

## Short Communication

# Effectiveness of smartphone application in increasing knowledge on COPD and its non-pharmacological management in COPD patients

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## Abstract

Chronic obstructive pulmonary disease (COPD) is among top ten of the world's causes of death. The development of the "Paru Sehat" smartphone application is a positive initiative and might have the potential to improve the disease management of COPD, improve patient's quality of life, and reduce complications associated with COPD. However, its effectiveness in improving the knowledge of the COPD patients is unknown. The aim of this study was to determine the effectiveness of "Paru Sehat" in increasing knowledge on COPD and its non-pharmacological management in COPD patients. A quasi-experimental study with a one-group pretest-posttest was conducted among stable COPD patients at Prof. Chairuddin Panusunan Lubis Hospital, Medan, Indonesia. Bristol COPD knowledge questionnaire (BCKQ) was used to assess the knowledge scores of the patients before and after exposure to the "Paru Sehat" twice a week for four weeks. A dependent Student t-test was used to compare the knowledge scores between pre- and post-intervention for both knowledge domains (i.e., knowledge on the disease and non-pharmacological management). Student t-test or one-way ANOVA were used to determine the association between patients' characteristics and the knowledge scores within pre- and post-treatment. Our data indicated a significant improvement of the knowledge scores on disease between pre- and post-treatment ( $15.92 \pm 3.79$  vs  $19.56 \pm 3.68$ ,  $p < 0.001$ ). The knowledge score on non-pharmacological management also increased significantly post-treatment ( $7.52 \pm 2.02$ ) compared to pre-treatment ( $10.08 \pm 2.379$ ),  $p < 0.001$ . In addition, this study found that educational attainment was associated with the scores of both knowledge domains of which individuals with senior high school or higher education level had significantly improvement of knowledge scores. This study highlights that although "Paru Sehat" application could improve the knowledge on COPD and its non-pharmacological management, its effects are less effective among individuals with low educational attainment.

**Keywords:** Stable COPD, Bristol COPD knowledge questionnaire, smartphone application, mHeath, education media



## Introduction

According to the World Health Organization (WHO) in 2019, chronic obstructive pulmonary disease (COPD) was the third cause of death worldwide and 80% of the total 3.23 million deaths were from low-and middle-income countries [1]. The Indonesian Basic Health Research reported that the prevalence of COPD in the country was 3.7% in 2018, mostly among men, with the prevalence rate increasing with age [2]. This chronic respiratory disease obstructs the lungs' functional capacity progressively with high levels of morbidity and mortality [3,4]. Based on the Global Initiative for Chronic Obstructive Lung Disease (GOLD) reports in 2022, COPD caused a significant economic burden with high treatment costs as disease severity increases and a social burden attributed to a high in disability-adjusted life year (DALY) [3].

The increased utilization of technology and mobile communications in the health sector in recent years has been considered a potential media for self-management of chronic diseases, such as asthma, cancer, COPD, and cardiovascular diseases [5,6]. Mobile applications could help screen and notify patients along with health professionals regarding suspicions of disease exacerbation; therefore, early interventions can be carried out. However, the compliances between patient, disease, and application, have become the main problem [6]. A study in 2020 showed that the Self-Management supported by Assistive, Rehabilitative, and Telehealth technologies-COPD (SMART-COPD) application was able to maintain and even increased the physical activity of COPD patients, although 47% of patients dropped out of the study due to the inability to use the technology [7]. A systematic review study in 2018 showed that COPD patients who used medical smartphone applications for self-management lowered their relative risk for hospital admission up to 27% compared to the group of patients without using the application, although no difference in length of stay was found [8].

Perceiving this potential, a newly developed smartphone application named "Paru Sehat" has the means to educate COPD patients regarding COPD and its management. The "Paru Sehat" aims to collect data, educate patients regarding COPD and its management, as well as provide recommendations for visits to the doctor regarding the patient's current condition. The "Paru Sehat" application is a daily Indonesian language application for COPD patients designed for education and initial independent management of COPD patients. The application is accessible through download on the Google Play Store smartphone application. The aim of this study was to determine the effectiveness of the "Paru Sehat" in increasing knowledge of COPD and its non-pharmacological management among stable COPD patients.

## Methods

### Study design

A quasi-experimental study design with a one-group pretest-posttest was conducted at the pulmonary outpatient clinic of Prof. Chairuddin Panusunan Lubis Universitas Sumatera Utara Hospital, Medan, Indonesia, on stable COPD patients for three months (from January until March 2023). The patients were recruited using consecutive sampling method. The intervention was the use of "Paru Sehat" smartphone application consisting of educational video of information related to COPD and COPD non-pharmacological management with frequency of twice a week for four weeks. The knowledge of the two domains were measured before and after the intervention.

### Participants

We included COPD patients diagnosed with stable COPD (all A-D GOLD classification) without exacerbations; aged 40–80 years; received therapy according to the COPD stable group from the pulmonary outpatient clinic of Prof. Chairuddin Panusunan Lubis Universitas Sumatera Utara Hospital, Medan, Indonesia; and were able to use Android smartphone application or had a companion capable of using Android smartphone application. COPD patients with any malignancy, cognitive impairment, and severe cardiovascular disorders such as acute coronary syndrome or acute on chronic heart failure, were excluded.

The participants were required using a non-probability sampling technique with consecutive sampling of which all patients who came sequentially and met the selection criteria were included in the study until sample size was met. The minimum sample size was calculated based on the sample formula for hypothesis testing on paired numerical data with the minimum sample size required was 22 individuals. To anticipate loss of follow-up, the sample size was increased to 25 individuals.

### **Study variables**

The independent variable is the use of the "Paru Sehat" smartphone application. The dependent variables were the patients' knowledge on COPD and knowledge on COPD non-pharmacological management. The Bristol COPD knowledge questionnaire (BCKQ) was used to assess the COPD patient's knowledge on COPD and COPD non-pharmacological management. The questionnaire has been translated into Indonesian and validated. Patients were asked five triple-ended questions (true, false, or do not know) for each of the 13 topics (divided into three main topics: (a) Six topics for disease knowledge; (b) Three topics for non-pharmacological management; and (c) Four topics for pharmacological management). In this present study the first two knowledges were presented only. The topics for disease knowledge were epidemiology and physiology, etiology, common symptoms, breathlessness, phlegm, and infections; while non-pharmacological management knowledge consisted of topics on exercise, smoking and immunization. Patients had to indicate if the statement was true, false, or that they did not know. Each correct answer to each question scored one and incorrect or do not know answers scored as zero. Therefore, the scores for disease knowledge and the non-pharmacological management knowledge ranged 0 to 30 and 0 to 15, respectively.

### **Data collection**

If the patient who meet the criteria agree to participate, they were asked to sign the consent form. Patients were required to respond all the questions in BCKQ before the exposure of the "Paru Sehat" smartphone application. The information of the educational attainment and the occupation were also collected. The patients then requested to install "Paru Sehat" and trained to use the application. After the intervention for four weeks, the patients were questioned with the same BCKQ questions.

### **"Paru Sehat" smartphone application intervention**

The "Paru Sehat" is a smartphone application and some features of the application are presented in **Figure 1**. The "Paru Sehat" application included the patient's data such as date of birth, height, city/district, address, cellphone number, and family cellphone number. The "Info & Educational Videos at a Glance" menu is divided into three sections based on pulmonary disease: asthma, COPD, and tuberculosis. Each section has disease-related information and educational videos that briefly explain the disease. The "Benefits of Exercise for Lung Patients" menu shows a brief explanation and guide regarding exercises that are beneficial for pulmonary disease patients. "Factors Causing Worsening Symptoms" include those that can precipitate exacerbations in COPD and asthma. Information on the initial treatment of an exacerbation is also provided in the application, along with recommended nearest hospitals if exacerbations do not relieve. The "Healthy Lung Community" menu includes information on programs, documentation of the "Paru Sehat" community activities, and a WhatsApp group/call center service of the "Paru Sehat" community. The application also arranges a menu section for inhaler medicine options, video tutorials on how to use them, and personal reminders that indicate when to use the patient's inhalers.

During the intervention, patients received information related to COPD and COPD non-pharmacological management knowledge from "Paru Sehat" application through educational video which they can access wherever and whenever they would, with minimum exposure twice a week over the course of four weeks. To ensure all patients used "Paru Sehat" application, messaging application group was created consisting of all patients and the researchers. The patients or the companions were reminded by researchers to use the application every 2–3 days and they were instructed to record or to provide the screenshot, and then share the evidence to the messaging group.

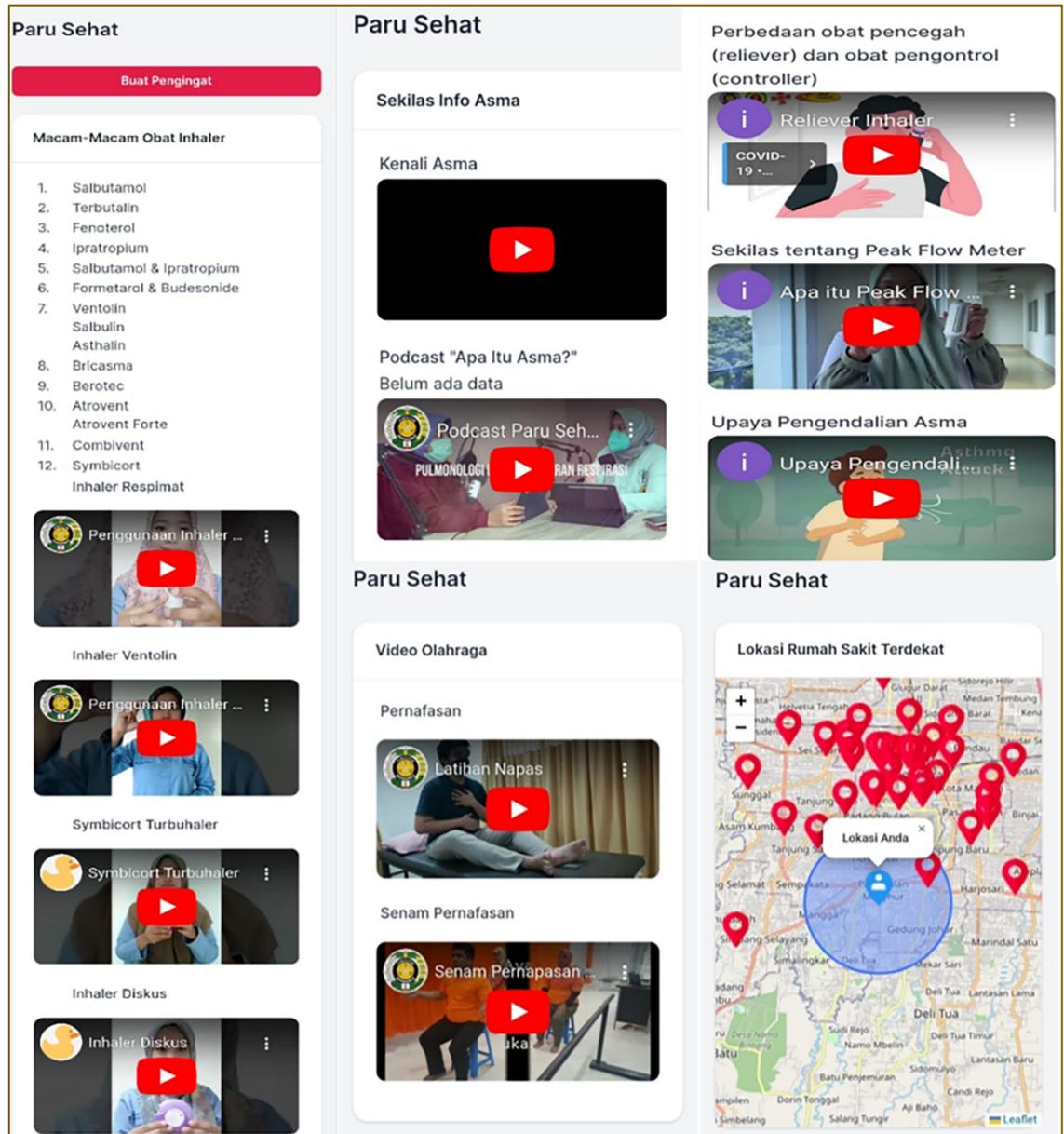


Figure 1. Some features of the "Paru Sehat" application

### Statistical analysis

The data obtained was tested for normality using the Shapiro-Wilk test. A dependent Student t-test was used to compare the knowledge scores between pre- and post-intervention for both knowledge domains. Student t-student or one-way ANOVA were used to determine the association between patients' characteristics and the knowledge scores within pre- and post-treatment. Student t-student test and Wilcoxon test were used to determine the association between educational attainment and knowledge score improvements between pre- and post-intervention. A  $p < 0.05$  is considered statistically significant. All data was managed and analyzed using a computerized system program with SPSS version 20 (IBM PSS, New York, USA).

## Results

### Characteristics of the patients

A total of 25 patients were included in the study, as presented in **Table 1**. Out of total patients, the majority of patients were male (80%) and most were aged 40 years old (92%). Among the patients, 40% of them were high school graduates and 60% were workers.

Table 1. Characteristics of COPD patients included in the study

Characteristics	Frequency	Percentage
Gender	Male	20
	Female	5
Age	≥40 years old	23
	<40 years old	2
Education	Elementary school	3
	Junior high school	3
	Senior high school	10
	Higher education	9
Occupation	Workers	15
	Unemployed	3
	Retiree	7

### Knowledge score on COPD and non-pharmacological management before and after intervention

Based on the normality test, the Shapiro-Wilk test resulted in normally distributed data. To compare the knowledge scores for before and after using the “Paru Sehat”, a paired Student t-test was used. The mean COPD knowledge before the intervention was  $15.92 \pm 3.79$  and increased significantly to  $19.56 \pm 3.68$  after the intervention,  $p < 0.001$  (Table 2). The mean non-pharmacological management knowledge before intervention was  $7.52 \pm 2.02$  and it improved significantly to  $10.08 \pm 2.379$  after the intervention with a  $p < 0.001$  (Table 2).

Table 2. Comparison of knowledge scores on disease and non-pharmacological management of COPD between pre- and post-intervention among COPD patients included in the study

Knowledge domain	Mean±SD	Difference score (±SD)	p-value
Knowledge on disease	Before	3.640 (3.04)	<0.001
	After		
Knowledge on non-pharmacological management	Before	2.56 (1.68)	<0.001
	After		

### Association between patients' characteristics with knowledge score on COPD and its non-pharmacological management before and after intervention

To determine the associations between patients' characteristic and knowledge scores before and after using the “Paru Sehat”, a student t-test and one-way ANOVA were used. Our data indicated that gender, age, education, and occupation had no association with knowledge scores related to the disease with  $p=0.278$ ,  $p=0.651$ ,  $p=0.058$ , and  $p=0.076$ , respectively (Table 3). However, the score of knowledge on disease was significantly different among educational attainment,  $p < 0.001$ .

In addition, gender, age, and occupation also had no association with knowledge scores in knowledge on non-pharmacological management of COPD (Table 4). Interestingly, knowledge scores were significantly different among educational attainment group for both pre-intervention ( $p=0.007$ ) and post-intervention ( $p < 0.001$ ).

Table 3. Association of patients' characteristics and score of knowledge on COPD pre-intervention and post-intervention

Characteristics	n	%	Pre-intervention Mean (±SD)	p-value	Post-intervention Mean (±SD)	p-value
Gender	Male	80	15.5 (3.32)	0.278 <sup>a</sup>	19.2 (3.38)	0.339 <sup>a</sup>
	Female	20	17.6 (5.46)		21 (4.9)	
Age	≥40 years old	92	16.04 (3.87)	0.651 <sup>a</sup>	19.52 (3.8)	0.880 <sup>a</sup>
	<40 years old	8	14.5 (3.54)		20 (2.83)	
Education	Elementary school	12	14.33 (1.16)	0.058 <sup>b</sup>	16 (1)	<0.001 <sup>b</sup>
	Junior high school	12	11.33 (0.58)		13.33 (1.53)	
	Senior high school	40	16.6 (3.41)		19.7 (2.11)	

Characteristics	n	%	Pre-intervention Mean ( $\pm$ SD)	p-value	Post-intervention Mean ( $\pm$ SD)	p-value
Higher education	9	36	17.22 (4.3)		22.67 (2.18)	
Occupation						
Workers	15	60	16.4 (3.38)	0.076 <sup>b</sup>	20.07 (2.99)	0.102 <sup>b</sup>
Unemployed	3	12	11.67 (0.58)		15.33 (2.52)	
Retiree	7	28	16.71 (4.54)		20.29 (4.61)	

<sup>a</sup> Analyzed using Student t-student

<sup>b</sup> Analyzed using one-way ANOVA

**Table 4. Association of patients' characteristics and score of knowledge on non-pharmacological management of COPD pre-intervention and post-intervention**

Characteristics	n	%	Pre-intervention Mean ( $\pm$ SD)	p-value	Post-intervention Mean ( $\pm$ SD)	p-value
Gender						
Male	20	80	7.45 (2.04)	0.703 <sup>a</sup>	9.95 (2.56)	0.596 <sup>a</sup>
Female	5	20	7.8 (2.17)		10.6 (1.52)	
Age						
$\geq$ 40 years old	23	92	7.61 (2.08)	0.539 <sup>a</sup>	10 (2.39)	0.648 <sup>a</sup>
<40 years old	2	8	6.5 (0.71)		11 (2.83)	
Education						
Elementary school	3	12	7.33 (1.53)	0.007 <sup>b</sup>	8.67 (1.53)	<0.001 <sup>b</sup>
Junior high school	3	12	5 (1)		6.67 (2.08)	
Senior high school	10	40	6.9 (1.79)		9.6 (1.71)	
Higher education	9	36	9.11 (1.45)		12.22 (1.2)	
Occupation						
Workers	15	60	7.87 (1.89)	0.065 <sup>b</sup>	10.2 (2.24)	0.111 <sup>b</sup>
Unemployed	3	12	5 (1)		7.67 (2.31)	
Retiree	7	28	7.86 (2.04)		10.86 (2.34)	

<sup>a</sup> Analyzed using Student t-student

<sup>b</sup> Analyzed using one-way ANOVA

Next, the role of educational attainment on knowledge score changes were assessed by comparing for both knowledge domains. Our data indicated that the participants with elementary and junior high school education levels had no significant improvement in knowledge scores in both knowledge domains, all had  $p > 0.05$  (**Table 5**). However, individuals with senior high school or higher education level had significantly improvement of knowledge scores for both types of knowledge (**Table 5**).

**Table 5. Association between educational attainment and knowledge score improvements between pre- and post-intervention**

Educational attainment	n	Course	Knowledge domain			
			Disease		Non-pharmacological management of COPD	
			Mean (SD)	p-value	Mean (SD)	p-value
Elementary school	3	Pre	14.33 (1.16)	0.102 <sup>a</sup>	7.33 (1.53)	0.057 <sup>a</sup>
		Post	16.00 (1.00)		8.67 (1.53)	
Junior high school	3	Pre	11.33 (0.58)	0.102 <sup>a</sup>	5.00 (1.00)	0.300 <sup>a</sup>
		Post	13.33 (1.53)		6.67 (2.08)	
Senior high school	10	Pre	16.60 (3.41)	<0.001 <sup>b</sup>	6.90 (1.79)	0.007 <sup>b</sup>
		Post	19.70 (2.11)		9.60 (1.71)	
Higher education	9	Pre	17.22 (4.30)	0.004 <sup>b</sup>	9.11 (1.45)	0.001 <sup>a</sup>
		Post	22.67 (2.18)		12.22 (1.2)	

<sup>a</sup> Analyzed using Student t-student

<sup>b</sup> Analyzed using Wilcoxon test

## Discussion

COPD is one of the most common respiratory diseases worldwide and disease control is important to prevent the development of COPD caused by exacerbations. Currently, several applications are being developed to support COPD patients in early detection of symptoms to prevent and manage exacerbations appropriately [9]. Even with appropriate medical care, patients with COPD experience symptoms and functional challenges every day, therefore patients must engage in long-term self-management to maintain physical, social and psychological health [10]. Self-

management, namely the patient's ability to deal with all aspects of chronic disease conditions, is an important part in management of patients with COPD [11].

The use of information and communications technology (ICT) to provide medical/clinical interventions remotely is one promising care solution [12]. Self-management interventions, supported by smartphone applications in recent years, can improve disease management in COPD patients and reduce hospital admissions [13]. In patients with COPD, the technology may also enable early detection of COPD exacerbations. In addition, the use of this application is not inferior to outpatient programs and does not affect the occurrence of side effects [14]. For example, a study explained the patient's flexibility in deciding daily home training recommended by the application. The application insisted the following exercises: 1) physical exercise for strength and mobility training which is delivered in short videos, 2) patient education based on established guidelines, and 3) mindfulness techniques for coping with illness. The patient was given one workout per category each day but can choose whether the patient wants to complete one, two, or all three workouts at once [15].

Self-management programs must provide information to increase the patient's disease knowledge, motivation to maintain behavior changes, and disease control to develop skills in overcoming the disease [11]. Implementing digital therapy to assist in the process of modifying healthy lifestyle choices in certain digital rehabilitation methods have been offered as a way to expand access to rehabilitation and provide structured exercise for a variety of indications in the developing field of chronic disease [16]. A number of study reviews have reported positive outcomes from promoting self-management, namely reduced rates of hospitalizations and emergency department visits, improved quality of life, decreased utilization of health services and increased levels of physical activity in COPD patients [11,17-18].

Previous studies on smartphone application have revealed positive results in various aspects for COPD patients. A study showed that COPD patients that received a 6-week period of COPD management program via the LINE social media platform, significantly improved clinical status compared to before receiving the program. This showed that COPD management programs are meaningful to increase the clinical status of COPD patients [19]. A study interviewed 14 patients with COPD with an average age of 69 years old. Results indicated that patients believed that by knowing their heart rate, oxygen saturation, and activities, technology could help control their disease better both during exacerbation and in regular life. The technology can help patients overcome feelings of fear and panic associated with exacerbations and can connect patients with health providers [20]. A study of six patients participated in the COPD application prototype trial, consisted of three men and three women. This study demonstrated that each individual had different levels of smartphone skills which affected the application usage time. Furthermore. The application were opened most frequently during the first week, however, usage declined over time [12]. Unfortunately, the "Paru Sehat" application cannot track user's activity in the application, besides conflicting with privacy policies.

Based on the study results, COPD patients that used the "Paru Sehat" smartphone application significantly increased knowledge scores on COPD and its non-pharmacological management. These findings are similar to a previous study that showed the mean COPD knowledge score in the study control group was lower than in the intervention group with mobile phone applications. The improvement in clinical status in the experimental group may not only be due to the intervention effect but also the effect of COPD knowledge before the intervention phase [19].

Technical problems and low compliance are major problems with digital interventions, and digital literacy among patients with COPD remains inconclusive [13]. A recent systematic review study of COPD self-management applications demonstrated difficulty maintaining application engagement over time. Patients were unwilling to use technology when it is difficult to use, threatens the patient's identity, independence and self-care, disrupts the patient's relationship with the primary care provider and interferes with daily life [20].

Even though smartphone applications for the management of COPD patients have been widely researched abroad and its effectiveness has also been proven, the "Paru Sehat" smartphone application is a new application in Indonesia with a language that is better understood by the Indonesians, thus providing new hopes in improving health quality services for COPD patients in

Indonesia. Future studies on digital management interventions in clinical practice should focus more on detailed subgroups, multidisciplinary approaches, technology-related aspects (such as acceptability), and refine their implementation in clinical practice.

## Conclusion

Our study suggests that the use of the “Paru Sehat” smartphone application significantly increase knowledge scores on both disease and its non-pharmacological management domains. The level of education influences the improvements of these knowledge scores. This indicates that “Paru Sehat” is less effective to improve the knowledge among individuals with low educational attainment. Nevertheless, this smartphone application could contribute to enhance public health education initiatives and might raise the standards of healthcare services.

## Ethics approval

Ethics approval to conduct the research was obtained from the Health Research Ethics Committee of the Faculty of Medicine, Universitas Sumatera Utara, Medan, Indonesia (No.508/KEPK/USU/2023).

## Competing interests

The authors declare that there is no conflict of interest.

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## Underlying data

Derived data supporting the findings of this study are available from the corresponding author on request.

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