respiratory failure	9 (28.1%)	11 (4.1%)	20 (6.7%)	< 0.0001

Patients who were DM2 (type 2 diabetes mellitus) followed by acute coronary syndrome, chronic obstructive pulmonary disease and respiratory failure

There was no statistical significance difference between the age of survivors and non survivors. 18 (56.3%) deaths occurred in the age group of 51–70 years with females comprising 43.8% and males comprising 56.3% of total mortality. A statistically significant correlation (p value < 0.05) of in hospital mortality was found with Type 2 diabetes mellitus followed by acute coronary syndrome, chronic obstructive pulmonary disease and respiratory failure [Table 4].

Significantly higher temperature, lower SBP, higher PR and higher RR was seen in non survivors as compared to survivors. The 24 Hour AVPU score was also found to correlate significantly with in-hospital mortality (p -value < 0.05). Only 3 out of 229 patients who had AVPU of 0 died in emergency (p -value < 0.05) dying (9.4% of total mortality) as compared to patients who were reacting to voice (6 out of 26 patients died i.e., 18.8% of mortality). The maximum mortality (43.8%) occurred in the group with the worst score of 3.

On evaluation of the association between MEWS at 0 and 24 hours with outcome, it was observed [Table 5] that at the time of admission 243 patients had MEWS ≤ 5 and out of these 14 (5.7%) died while 229 (94.2%) survived. 137 (56.4%) survived after a complicated hospital stay and 92 (37.8%) had an uneventful hospital stay. Among the 57 patients who had MEWS > 5 at admission 18 (31.6%) died and 39 (68.3%) survived. 31 (54.3%) had a complicated hospital stay and only 8 (14%) had an uneventful course. Thus MEWS > 5 at admission was associated significantly with mortality and periarrest situation requiring ICU care or a prolonged complicated course (p value < 0.00001).

On correlating MEWS at 24 hours with outcome it was found that 258 (86%) patients had Mews ≤ 5 at 24 hours of admission. Out of this group only 7 (2.7%) patients expired and 251 (97.3%) survived and of these survivors 151 (58.6%) patients survived with complicated or prolonged hospital stay while 100 (38.7%) had an uncomplicated stay and were discharged within a week. Of the 42 patients who had MEWS > 5 at 24 hours 25 (59.5%) patients expired and all 17 (40.47%) survivors had complicated course in the form of mechanical ventilation/dialysis/micu admission or prolonged stay.

The outcome of 300 patients, included in the study and monitored in the medical emergency was also compared in terms of emergency investigations [Table 6]. The survivors had a mean TLC of $8510.09 \pm 3438.34/\text{mm}^3$, mean serum creatinine of 2.69 ± 2.87 mg/dl and mean serum sodium of 136.1 ± 4.86 mEq/l. Those who died had a mean TLC of $11443.13 \pm 3751.86/\text{mm}^3$, mean serum creatinine of 3.96 ± 3.40 mg/dl and the mean serum sodium was 131 ± 7.69 mEq/l, respectively. Statistically significant difference was found in these investigations between the group of survivors and non-survivors, indicating that higher TLC count, higher serum creatinine and lower serum sodium levels in the emergency had significant impact on hospital mortality.

Table 5: Association of patient outcomes with mews at 0 and 24 hours.

Patient Outcomes	No of Patients	MEWS 0 H				MEWS 24 H			
		<=5		>5		<=5		>5	
		No.	%	No.	%	No.	%	No.	%
Died	32	14	5.7	18	31.6	7	2.7	25	59.5
Alive									
Complicated course	168	137	56.4	31	54.4	151	60.8	17	40.5
Uneventful course	100	92	37.9	08	14.0	100	40.3	0	00
	300	243		57		248		42	

At the time of admission 236 (76%) had mews <=5 and 64 (21%) had mews more than 5. At 24 h of admission in emergency, 86% had mews <=5 and 14% had more than 5. out of 32 in hospital deaths 21.9% belonged to mews group <=5 and 78% belongs to mews group >5. Mews >5 at 0 as well as at 24 h was correlated with poor outcome. (P<0.05 for both)

Table 6: Association of emergency investigations with outcome

Emergency investigation	Mean±SD		t	P
	Death	Alive		
Haemoglobin	11.81±2.35	12.00±1.74	-0.563	0.574
TLC	11443.13±3751	8510.09±3438	4.516	0.000
Serum Creatinine	3.96±3.40	2.69±2.87	2.310	0.022
Serum sodium	131.09±7.6	136.11±4.86	-5.132	0.000
Serum potassium	4.77±0.61	5.01±0.77	-1.733	0.084

The mean of TLC, serum creatinine and serum sodium who survived was 8510.09±3438.34, 2.69±2.87, 136.1±4.86 as compared to those who died was 11443.13±3751.86, 3.96±3.40 and 131±7.69 respectively. Statistical significant difference was found in the values of TLC, serum creatinine and serum sodium in emergency between the survivors and non survivors

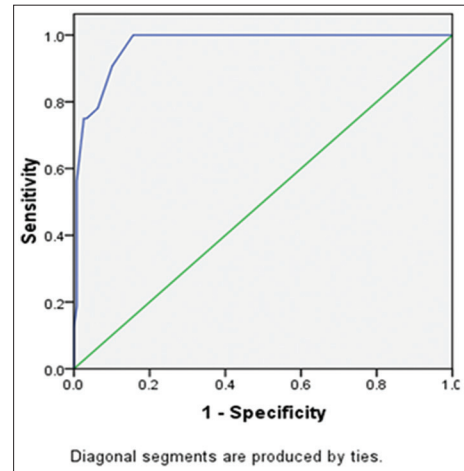
A ROC curve was plotted for MEWS (24 hours) which showed area under the curve (AUC) to be 0.970 (95% confidence interval (CI): 0.951–0.989, P < 0.001) [Graph 1].

Discussion

In this prospective, observational study, the Modified Emergency Score (MEWS) was used to monitor 300 patients aged 18 years and more in the medical emergency and their course monitored with the aim to use MEWS to prognosticate about patient outcome. A written consent and institutional clearances were taken. There was no financial or intellectual conflict of interest.

A MEWS score <=5 or >5 during the first 24 hours of admission was correlated with the hospital outcome of the patient. Of the 300 patients, 53.7% were in age group of 41-60 years with a mean age of 49 ± 13.29 years. This is comparable to the findings of Fullerton *et al.*^[18] leong,^[20] Burch *et al.*,^[16] Lam *et al.*^[21] and Subbe *et al.*^[16] 61% of emergency admissions were males and 39% female, the reason for which is not known but a similar gender distribution was reported by An-yi Wang,^[22] Burch *et al.*^[16] and Subbe *et al.*^[16]

Metabolic diseases were the leading clinical conditions among our patients with 22.7% suffering from diabetes mellitus and 19.7% with hypertension whereas 16.7% had anemia and 16% had chronic kidney disease followed by 13% with heart failure, followed by CAD, COPD, Respiratory Failure, and ACS. This probably reflects the fact that India is the diabetes capital of the world with 7.7% prevalence and presents with many



Graph 1: ROC for MEWS Score 0 hours with mortality- A ROC curve was constructed for MEWS. The area under the curve (AUC) was 0.970 (95% confidence interval (CI): 0.951–0.989, P < 0.001)

complications. Goldhill *et al.*^[23] also reported diabetes in 22.7% while Perera *et al.*^[24] reported sepsis and chest pain as leading cause of emergency admission.

At admission, out of 300, 57 (21.3%) patients had Mews >5 and 243 (78.6%) had MEWS <= 5. After 24 hours of treatment it was observed that 42 (14%) had MEWS >5 while 258 (86%) patients had MEWS <=5. Thus, the proportion of serious patients who had mews score >5 reduced from 21.3% to 14% as a result of treatment given in the emergency or during the first 24 hours.

At admission 243 patients had MEWS <= 5 out of which 14 (5.7%) died, 137 (56.3%) survived after a complicated course and 92 (37.8%) had an uneventful short stay. 57 patients had MEWS >5 and out of these 18 (31.5%) died, 31 (54.3%) had a complicated hospital stay and survived and 8 (14%) had an uneventful discharge. At 24 hours 258 patients with MEWS <=5 had increased to 258 and out these only 7 (2.7%) patients expired in hospital while 151 (58.5%) patients survived with complicated or prolonged hospital stay and 100 (38.7%) had an uncomplicated stay. 42 patients had MEWS >5 out of which 25 (59.5%) died all 17 (40.7%) survivors had a complicated hospital course. The mean MEWS score of the patients who survived was 2.09 ± 1.83 and that of patients who died was 8.47 ± 2.55. Statistically significant correlation was found

between mortality and MEWS Score at 0 and 24 hours. Thus MEWS >5 was associated with increased mortality (95% CI 5-7; P value < 0.05) and a complicated hospital stay. C.PSubbe *et al.*^[16] also reported that MEWS >= 5 was a predictor of death (OR 5.5 95% CI 2.8-10), ICU admission (OR 10.9 95% CI 2.2-55.6) and HDU admission (3.3% 95% CI-1.2-9.2). Kruisselbrink^[25] and Raju Shine *et al.*^[26] also reported that MEWS >5 effectively predicts admission in critical areas. Tsm lam^[21] also reported that Scores of >4 in ED patients were significantly associated with mortality and ICU admission. Burch *et al.*^[16] concluded that MEWS is an accurate predictor of death/cardiac arrest in the next 48 hours. Fullerton^[18] studied that MEWS was a good predictor of adverse outcomes and recommended that MEWS \geq 5 + clinical judgment: sensitivity 72.4% (95% CI 62.5–82.7%), specificity 84.8% (95% CI 83.52–86.1%). Perera^[24] also reported that 89.5% of patients who died were having mews score more than 5. A study by Suwanpasu and Sattayasomboon^[27] also reported similar findings. In contrast Leong^[19] MEWS to be a poor predictor of mortality in critically ill patients in hospital emergency department.

Thus, our findings consistent with other investigators in that MEWS score >5 during emergency admission of 24 hours has a positive correlation with high mortality and critical care requirements by medical emergency patients. MEWS requires no equipment and this scoring system may be used at all levels of healthcare delivery by medical and paramedical staff to improve patient survival.

In our study it was observed that out of 32 deaths 25 (78.12%) patients had MEWS >5 indicating that mews score >5 is related to poor outcome. There were 42 patients with mews score >5 and During emergency admission over 24 hours the patients with MEWS >5 reduced from 57 (19%) to 42 (14%) as a result of intensive monitoring of physiological parameters that included MEWS and resulting interventions affirming that effective monitoring of physiological parameters at intervals helps in improving the survival rate and contribute to positive patient safety culture. Significant reduction in mortality of hospitalized patients was reported by Mitchell.^[28] (-0.8%, P = 0.03), Moon^[29] and Paterson^[12] (-2.8%) after implementation of MEWS monitoring.

Our study shows that the ROC (receiver operator characteristic curve) revealed the area under curve was AUC = 0.9. (95% CI: 0.95-0.98) [Graph 1] as a predictor of death with sensitivity (78%) and specificity (94%) As similar to Kellett *et al.*^[30] conducted a prospective cohort study using the abbreviated MEWS at admission and reported an area under the receiver operator characteristic curve (AUROC) of 0.89 (95% CI: 0.85-0.92) as a predictor of mortality within 48 hours. Similarly, Shamout^[31] conducted a prospective study and concluded that MEWS score predicted death within 24 hours with sensitivity (67%) and specificity (90%).

In our study we found that out of 42 patients who had a MEWS score >5 at 24 hours of emergency admission, on following them

for in hospital course 25 (59.5%) died and 17 survived (40.1% of deaths in the group) but all of them (100%) of the survivors required ICU care, mechanical ventilation or dialysis or had a prolonged stay of more than 7 days. Thus, even the survivors in this group had a complicated or prolonged hospital stay. Among the 258 patients who had MEWS = /<5, only 7 (2.7%) died and 251 (97.3%) survived and out of the survivors 151 (60.15%) of survivors in this group had a complicated course of illness involving ICU care, mechanical ventilation, dialysis or prolonged stay while 100 (39.75%) of survivors of this group had uneventful course and were discharged within 1 week. It is evident from our findings that MEWS >5 at 24 hours is also an effective predictor of the complications like need for critical care, respiratory support, renal replacement therapy, and prolonged duration of hospital stay in emergency admissions. It can be effectively used to transfer patients for appropriate interventions and assist in improving survival of sick or deteriorating patients. However Perera^[24] reported a poor correlation between duration of hospital stay with MEWS score (p < 0.04) while Paterson^[12] reported that hospital stay extended significantly in relation to increase in MEWS (P < 0.0001). At the primary care level such as home care of geriatric persons, MEWS was found to be useful for assessment and decision making by nurses and general practitioners.^[32] In the context of the COVID-19 pandemic which threatens to overwhelm healthcare delivery systems at all levels new condition studies have highlighted the use of MEWS score to predict clinical decline in COVID-19 patients prompting timely transfer for ICU care,^[33,34] thus highlighting its applicability for primary care physicians who face large footfall of COVID patients who need triage and transfer. Low daily MEWS scores on the other hand were found to be useful to plan discharge of hospitalized patients.^[35]

We also found a significant independent correlation between physiological parameters like pulse rate, SBP, RR and AVPU score with mortality while investigations like Hemoglobin, TLC, and serum sodium also had an independent and statistically significant relation to mortality. There was no correlation of mortality with serum potassium which was similar to the findings of Burch^[14] who named systolic blood pressure, respiratory rate and impaired level of consciousness as important independent predictor of mortality. Perera^[24] found albumin level to be the strongest predictor of duration of hospital stay, followed by CRP level and CRP/albumin ratio. Among physiological parameters systolic blood pressure was the strongest predictor of mortality.

Conclusion

In summary, in 300 patients in ED who were monitored using MEWS and followed up, a MEWS score of > 5 at admission and 24 hours was associated with a significant increase in hospital mortality and ICU admission as compared to those with a MEWS of <= 5. A higher TLC and serum creatinine and lower serum Sodium also predicted poor outcomes in these patients. Thus, MEWS, is an effective tool for triage of patients in ED especially

in view of high demand during COVID-19 pandemic. It can be used to identify high-risk patients and prognosticate outcomes at all levels of healthcare delivery so that timely interventions and appropriate referral may be instituted with optimal use of healthcare services resulting in improved outcomes. Routine use of MEWS score in crowded and understaffed EDs of hospitals in India is highly recommended because it can aid in improving the effectiveness of emergency services and in optimizing patient outcomes.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient (s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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