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Association between Awareness on the Neurophysiologic Effects of Caffeine and Consumption of Caffeinated Beverages among Saudi University Students

Hassan Alshakhs[1], Eduardo Fabella[1,*], Yasser Al Hassan[2], Muntathir Alsultan[1] and Mohammed Alshuwyash[1]

[1]*Department Public Health, King Faisal University, Dammam, Saudi Arabia*
[2]*Department of Health Programs, Public Health Directorate, Al Ahsa General Health Affairs, Ministry of Health, Al Ahsa, Saudi Arabia*

Abstract:

Background:

Caffeine is known to have numerous neurophysiologic effects. This study aimed to determine the association between university students' awareness on the neurophysiologic effects of caffeine and their coffee consumption.

Methods:

An analytic cross-sectional study design was utilized. A 45-item questionnaire was distributed to 523 randomly selected students at the College of Applied Medical Sciences at King Faisal University, Al-Ahsa, Saudi Arabia. Collected data was subjected to estimation of proportion and logistic regression analyses using EpiInfo version 7.

Results:

Coffee consumption was prevalent among the university students (58.62%, 95% CI: 54.22% - 62.89%). Majority of university students were unaware about the potential effects of caffeine to reduce suicide risk and the development of Alzheimer's disease. Increased coffee consumption was associated with awareness that caffeinated beverage consumption could lead to a decrease in suicide risk (OR = 1.6286, p = 0.0506) and awareness that caffeinated beverage consumption could help increase alertness (OR = 2.4462, p = 0.0458).

Conclusion:

Caffeinated-beverage consumption is prevalent among Saudi university students. Awareness on potential increased alertness effects of caffeine consumption were significantly associated with caffeinated beverages consumption.

Keywords: Caffeine, Neurophysiologic effects, University students, Caffeinated beverages, Alzheimer's disease, Coffee.

1. INTRODUCTION

Caffeine is a physiological stimulant [1]. The consumption of this psychoactive substance is highly prevalent as it is naturally found in many food products and beverages [2 - 4]. It is estimated that as much as 80% of the world's population consumes caffeine-containing beverages [5]. In recent years, there has been a dramatic increase in caffeine use on a global scale [6]. Caffeine is found in natural and non-natural food products [6 - 9].

The level of caffeine varies among natural sources and food items. Among the natural beverages, coffee has the highest level of caffeine [4]. Caffeine concentration in coffee ranges from as low as 71 mg to as high as 220 mg of caffeine per 150 ml of coffee [10].

Coffee is a source of biologically active natural metabolites. As a beverage, coffee has cardioprotective, hepatoprotective and neuroprotective properties [4]. Apart from caffeine, there are other bioactive substances found in coffee which potentially affect health including polyphenols, alkaloids and diterpenes [4, 7, 11, 12]. It is a very popular pharmacologically active beverage habitually consumed by many societies around the world. Coffee is chiefly used for its taste and aroma. However, a growing number of people intentionally consume coffee for its psycho-stimulating effect and health-promoting properties [12].

* Address correspondence to this author at the Department Public Health, King Faisal University, Saudi Arabia; Tel: 0534918736; E-mail: efabella@kfu.edu.sa

According to the Saudi Ministry of Health, caffeine consumption amount should not exceed 400 mg per day for the purpose of avoiding possible side effects [13]. The European Food Safety Authority has also declared that coffee intake for up to 400 mg which approximates to 4 cups per day to be safe for adults [14]. It is also suggested that 2.5 mg/kg/day is safe for children and adolescents [7].

While excessive coffee consumption can potentially lead to several harmful health effects including elevation of total cholesterol, hypertension, tachycardia and arrhythmia, its beneficial effects have been explored in many studies [12], ranging from weight loss and improved physical activity to a lower risk of chronic diseases and mortality [15], protection against cirrhosis and hepatocellular cancer, reduction of risk for Type 2 diabetes mellitus and heart disease [16]. The antioxidant and anti-inflammatory properties of caffeine have been postulated to play a role in lowering the risk for stroke and coronary heart disease, cancer and cardiovascular disease mortality [10, 12, 14].

The neurophysiologic effects of caffeine intake such as reduction of depression and suicide risk, enhancement of long-term memory, increased alertness and attention, and reduction of the risk for developing Alzheimer's disease and Parkinson's disease have been documented [4, 7, 17]. Several observational and interventional studies have demonstrated an inverse risk for neurodegenerative disorders among chronic coffee consumers [4, 12, 18].

Caffeinated beverage consumption appears to have a protective effect against depression and suicide [12, 19]. The results from three prospective cohort studies of American adults have found that people who drank more than two or three cups of coffee per day had 45% decreased risk of suicide compared to people drinking less than one cup a week while those who drank four or more cups a day were at 53% reduced risk of suicide [20]. On the other hand, another study showed that reduction in suicide related to caffeine intake only occurs in women, with no reduction noted among men [2].

Dietary approaches and the use of phytochemicals for the prevention of age-related cognitive impairment are currently being investigated [14]. Caffeine has been shown to enhance memory among young adults during their non-optimal time of the day and significantly lower the risk for Alzheimer's Disease [21, 22]. The role of coffee consumption in lowering the risk for cognitive decline has been reported by several studies [10, 12]. Caffeine has been demonstrated to significantly decrease the risk for Alzheimer's disease in a case control study [22]. In addition to Alzheimer's disease, coffee has been documented to be protective against two other neurodegenerative disorders namely, Parkinson's Disease and Amyotrophic Lateral Sclerosis [4, 23].

University students who consume caffeine were shown to have improved explicit memory [21]. Caffeine improves both early cognitive processes and individual automatic reactions [24]. Coffee is the preferred caffeinated beverage among college students [25]. Students intentionally consume caffeinated beverages on the belief that caffeine can make them more alert, more energetic, and even improves their concentration, attention and motivation towards work. They also believe that it helps in stress alleviation [25 - 27].

Some local studies have found that students who consume caffeinated beverages experience a reduction in hours of sleep and negative effects on their academic performance and life satisfaction [28]. Consumption of caffeinated beverages such as energy drinks had a high relationship with the decreased sleep rate. The sleep-altering effect of caffeinated drinks was the most common reason for the consumption of energy drinks among students preparing for examinations [29 - 31].

Different studies among students in Arab countries have found that most students consume caffeinated beverages in excess of the recommended limit [6, 32 - 35]. Local studies have also found that the majority of Saudi students consume caffeinated beverages during exams preparation. Tea, black coffee, and Arabic coffee are the most commonly consumed caffeinated beverages among students [36, 37]. Students consume caffeinated beverages to gain energy for studying, and enhance their mood and alertness. They consume caffeinated beverages to achieve their tasks and are usually not aware of the effects that it can cause to their health [38].

Caffeinated beverages' consumption is expected to rise in the next few years because of the huge increase in coffee shops market in Saudi Arabia. Within the vicinity of the university, there are numerous coffee shops that are easily accessible to students and have become common venues for group studies and social meetings. The rising trend of caffeinated beverage consumption among adolescents and young adults related to the unregulated opening of coffee shops around universities is a cause of concern [31].

Because coffee and tea are accepted culturally, there is little education about the health effects of caffeine [36]. Reports on consumption patterns among university students are limited [32]. Most of the local studies on caffeinated beverages center on energy drinks and only a limited number have explored other sources of caffeine. Even fewer studies highlight the health effects of excessive consumption of caffeinated beverages. There is limited knowledge about the level of awareness of university students about the health effects of caffeinated beverage consumption. Therefore, this study aimed to describe the caffeinated beverage consumption patterns of university students, assess their awareness of the neurophysiologic health effects of caffeinated beverages consumption, and determine the association between awareness of the health effects of caffeine and caffeinated beverage consumption.

2. METHODS

The study utilized a cross-sectional design. A researcher-developed questionnaire that has been validated and pre-tested among students of similar characteristics as the study respondents, was used as the research tool. The questionnaire consisted of 45 questions divided into three sections (sociodemographic variables, awareness of the neurophysiologic effects of caffeinated beverages, and caffeinated beverages consumption patterns). Items 1-4 were general demographic questions; items 5-17 assessed caffeine consumption patterns (type and amount); items 18-23 were

general questions on caffeinated beverages consumption; finally, items 24-45 were awareness questions on the effects of caffeinated beverage consumption.

The sample size was computed using OpenEpi to be 267 based on the total 875 students' population of the College of Applied Medical of Sciences (CAMS) of King Faisal University, with an expected frequency of 50%, margin of error of 5%, and a level of confidence of 95%.

Data was collected from subjects using a self-administered questionnaire that was distributed by Google Forms from November 12 to November 24, 2020. All students registered to any of the four programs of the College of Applied of Medical Sciences regardless of year level were considered eligible to participate in the study. A total of 523 students responded and consented to participate in the study.

The awareness status of the respondents was determined based on their response to questions about the neurophysiologic effects of caffeinated beverages such that a "yes" response was counted as awareness on the specific question. Caffeinated beverage consumption was based on the students' answer to the question "Do you drink caffeinated beverages?". Specific consumption patterns were determined from their response to the amount and schedule of intake.

Students participated on a voluntary basis and were assured of their anonymity and the confidentiality of their responses. Following the approval of the research proposal by the College of Applied Medical Sciences, ethical clearance was sought from the Research Ethics Committee of the Deanship of Scientific Research, King Faisal University, Hofuf, Al-Ahsa, Kingdom of Saudi Arabia (KFU – REC/2020 – 12 – 06).

Collated data were encoded in Microsoft Excel and were subsequently cleaned for missing information prior to statistical treatment using EpiInfo® version 7. Descriptive analysis was applied to the demographic data. Awareness on the neurophysiologic effects of caffeinated beverages was determined using the estimation of proportion. Simple logistic regression was used to calculate the crude association between awareness on neurophysiologic effects of caffeine and coffee consumption. Those that were found to be statistically significant at alpha level of 25% were subjected to multivariate analysis.

3. RESULTS

3.1. Demographic Profile of Respondents

There were 523 respondents, 80.69% of which were females. The respondents represented 81.97% of the student population of the College of Applied Medical Sciences (CAMS) in the Academic Year 2020-2021. Nursing students comprised 56.6% while Public Health majors represented 23.3% of all respondents. The remaining respondents belong to the new CAMS programs (Health Informatics, 8.1%; Clinical Nutrition, 11.7%).

The highest proportion (56.59%) of respondents were nursing students while the lowest number of respondents were from Health Informatics department representing only 8.41% of the total study participants.

3.2. Caffeinated Beverage Consumption Patterns of University Students

Among the 523 students who participated in the study, 493 (94.26%) reported to consume caffeinated beverages. More than half (58.62%, 95% CI: 54.22% - 62.89%) of the students who drink caffeinated beverages preferred coffee while 24.54% (95% CI: 20.95% - 28.53%) selected tea as the caffeinated beverage that they drink regularly. Caffeinated soda was commonly consumed by 13.18% (95% CI: 10.48% - 16.46%) of the students but only 3.65% (95% CI: 2.32% - 5.70%) drank energy drinks.

In terms of consumption patterns, a higher proportion of male respondents reported to consume caffeinated beverages compared to female university students (Table **1**).

Table 1. Caffeinated beverage (CB) consumption patterns of university students.

Variable	Count	Proportion, %	95% Confidence Interval	
Gender Male				
Yes	99	98.0	93.03	99.76
No	2	1.98	0.24	6.97
Female				
Yes	394	93.36	90.58	95.37
No	28	6.64	4.63	9.42
Frequency of CB consumption				
Daily	220	44.62	40.29	49.04
Most days of the week	137	27.79	24.02	31.90
At least once a week	99	20.08	16.78	23.84
Every 3 weeks	17	3.45	2.16	5.45
Every 4 weeks	20	4.06	2.64	6.18
Amount of coffee consumption*				
Low	469	89.70	86.59	91.85
High	54	10.30	8.15	13.41

*Low = less than 3 cups/day; High = 3 or more cups

Almost half of the respondents consumed caffeinated beverages daily. Those who consume caffeinated beverages on most days of the week or at least once a week comprised 47.87% of the university students. Only 4.06% of respondents claimed to consume caffeinated beverages once a month.

Nearly nine out of every ten university students consumed less than three cups of coffee per day. Additionally, there was an almost equal proportion of students who claimed to consume excessive amounts of caffeinated beverages and those who do not.

Among the students who consume caffeinated beverages excessively, 151 (61.89%, 95% CI: 55.47 – 68.01%) consumed excessively as they prepare for exams; 51 (20.90%, 95% CI: 15.98% - 26.55%) consumed caffeinated beverages during periods of stress; 15 (6.15%, 95% CI: 3.48% - 9.94%) caffeinated beverages to prepare for physical activity; 13 (5.33%, 95% CI: 2.87% - 8.94%) caffeinated beverages for travel preparation; 8 (3.28%, 95% CI: 1.43% - 6.36%) caffeinated beverages for enjoyment with family and friends;

finally, 6 (2.46%, 95% CI: 0.91% - 5.28%) caffeinated beverages during free time.

In addition, 216 (41.3%) of respondents claimed to have increased their coffee because of the increasing number of new coffee shops opening in Al-Ahsa. Among those who claim to have increased their caffeinated beverage consumption because of the new coffee shops, 89.35% frequently visited the coffee shops with their friends rather than family members.

3.3. Awareness of the Neurophysiologic Effects of Caffeinated Beverages

As seen in Table **2**, a high proportion of respondents were aware of most of the neurophysiologic effects of drinking caffeinated beverages. Nearly 9 out of every 10 students were aware that it could increase alertness. Eight out of 10 students were aware that drinking caffeinated beverages could cause sleep disturbance. Five out of 10 were aware that it could enhance long-term memory while 6 out of 10 were aware that it could enhance brain function.

Table 2. Awareness on the neurophysiologic effects of caffeine among KFU students.

Neurophysiologic effects	Frequency	Percentage	95% Confidence Interval	
Reduced risk for suicide				
Not Aware	391	74.76	70.87	78.29
Aware	132	25.24	21.71	29.13
Enhanced long-term memory				
Not Aware	260	49.71	45.45	53.98
Aware	263	50.29	46.02	54.55
Reduced risk for Alzheimer's disease				
Not Aware	338	64.63	60.44	68.60
Aware	185	35.37	31.4	39.56
Sleep disturbance				
Not Aware	75	14.34	11.60	17.60
Aware	448	85.66	82.40	88.40
Enhanced brain function				
Not Aware	188	35.95	31.95	40.15
Aware	335	64.05	59.85	68.05
Increased alertness				
Not Aware	61	11.66	9.19	14.7
Aware	462	88.34	85.3	90.81

However, only a small proportion of respondents were aware that drinking caffeinated beverages could potentially reduce the risk for suicide (25.24%) and reduce Alzheimer's disease (35.37%).

3.4. Association between Coffee Consumption and Awareness of the Health Effects Among University Students

Upon application of simple logistic regression, awareness of the six neurophysiologic effects of caffeine-containing beverages was all individually associated with caffeinated beverages consumption (Table **3**).

Table 3. Association between awareness on neuropsychological effects of caffeine and coffee consumption.

Awareness on Benefits Domains	Crude OR (95% CI)	*p*-value	aOR (95% CI)	*p*-value
Potential to decrease suicide risk	2.4601 (1.6404-3.6893)	<0.0001	1.6286 (0.9986–2.6561)	0.0500
Yes				
No	1.0000		1.0000	
Potential todecrease Alzheimer's Disease	2.2884 (1.5731-3.3288)	<0.0001	1.3280 (0.8027 - 2.1972)	0.2694
Yes				
No	1.0000		1.0000	
Potential to help boost long-term memory	2.1362 (1.4754 - 3.0930)	0.0001	1.1520 (0.6919–1.9179)	0.5864
Yes				
No	1.0000		1.0000	
Potential to enhance brain function	2.3045 (1.5383 - 3.4525)	0.0001	1.3667 (0.8353–2.2360)	0.2136
Yes				
No	1.0000		1.0000	
Potential to cause sleep disturbance	2.5404 (1.3779 - 4.6835)	0.0028	1.2637 (0.6170–2.5882)	0.5224
Yes				
No	1.0000		1.0000	
Potential to increase alertness	3.8919 (1.8075-8.3799)	0.0005	2.4462 (1.0169–5.8848)	0.0458
Yes				
No	1.0000		1.0000	

There was a significant association between awareness on two of the neuropsychological effects of caffeinated beverage consumption examined. University students who were aware that caffeinated beverage consumption could decrease suicide risk were 2.46 times more likely to drink caffeinated beverages than those who were not aware of this potential effect. However, when the awareness of other neuropsychological domains was constant, those who were aware that caffeinated beverages consumption decreases suicide risk were only 1.62 times more likely to drink caffeinated beverages.

In addition, students who were aware that caffeinated beverage consumption could help increase alertness were 3.89 times more likely to drink caffeinated beverages compared to those who were not aware of caffeinated beverages' effect on alertness. However, when the awareness of other neuropsychological effects domains was constant, those who were aware that caffeinated beverage consumption increases alertness were only 2.44 times more likely to drink caffeinated beverages.

On other hand, while awareness of reduction of Alzheimer's disease risk, helping boost long-term memory, enhanced brain function, and sleep disturbance appeared to double the likelihood of caffeinated beverage consumption, there were no significant associations between the awareness of these potential neuropsychological effects of caffeinated beverages consumption when multiple logistic regression was performed.

4. DISCUSSION

Consumption of caffeinated beverages is highly prevalent among university students. However, students were not aware of all the neurophysiologic effects of caffeinated beverage consumption. This study showed that students who were aware that caffeinated beverage consumption has the potential to reduce suicide risk and the risk for developing Alzheimer's Disease, enhance the brain function, and cause sleep disturbance appeared to be twice more likely to consume caffeinated beverages than those who were not aware of these effects. On the other hand, students who were aware that caffeinated beverages have the potential to increase alertness were nearly four times more likely to drink caffeinated beverages than students who were not aware of this.

This study has shown that nearly all university students regularly drank caffeinated beverages. While the students consume a variety of caffeinated beverages, coffee was preferred by nearly 60% of students. This result was almost similar to the findings in a study conducted in Riyadh among medical students [39].

Caffeinated beverage consumption is culturally accepted among young adults [7, 12, 36]. The habit of drinking coffee usually begins upon entry to the university but exposure to coffee consumption starts in the early childhood usually by observing family members.

There is a common belief that coffee consumption aids in maintaining wakefulness during examination preparation periods. In the current study, there was a slightly higher proportion of male students who used to drink coffee. This finding was consistent with what was reported in another university in Mecca [36]. Among American university students, coffee was also the most common caffeinated beverage consumed [25].

The opening of trendy coffee shops has led to an increase in coffee consumption, most students use this as an opportunity to socialize with friends. The social prestige of going to new coffee shops was noted to be a factor in the caffeinated beverage consumption of university students in Mecca [36].

The daily average consumption of coffee among the Saudi university students in this study was two cups per day. The Saudi Ministry of Health recommends that adults consume not more than four cups per day [13]. Only 10% of the students consumed coffee in amounts that exceeded the recommended limit defined by the Ministry of Health.

In contrast, university students in Egypt tend to consume caffeinated beverages beyond the accepted safe levels [33]. In the United Arab Emirates, 35% of the respondents consumed caffeinated beverages above the recommended limit of 400 mg/day [6]. Excessive coffee consumption is known to potentially lead to several harmful cardiovascular effects such as elevation of total cholesterol, hypertension, tachycardia and arrhythmia [12, 40]. In addition, high caffeine intake was noted to be associated with neuropsychological effects such as headaches, anxiety, and psychological distress among university students in Bahrain [41].

This study has shown that while the majority of university students were aware about caffeine's role in increasing alertness, a relatively smaller proportion of students were aware about other neuropsychological effects of a caffeinated beverage, particularly its potential to decrease the risk for suicide and the potential to decrease the risk for developing Alzheimer's disease. University students generally have less awareness about the health effects of caffeinated beverages [30, 42]. A study in Oman also observed excessive consumption which was associated with a lack of knowledge of the health consequences of caffeine [35].

Nearly half of the Saudi university students consumed excessive amounts of caffeinated beverages during periods of stress and during exam preparation. The same was seen in another Riyadh study [36]. Caffeine is the most highly used stimulant used by university students [38]. Students commonly drink caffeinated beverages for caffeine's reported effects on alertness and concentration in addition to stress reduction [5, 34]. Stress reduction was also a common reason for drinking caffeinated beverages among Saudi university students [37, 43].

The current study also found that students who were aware that caffeinated beverages could cause sleep disturbance were more likely to consume them. For university students, the sleep-altering effect of caffeinated beverages was not viewed as a negative effect. In fact, wakefulness effects have been found to be the primary reason for the ingestion of caffeine-containing beverages among university students [5]. Significant sleep reduction by as much as 26% has been observed in a Saudi study [29]. Energy drinks in particular, have been reported to cause insomnia in a study involving medical students [31].

This study has shown that students who were aware that coffee consumption could decrease suicide risk were more likely to drink caffeinated beverages. Newer investigations on the effects of caffeine focus on its potential to alleviate depression and suicide risk reduction [9]. Coffee intake has been reported to decrease the prevalence of depressive symptoms [44]. Phytochemical studies have shown that caffeine is the main component of coffee that is responsible for its antidepressant effect [4]. Regular intake of moderate levels of caffeine was found to likely reduce suicide risk among women with depression. However, the quantity of coffee consumption that leads to decreased suicide risk is yet to be determined [4].

Furthermore, this study has shown that students who were aware that coffee consumption boosts long-term memory were more likely to drink coffee. However, awareness on the potential of caffeinated beverages to decrease the risk for Alzheimer's disease is very low. The cognitive benefits of caffeinated beverages were among the consistently cited reasons for their consumption among university students [5].

Existing research on the association between Alzheimer's disease and caffeine is still inconsistent. Coffee consumption has been reported to be inversely associated with depression and Alzheimer's Disease [9]. Improved cognitive function has been demonstrated among elderly patients who consume caffeinated beverages. This association was evidenced in

neurophysiological tests [45]. But while a recent large-scale study has found that the consumption of coffee, caffeinated coffee and caffeine intake positively was correlated with cognitive performance among people who are 60 years or older, a recently published meta-analysis has shown no statistically significant association between coffee consumption and risk for dementia nor between coffee consumption and Alzheimer's disease [8, 10].

The study has several limitations. Possible misclassification of caffeinated beverage consumption may have occurred, as there was no distinction made in the questionnaire about Arabic and non-Arabic coffee. These two types of caffeinated beverages do not have similar caffeine content. The possible effects of demographic characteristics of students were not included in the analysis of the association between awareness and coffee consumption. Further studies involving other university students need to be conducted to check if the same results would be seen.

Awareness of university students about the neurophysiologic effects of caffeinated beverage consumption, particularly reduction of suicide risk, enhancement of brain function, sleep disturbance and increased alertness was shown to have an effect on their caffeinated beverage consumption. However, when all other awareness domains were held constant, only awareness that coffee consumption can potentially increase alertness was shown to significantly increase caffeinated beverage consumption by Saudi university students. Whether this relationship is causal could not be established in this study.

There is a scarcity of educational campaigns conducted to educate the public about the health effects of caffeinated beverages however, there are numerous advertisements for caffeinated beverages in social media. Recently, numerous coffee shops intended to attract young clients have been opening in Al-Ahsa which may contribute to the increase in caffeine consumption among the university students in Al-Ahsa. Caffeinated beverages are easily accessible to students in shops and supermarkets. Access to caffeinated beverages is largely unregulated [46]. Adolescents and young adults are susceptible to develop unhealthy diets. Many are unaware that they are using stimulants coming from caffeinated energy drinks [47].

The university must undertake collaborative informational campaigns with the Saudi Ministry of Health to educate different sectors of society about the health effects of caffeinated beverages consumption. Advocacies for policy development regarding the caffeinated beverage shop operations should be considered.

CONCLUSION

Caffeinated beverage consumption was highly prevalent among Saudi university students. However, awareness about the health effects of caffeine was insufficient. Awareness of university students of the neurophysiologic effects of caffeinated beverage consumption was shown to be associated with their caffeinated beverage consumption.

LIST OF ABBREVIATION

CB = Caffeinated Beverage

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This research has received approval from the Research Ethics Committee of the Deanship of Scientific Research, King Faisal University, Al-Ahsa, KSA (KFU – REC/2020 – 12 – 06).

HUMAN AND ANIMAL RIGHTS

No animals were used in the studies that are the basis of this research. All the human procedures used were in accordance with the Helsinki Declaration of 1975.

CONSENT FOR PUBLICATION

Participants of the study gave full consent to have the results published.

AVAILABILITY OF DATA AND MATERIALS

Fabella, Eduardo (2021), "Caffeine", Mendeley Data, V1, doi: 10.17632/dp7pdhnjf8.1.

CONFLICT OF INTEREST

The authors declare no conflict of interest financial or otherwise.

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