App Use and Abstinence Outcomes: The Moderating Role of Sociodemographic Variables in a Psychological Intervention to Quit Smoking

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Footnotes

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ABSTRACT

Background: App use is related to smoking cessation outcomes in mobile-based interventions but studies that examine its impact on traditional interventions combined with an app are still scarce. Moreover, the interplay between app use and participants' sociodemographic characteristics remains unexplored, particularly in blended smoking cessation interventions. Objectives: The study aims to explore the main effect of app use and the interactive effect of this variable and sociodemographic variables on abstinence outcomes. The sample composed of 102 participants (M_{age}= 44.96, SD=

9.97; 57.8% female) who received a psychological cognitive-behavioral smoking cessation intervention combined with the “Non Fumo” app. The Mann–Whitney U-test was used to examine differences in app use according to the smoking status at the end of the intervention, and moderation analyses were conducted to examine the interaction between app use and sociodemographic variables. Results: Results showed that abstinent participants, compared to participants who smoke, used the “Non Fumo” app significantly more. However, app use did not predict abstinence at the end of treatment. Regarding moderation analyses, younger participants with greater app use were more likely to achieve abstinence at the end of the treatment compared to older participants.

Conclusions/Importance: This study suggests that the association between app use and cessation outcomes could vary according to specific sociodemographic variables. Findings highlight the relevance of further investigating~~continuing to explore~~ the relationship between personal~~association of people who smoke~~ characteristics and tobacco outcomes in app-based interventions. AQ2 This would allow tailoring interventions according to individual characteristics to improve their effectiveness. AQ3

KEYWORDS

Smoking cessation; app use; sociodemographic variables; mHealth app; psychological intervention

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Introduction

Smoking causes around 8 million deaths every year worldwide and is one of the most important public health concerns (World Health Organization [WHO], 2023). There are several effective psychological treatments for quitting smoking that have shown their efficacy (Patnode et al., 2021) and, nowadays, new delivery smoking cessation interventions, like smartphone apps, are emerging

(Barroso-Hurtado et al., 2021; US Department of Health and Human Services [USDHHS], 2020). The effectiveness of app-based interventions is not clear, as some studies found higher abstinence rates compared to other interventions for quitting (e.g., BinDhim et al., 2018; Masaki et al., 2020), whereas other studies found no differences (e.g., Garrison et al., 2020; Hébert et al., 2020) or found differences in favor of the control groups (e.g., Baskerville et al., 2018; Buller et al., 2014). Previous research has suggested that the frequency of app use could play an important role in explaining these differences in study results (Etter et al., 2023; Hoepper et al., 2022). Most studies have examined the effect of app use frequency on smoking outcomes in stand-alone apps. Buller et al. (2014) reported that a higher frequency of use of the REQ-Mobile app (The Real e Quit mobile application) was associated with a greater abstinence rate at the 12-week follow-up. Similarly, Etter et al. (2023) found that the Stop-Tabac smartphone app use frequency predicted abstinence after a 6-month follow-up and a higher reduction in the number of cigarettes per day (CPD) in participants who continued to smoke at this follow-up. In contrast, Iacoviello et al. (2017) found that opening the Clickotine app a greater number of times did not predict abstinence at the end of the study (8 weeks). Finally, Bricker et al. (2022), who analyzed the influence of frequency of use of two smoking cessation apps (iCanQuit app vs. QuitGuide app) in abstinence outcomes, found that participants who used the iCanQuit app for more weeks (4- and 26-week users) were significantly more likely to quit smoking at the 12-month follow-up than those with lower usage (1-week users). However, no difference was found in the likelihood of abstaining at that assessment point between participants who used the QuitGuide app for 1 or 3 weeks.

Other studies have focused on smoking cessation interventions combined with apps. O'Connor et al. (2020) observed that participants who completed the four components of the app had a higher probability of abstinence at the 6-month follow-up than those who did not complete it. Janes et al. (2019) found a relationship between more completed modules of app-based mindfulness training program and a greater reduction in CPD. Masaki et al. (2020) reported that the daily use of specific CASC (CureApp Smoking Cessation) app components (e.g., digital diary entries, behavioral therapy to avoid smoking, and educational tutorials) was more frequent among participants who had successfully quit smoking than those who had failed. Businelle et al. (2016), who combined usual care with the Smart-T app (Smart Treatment app), observed that higher use of some specific app

components, such as the Quit Tips (number of Tips viewed), was significantly related to being a person who smokes at the 2-, 4-, and 12-week follow-ups.

Given the heterogeneity of literature, more research is needed on the effect of app use in combined smoking cessation interventions. Some variables may influence these results regarding the relationship between frequency of app use and smoking cessation treatment outcomes, so it would be interesting to analyze the presence of moderating variables. To our knowledge, no studies have examined the influence of these kinds of variables on this relationship. However, several studies have been carried out to analyze moderating variables in other digital interventions for quitting smoking, such as using websites or phone calls (Graham et al., 2015; Shahab & McEwen, 2009; Strecher et al., 2006). Analyzing these moderating variables allows us to determine in which contexts and for what kind of participants a smoking cessation treatment is effective (Graham et al., 2015).

Previous literature shows that sociodemographic variables are related to tobacco outcomes. In a review of the literature, Smith et al. (2016) showed that in effectiveness trials, compared to men, women were significantly less likely to stop smoking. Studies analyzing differences according to age in smoking cessation clinical settings report mixed results. For example, J.-R. Kim et al. (2005) found that younger participants were significantly more likely to quit smoking at the 5-month follow-up than older people. On the contrary, Ochoa-Prieto et al. (2010) observed that older participants had greater odds of achieving continuous abstinence at the 12-month follow-up than younger people. Regarding employment status, in a population survey, Williams et al. (2001) found that being employed or seeking work compared to being retired/homemaker was associated with a higher likelihood of current smoking in older adults. On the other hand, De Vogli and Santinello (2005) reported that unemployed people were more likely to smoke than those who were working. Concerning the role of educational level, previous studies using longitudinal surveys showed that high education was associated with smoking cessation (Cao et al., 2023; Ruokolainen et al., 2021). In the context of smoking cessation apps, scarce literature has studied the influence of these variables on smoking cessation. For instance, Etter and Khazaal (2022) showed that a smoking cessation app had no effect on smoking cessation independently of sex or age. Bricker et al. (2022) found that high educational level was significantly related to smoking cessation at the 12-month

follow-up. However, more research is needed to investigate the influence of these variables in the context of smoking cessation smartphone app-based interventions.

Given that app frequency of use and sociodemographic variables are related to smoking cessation outcomes, we need to analyze their interactive effect to identify the characteristics of individuals who would benefit the most from smoking cessation treatments combined with smartphone apps. The present study aims to examine the main effect of the frequency of app use and its interactive effect with sociodemographic variables on abstinence at the end of treatment.

Materials and methods

Participants

The sample included 102 ~~(anonymized for blinded peer review)~~ spanish participants who received a psychological smoking cessation treatment combined with the "Non Fumo" app at the ~~(anonymized for blinded peer review)~~Smoking Cessation and Addictive Disorders Unit of the University of Santiago de Compostela. AQ4 AQ5 Participants were eligible if they: (1) were at least 18 years old, (2) wished to participate in the smoking cessation intervention, (3) had a smartphone, (4) smoked ≥6 CPD, (5) provided written informed consent, and (6) completed the assessment questionnaires at pretreatment. The exclusion criteria were (1) having a concurrent substance use disorder (e.g., cannabis or cocaine), (2) a diagnosis of severe mental disorder (e.g., bipolar disorder), and (3) a high life-risk pathology that required immediate intervention (e.g., lung or breast cancer).

Measures

The questionnaires used at pretreatment were:

- The Smoking Habit Questionnaire (Becoña, 1994). The questionnaire is made up of 59 items designed to obtain information about sociodemographic variables (e.g., sex, age, employment situation, marital status), history of physical illnesses, and smoking-related variables (e.g., cigarettes smoked per day, consumption of other tobacco products, tobacco brand, past quit attempts).

- Fagerström Test for Cigarette Dependence (FTCD; Heatherton et al., 1991). This is a six-item self-report questionnaire whose total score ≥6 indicates cigarette dependence (Fagerström et al., 1996). For the present study, we used the Spanish version of the questionnaire, which has a Cronbach's alpha of .66 (Becoña & Vázquez, 1998).

Additionally, the following measures were assessed:

- App use. The usage frequency of the "Non Fumo" app was calculated by the number of times each participant accessed the app during the 8-weeks smoking cessation treatment period.
- Abstinence was self-reported at the end of the treatment. Participants who did not smoke (even a puff) for at least 24 h were considered abstinent people. Due to the sanitary measures applied by the COVID-19 pandemic, biochemical verification using exhaled carbon monoxide (CO) measurements was obtained from only 26.5% (n = 27) of the sample.

Procedure

The present study is a secondary analysis of the work by ~~by~~ Barroso-Hurtado et al. (2024) ~~(anonymized for blinded peer review)~~. It was conducted between September 2019 and May 2021. Participants were recruited through posters (e.g., healthcare centers, hospitals, university), mass media (e.g., newspaper or television), posts on the ~~(anonymized for blinded peer review)~~ Smoking Cessation and Addictive Disorders Unit social networks (Instagram and Facebook), referred by the primary care physicians or other health professionals (e.g., dentist), and recommended by other people who previously participated in the smoking cessation treatment.

Participants interested in the intervention contacted the Smoking Cessation Unit~~(anonymized for blinded peer review)~~ and were scheduled for an individual pretreatment assessment session, in which information about sociodemographic and smoking-related variables was collected.

Participants who met the abovementioned inclusion criteria received a cognitive-behavioral smoking cessation treatment called "Programa para Dejar de Fumar" ([Program to Quit Smoking]; Becoña (2007)~~anonymized for blinded peer review~~) combined with the "Non Fumo" app. This is a

psychological cognitive-behavioral treatment to quit smoking, consisting of eight group sessions (one hour per week) through video calls. Additionally, participants had access to the “Non Fumo” app during the eight treatment sessions. The app includes two main components: (a) the smoking self-monitoring tool, which allows participants to record daily the number of cigarettes smoked/day and (b) treatment-related materials. Participants could access the written materials provided to them at each of the intervention sessions through the app. A more detailed description of the app and the smoking cessation treatment can be found in ~~(anonymized for blinded peer review)~~Barroso-Hurtado et al. (2024).

All participants provided signed written consent before smoking cessation treatment. The Bioethics Committee of the ~~(anonymized for blinded peer review)~~University of Santiago de Compostela reviewed and approved this study (reference number USC-26/2020~~anonymized for blinded peer review~~).

Data analytic strategy

Descriptive statistics of sociodemographic characteristics and tobacco-related variables at pretreatment are shown as means or frequencies, with standard deviations or percentages, respectively. Chi-square statistic (χ^2) and Student’s t-test were used to examine baseline variables according to participants’ smoking status at the end of treatment (abstinent participants vs. participants who smoke).

Furthermore, the Mann–Whitney U-test was used to analyze the differences in app use according to the smoking status at the end of treatment (abstinent participants vs. participants who smoke) because the assumption of normality was not met.

Moderation analyses were performed using PROCESS (version 4; model 1) for IBM SPSS Statistics for Windows, Version 27.0 (IBM Corp., Armonk, New York, USA). This analysis measures whether the effect of the variable X on Y is moderated by a variable W and whether the variables W and X interact in their influence on the outcome variable (Y) (Hayes & Little, 2018). Specifically, “Non Fumo” app use was included as the independent variable (X), and sex (0 = male; 1 = female),

age, employment status (0 = employed; 1 = not working [e.g., unemployed, retired, or student]), and educational level (0 = non-university studies; 1 = University or technical school) were included as moderators (W) in each model. The dependent variable (Y) was abstinence at the end of treatment (0 = smoking; 1 = abstinence). Moderation analyses were conducted unadjusted and adjusted for the following variables: sex, age, employment status, educational level, and treatment completion (0 = attended seven or fewer sessions; 1 = attended all eight treatment sessions).

Confidence intervals were generated to analyze the research aim, using bootstrapping analysis with bias correction (20.000 resampling). Moderation analysis was considered statistically significant if the 95% confidence interval (CI; lower limit and upper limit) did not include 0 (Hayes & Little, 2018). A statistical significance level was set at $p \leq 0.05$.

Results

Descriptive analysis

Descriptive data of the total sample are shown in Table 1. Regarding tobacco-related variables, participants had been smoking for an average of 24.55 years (SD = 12.40), smoked an average of 18.66 CPD (SD = 9.61) with an amount of 0.77 mg nicotine content (SD = 0.20) and according to the cutoff point established by the FTCD (score ≥ 6), 41.2% of participants were cigarette-dependent.

Table 1. Sociodemographic data of the sample (N = 102).

	Total sample at baseline (N = 102) Mean/n (SD/%)
Age (years)	44.96 (9.97)
Sex	
Female	59 (57.8)
Male	43 (42.2)

Education	
Non-university education	45 (44.1)
University or technical school	57 (55.9)
Employment status	
Employed	63 (61.8)
Not working (e.g., unemployed, retired, or student)	39 (38.2)
Marital status	
Married	51 (50)
Unmarried (e.g., single, divorced, or separated)	51 (50)

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Regarding the treatment outcomes, 64.7% of the participants achieved abstinence at the end of the smoking cessation intervention.

App use according to smoking status

Abstinent participants at the end of treatment used the app an average of 278.79 times (SD = 136.82), and participants who smoke 217.94 times (SD = 245.06).

Significant differences were found in app use according to smoking status at the end of treatment. Specifically, abstinent participants used the app significantly more ($U = 842.500$, $p = 0.016$) than participants who smoked (Mdn = 265.50 vs. Mdn = 156.00).

Moderation analysis results

Unadjusted models are reported in the Supplementary Material 1.

Concerning the age analysis, the full model was significant ($p < 0.001$, Nagelkerke $R^2 = 0.5002$). Results showed a significant effect of the use of the app on abstinence and a significant interaction between the frequency of app use and age on abstinence. However, no significant effect of age on abstinence outcomes was found. When app use was higher, the younger group showed a higher

abstinence rate at the end of treatment (Table 2 and Figure 1).

Figure 1. Adjusted moderation analysis plot.

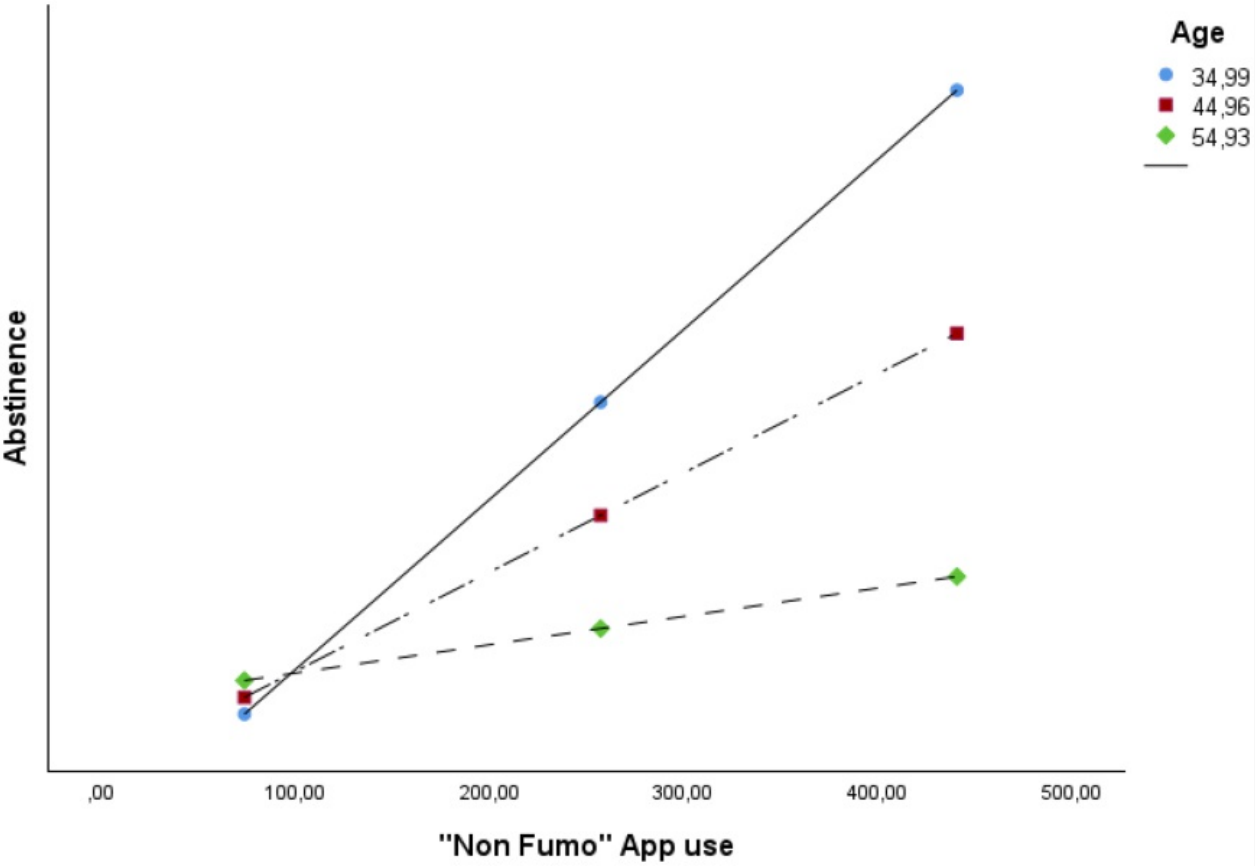

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Table 2. Results of the adjusted moderation models.

Sex[a]	β	SE	P	LLCI	ULCI
X → Y	.0011	.0017	.4907	−0.0021	.0044
W → Y	−0.2529	.8854	.7752	−1.98831	1.4825

X*W → Y	.0048	.0030	.1107	−0.0011	.0107
Age[b]					
	β	**SE**	**p**	**LLCI**	**ULCI**
X → Y	.0243	.0097	.0122	.0053	.0432
W → Y	.0401	.0453	.3752	−0.0486	.1288
X*W → Y	−0.0004	.0002	.0238	−0.0008	−0.0001
Conditional effect	β	*SE*	*p*	LLCI	ULCI
34.98	.0099	.0036	.0060	.0028	.0169
44.96	.0057	.0022	.0081	.0015	.0100
54.93	.0016	.0018	.3540	−0.0018	.0051
Employment status[c]					
	β	**SE**	**p**	**LLCI**	**ULCI**
X → Y	.0013	.0016	.3886	−0.0017	.0044
W → Y	−1.4351	1.0173	.1583	−3.4290	.5588
X*W → Y	.0062	.0036	.0853	−0.0009	.0133
Educational level[d]					
	β	**SE**	**p**	**LLCI**	**ULCI**
X → Y	.0048	.0026	.0630	−0.0003	.0098
W → Y	.2417	.8675	.7806	−1.4586	1.9419
X*W → Y	−0.0031	.0030	.2981	−0.0089	.0027

Note. X: App use; Y: abstinence; W: sex, age, employment status or educational level; X*W: interaction between app use and sex/age or employment status and treatment completion.

Covariates a: age, employment status, educational level and treatment completion.

Covariates b: sex, employment status, educational level and treatment completion.

Covariates c: sex, age, educational level and treatment completion.

Covariates d: sex, age, employment status and treatment completion.

The full models were significant in the analysis according to sex ($p < 0.001$, Nagelkerke $R^2 = 0.4580$), employment status ($p < 0.001$, Nagelkerke $R^2 = 0.4633$), and educational level ($p < 0.001$, Nagelkerke $R^2 = 0.4433$). The results showed that there was no significant effect of the use of the "Non Fumo" app, sex/employment status/educational level on abstinence at the end of the smoking cessation treatment. Furthermore, a nonsignificant interactive effect of app use × sex/employment status/educational level on abstinence at the end of treatment was found (Table 2).

Discussion

The main aim of the present study was to investigate the effect of the use of the "Non Fumo" app on abstinence at the end of the smoking cessation treatment and the moderation role of age, sex, employment status, and educational level. Even though results showed that abstinent participants used the app significantly more than participants who smoked, app use did not predict cessation outcomes at the end of treatment. This aligns with previous literature on stand-alone apps, showing that higher use does not predict greater abstinence rates (Bricker et al., 2022; Iacoviello et al., 2017). However, establishing comparisons with studies focusing on smoking cessation interventions combined with apps is difficult due to their heterogeneity. For instance, some studies measured app use as the number of app modules/components completed (e.g., Janes et al., 2019; O'Connor et al., 2020) or the use of specific app components (e.g., Businelle et al., 2016; Masaki et al., 2020).

When examining the interactive effect of sociodemographic variables, a significant effect was found for age. Specifically, our results showed that younger participants with greater use of the smartphone app had a higher probability of abstinence at the end of the smoking cessation intervention compared to older participants. These outcomes contrast with most of the previous studies in smoking cessation clinical settings in which older smokers who have attempted to quit smoking are found to have higher abstinence rates than younger smokers (e.g., Monsó et al., 2001; Ochoa-Prieto et al., 2010). Our findings suggest that incorporating mobile applications as an adjunct to smoking cessation interventions may enhance engagement and motivation to quit among younger people who smoke. This is in consonance with previous research indicating that using smartphone applications aligns with the preferences of younger individuals (Pallejà-Millán et al., 2020) and that this age group has a higher frequency of smartphone application use compared to older adults (Yu & Sussman, 2020). However, despite the potential of smoking cessation applications, further research is warranted (Zhou et al., 2023). Sex, employment status, and educational level did not moderate the relationship between app use and abstinence at the end of treatment. Studies employing stand-alone smoking cessation apps have obtained mixed results regarding the effect of these sociodemographic variables on abstinence outcomes (Bricker et al., 2022; Etter & Khazaal, 2022). More research is needed on the influence of participants' sociodemographic variables in studies

using apps blended with other smoking cessation treatments.

The present study has some limitations. First, participants' abstinence at the end of treatment was self-reported, and no biochemical verification of the sample was obtained. However, previous literature has indicated that in smoking cessation app studies, abstinence is usually self-reported (Chu et al., 2021). Furthermore, abstinence outcomes are reliable in studies with limited personal contact or in which the biochemical verification is difficult to perform (e.g., telephone or internet) (SRNT Subcommittee on Biochemical Verification, 2002). Second, regarding app use variable, we only considered the number of times that participants accessed the app but not the duration of use. Further research is needed using precise measures of app use. Finally, as this was a secondary analysis of the study by Barroso-Hurtado et al. (2024)~~(anonymized for blinded peer review)~~, the sample size might not be large enough to detect small effects. Therefore, future research with larger samples is needed to continue examining the influence of these demographic variables on the relationship between the frequency of app use and tobacco outcomes.

Despite the mentioned limitations, this research has several strengths. First, this study contributes to filling a gap in the literature about the moderating role of the demographic variables on the relationship between app use and abstinence outcomes at the end of a smoking cessation treatment. Second, given that most studies analyzing the effect of frequency of smoking cessation app use on smoking outcomes use stand-alone apps (e.g., Buller et al., 2014; Hoepper et al., 2022), the present study contributes to expanding the scarce literature on the use of apps in blended interventions. Finally, the present analysis controlled for different potential confounding effects.

Our study has important clinical implications, as knowing the personal characteristics of the participants who are likely to have specific engagement patterns with smoking cessation apps could help to reduce the problem of low app utilization. In turn, this could allow tailoring smoking cessation app interventions to participants' baseline characteristics (Bricker et al., 2022; Zeng et al., 2015). In this sense, authors such as Zeng et al. (2015) suggest that it is important to design more personalized smoking cessation app features according to specific user groups. For this reason, future studies should focus on investigating the role of other participants' personal variables (e.g., smoking-related or psychological variables) in the use of smoking cessation apps and how this

relates to tobacco outcomes.

This study underlines the relevance of age as moderator in the relationship between the frequency of the app use and abstinence at the end of the smoking cessation treatment. Examining the influence of sociodemographic variables could contribute to clarifying who benefits ~~the most~~ from ~~the use of~~ smoking cessation app-based interventions. Additionally, it can guide ~~app~~ the design of personalized smoking cessation apps~~and to address design changes according to the people who smoke personal characteristics~~ to improve ~~smoking~~ cessation ~~treatment~~ outcomes. AQ6 Finally, more research is needed to better understand the impact of app use frequency on abstinence outcomes and the influence of personal variables on that relationship.

Disclosure of interest

No potential conflict of interest was reported by the author(s).

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