Original Article

Association Between Obstructive Sleep Apnea (OSA) Assessed by STOP-Bang and Reaction Time in Emergency Department Healthcare Workers at Persahabatan Hospital

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Abstract

Background: Reaction time is the interval between an external stimulus and motor response, is closely linked to alertness and is critical in professions requiring rapid responses such as doctors and nurses. Obstructive sleep apnea has an impact on cognitive function, including impaired alertness, poor cognitive performance and difficulty maintaining attention. This study aims to examine the relationship between OSA and reaction time, determine the proportion of OSA measured using the STOP-BANG questionnaire and reaction time in emergency department healthcare workers at Persahabatan Hospital.

Methods: A cross-sectional study was conducted in Juny-July 2025 involving healtcare workers at Persahabatan Hospital. Eligible healthcare workers completed STOP-BANG questionnaire, had their visual and auditory reaction times measured.

Results: This study included 70 participants. The mean STOP-BANG questionnaire score was 0,917 with the lowest score 0 and the highest score 6. The mean visual reaction time was 197,2 ms and the mean auditory reaction time was 181,1 ms. A significant association was found between reaction time and years of service ($p < 0.001$). However, no association was observed with other factors such as age, sex, work pattern, BMI, neck circumference and smoking status. The correlation between OSA and visual reaction time showed $r = -0.056$ ($p = 0.642$), while for auditory reaction time $r = -0.069$ ($p = 0.568$). The correlation between STOP-BANG risk and visual reaction time $p = 1.000$ and auditory reaction time $p = 1.000$.

Conclusion: There was no significant relationship between OSA risk based on the STOP-BANG questionnaire and either visual or auditory reaction time.

Keywords: cognitive function, obstructive sleep apnea, reaction time.

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INTRODUCTION

Reaction time can be defined as a specific period between the application of an external stimulus and the corresponding motor response to that stimulus. It is also described as the time interval between the presentation of a stimulus and the emergence of a voluntary response in a subject. In clinical and research settings, reaction time is commonly expressed in milliseconds (ms).[1] Reaction time is an important parameter reflecting the integrity of sensory processing, central nervous system function, and motor response. Physicians and nurses, particularly those working in the emergency department, are required to maintain a high level of alertness, as well as speed and accuracy in patient management.[2]

The management of emergency cases in a rapid and appropriate manner represents a fundamental component of life-saving efforts and must be carried out effectively and efficiently. Timely and precise interventions are essential in preventing mortality and minimizing morbidity. The success of emergency patient management is frequently evaluated based on response time, which reflects the promptness in delivering high-quality medical care aimed at saving lives or preventing long-term disability.[3]

Obstructive sleep apnea (OSA) is a sleep-related breathing disorder that has been shown to have significant effects on cognitive function, including impaired alertness, reduced cognitive performance, and a decreased ability to sustain attention. Previous studies have demonstrated that patients with OSA exhibit prolonged reaction times, particularly in relation to the perception of visual stimuli. Furthermore, neurophysiological studies in individuals with OSA have identified impairments in psychomotor performance, which may contribute to an increased risk of occupational injuries and a decline in overall health status. The relatively high prevalence of OSA is associated with various complications, yet the condition often remains undetected and underdiagnosed in clinical practice.[4,5]

Given the critical importance of optimal cognitive and psychomotor performance in emergency department settings, as well as the potential impact of OSA on reaction time, further investigation of this relationship among healthcare workers is warranted. Accordingly, this study was conducted to determine the proportion of OSA assessed using the STOP-Bang questionnaire and to evaluate reaction time measured using the L77 Lakassidaya reaction time device among emergency department healthcare workers at Persahabatan Hospital, Jakarta, in June 2025.

Furthermore, this study aims to characterize emergency department healthcare workers at Persahabatan Hospital, to determine the mean reaction time, to examine the association between OSA and reaction time, and to evaluate the relationship between subject characteristics and reaction time among emergency department healthcare workers.

METHODS

This study included emergency department (ED) physicians and nurses who were actively working at Persahabatan Hospital, aged between 23 and 50 years, and willing to participate by providing written informed consent. Subjects were excluded if they had a history of psychiatric disorders, hearing impairment, or visual impairment; were currently receiving antidepressant treatment or using illicit drugs and alcohol; or had sleep disorders other than obstructive sleep apnea (OSA). The sample size was determined using a total sampling method, with a total of 70 subjects recruited, of whom 4 were excluded based on the predefined exclusion criteria.

The study was conducted among ED healthcare workers during the morning shift at ISO 3 Emergency Department of Persahabatan Hospital in June 2025. Data collection was performed prior to the start of work activities. The investigator first introduced the study and provided an explanation regarding its objectives, benefits, and eligibility criteria. Subjects who met the inclusion criteria and agreed to participate were asked to provide written informed consent. Baseline characteristic data were then collected, followed by administration of the STOP-Bang questionnaire and measurement of vital signs. Subsequently, all subjects underwent reaction time assessment using the L77 Lakassidaya reaction time measurement device.

Data analysis was performed using the Statistical Package for Social Sciences (SPSS) version 26.0. Numerical data were initially tested for normality using the Kolmogorov–Smirnov test. Data with a normal distribution were presented as mean and standard deviation, whereas non-normally distributed data were presented as median with minimum–maximum values. To assess the correlation between OSA and reaction time, the Pearson correlation test was used when both variables were normally distributed, while the Spearman correlation test was applied when at least one variable was not normally distributed.

RESULTS

A total of 70 subject who met the inclusion and exclusion criteria were included in the study. All study subjects were healthcare workers working in a shift-based system consisting of three shifts: morning (08:00–14:00), afternoon (14:00–21:00), and night (21:00–08:00). All participants provided written informed consent prior to participation. Subsequently, subjects underwent interviews using the STOP-Bang questionnaire, followed by reaction time assessment.

The baseline characteristics of the study subjects are presented in Table 1. The mean age was 31.82 ± 5.41 years, with a predominance of female subjects. Most participants had a normal body mass index and were non-smokers. The majority had a working duration of less than 5 years and followed work pattern B. Only a small proportion of subjects had comorbidities.

Table 1. Example Baseline Characteristics of Study Subjects

Variable	n(%)	Mean $\pm$ SD
Age (years)		31,82 $\pm$ 5,41
Sex		
Male	19 (21,7%)	
Female	51 (72,9%)	
Education		
Diploma (D3)	38 (54,3%)	
Bachelor's degree (S1)	30 (42,9%)	
Master's degree (S2)	2 (2,9%)	
BMI Category		
Underweight	2 (2,9%)	
Normal	36 (51,4%)	
Overweight	21 (30%)	
Obesity	11 (15,7%)	
Smoking Status		
Former smoker	3 (4,3%)	
Current smoker	2 (2,9%)	
Mild BI	4 (5,7%)	
Moderate BI	0 (0,0%)	
Severe BI	61 (87,1%)	
Non-smoker		
Years of Service		
(0-5 years)	41 (58,6%)	
(6-10 years)	16 (22,9%)	
(>10 years)	13 (18,6%)	
Work Pattern		
Pattern A (4 working days 2 days off)	7 (10%)	
Pattern B (5 working days 2 days off	60(85,7%)	
Pattern C (6 working days 1 days off)	3 (4,3%)	
Comordibities		
Hypertension	2 (2,9%)	
Diabetes mellitus	2 (2,9%)	
Asthma	1 (1,4%)	
Hyperthyroidism	1 (1,4%)	
Autoimmune disease	1 (1,4%)	
Ovarian cancer	1 (1,4%)	
Neck Circumference (cm)		32,82 $\pm$ 3,62

The distribution of OSA risk based on the STOP-Bang questionnaire is presented in Figure 1. The majority of subjects were classified as having low risk (score 0–2), accounting for 68 subjects (97.1%), while only 2 subjects (2.9%) were categorized as high risk (score ≥3). The mean STOP-Bang score was 0.92, with a median value of 0.5. As shown in Figure 1, the percentage distribution of subjects according to

OSA risk categories, confirming the dominance of the low-risk group.

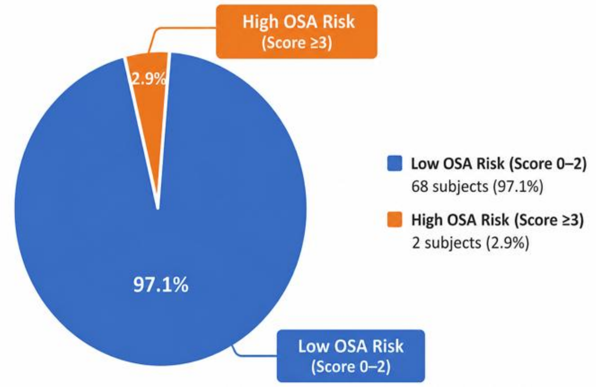

Fig 1. Percentage of subjects according to OSA risk

The characteristics of subjects classified as high risk for OSA are presented in Table 2.

Table 2. High Risk Subject Demography

Variable	Subject	
	1	2
Age (years)	27	36
Sex	Male	Female
Education	D3	S1
BMI	Obesity	Obesity
Neck circumference (cm)	44	43
Work Pattern	5 working days 2 days off	3 Working days 2 days off
Years of Service	(0-5 years)	(0-5 years)
Profession	Nurse	Medical Doctor

In general, subjects demonstrated relatively faster auditory reaction times compared to light reaction times. Based on classification, 61 subjects (87.1%) had normal light reaction times, while 9 subjects (12.9%) exhibited prolonged reaction times. A similar distribution was observed for auditory reaction time, with 61 subjects (87.1%) classified as normal and 9 subjects (12.9%) showing prolonged reaction times, as presented in Table 3. Among these, 5 subjects exhibited prolonged reaction times in both light and auditory modalities.

Table 3. Reaction Time Assessment Results

Variable	Median (min-max)
Light Reaction Time	
Mean	197,20 ms (145,40-366,20 ms)
Minimum	162,00 ms (100,00-237,00 ms)
Maximum	268,50 ms (175,00-575,00 ms)
Auditory Reaction Time	
Mean	181,10 ms (138,60-307,20 ms)
Minimum	137,00 ms (100,00-237,00 ms)
Maximum	256,00 ms (162,00-512,00 ms)

A statistically significant association was observed between years of service and both light and auditory reaction times ($p < 0.001$), as presented in Table 4. Subjects with a shorter duration of employment (0–5 years) more frequently exhibited prolonged reaction times compared to those with moderate (6–10 years) and longer (>10 years) durations of employment. In contrast, subjects with moderate and longer work experience predominantly demonstrated normal reaction times, with a lower proportion of prolonged responses compared to those with shorter work duration.

Table 4. Reaction Time Assessment Results Based on Years of Service

Years of Service	Reaction Time		P value
	Normal (n=61)	Prolong (n=9)	
Light Reaction Time			<0,001
(0-5 years)	36	5	
(6-10 years)	15	1	
(>10 years)	10	3	
Auditory Reaction Time			<0,001
(0-5 years)	36	5	
(6-10 years)	14	2	
(>10 years)	11	2	

*Analysis was performed using Fisher's exact test

The correlation analysis between STOP-Bang scores and reaction time using the Spearman test showed no significant association. For light reaction time, the correlation coefficients were $r = -0.056$ ($p = 0.642$), $r = 0.097$ ($p = 0.422$), and $r = -0.101$ ($p = 0.407$), while for auditory reaction time, the coefficients were $r = -0.069$ ($p = 0.568$), $r = -0.130$ ($p = 0.284$), and $r = -0.123$ ($p = 0.311$). All subjects classified as high risk for OSA (n = 2) demonstrated normal light and auditory reaction times. Fisher's exact test also showed no significant association between STOP-Bang scores and reaction time for both light and auditory stimuli (p = 1.000). Furthermore, no significant associations were found between reaction time and subject characteristics, including age, auditory, neck circumference, sex, smoking status, and body mass index, as presented in Table 5.

Table 5. Reaction Time Analysis According to Subject Characteristics

Variable	Light reaction time		Auditory reaction time	
	Correlation coefficient (r)	P value	Correlation coefficient (r)	P value
Age (years)*	0,021	0,863	0,094	0,440
Sex**		0,895		0,895
Smoking status***		0.982		0.999
BMI***		0.095		0.889
Neck circumference (cm)*	0,011	0,926	0,051	0,673

*Analysis performed using the Spearman test
**Analysis performed using the Mann–Whitney test
***Analysis performed using the Kruskal–Wallis test

DISCUSSION

Baseline Characteristics of Study Subjects and STOP-Bang Assessment Results

This study involved 70 healthcare workers, consisting of 17 general practitioners and 53 nurses working in the emergency department of Persahabatan Hospital, with a mean age of 31.82 ± 5.41 years and a predominance of female subjects (72.9%). The majority of subjects had a normal body mass index (51.4%) and a low prevalence of comorbidities. Demographic and anthropometric characteristics are important in the interpretation of this study, as factors such as age, body mass index, neck circumference, and comorbidities are well-established determinants of OSA risk in the general population.[6,7]

The relatively young age of the study population and the predominance of normal BMI likely contributed to the low prevalence of OSA risk observed based on the STOP-Bang questionnaire. The distribution of STOP-Bang scores demonstrated a clear predominance of low-risk OSA, with 97.1% of subjects categorized as low risk (score <3) and only 2.9% classified as high risk (score ≥3). These findings are consistent with the demographic and anthropometric characteristics of the study population.[6,7]

From a broader clinical perspective, respiratory disorders such as OSA require integrated approaches to screening and early detection, particularly in high-risk occupational groups. Early identification is essential because cognitive dysfunction associated with sleep-related breathing disorders may contribute to impaired vigilance and slower reaction time, increasing the risk of human error in critical settings. This is particularly relevant in healthcare workers, where rapid decision-making and sustained attention are essential for patient safety.[8]

STOP-Bang questionnaire is a widely validated screening tool with high sensitivity but relatively low specificity for detecting OSA risk. Therefore, interpretation of its results should consider the characteristics of the study population. While STOP-Bang is useful as a screening instrument, it cannot replace polysomnography (PSG) for definitive diagnosis and assessment of OSA severity. These findings are consistent with a systematic review and meta-analysis by Chen et al., which evaluated the diagnostic accuracy of STOP-Bang across various populations, including those with a low prevalence of OSA.[6,7]

Reaction Time Profile

The results of this study showed that the mean reaction time to visual stimuli was 197.2 ms and the mean reaction time to auditory stimuli was 181.1 ms. The proportion of subjects with prolonged reaction time (>240 ms) was relatively small (12.9%). The difference between auditory responses, which tended to be faster, and visual responses is consistent with findings from neurophysiological literature that explain differences in sensory processing pathways and neural transmission time. The findings of this study, which show that reaction time to auditory stimuli is faster than to visual stimuli (median 181.1 ms and 197.2 ms), are in accordance with the study by Lim and Dinges, which examined the neurophysiological mechanisms underlying this difference.[9]

This difference can be explained by the underlying neurophysiological processes involved in sensory transmission. Processing of auditory stimuli involves a shorter transmission pathway to the primary auditory cortex compared to visual processing, which passes through multiple stages involving the retina, lateral geniculate nucleus, and primary visual cortex before producing a motor response. In addition, the literature emphasizes that simple reaction time tasks are used to measure alertness and basic sensorimotor processing speed, whereas more complex tasks such as the psychomotor vigilance task (PVT) are more sensitive in detecting vigilance impairment due to sleep deprivation or chronic sleep disorders. [9]

Previous studies have also demonstrated similar patterns across different professional groups. Namita et al. conducted a study on differences in auditory and visual reaction times among professionals (security personnel, nurses, and resident physicians) and found that auditory reaction time was shorter than visual reaction time. Among nurses working day shifts, the mean auditory reaction time was 233.93 ± 45.05 ms and the visual reaction time was 239.02 ± 29.92 ms, while among resident physicians, the mean auditory reaction time was 218.44 ± 29.34 ms and the visual reaction time was 227.18 ± 20.41 ms. These findings are consistent with the results of the present study.[10]

Kemp et al. demonstrated that auditory stimuli require approximately 8–10 ms to reach the brain, whereas visual stimuli require approximately 20–40 ms. This suggests that the faster a stimulus reaches the motor cortex, the faster the resulting reaction time. Therefore, reaction time to auditory stimuli tends to be faster than to visual stimuli because auditory stimuli have a shorter conduction time to the motor cortex along with more rapid processing in the auditory cortex.[11]

In addition to physiological factors, the conditions under which measurements are performed may also influence the results. Anderson et al. emphasized that reaction time measurement should ideally be performed under relatively well-rested conditions, such as in the morning before a work shift, and may not fully capture the cumulative effects of sleep deprivation on vigilance. This is consistent with the design of the present study, in which reaction time was measured during the morning shift before the start of work activities. Consequently, the potential effects of OSA risk or long-term occupational fatigue on performance may not have been fully reflected.[12]

A similar pattern has also been observed in studies evaluating OSA risk among healthcare workers. A study by Duarte et al. in Brazil assessing the validity of the STOP-Bang questionnaire in a hospital healthcare population reported that most subjects had low STOP-Bang scores (≤2), with a mean age of 34.6 years and a predominance of female participants. These findings further support that in younger healthcare worker populations, the prevalence of high-risk OSA is relatively low, which may partly explain the limited variation in reaction time observed in this study.[13]

Relationship Between Reaction Time and OSA Risk

The correlation analysis in this study demonstrated no significant association between STOP-Bang scores and both light and auditory reaction times. This finding may be explained by the highly unbalanced distribution of OSA risk among the study subjects, in which the vast majority were classified as low risk, making it difficult to detect potential effects on reaction time among individuals with moderate to high OSA risk. Previous studies that have reported an association between OSA and prolonged reaction time generally involved patients with confirmed OSA of moderate to severe severity, in whom cognitive impairments are more apparent.[8]

Yun et al. reported that significant impairments in reaction time are typically observed in patients with moderate to severe OSA, whereas individuals with mild OSA tend to demonstrate near-normal reaction time performance. Furthermore, Yun et al. emphasized the use of more complex cognitive tasks, such as the psychomotor vigilance task (PVT) or sustained attention tests, which are more sensitive in detecting reaction time deficits related to OSA compared to simple reaction time measurements.[14]

Similarly, findings from Unlu et al. suggest that there is an association between OSA risk and prolonged reaction time. Obstructive sleep apnea, characterized by sleep fragmentation and intermittent hypoxemia, may lead to reduced energy availability in the cerebral cortex when required. This disturbance can adversely affect cognitive performance, particularly in domains of attention and response speed, which may clinically increase the risk of errors in decision-making and actions, especially in high-risk environments such as the emergency department. Therefore, the absence of a significant association in this study may be attributed to the limited representation of higher-risk OSA subjects, and further studies with a more balanced distribution and greater inclusion of moderate-to-high risk individuals are warranted.[15]

Relationship Between Subject Characteristics and Reaction Time

In this study, age, sex, smoking status, body mass index (BMI), and neck circumference were not significantly associated with reaction time. The relatively narrow age range and predominance of normal BMI may have reduced the variability required to detect meaningful correlations. Similarly, the analysis of smoking status in relation to reaction time showed no significant association, which may be influenced by the unequal distribution of subjects across smoking categories. However, Riaz et al. reported that smokers had significantly slower choice reaction times compared to non-smokers, supporting the presence of cognitive processing and sensorimotor speed impairment in smokers. In their study, mean choice reaction time latency was significantly higher in smokers (509.87 ± 129.83 ms) compared to non-smokers (455.20 ± 65.73 ms).[16]

No significant association was also observed between BMI and both visual and auditory reaction times in this study. Previous studies examining the relationship between BMI and reaction time have reported inconsistent findings, depending on population characteristics and methodological approaches. Zalke et al. reported that higher BMI is associated with slower or prolonged reaction times, suggesting that excess body weight may impair sensorimotor response efficiency.[17]

Hakim et al. evaluated the relationship between neck circumference and reaction time in children with and without a history of sleep-disordered breathing (SDB) using the psychomotor vigilance task (PVT). Their results showed that median neck circumference was significantly higher in the SDB group compared to controls ($p = 0.001$).

However, despite the association between larger neck circumference and SDB risk, no significant differences were found in median reaction time between the two groups ($p = 0.389$), and the proportion of children exceeding normative reaction time values was also comparable ($p = 0.326$). These findings suggest that while neck circumference may serve as an indicator of SDB risk, it is not directly associated with impaired reaction time performance in pediatric populations.[18]

Regarding years of service, most subjects with moderate (6–10 years) and long (>10 years) work experience demonstrated normal reaction times, with a lower proportion of prolonged reaction times compared to those with shorter employment duration. The findings of this study are consistent with a study conducted among emergency department nurses by Nurzaman and Wiyadi at Medirossa Cikarang Hospital and A. Wahab Sjahranie Hospital, Samarinda, which reported a significant association between years of service and reaction time. This relationship was attributed to increased skill and experience with longer work duration. Work experience in nurses is closely related to accumulated clinical exposure, whereas newly graduated nurses require additional experience and training in emergency care situations.[19]

Relationship Between Subject Characteristics and STOP-Bang

STOP-Bang scores in this study showed no significant correlation with age ($p = 0.344$). However, there was a significant difference based on sex ($p < 0.001$). Male subjects had higher median STOP-Bang scores compared to females. Smoking status and body mass index (BMI) were also not significantly associated with STOP-Bang scores ($p = 0.064$ and $p = 0.462$). In contrast, neck circumference showed a significant positive correlation with STOP-Bang scores ($r = 0.485$; $p < 0.001$). Analysis based on OSA risk categories also showed significant differences in sex, smoking status, BMI, and neck circumference. Age did not affect either STOP-Bang score or OSA risk category. These findings are consistent with the study conducted by Salim et al. in hypertensive patients in Kenya, which reported that OSA risk was higher in males and was associated with increased BMI and neck circumference.[20]

Sex differences, particularly male sex, are significantly associated with STOP-Bang scores because anatomically and physiologically, males tend to have a higher susceptibility to upper airway obstruction. Males generally have more central fat distribution, including fat deposition in the neck and upper airway region, which may narrow the pharyngeal lumen and increase the risk of airway collapse during sleep.[21,22] Smoking status also has an influence on OSA risk. Pataka et al. stated that heavy smokers have a higher risk of OSA. Smoking worsens OSA through inflammation of the upper airway and impairment of upper airway neuromuscular function.[23] Krishnan et al. explained the mechanisms of smoking on OSA, including relaxation of upper airway muscles due to nicotine, increased arousal threshold from sleep induced by nicotine, and increased upper airway inflammation due to inhaled cigarette smoke.[24]

Body mass index did not show a significant association with reaction time, either light or auditory ($p = 0.095$ and $p = 0.889$). This indicates that variation in BMI among study subjects does not directly affect simple motor response speed. Physiologically, reaction time is influenced by sensory system integration, attention, and neural conduction speed, which may not be directly related to adiposity status.[25,26] A study by Folkard et al. showed that shift workers have a higher risk of cognitive performance impairment, including prolonged reaction time, due to circadian rhythm disruption and accumulated fatigue. However, other studies found that the effect of work patterns on reaction time can also be influenced by compensatory factors such as sleep quality, individual adaptation, and lifestyle habits.[27]

LIMITATION

This study employed a cross-sectional design, which precludes any inference of causality between OSA risk and reaction time. Participants identified as high-risk for OSA declined to undergo polysomnography (PSG), thereby limiting the availability of objective diagnostic confirmation and preventing assessment of OSA severity. Reaction time was measured only once in the morning, which may not adequately capture fluctuations in alertness related to night-shift work or cumulative fatigue. In addition, several potential confounding variables—including prior sleep quality, caffeine intake, psychological stress, and workload—were not strictly controlled, which may have influenced the observed outcomes.

CONCLUSION

The prevalence of high-risk obstructive sleep apnea (OSA) among emergency department healthcare workers at Persahabatan Hospital was low (2.9%), with most participants categorized as low risk based on the STOP-BANG questionnaire. The study population was predominantly young, female, and had generally normal anthropometric and smoking profiles. Mean reaction times were within normal range for both visual and auditory stimuli, with a small proportion showing prolonged responses. No significant association was found between OSA risk and reaction time, while a significant relationship was observed between reaction time and duration of employment, with no other demographic or occupational factors showing meaningful associations.

Overall, OSA risk was not associated with psychomotor reaction time in this population, whereas longer duration of employment may be more relevant to variations in reaction performance. Future studies should incorporate objective diagnostic tools such as polysomnography, include more diverse and larger samples, and consider longitudinal and more comprehensive cognitive assessments to better elucidate the relationship between sleep-related disorders and cognitive performance in healthcare workers.

DISCLAIMER

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Conflict of Interest

The authors declare that there are no conflicts of interest related to the design, conduct, analysis, or reporting of this study. No financial, personal, or professional relationships exist that could have influenced the findings or interpretation of the results.

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