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# Utility of prognostic models and early predictors of functional outcome in Guillain-Barré syndrome in an Indian cohort

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### *Abstract*

*Objectives:* The study aimed to evaluate the prognostic models modified Erasmus Guillain–Barré syndrome(GBS) outcome score (mEGOS) and Erasmus GBS respiratory insufficiency score (EGRIS) and to examine biochemical and hematological predictors of functional outcomes in an Indian GBS cohort. *Methods:* An ambispective observational study was conducted in the neurology department of a tertiary care center in northwest India from 2021 to 2024 including 68 patients aged 18 and older, diagnosed with classical GBS per the Brighton criteria. *Results:* Among the 68 patients (mean age 39.28 years), 63.2% were male, 95.6% presented within two weeks of illness onset, 25% had prodromal illnesses, and 35.3% had cranial nerve involvement. Nerve conduction studies revealed acute inflammatory demyelinating polyneuropathy, acute motor axonal neuropathy, and acute motor-sensory axonal neuropathy in 27.9%, 42.6%, and 2.9% of patients respectively. Mean(±SD) GBS disability scale (GDS) scores at admission, 1 month, and 6 months were 3.50 (±0.74), 1.79 (±1.26), and 0.84 (±1.00), respectively, mean(±SD) mEGOS and EGRIS scores at admission were 4.68 (±3.10) and 1.86 (±1.46), respectively. In 1.5% of patients, mechanical ventilation was needed, and 88.2% received intravenous immunoglobulin. The mEGOS score correlated significantly with the GDS at admission, 1 month, and 6 months. Significant correlations were found between neutrophil/lymphocyte ratio, lymphocyte percentage, and GDS score at admission. Platelet count correlated with GDS scores at 6 months ($p < 0.05$).
*Conclusion:* Prognostic models mEGOS and EGRIS, along with inflammatory biochemical markers, effectively assess disease severity, need for intensive care, and predict functional outcomes in the Indian GBS population.

*Keywords:* Guillain–Barré syndrome (GBS), Guillain–Barré syndrome disability score (GDS), Erasmus Guillain–Barré syndrome respiratory insufficiency score (EGRIS), modified Erasmus Guillain–Barré syndrome outcome score (mEGOS), mechanical ventilation

## INTRODUCTION

Guillain-Barré Syndrome (GBS) is an acute immune-mediated neuropathy characterized by a highly variable disease course and outcome. While the majority of patients achieve full recovery, approximately 20% experience persistent disability.[1] Furthermore, nearly 20% of GBS cases require mechanical ventilation during the acute phase, with reported mortality rates reaching up to 5%.[2,3] Several factors have been identified as predictors of poor prognosis, including advanced age, preceding diarrhea, *Campylobacter jejuni* infection, dysautonomia, need for mechanical ventilation, and the axonal subtype of GBS.[4-6] Identifying these prognostic factors is crucial for guiding early therapeutic interventions and optimizing clinical outcomes in high-risk patients.

To aid prognostication, the Dutch research group developed two predictive models: the Erasmus GBS Outcome Score (EGOS) and its modified version (mEGOS), both of which estimate functional outcomes at six months. Additionally, the Erasmus GBS Respiratory Insufficiency Score (EGRIS) predicts the likelihood of mechanical ventilation within the first week of hospitalization. EGOS is based on

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age, preceding diarrhea, and the GBS Disability Score (GDS) on day 14 of admission.[3] The later-developed mEGOS replaces the GDS with the Medical Research Council (MRC) sum score, improving predictive accuracy when applied at admission and on day seven.[7] Meanwhile, EGRIS utilizes the duration of weakness before admission, the presence of facial and/or bulbar weakness, and the MRC sum score at admission to predict respiratory insufficiency.[8]

The predictive validity of mEGOS has been well established in the Netherlands, where it demonstrated strong performance, with area under the curve (AUC) values of 0.75 and 0.77 for scores assessed at admission and on day seven, respectively. However, its applicability across diverse patient populations remains uncertain. While mEGOS proved effective in a Japanese cohort[9], its predictive capability in a Brazilian population was found to be limited, with the original EGOS model demonstrating lower utility in that setting.[10] Similarly, EGRIS has been validated in both the Netherlands and Japan, where it successfully predicted the need for mechanical ventilation within the first week of admission.[8,9]

Beyond these prognostic models, recent studies have explored additional biomarkers that may enhance outcome prediction in GBS.[11,12] Elevated cerebrospinal fluid (CSF) protein levels indicate active myelin damage and antibody-mediated injury, with increased blood-nerve barrier permeability contributing to disability in acute inflammatory demyelinating polyneuropathy (AIDP).[13,14] Furthermore, several hematological and biochemical markers, including decreased albumin, elevated neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), and C-reactive protein (CRP), have been associated with poor outcomes in GBS. These markers, commonly used as indicators of systemic inflammation in conditions such as cardiovascular diseases and malignancies, may also play a role in disease severity and recovery in GBS.[13,15,16] Additionally, hyponatremia, often due to the syndrome of inappropriate antidiuretic hormone secretion (SIADH), has been linked to adverse outcomes in GBS.[17] Moreover, Huang et al. demonstrated an association between reduced thyroid-stimulating hormone (TSH) levels and increased disease severity in GBS.[18]

The clinical presentation of GBS varies geographically, with AIDP being the predominant subtype in North America and Europe, whereas acute motor axonal neuropathy (AMAN) and acute motor-sensory axonal neuropathy (AMSAN) are more commonly reported in Asia.[19,20] Given these variations, this study aims to evaluate the predictive value of mEGOS, EGRIS, and various biochemical and hematological prognostic markers in an Indian GBS cohort.

## METHODS

This ambispective observational study was conducted in the neurology department of a university medical college tertiary care center in northwest India over a two-year period from August 2021 to July 2023. The study was approved by the Institute Human Ethics Committee (IHEC). It included patients aged 18 and older with a clinical diagnosis of classical (GBS) based on the Brighton criteria [level of certainty (Level 1 or 2)], who were receiving treatment in the department of neurology and provided informed written consent. Patients with Miller-Fisher syndrome, other regional variants, and the pure sensory variant of Guillain–Barré syndrome (GBS) were excluded from the study.

Baseline characteristics such as demographics, prodromal illnesses, duration of illness, cranial nerve or bulbar involvement, Medical Research Council (MRC) grading, hospitalization course, need for intensive care, mechanical ventilation, and treatment response were documented. Routine hematology and biochemistry checks at admission, nerve conduction studies, and cerebrospinal fluid examination were performed. The mEGOS, EGRIS scores at admission and the Guillain–Barré syndrome (GBS) disability scale(GDS) scores at admission, one month, and six months of follow-up were recorded. Nerve conduction studies(NCS) using Uncini's criteria was performed in all patients at admission to determine GBS subtype.

The collected data was manually entered into Microsoft Excel and analyzed using Software for Statistics and Data Science (Stata) version 16. Descriptive analyses were presented using numbers and percentages for categorical variables and mean with standard deviation or median with interquartile range for continuous variables. The chi-square test of significance (two-sided) or independent t-tests (two-sided) was used to test associations. Pearson's correlation test was employed to assess the relationship between the GDS and mEGOS scores. Receiver operating characteristic curve analysis was conducted to evaluate the performance of the prognostic models. Statistical significance was set at $p < 0.05$.

## RESULTS

The study included 68 patients with a clinical diagnosis of classical Guillain-Barré syndrome (Guillain–Barré syndrome (GBS)) based on the Brighton criteria [level of certainty (Level 1 or 2)]. The mean age of the patients was 39.28 years (± 17.47), with 55.9%(38) of the patients being 40 years of age or younger. Males made up 63.2%(43) of the study population, while 36.8%(25) were females, 95.6%(65) of patients were admitted within two weeks of symptom onset, and 4.4%(3) were admitted after two weeks. Prodromal symptoms were reported in 25%(17) of patients, and 35.3%(24) experienced either facial or bulbar involvement. NCS revealed that 27.9%(19) of patients had AIDP, 42.6%(29) had AMAN, 2.9%(2) had AMSAN, 25%(17) had equivocal findings, and 1.5%(1) had normal findings.

The mean GDS scores at admission, one month, and six months were 3.50 (± 0.74), 1.79 (± 1.26), and 0.84 (± 1.00), respectively. At admission, 88.2%(60) of patients had GDS scores between 3 and 6; at one month, 70.6%(48) had scores between 0 and 2; and at six months, 89.7%(61) had scores between 0 and 2. The mEGOS and EGRIS scores at admission were 4.68 (± 3.10) and 1.86 (± 1.46), respectively. Only 1.5%(1) of patients required mechanical ventilation, while 88.2%(60) received intravenous immunoglobulin (Table 1).

**Table 1: Clinical characteristics, electrodiagnostic, treatment, and outcome details of the study population**

| | | n (%) | Mean (±SD) |
|---|---|---|---|
| Age (in years) | ≤40 | 38 (55.9) | 39.28 (±17.47) |
| | 41 to 60 | 21 (30.9) | |
| | ≥61 | 9 (13.2) | |
| Gender | Female | 25 (36.8) | |
| | Male | 43 (63.2) | |
| Duration from onset to admission | <2 weeks | 65 (95.6) | 7.27 (±5.28) |
| | ≥2 weeks | 3 (4.4) | |
| GBS disability scale scores – at admission | 3 to 6 | 60 (88.2) | 3.50 (±0.74) |
| | 0 to 2 | 8 (11.8) | |
| GBS disability scale scores – at 1 month | 3 to 6 | 20 (29.4) | 1.79 (±1.26) |
| | 0 to 2 | 48 (70.6) | |
| GBS disability scale scores – at 6 months | 3 to 6 | 7 (10.3) | 0.84 (±1.00) |
| | 0 to 2 | 61 (89.7) | |
| mEGOS – at admission | | | 4.68 (±3.10) |
| EGRIS – at admission | | | 1.86 (±1.46) |
| Prodrome | Absent | 51 (75.0) | |
| | Present | 17 (25.0) | |
| Facial or bulbar involvement | Absent | 44 (64.7) | |
| | Present | 24 (35.3) | |
| Mechanical ventilation | Yes | 1 (1.5) | |
| | No | 67 (98.5) | |
| IV immunoglobulin | Yes | 60 (88.2) | |
| | No | 8 (11.8) | |
| NCS (Electrodiagnosis using Uncini's criteria) | AIDP | 19 (27.9) | |
| | AMAN | 29 (42.6) | |
| | AMSAN | 2 (2.9) | |
| | Equivocal | 17 (25.0) | |
| | Normal | 1 (1.5) | |

SD, Standard deviation; GBS, Guillain–Barré syndrome; EGRIS, Erasmus GBS respiratory insufficiency score; mEGOS, Modified Erasmus GBS outcome score; IV, Intravenous; NCS, Nerve conduction studies

Correlation analysis showed that platelet counts had a significant negative correlation with GDS scores at six months (r = -0.266; p = 0.029). Lymphocyte percentage also had a significant negative correlation with GDS scores at admission (r = -0.223; p = 0.046). In contrast, the neutrophil/lymphocyte ratio had a significant positive correlation with GDS scores at admission (r = 0.244; p = 0.045) (Tables 2 and 3).

The mEGOS scores at admission showed a significant positive strong correlation (r = 0.668) with GDS scores at admission, a significant positive moderate correlation (r = 0.326) with GDS scores at one month, and a significant positive moderate correlation (r = 0.291) with GDS scores at six months (Figure 1). The area under the curve (AUC) for mEGOS scores at admission were 0.984, 0.628, and 0.589 with GDS scores at admission, one month, and six months, respectively (Table 4). The mean mEGOS scores at admission did not vary significantly by patient outcomes (p = 0.466). Similarly, the mean EGRIS scores did not vary significantly with the need for mechanical ventilation (p = 0.539) (Figure 2).

## DISCUSSION

GBS presents with a highly variable clinical course, making early identification of high-risk patients critical for timely therapeutic interventions. Our study findings indicate that the modified Erasmus GBS Outcome Score (mEGOS) is a reliable tool for predicting poor functional outcomes, while the Erasmus GBS Respiratory Insufficiency Score (EGRIS) effectively stratifies patients at risk of developing respiratory insufficiency.

Our results are in concordance with those observed in an Asian cohort from Japan.[9] In our study, the mean mEGOS score at admission (4.68) was notably higher than the reported score in the Japanese study (3). Despite this difference, functional outcomes remained comparable, with 10.3% of our patients unable to walk independently at six months, a percentage similar to the 11% documented in the Japanese cohort. Additionally, EGRIS consistently demonstrated its predictive utility for respiratory insufficiency, aligning with prior findings[9] and reinforcing its role in early risk stratification. A significant proportion of our study population (35.3%)

**Table 2: Laboratory parameters, GBS disability scale (GDS), modified Erasmus Guillain–Barré syndrome (GBS) outcome score (mEGOS), & Erasmus Guillain–Barré syndrome (GBS) respiratory insufficiency score (EGRIS) of the study population**

| | Minimum | Maximum | Mean (±SD) |
|---|---|---|---|
| Platelet count | 143000 | 543000 | 304617.65 (±93650.20) |
| TLC | 5010 | 31910 | 10731.32 (±4326.60) |
| Neutrophil percent | 35 | 85.6 | 66.57 (±10.93) |
| Neutrophil count | 2565 | 25528 | 7326.97 (±3755.91) |
| Lymphocyte percent | 7 | 60 | 25.43 (±10.85) |
| Lymphocyte count | 455 | 5420 | 2581.21 (±1186.90) |
| PLR | 33.4 | 492.3 | 146.27 (±89.59) |
| NLR | 0.6 | 12.1 | 3.48 (±2.40) |
| Serum albumin | 2.80 | 4.90 | 3.89 (±0.55) |
| Serum sodium | 126.2 | 145.9 | 137.62 (±4.51) |
| CSF protein | 27.0 | 628.0 | 148.21 (±107.96) |
| GBS disability scale scores – at admission | 1 | 4 | 3.50 (±0.74) |
| GBS disability scale scores – at 1 month | 0 | 4 | 1.79 (±1.26) |
| GBS disability scale scores – at 6 months | 0 | 4 | 0.84 (±1.00) |
| mEGOS – at admission | 0 | 8 | 4.68 (±3.10) |
| EGRIS – at admission | 0 | 6 | 1.86 (±1.46) |

EGRIS, Erasmus GBS respiratory insufficiency score; mEGOS, Modified Erasmus GBS outcome score; SD, Standard deviation; TLC, Total leucocyte count; NLR, Neutrophil/lymphocyte ratio; PLR, Platelet/lymphocyte ratio; CSF, Cerebrospinal fluid; GBS, Guillain–Barré syndrome

**Table 3: Association of biochemical parameters with Guillain–Barré syndrome (GBS) disability scale(GDS) scores at admission, at 1 month, and 6 months**

| | GBS disability scale(GDS) scores | | | | | |
|---|---|---|---|---|---|---|
| | Admission | | 1 month | | 6 months | |
| | r | p value | R | p value | R | p value |
| Platelet count | -0.119 | 0.332 | -0.076 | 0.536 | -0.266 | 0.029* |
| TLC | 0.105 | 0.392 | -0.051 | 0.682 | -0.169 | 0.168 |
| Neutrophil percent | 0.196 | 0.109 | -0.050 | 0.685 | -0.092 | 0.457 |
| Neutrophil count | 0.153 | 0.213 | -0.041 | 0.737 | -0.149 | 0.224 |
| Lymphocyte percent | -0.223 | 0.046* | 0.010 | 0.937 | -0.007 | 0.954 |
| Lymphocyte count | -0.136 | 0.269 | -0.075 | 0.543 | -0.163 | 0.183 |
| PLR | 0.118 | 0.338 | 0.008 | 0.948 | 0.056 | 0.648 |
| NLR | 0.244 | 0.045* | -0.025 | 0.837 | -0.004 | 0.976 |
| Serum albumin | 0.080 | 0.515 | 0.055 | 0.655 | 0.137 | 0.265 |
| Serum sodium | -0.055 | 0.658 | -0.126 | 0.304 | -0.047 | 0.703 |
| CSF protein | 0.034 | 0.837 | 0.226 | 0.160 | 0.058 | 0.723 |

*Statistically significant at p<0.05

TLC, Total leucocyte count; NLR, Neutrophil/lymphocyte ratio; PLR, Platelet/lymphocyte ratio; CSF, Cerebrospinal fluid; GBS, Guillain–Barré syndrome

exhibited facial or bulbar involvement, and patients with EGRIS scores ranging from 4 to 6 had a greater likelihood of requiring mechanical ventilation, though only one patient eventually required ventilatory support. Conversely, none of the patients with EGRIS scores between 0 and 3 necessitated intensive care. Given that 88.2% of the cohort received intravenous immunoglobulin (IVIg) therapy, the prompt initiation of treatment may have contributed to the lower incidence of mechanical ventilation requirements. Additionally, other contributing factors, including selection bias and an overall milder disease severity in our cohort, may have influenced the low frequency of ventilatory support. Although both IVIg and plasma exchange (PLEX) remain well-established therapeutic options for GBS, none of the patients in our cohort underwent PLEX, which aligns with our institutional treatment practices.

EGRIS has undergone extensive validation across multiple populations, including cohorts in the Netherlands and Japan, demonstrating consistent reliability in predicting early respiratory failure.[8,9] Our study further substantiates its applicability within the Indian population, underscoring its clinical utility in guiding intensive care resource allocation.

Additionally, our findings revealed correlations between hematological markers—including neutrophil-to-lymphocyte ratio (NLR), lymphocyte percentage, platelet count—and GBS Disability Scale (GDS) scores. However, these

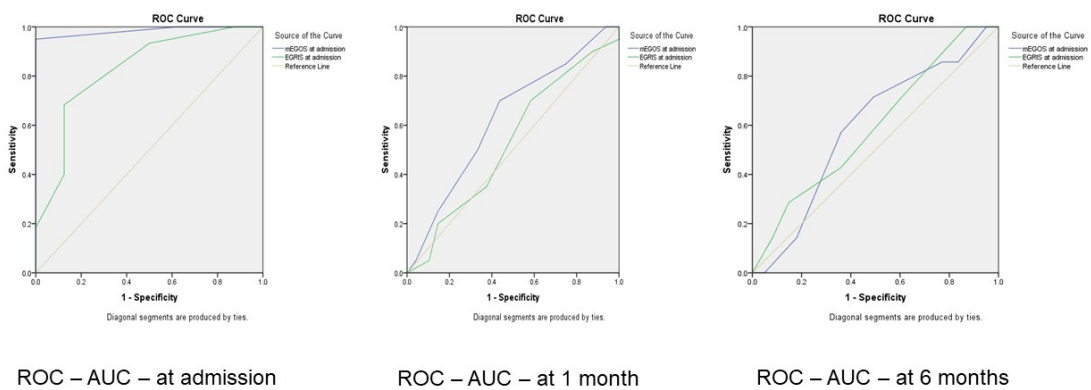


Figure 1: Comparison of ROC Curves for Predictive Performance at Admission, 1 Month, and 6 Months

**Table 4: Correlation between modified Erasmus Guillain–Barré syndrome (GBS) outcome score (mEGOS) and Erasmus Guillain–Barré syndrome (GBS) respiratory insufficiency score (EGRIS) at admission and Guillain–Barré syndrome (GBS) disability scale(GDS) scores at admission, 1 month and 6 months**

| | GBS disability scale(GDS) scores | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Admission | | | 1 month | | | 6 months | | |
| | R | p value | AUC | R | p value | AUC | R | p value | AUC |
| mEGOS – at admission | 0.668 | <0.001* | 0.984 | 0.326 | 0.007* | 0.628 | 0.291 | 0.016* | 0.589 |
| EGRIS – at admission | 0.517 | <0.001* | 0.827 | 0.174 | 0.157 | 0.529 | 0.206 | 0.092 | 0.593 |

*Statistically significant at p<0.05

associations exhibited variability, which may be attributed to the dynamic nature of inflammatory responses and interindividual variations in immune mechanisms.[15] Although no statistically significant correlations were observed between serum sodium, serum albumin, or cerebrospinal fluid (CSF) protein levels with disability scores at different time points, a discernible trend was noted. Lower sodium and albumin levels, as well as elevated CSF protein levels, were associated with increased disease severity, findings that align with prior research.[21]

Several hematological and inflammatory markers, including NLR and platelet count, have been proposed as potential prognostic indicators in GBS. Our study identified meaningful correlations between these biomarkers and functional outcomes, corroborating previous studies.[15,22] However, given the multifactorial and dynamic nature of systemic inflammation, further prospective research is warranted to establish their definitive clinical utility. Future investigations should explore whether integrating these biomarkers into existing prognostic models could enhance risk stratification and provide a more individualized approach to patient management in GBS.

NLR has gained prominence as a potential biomarker of systemic inflammation, with prior studies underscoring its relevance in various neurological and autoimmune conditions.[15,22] Berciano et al. identified the presence of neutrophil leukocytes and T lymphocytes in spinal root sections undergoing macrophage-mediated demyelination, highlighting the role of these immune cells in GBS pathogenesis.[23] Hematological markers such as NLR and platelet counts offer valuable insights into systemic inflammatory activity, which may influence disease trajectory and recovery in GBS.[15]

Recent advancements in artificial intelligence (AI) and machine learning (ML) have significantly

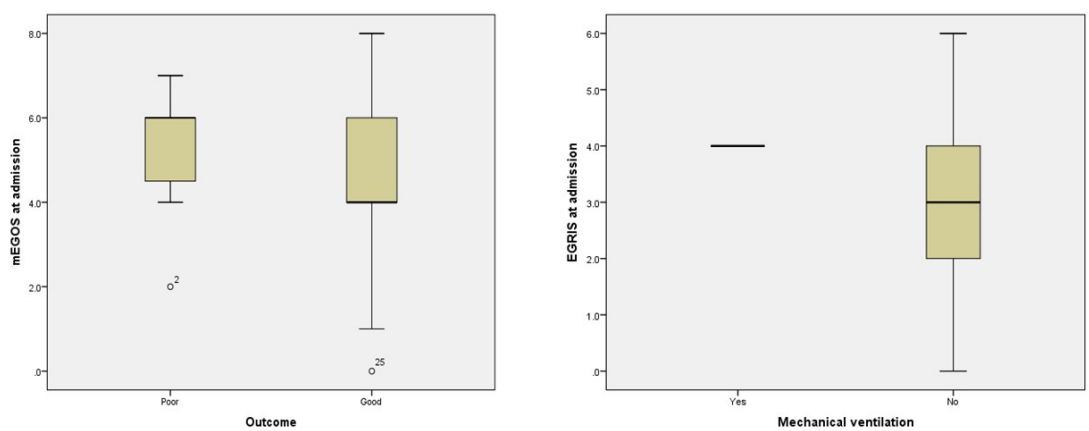


Figure 2. Comparison of modified Erasmus Guillain–Barré syndrome (GBS) outcome score (mEGOS)-OA with the functional outcome at 6 months(A); and comparison of Erasmus Guillain-Barré syndrome respiratory insufficiency score(EGRIS) with the requirement of mechanical ventilation (B)

enhanced prognostic modeling in neurological disorders, demonstrating improved predictive accuracy in conditions such as stroke[24] and epilepsy.[25] Given these advancements, incorporating ML-based approaches into GBS prognostic modeling could refine existing tools by integrating a broader array of clinical, biochemical, and electrophysiological variables. Future studies should explore AI-driven approaches to optimize risk stratification and personalized treatment planning in GBS.

This study has several limitations that warrant consideration. The relatively small sample size may limit the generalizability of our findings and reduce statistical power. Additionally, regional treatment preferences and institutional protocols may have influenced patient management decisions, potentially affecting the broader applicability of our results. Our study primarily focused on validating mEGOS and EGRIS in an Indian cohort and did not directly compare them with other prognostic models.

In conclusion, present study reinforces the utility of mEGOS and EGRIS as valuable prognostic tools for predicting functional outcomes and respiratory insufficiency in an Indian GBS cohort. However, their predictive robustness at one and three months was limited, necessitating further validation in larger, more diverse patient populations. Given that prognostic models for GBS demonstrate variability across different geographic and ethnic populations, region-specific validation remains essential. Furthermore, our study underscores the potential of hematological and biochemical markers in prognostication, particularly in identifying patients with a poor prognosis. Future research should focus on refining existing prognostic models, integrating AI-driven methodologies, and incorporating hematological and biochemical markers to enhance risk stratification and optimize individualized patient management in GBS.

## DISCLOSURE

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Conflict of interest: None

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