# Analysis of the Effects of Blenderized Tube Feeding, Diagnostic Complexity, and Length of Stay on BMI Changes in the ICU at Universitas Airlangga Hospital

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**KEYWORDS**

Blenderized Tube Feeding, Body Mass Index, Criticallyill, Nutrition

**ABSTRACT:**

**Background:** Implementing Blenderized Tube Feeding (BTF) to patients in the Intensive Care Unit (ICU) presents challenges.The nutritional content of BTF is often considered insufficient for critically ill patients in the ICU, necessitating a thorough analysis to provide accurate contributions to ICU patient outcomes. **Objective:** This study aims to analyze the effectss of enteral BTF nutrition, diagnostic complexity, and Length of Stay (LOS) on changes in BMI for ICU patients at Universitas Airlangga Hospital. **Methods:** This retrospective study included patients who received BTF during their ICU stay at Universitas Airlangga Hospital from November 2023 to May 2024, with approval from the Hospital Ethics Committee, number UA-02-23221.Demographic data included gender, age, Body Mass Index (BMI) based on the Center for Disease Control (CDC), and diagnosis recognized by the healthcare payer. Data analysis was performed using R statistical software. **Results:** The total number of subjects analyzed in this study was 173, with 38 subjects excluded, resulting in a final sample size of 135.Data analysis revealed that the type of BTF nutrition and diagnostic complexity had a significant effects on BMI changes in the ICU at Universitas Airlangga Hospital, with p-values of 0.002 and 0.013, respectively.There was no significant effects of length of stay on BMI changes at admission and discharge. **Conclusion:** BTF significantly affects BMI changes. Diagnostic complexity and BTF nutrition have a more significant effects on BMI changes.The results of this study can serve as a recommendation for BTF nutritional calculations for ICU patients.

**Running Title:** Effects of BTF, Diagnostic Complexity, and LOS on BMI Changes in ICU

## Background

Blenderizedtube feeding is a method of providing nutrition to individuals who are unable to eat or swallow food normally [1].It is typically utilized for individuals with health conditions such as digestive disorders, dysphagia (difficulty swallowing), or other issues that impede normal consumption of solid or liquid foods.Using this approach, food is first cooked and then blended into a softer and more liquid texture using a blender or other equipment.The blended food is then administered through a feeding tube or nasogastric tube (NGT) connected to the stomach or other parts of the digestive system. This process enables individuals to receive the necessary nutrients without the need to chew or swallow food directly.[2].

Schmitz and Bennett have reported that BTF is a safe and effective method for meeting the nutritional needs of individuals requiring special care[3, 4]. This method has proven particularly useful for those with eating disorders, digestive problems, or individuals recovering from injuries or surgeries.Additionally, tube feeding ensures that essential nutrients are adequately absorbed by the body without triggering further disturbances in the digestive system[5].

The use of low-protein BTF has gained increasing attention in medical nutrition research [6, 7]. This approach allows for the provision of nutrition tailored to individual needs, particularly for those requiring restricted protein intake.While protein is vital for growth and tissue maintenance, certain medical conditions require careful regulation of protein consumption[3].For example, individuals with specific kidney diseases may need to limit their protein intake to reduce renal workload.In such cases, low-protein tube feeding can help meet nutritional requirements without placing excessive strain on kidney function.

The administration of blenderized tube feeding (BTF) for patients can have implications on hospital expenditures.Considering factors such as better management of gastrointestinal complications and the potential reduction in long-term complication risks[8], the use of this method may decrease the need for additional care and medical interventions, thereby potentially affecting hospital care costs.Introducing a BTF diet with low protein content may also reduce the likelihood of intolerance caused by manufactured nutrition products.However, the use of BTF also affects hospital expenses.While BTF may reduce the risk of nutrition-related complications and the need for additional medical interventions, it can introduce additional costs related to the more complex preparation, processing, and administration of the food[1].The involvement of additional medical personnel and equipment for BTF preparation may also result in extra costs.

Mezzomo compared the nutritional composition and expenses between BTF and commercial enteral nutrition (EN) and found that the nutritional formulation in commercial EN was higher than in BTF, whereas BTF preparation required lower costs compared to commercial EN[9]. Research comparing the efficacy of different types of EN was also conducted by comparing the BMI of patients receiving commercial EN and those on BTF after eight weeks of treatment.The results showed that patients receiving commercial EN maintained a more stable BMI compared to before treatment, while patients on BTF experienced a slight but significant increase in BMI after eight weeks of care[10].A study by Hurt demonstrated that BTF is nearly as effectsive as commercial EN in maintaining patient weight[11].

Based on the aforementioned literature recommendations, we conducted an analysis of the effects of BTF and the diagnosis complexity on changes in BMI among critically ill patients in the ICU.

**Method**

This retrospective study was conducted at Universitas Airlangga Hospital after receiving ethical approval from the hospital, with the ethical approval number UA-02-23221. The research was conducted from November 2023 to April 2024. Informed consent was obtained from the patient's guardians before the start of the study.

The study subjects included all patients in the ICU during this period who met the inclusion criteria, which were receiving BTF in the ICU at Universitas Airlangga Hospital and being over 17 years of age. Exclusion criteria included pediatric and cancer patients. Patients with incomplete medical records were classified as dropouts. Patient demographic data, including age, gender, length of stay, and BMI at ICU admission and discharge, were compiled for this study.BMI was calculated using the following formula:

$$BMI = \frac{Ideal\ Weight\ (kg)}{Height\ (m)^2}$$

The diagnosis of study subjects was recorded according to the working diagnosis connected with the Indonesian Health Insurance System (BPJS).

The classification of diagnosis complexity was divided into three categories: low complexity included patients without a ventilator, with or without hemodialysis; moderate complexity included patients with a ventilator without hemodialysis; and high complexity included patients using both a ventilator and hemodialysis. The type of nutrition administered to patients was also recorded and categorized into three groups: low-protein BTF with a protein content of 5% of total calories, adequate-protein BTF with a protein content of 7% of total calories, and high-protein BTF with a protein content of 13% of total calories. These compositions were guidelines used at Universitas Airlangga Hospital, intended to align with the consistency of the BTF and the limitations of human resources, facilities, and funding. Data were analyzed using R statistics to determine the relationship between BTF nutrition administration, length of stay, and diagnosis complexity on patient BMI. The results were presented in tables and graphs.

**Results**

The data analysis derived from medical records indicated that greater diagnostic complexity was associated with longer lengths of hospital stay. Additionally, subjects receiving low-protein BTF experienced longer lengths of stay compared to those receiving high-protein nutrition. These findings are illustrated in Table 1, Figure 1, and Figure 2.

Table 1: Descriptive analysis of diagnosis complexity and BTF administration on length of stay.

| **Length of Stay** | | **N** | **Mean** | **Median** | **Standard Deviation** |
|---|---|---|---|---|---|
| Diagnosis Complexity | Mild Complexity | 22 | 4.500 | 3.000 | 4.285 |
| | Moderate Complexity | 91 | 7.857 | 6.000 | 6.131 |
| | High Complexity | 22 | 8.864 | 8.000 | 6.274 |
| BTF Nutrition | Low Protein | 80 | 7.963 | 6.000 | 6.188 |
| | Adequate Protein | 1 | 3.000 | 3.000 | NA |
| | High Protein | 54 | 6.833 | 5.000 | 5.762 |

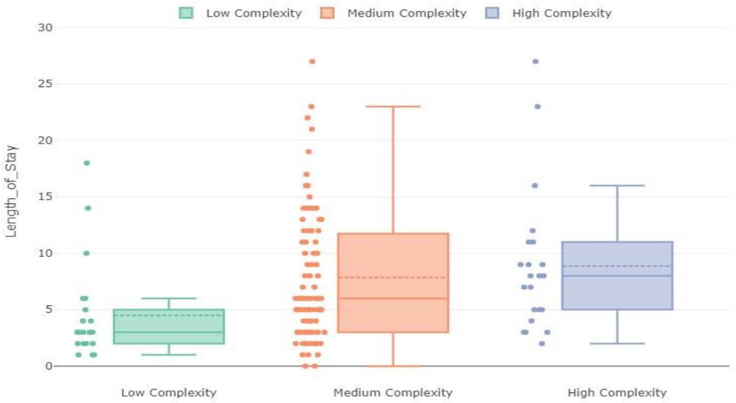



Figure 1. Boxplot of diagnosis complexity versus length of stay.

The results above indicate the average length of stay for patients based on the complexity of their diagnosis. According to the table and graph, the highest average length of stay was observed in the high-complexity category, with a mean of 8.864 ± 6.274 and a median of 8.000. This finding suggests that the higher the diagnostic complexity of a patient, the longer the length of stay in the hospital. Conversely, the lowest average length of stay was in the mild complexity category, with a mean of 4.500 ± 4.285 and a median of 3.000.

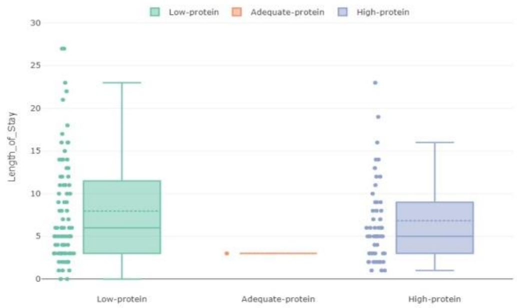



Figure 2. Average length of stay for patients receiving low-protein, adequate-protein, and high-protein BTF.

The plot in Figure 2 illustrates the average length of stay for patients based on the type of BTF nutrition. From the table and graph, it can be seen that the highest average length of stay occurred in the low-protein BTF category, with a mean of 7.963 ± 6.188 and a median of 6.000. This indicates that lower protein content is associated with a longer length of stay. The shortest average length of stay was found in the adequate-protein BTF category, at 3.000 with a median of 3.000. However, this category had only one sample, resulting in the standard error being not available (NA).

BMI measurements were taken upon patients' admission to and discharge from the ICU to assess changes in BMI. These results are presented in Table 2 below:

Table 2. Average BMI at ICU admission and discharge.

| **BMI** | | **N** | **BMI at admission** | | **BMI at discharge** | |
|---|---|---|---|---|---|---|
| | | | **Mean** | **Standard Deviation** | **Mean** | **Standard Deviation** |
| Diagnosis Complexity | Mild complexity | 22 | 24.392 | 10.538 | 9.426 | 13.378 |
| | Moderate complexity | 91 | 26.672 | 9.259 | 19.086 | 15.141 |
| | High complexity | 22 | 28.337 | 4.508 | 19.768 | 15.740 |

From Table 2, the data shows the average BMI of patients at admission and discharge, categorized by diagnostic complexity. Based on Table 2 and Figure 3, the highest average BMI at admission was found in the high-complexity category, with a mean of 28.337 ± 4.508. This indicates that the higher the diagnostic complexity, the higher the average BMI tends to be, compared to the average BMI of patients at admission in the mild complexity category, which was 24.392 ± 10.538. A similar pattern was observed for the average BMI at discharge, with the highest being in the high-complexity category at 19.768 ± 15.740, compared to the average BMI at discharge in the mild complexity category, which was 9.426 ± 13.378. Table 2 and Figure 3 also show that the comparison of the average BMI at admission and discharge across all diagnostic complexity categories indicates that the average BMI at discharge tends to be lower than the average BMI at admission.

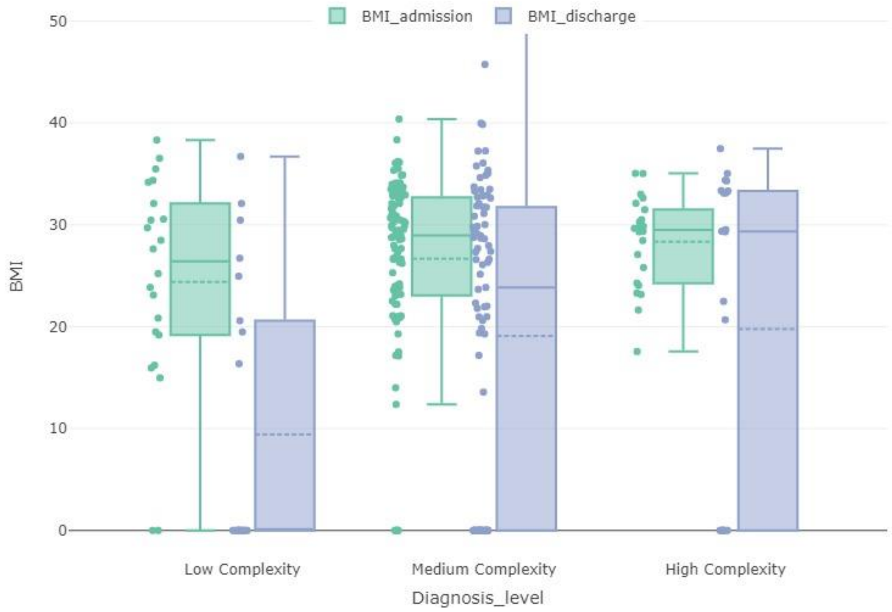



Figure 3. Boxplot of BMI changes at ICU admission and discharge

Furthermore, Figure 4 presents a scatter plot showing the relationship between length of stay and the difference in BMI at admission and discharge.In this case, a linear pattern between these two variables tends to be flat, indicating no significant effects of length of stay on the difference in patient BMI. The scatter plot also shows that in the 0-30days length of stay interval, the difference in patient BMI is predominantly negative, confirming the earlier boxplot that the majority of patients have a higher BMI upon admission compared to their BMI at discharge.

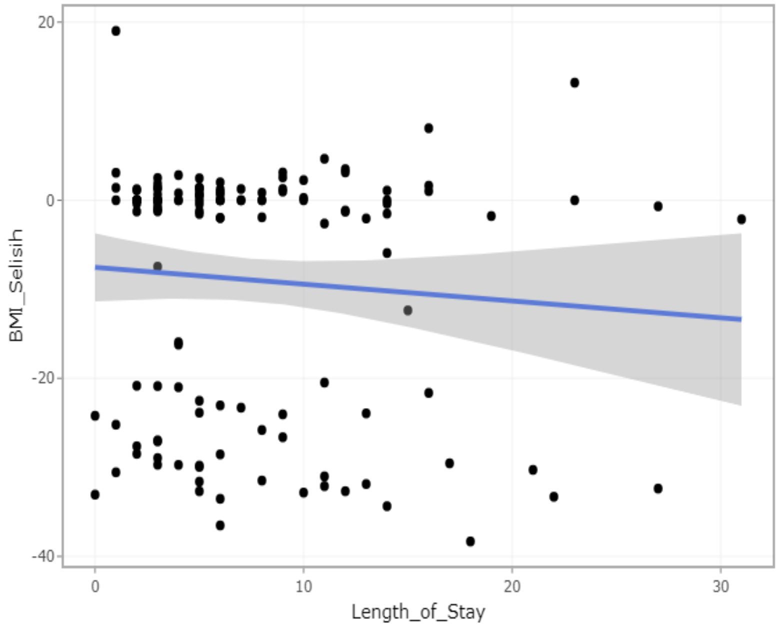



Figure 4: Scatter plot of the relationship between length of stay and the difference in BMI at ICU admission and discharge.

The next step involved testing the difference in BMI between admission and discharge. A paired t-test was used to analyze the difference in BMI at admission and discharge.The results of this analysis can be seen in Table 3.

Table 3: Paired t-test for changes in BMI at ICU admission and discharge.

| Variable | Mean ± Std.Deviation | t | p-value |
|---|---|---|---|
| BMI at Admission | 26.572 ± 8.914 | 7.413 | 0.000* |
| BMI at Discharge | 17.623 ± 15.299 | | |

*) Significant at α=5%

Table 3 shows that the average BMI of patients at admission was 26.572 with a standard deviation of 8.914, while the average BMI at discharge was 17.623 with a standard deviation of 15.299.This resulted in a difference of 8.949, indicating a decrease in the average BMI from admission to discharge. The statistical test yielded a p-value of 0.000, which is smaller than the alpha value of 0.05. Based on these statistical results, it can be concluded that the average BMI at discharge is significantly lower than the average BMI at admission.

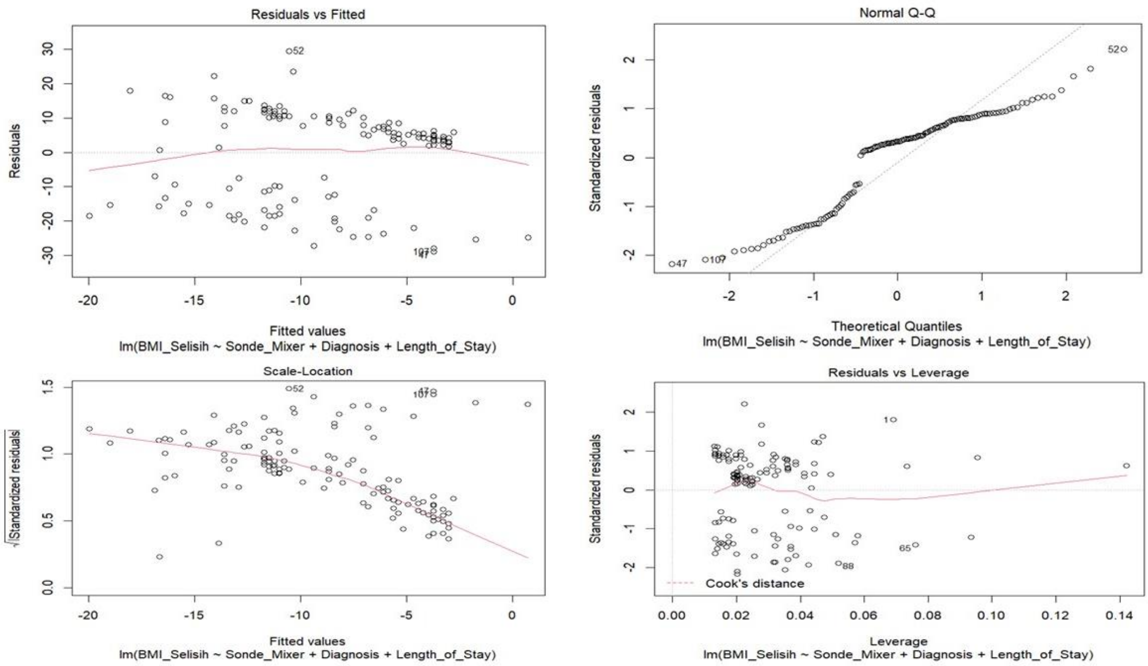
The regression analysis results are summarized in the table below based on the R output (Table 3). Table 4 presents the regression model estimation of the effects of BTF, diagnostic complexity, and length of stay on BMI changes in the ICU at Universitas Airlangga Hospital.

Table 4: Regression Model Estimates

| Model | Estimate | Std. Error | t | Pr(>\|t\|) |
|---|---|---|---|---|
| (Intercept) | -24.9476 | 5.3986 | -4.621 | 0,000 |
| Blenderized Tube Feeding | 3.8702 | 1.2271 | 3.154 | 0.002 |
| Diagnosis Complexity | 5.3864 | 2.1387 | 2.519 | 0.013 |
| Length of Stay | -0.2367 | 0.1981 | -1.195 | 0.234 |
| Dependent Variable: Change in BMI<br><br>F statistic = 4.734 (p = 0.004)<br>R Square = 0.0978 | | | | |

The contribution of the influence of BTF, diagnostic complexity, and length of stay on BMI changes in the ICU at Universitas Airlangga Hospital can be determined through the coefficient of determination ($R^2$), which is 0.0978,as shown in the table above. This indicates that these factors explain 9.78% of the variation in BMI changes, while the remaining percentage is due to other factors not included in this study.

Tabel 5.BTF and diagnostic complexity




Based on Table 5, it is evident that both BTF and diagnostic complexity have a significant effects on BMI changes in the ICU at Universitas Airlangga Hospital at the 5% significance level.This is indicated by p-values of 0.002 and 0.013, respectively.The test results show that p-value< alpha (5%). The positive regression coefficients suggest a positive effects of BTF and diagnostic complexity on BMI changes in the ICU at Universitas Airlangga Hospital, implying that higher levels of BTF or increased diagnostic complexity are associated with greater changes in BMI from admission to discharge.

On the other hand, the test for the effects of length of stay on BMI changes in the ICU at Universitas Airlangga Hospital yielded a t-statistic of -1.195 with a p-value of 0.234.Since the p-value (0.234) is greater than the alpha level of 0.05, there is no significant effects of length of stay on BMI changes at the 5% significance level.

**Discussion**

This study aimed to determine the effects of BTF, diagnostic complexity, and length of stay on changes in patients' BMI.The study involved 135 patients admitted to the ICU between November 2023 and April 2024. Among these patients, 80 (59.3%) received low-protein BTF, 1 (0.7%) received moderate-protein BTF, and 54 (40%) received high-protein BTF. Based on diagnostic complexity, patients were categorized into three groups: 22 patients (16.3%) with low complexity, 91 patients (67.4%) with moderate complexity, and 22 patients (16.3%) with high complexity.

This study focused on measuring BMI in ICU patients to address various issues related to the effects of BMI on ICU patient outcomes. Some literature suggests that a patient's nutritional status significantly affects mortality and morbidity rates.[12]. A meta-analysis indicated no significant association between obesity and mortality compared to normal weight,nor was there a meaningful relationship regarding the duration of mechanical ventilation and length of stay.[13]. Our study analyzed the extent of BMI changes in ICU patients to determine whether these changes were influenced by the type of nutrition, length of stay, or diagnostic complexity upon ICU admission.

It has been suggested that underweight patients have higher mortality rates than obese and overweight patients.[14]. Therefore, it is essential to examine the nutritional status of ICU patients at Universitas Airlangga Hospital. Our findings showed a significant decrease in BMI.This could be attributed to various factors, such as the composition and quantity of nutrition provided, disease complexity, and length of stay.

The initial analysis was a descriptive examination of the relationship between diagnostic complexity, the type of BTF, and length of stay. The results indicated that the highest average length of stay occurred among patients with high diagnostic complexity and those receiving low-protein BTF. Conversely, the lowest average length of stay was observed in patients with low diagnostic complexity and those receiving moderate-protein BTF. According to a study by Böhmer et al., the severity of illness in surviving patients is associated with the duration of their ICU stay[15]. The finding that moderate to high-protein BTF can reduce the average ICU length of stay may be related to the significant protein loss during the early acute phase, highlighting the importance of adequate protein provision[16]. Suzuki also found that high-protein nutrition could lower mortality rates. Although high-protein nutrition is associated with an increase in blood urea nitrogen (BUN),changes in BUN levels do not negatively affect patient prognosis[16].

The nutritional composition used at Universitas Airlangga Hospital does not meet the necessary requirements.Consequently, this study showed a significant decrease in BMI at the time of ICU discharge.The nutrition provided was not optimal due to various limitations, such as limited human resources, processing facilities, and funding from healthcare payers.The rationale for using protein formulas of 5%, 7%, or 13% is that higher protein content leads to a thicker BTF consistency, making it more difficult to administer through a nasogastric tube (NGT).The thickness of BTF is influenced by the energy density of the formula, the duration of mixing, and the elapsed time since BTF preparation[17].

Based on the findings of this study, it was determined that the type of BTF and the level of diagnostic complexity affect changes in patients' BMI in the ICU at Universitas Airlangga Hospital. The average BMI of patients at discharge was found to be lower compared to their BMI at admission. A study indicated that ICU patients lose approximately 10% of muscle mass during the first 10 days after ICU admission[18]. Previous research has shown a positive correlation between high-protein nutritional intake and beneficial outcomes in critical conditions, or even maintenance of muscle mass in ICU patients [19, 20].

ICU patients often experience digestive issues and constipation,commonly due to medications such as vasoactive drugs, low-fiber enteral diets, and/or electrolyte imbalances. These conditions can extend the length of stay and increase mortality rates[21]. Pawluk found that inadequate protein-calorie intake could worsen patients' overall condition and increase the risk of malnutrition, negatively affecting clinical outcomes in the hospital[22]. Low protein intake tends to adversely affect survival rates, increase mortality, and elevate the likelihood of malnutrition. It is recommended that patients achieve the recommended protein intake levels within 72 hours.

**Conclusion**

Based on this study, it can be concluded that length of stay does not significantly affect changes in BMI.However, BTF nutrition and diagnostic complexity do significantly influence changes in BMI at ICU admission and discharge.Therefore, selecting the appropriate type of nutrition, the quantity of nutrition, and the timing of its administration are crucial considerations for critically ill patients in the ICU. This study is limited by the lack of analysis regarding the specific type and quantity of nutrition provided to patients, as the medical records did not contain complete data.

**Ethical statement**

Ethical approval for this study was conducted at Universitas Airlangga Hospital after receiving ethical approval from the hospital, with the ethical approval number UA-02-23221.

**Clinical trial number**

not applicable

**Conflicts of interest** None declared
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