





Body mass index as the main predictor for length of stay in COVID-19 patients with mild and moderate symptoms: a cross-sectional study in COVID-19 emergency hospital in Indonesia

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ABSTRACT

Introduction: COVID-19 emerged as a novel global health crisis. While it has since been downgraded from its status as a public health emergency of international concern, the virus persists as a global health challenge. Thus, understanding the factors affecting length of stay (LoS) is pivotal to be considered in hospital capacity planning. Meanwhile, increasing evidence shows that obesity is one of the most common conditions recently associated with COVID-19. This study was aimed to analyze the predictors of LoS in COVID-19 patients based on nutritional status and patient characteristics data.

Methods: Participants of this study were the COVID-19 patients with mild to moderate symptoms who registered in COVID-19 Emergency Hospital, East Java, Indonesia. This study involved 2850 patients extracted from medical records for further analysis. Body mass index (BMI) was generated following the standard formula measured on the first day of hospitalization. LoS was determined by the number of days of hospitalization. The Chi-square automatic interaction detection (CHAID) algorithm was employed for model building.

Results: Most participants were overweight (34.6%) and obese (17.2%). Only a few participants were hospitalized with comorbidities such as hypertension (11.6%) and diabetes mellitus (4.1%). The predictive model of LoS indicated that BMI was the main predictor of COVID-19 LoS, with higher BMI showed to prolong the LoS of mild to moderate symptoms patients. Other than BMI, gender and symptoms were also indicated as COVID-19 LoS predictors.

Conclusions: Nutritional status is one of the predictors of LoS in COVID-19 patients. Having higher BMI tends to prolong the LoS, especially in male and having fever. LoS was also seen among those with lower BMI less than 18.5, in patients who had cold and flu.

Keywords: covid-19, length of stay, nutritional status, obesity, predictive model

Introduction

COVID-19 was a new global health emergency. Although the disease epidemiology has changed and COVID-19 is no longer a public health emergency of global concern, it continues to pose a worldwide threat. The World Health Organization (WHO) received reports (cumulative total) of over 775 million COVID-19 cases as of April 2024, and over 7 million COVID-19-related deaths (WHO, [2024a](#)). In Indonesia, the WHO received reports (cumulative total) of over 6.8 million COVID-19 cases as of April 2024 and over 100 thousand COVID-19-related deaths (WHO, [2024a](#)). Previous research has shown that, despite long-term recovery, some COVID-19 survivors may still have sequelae, such as pulmonary fibrosis, chronic debilitating symptoms, and/or psychological issues, which affect their quality of life (Liao et al., [2022](#)).

Obesity is a chronic disease that is rising in prevalence and is currently considered to be a global epidemic. Since 1990, the global rate of adult obesity has more than doubled, while the rate of adolescent obesity has quadrupled. In 2022, about 2.5 billion adults (18 years of age and above) were overweight, and 890 million of them were obese at the time (WHO, [2024c](#)). The prevalence of obesity in Indonesia in the adult age group tends to increase every year. Based on data from the Basic Health Research (RISKESDAS) in 2018, the prevalence of obesity in Indonesia increased by 6.4% from RISKESDAS in 2013, from 15.4% to 21.8% (Ministry of Health Republic Indonesia, [2018](#)).

Increasing evidence shows that obesity is one of the most common conditions currently associated with COVID-19 (Boutari and Mantzoros, [2022](#)). According to epidemiological data from the US Centers for Disease Control and Prevention, among obese COVID-19 patients, 69% of them had a BMI between 30 and 40 kg/m², and 30.1% were severely obese (BMI ≥40 kg/m²). Furthermore, it is known that 40% of COVID-19 hospitalized patients were obese (Garg et al., [2020](#); Rees et al., [2020](#); Richardson et al., [2020](#)). In particular, obesity appears to be associated with a severe clinical course (Klang et al., [2020](#); Simonnet et al., [2020](#)) and a longer length of stay (LoS) (Klang et al., [2020](#)).

Obesity is defined by BMI classification criteria that has a high specificity but low sensitivity in identifying individuals with a high body fat index (Okorodudu et al., [2010](#)). According to research from Yu et al. ([2021](#)), patients with obesity had a higher average length of hospital stay than patients without obesity (20.6 vs 16.0 days). This shows that the recovery time of COVID-19 patients with obesity may be different from patients

with normal-weight, with longer discharge time (Yu et al., [2021](#)). The link between obesity and the severity of COVID-19 has shown consistent evidence. However, there is no strong evidence of the relationship between the body weight of COVID-19 patients with LoS in Indonesia.

The COVID-19 Emergency Hospital of East Java government is aimed for patients COVID-19 with mild and moderate symptoms. Established since June 2020, the hospital has treated more than 5000 patients as per January 2021. The COVID-19 pandemic caused by SARS-CoV-2 has resulted in more than 7 million reported deaths as of April 7, 2024 (WHO, [2024b](#)). A systematic review and meta-analysis from Vekaria et al. ([2022](#)) showed that the mean of hospital LoS for COVID-19 patients across different continents was 14.49 days or more than 10 days. The LoS is an important indicator of hospital management efficiency. A decrease in the number of days of hospitalization will have an impact on decreasing risk of infection and treatment side effects, improve quality of care, and increase hospital benefits with more efficient bed management (Baek et al., [2018](#)). Patient characteristics such as age and comorbidities have an impact on the severity of the disease and are likely to affect the LoS. If a significant difference in LoS is observed, then the hospital capacity planning may need to consider the characteristics to provide accurate predictions on the number of beds required at each level of the care units (Rees et al., [2020](#)).

Prospective cohort studies of the LoS index based on the nutritional status and COVID-19 patients' characteristics are still limited. To the author's knowledge, this current study is the first to predict the COVID-19 LoS in Indonesia with consideration on the nutritional status calculated by body mass index. The current study was aimed to analyze the LoS index based on COVID-19 patients' nutritional status, changes in body weight, comorbidities and socio-demographics characteristics. Subsequently, a prediction of LoS in COVID-19 patients with mild and moderate symptoms according to the patient's characteristic can be formulated.

Materials and Methods

Study Design and Participants

This retrospective study investigated data that were consecutively collected from medical records of patients treated at the COVID-19 Emergency Hospital in Surabaya, East Java, Indonesia, a temporary hospital that served COVID-19 patients during the COVID-19 outbreak. A total of 2850 patients who tested positive

for COVID-19 using real-time RT-PCR and were hospitalized between November 2020 and January 2021, whose medical record data were complete, who were not discharged against medical approval, and who were not patients entrusted from another hospital, were included. Participants' records were anonymized prior to access to ensure their privacy.

Data Collection

Data were extracted from the patients' medical records and comprised of clinical and non-clinical data. Clinical data included diagnosis-related data such as comorbidities and clinical symptoms. The clinical symptoms were categorized as severe and mild. Non-clinical data included age and gender. Nutritional attributes that were collected comprised body weight, height, and BMI. BMI was calculated, then the nutritional status was categorized according to the WHO standard for the Asian population. Body weight and height were measured on the first and last day of hospitalization. The LoS was the total number of days the patients stayed in the hospital.

Predictive Modeling

A decision tree was constructed to predict the LoS of COVID-19 patients based on a patient's clinical and non-clinical data, as well as nutritional attributes. In total, 2850 patients' information was used as input for both sample and training of the model. The Chi-square automatic interaction detection (CHAID) algorithm with

a maximum tree depth of 5 with validation using 10 fold cross-validation was employed for model building. The CHAID algorithm can construct a predictive tree that determines how independent variables merge to explain the outcome of the dependent variable. The dependent variable of our model was the LoS, with the independent variables being nutritional status, age, gender, and symptoms of the patients. In this study, all independent variables were determined, and included in CHAID analysis. All the procedures of merging, splitting, and stopping criteria were done by using statistical software.

Ethics Declarations

This study was reviewed and ethically approved by the ethical board of Universitas Airlangga Faculty of Dental Medicine Health Research Ethical Clearance Commission with certificate number 238/HRECC.FODM/V/2021. The requirement for written informed consent was waived by the ethical board of Universitas Airlangga Faculty of Dental Medicine Health Research Ethical Clearance Commission because the dataset comprises de-identified secondary data for research purposes. All methods were carried out in accordance with relevant guidelines and regulations.

Table 1. Characteristics of COVID-19 patients treated in Emergency Hospital of East Java participated in the prospective cohort study (n = 2850)

	Mean	SD
LoS (Length of Stay)	8.04	3.10
Age	36.74	12.16
	n	%
Gender		
Men	1656	58.1
Woman	1194	41.9
BMI		
Underweight	138	4.8
Normal	1234	43.3
Overweight	987	34.6
Obesity	491	17.2
Symptoms		
Dry cough	394	13.8
Wet cough	712	25.0
Fever	418	14.7
Muscle pain	79	2.8
Headache	297	10.4
Shortness of breath	145	5.1
Diarrhea	87	3.1
Nausea	222	7.8
Vomiting	43	1.5
Have a cold	479	16.8
Anosmia	573	20.1
Stomach pain	41	1.4
Comorbidities		
Hypertension	331	11.6
Diabetes mellitus	118	4.1
Total Comorbid/patient	Median	Range
	0	0-4

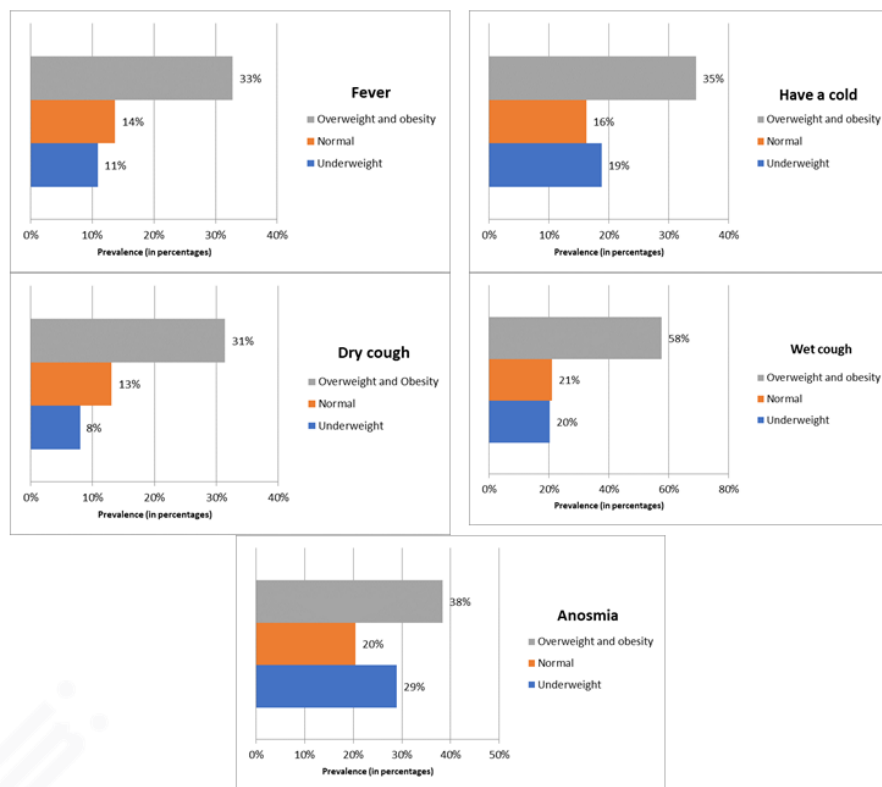


Figure 1. The cross-tabulation analysis of the nutritional status and COVID-19 symptoms. Data were presented as the percentage of patients who have the symptoms in each nutritional status groups. The nutritional status was determined from BMI and was categorized following WHO standards for Asian population.

Results

Characteristics of COVID-19 Patients

Participants majority were at productive age, ranged from 26 to 40 years old, with both male and female were in the comparable number. The proportion of patients with malnutrition was 56.6% of 2850, with 1,478 participants were overnutrition. In total, 15.7% of the participants were hospitalized with comorbidities. The total comorbidities that each patient experienced ranged from 0-4 comorbidities. We recorded hypertension and diabetes mellitus as the most prevalence comorbid during the study period. Wet cough was observed as the most prevalence symptoms and later was anosmia. Patients' characteristics were summarized in Table 1.

Cross tabulation analysis of the nutritional Status and COVID-19 Symptoms

The five most prevalent COVID-19 symptoms were selected for cross-tabulation analysis with the nutritional status of the participants, comprises of fever, wet cough, dry cough, anosmia and cold (Figure 1). The results indicated those patients who were overnutrition had the higher prevalence of having the symptoms, with wet cough was the highest. Those in normal and underweight group were less likely to experience the

symptoms. Anosmia and wet cough were the most prevalent symptoms in normal and underweight groups.

Prediction of COVID-19 Patients' Length of Stay in the Emergency Hospital

From CHAID algorithm analysis a decision tree model of LoS in Emergency Hospital for COVID-19 patients was constructed (Figure 2). Decision tree models are perceived as the most simple-to-interpret and easy-to-apply predictive model for medical use. In this test, the independent variables included in the test were BMI, age, gender, and some symptoms such as the presence of fever, wet cough, dry cough, headache, muscle soreness, anosmia, and stomach-ache. Based on the results in Figure 2., only the variables BMI, gender, the presence of fever, wet cough, dry cough, and anosmia play a role in LoS. According to the data collected, the predictive LoS of for COVID-19 patients in Emergency Hospital was eight days. BMI was the main predictor that contributes to the LoS in our model (p-value = 0.006). Patients with higher BMI need more time for hospitalization compared to those with lower BMI. However, some other factors were also predicted to increase the length of stay: the groups with lower BMI who experience fever were more likely to have longer LoS. The predictors of LoS in higher BMI group from the strongest to weakest were gender, the presence of

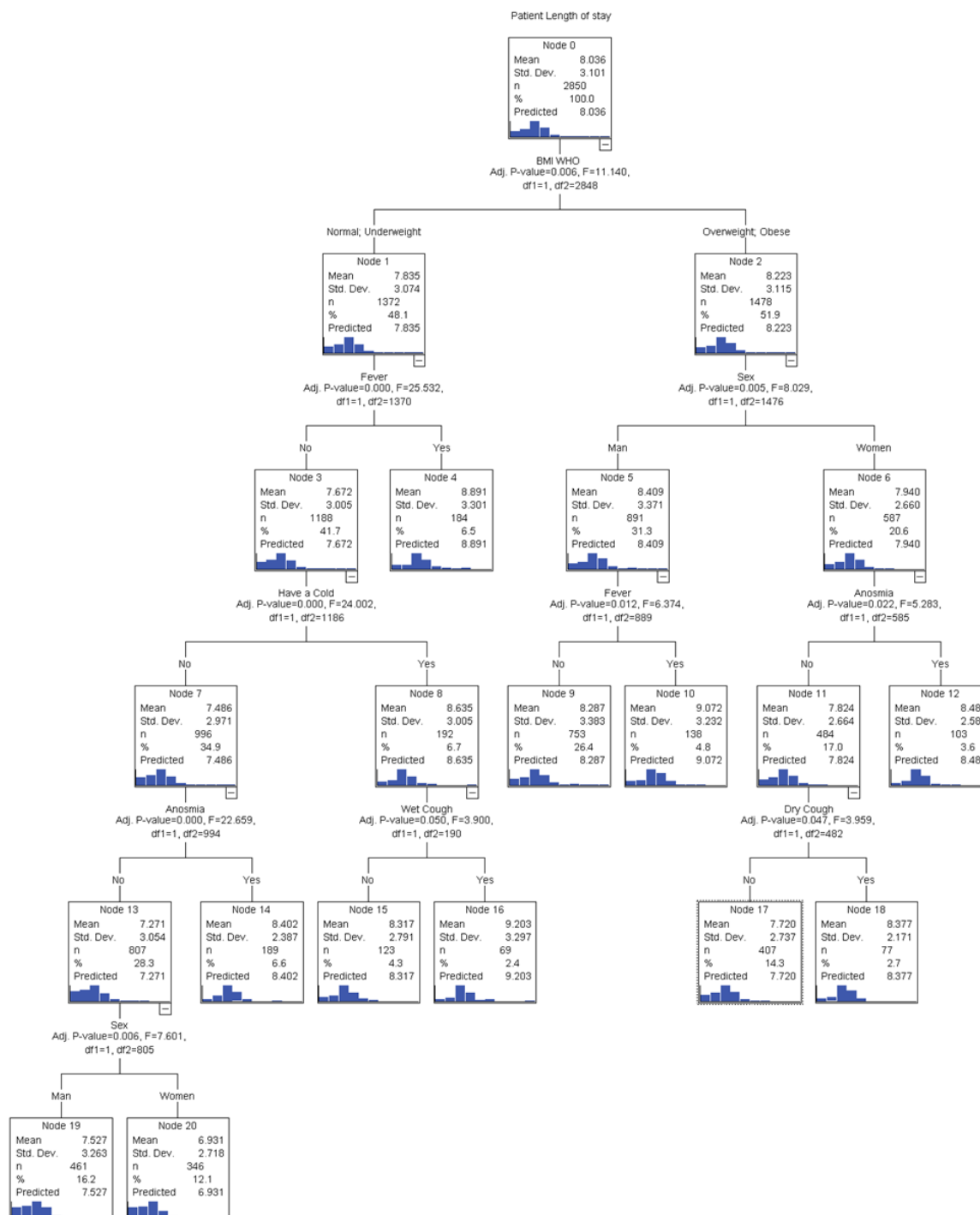


Figure 2. Decision tree of predictive LoS of COVID-19 patients. The decision tree was generated using CHAID algorithm. All data were used for the test. Independent variables inputted to the test were BMI, age, gender, the presence of fever, wet cough, dry cough, headache, muscle soreness, anosmia, and stomach-ache.

fever, anosmia and wet cough, respectively. In the lower BMI group the presence of fever, cold, anosmia, wet cough and gender, respectively, assisted as the predictors. Apparently in our predictive model, the risk of having longest LoS would emerge when a patient was in lower BMI group with cold and wet cough. Also, a patient assigned in higher BMI group would have longest LoS in male and having fever.

Discussions

The emerging of COVID-19 causes significant impact in many aspects, not only health but also sociological and economic burden. In developing countries, most of the health facilities were not prepared for COVID-19 management at its first emerging, including Indonesia. The disparities among healthcare facilities in every

region of Indonesia are wide. Only big cities were equipped with facilities for COVID-19 treatments, yet few met the standards. For Indonesia, in which the number of COVID-19 cases was not under control, managing the healthcare facilities efficiently was pivotal. During the first wave of COVID-19, the Indonesian government adopted the policy of building an emergency hospital for COVID-19 (Menkes RI, [2021](#)). Patients who were treated in the emergency hospital were those with mild and moderate COVID-19 symptoms (Widyawati, [2021](#)). It is reported that, during the peak of COVID-19 cases, the hospital beds were not sufficient enough to accommodate the number of patients (Saputra, Sodiq and Mustopa, [2021](#)). Therefore, it is necessary to predict the LoS of COVID-19 patients in order to develop the hospital capacity planning for appropriate management.

The current study observed the characteristic of patients in the COVID-19 Emergency Hospital of East Java, Indonesia, during November 2020 to January 2021. It is important to notice that LoS is affected by many aspects of a patient's characteristics, including age, gender, severity of the symptoms, nutritional status and the presence of comorbidities (Wu et al., [2020](#); Di Filippo et al., [2021](#)). Approximately half of the study participants were overweight/obese. Therefore, we conducted a cross-tabulation analysis to observe the correlation of nutritional status and the COVID-19 symptoms (Figure 1). The findings showed that, in overweight/obese group, the symptoms are more prevalent compared to the normal and underweight group. It is more likely that overweight/obese patients experience more severe symptoms due to obesity-derived inflammation. Consequently, immunological dysfunction of COVID-19 patients may be present in overweight/obese patients (Moriconi et al., [2020](#); Mahboub et al., [2021](#)). Furthermore, obesity can lead to hypoxemia, which increases the severity of the symptoms when infected by SARS-COV2. We can conclude that the longer LoS might be observed in patients with obesity.

We found a mean LoS of eight days in the current study, which is shorter compared to the study in North Sumatera, Indonesia, with the LoS of 11 days (Lestari, Yurina and Lyrawati, [2022](#)), yet comparable to the LoS of COVID-19 patients without ICU in the UK (Vekaria et al., [2021](#)). Study in North Sumatera was conducted in patients with more severe COVID-19 symptoms; this explains the difference of LoS to the current study. Early diagnostic and prediction of LoS by patients' data can enhance the therapeutic options available and enable the effective allocation of resources to treat the

patients. Subsequently, the patients' characteristics data were employed to build a predictive model of LoS. The mean LoS of our study was confirmed by predictive modelling, which showed consistent results (Figure 2).

The most important predictor of LoS according to our model was nutritional status (BMI). Those with higher BMI tend to stay longer in the hospital. Especially when male and fever are present, the LoS is predicted to be one day longer. Male is expected to develop more severe symptoms due to gender-related factors that worsen the disease evolution (Foresta, Rocca and Di Nisio, [2021](#); Vahidy et al., [2021](#)). The actors that may play a role in the manifestation of SARS-COV2 infection are ACE2 and TMPRSS2, which are regulated by sex hormones. These actors accompany a protective effect to the development of disease in women (Foresta, Rocca and Di Nisio, [2021](#)), which explain the shorter LoS prediction in the female group. Also, in Indonesia the prevalence of smoker is higher in men than in women, which might explain the longer LoS in male due to severity of the symptoms. Interestingly, when overweight/obese was absent, the LoS was not affected by gender.

For patients with underweight/normal nutritional status, the presence of fever became the aggravating factor that affected the LoS. According to our data, patients with fever had LoS of one day longer. Previous study in China observed that patients with fever had LoS of 3.5 days longer (Wu et al., [2020](#)). However, when fever was absent, the cold and wet cough could also prolong the LoS of underweight/normal patients from 7.6 to 9.2 days. Our finding indicated that cold and wet cough could exacerbate the COVID-19 outcome in lower but not in higher BMI patients.

Based on the results of the model, nutritional status is one of the main factors affecting the severity and LoS of COVID-19 patients. Patients with poor nutritional status, especially patients with higher BMI or obesity, will be associated with various comorbid diseases which will affect the severity of COVID-19 disease (Noor and Islam, [2020](#); Vera-Zertuche et al., [2021](#)). Therefore, the need to maintain healthy status with a good BMI can be an effort to prevent metabolic diseases while avoiding adverse effects on COVID-19 patients in the future (Kang and Kong, [2021](#)). Implementation of proper patient management is needed as a form of good service to patients. Hospitals can update treatment service protocols for COVID-19 patients based on WHO guidelines, health ministry regulations, and regional policies (Modjo et al., [2023](#)).

Our data may provide a novel prediction for COVID-19 LoS; however, the limitation of the CHAID algorithm

is its sensitivity to the change of the variables. The predictors might be changed if more variables and samples were added. Therefore, it is necessary to validate the algorithm with other predictive modeling. We also recommend to add more variable-related symptoms and treatment to the analysis, so that a complete picture of predictive model for COVID-19 LoS can be obtained.

Conclusion

Our findings indicated that nutritional status could affect the LoS of COVID-19 patients. The LoS could be extended when overweight/obese, male, and fever were present. However, for patients with underweight/normal nutritional status, the presence of cold and wet cough could be the aggravating factors. Referring to our findings, studies to explore other variables that are related to the COVID-19 symptoms and affecting LoS with regards to nutritional care need to be performed in the future.

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Conflict of interest

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We declare that there is no conflict of interest in this study.

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