

COMPARISON OF THE EFFECTIVENESS OF WRITTEN LITERATURE ONLY VERSUS AN INTERVENTION PROGRAM TO REDUCE COVID-19 VACCINE HESITANCY AMONG HIGH SCHOOL STUDENTS IN PAKISTAN

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Abstract. Coronavirus disease-2019 (COVID-19) vaccine hesitancy can interfere with efforts to control the disease. In this study we aimed to compare the efficacy of a school-based program versus an already used educational brochure to reduce COVID-19 vaccine hesitancy among 9th and 10th grade students in Balochistan, Pakistan, in order to inform efforts to improve vaccine uptake in the study population. Study subjects were recruited from 30 schools in Balochistan, Pakistan during September 2023 - February 2024. Inclusion criteria for study subjects were, being a 9th or 10th grade student at a study school and being willing to participate in the study. Exclusion criteria for study subjects were being unwilling to participate in the study or attending a non-study school. Study subjects were divided into 2 groups: an intervention group and a control group. Intervention subjects underwent an educational program about COVID-19 and the COVID-19 vaccine that consisted of lectures and presentation of various media. Control subjects were given a routinely used educational brochure about COVID-19 and the COVID-19 vaccine. Both control and intervention subjects were asked to complete a questionnaire both prior to and after the intervention. The questionnaire assessed subject knowledge about COVID-19 and the COVID-19 vaccine, subject confidence (subject

trust in the efficacy and safety of the COVID-19 vaccine and subject trust in healthcare professionals and policymakers endorsing the vaccine), vaccine convenience (subject perceived ease of being vaccinated with the COVID-19 vaccine) and subject complacency (subject perceived risk and necessity of receiving the COVID-19 vaccine). Each question was given a score, and the scores were totaled and classified. Subject knowledge, subject confidence, vaccine convenience and subject complacency were classified by percentile: having a low score (<34th percentile), medium score (34th-66th percentile) and high score (>67th percentile). For complacency, a higher score indicated a lower complacency. A total of 780 subjects were included in the study: 386 (49.5%) (with 59.3% males) in the intervention group and 394 (50.5%) (with 56.6% males) in the control group. The mean (\pm standard deviation (SD)) ages of intervention and control subjects were: 16 (\pm 1.3) (range: 10-19) and 15.6 (\pm 1.3) (range: 10-19) years, respectively. The mean (\pm SD) knowledge scores in the intervention and control groups increased significantly ($p=0.001$ and $p=0.001$, respectively) from before intervention (8.7 (\pm 2.9) and 9.0 (\pm 2.7), respectively) to after the intervention (11.7 (\pm 2.5) and 9.6 (\pm 2.3), respectively). The mean (\pm SD) subject knowledge scores in the intervention and control groups prior to the intervention were not significantly different from each other ($p=0.120$). The mean subject knowledge score in the intervention group after the intervention was significantly higher ($p<0.001$) than the control group after the intervention. The mean (\pm SD) subject confidence score in the intervention group decreased significantly ($p<0.001$) from before the intervention (41.4 (\pm 6.4)) to after the intervention (40.5 (\pm 6.5)) and the mean (\pm SD) subject confidence score in the control group increased significantly ($p<0.001$) from before the intervention (41.0 (\pm 6.3)) to after the intervention (42.8 (\pm 6.2)). The mean subject confidence scores in the intervention and control groups before the intervention were not significantly different from each other ($p=0.330$). The mean subject confidence score in the intervention group was significantly lower than the control group ($p<0.001$) after the intervention. The mean (\pm SD) vaccine convenience score in the intervention group increased significantly ($p<0.001$) from before the intervention (38.5 (\pm 7.6)) (to after the intervention (40.1 (\pm 6.2)) but the mean (\pm SD) vaccine convenience score in the control group decreased significantly ($p<0.001$) (from before the intervention (37.9 (\pm 7.1)) to after the intervention (35.8 (\pm 5.3)). The mean vaccine convenience scores were not significantly different between the intervention and control groups before the intervention. The mean vaccine convenience score was significantly higher ($p<0.001$) in the intervention group after the intervention than in the

control group after the intervention. The mean (\pm SD) subject complacency score in the intervention group increased significantly ($p=0.006$) in the intervention group from before the intervention (30.6 (\pm 6.4)) to after the intervention (34.2 (\pm 0.7)) and the mean (\pm SD) subject complacency score in the control group increased significantly ($p=0.006$) from before the intervention (31.5 (\pm 5.8)) to after the intervention (35.5 (\pm 5.8)). The mean subject complacency scores in the intervention and control groups before the intervention were not significantly different from each other ($p=0.034$). The mean subject complacency score after the intervention was significantly higher in the intervention than the control group ($p=0.006$), indicating lower complacency and greater recognition of COVID-19 risks and need for vaccination in the intervention group. Significantly more (adjusted odds ratio (aOR) = 3.716; 95% confidence interval (CI): 1.323-10.443; $p=0.013$) subjects in the intervention (51.0%) than the control group (35.0%) stated they would be willing to receive the COVID-19 vaccine after the intervention. In the intervention group, there was a significant positive association between being willing to have the COVID-19 vaccine and having a high knowledge score (aOR = 6.085; 95% CI: 2.523-14.676; $p<0.001$), having a high vaccine convenience score (aOR = 4.899; 95% CI: 1.984-12.094; $p=0.001$) and having a high subject complacency score (aOR = 4.521; 1.887-10.828; $p=0.001$). Female subjects in the intervention group, but not in the control group, were significantly more likely to receive the COVID-19 vaccine than male subjects (aOR = 4.761; 95% CI: 1.711-13.251; $p=0.001$). Prior to the intervention, 43.0% of subjects in the intervention group and 35.0% of subjects in the control group were willing to receive the COVID-19 vaccine ($p=0.022$) and after the intervention, 51.0% of subjects in the intervention group and 35.5% of subjects in the control group ($p<0.001$) were willing to receive the vaccine. The percentage of subjects in the intervention group who were willing to receive the vaccine after the intervention increased significantly ($p<0.001$) and the percentage of subjects in the control group who were willing to receive the vaccine after the intervention also increased significantly ($p<0.001$) but to a lower extent. Our results show the school-based intervention significantly improved subject knowledge and subject convenience and decreased subject complacency and subject confidence about receiving the COVID-19 vaccine and was more effective than the control brochure. After the intervention, subjects in the intervention group were significantly more likely than subjects in the control group to receive the COVID-19 vaccine. However, the proportion of subjects who were willing to receive the vaccine was still low (only 51.0%). Further studies are needed to

determine what interventions might improve the willingness to receive the COVID-19 vaccine.

Keywords: COVID-19 vaccine hesitancy, cluster randomized trial, school-based intervention, 3C Model, Balochistan Pakistan

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INTRODUCTION

Coronavirus disease-2019 (COVID-19) caused by the severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2), was first reported from Wuhan, China in 2019 (Zhu *et al*, 2020). By May 2024, the reported number of deaths caused by COVID-19 was more than 6.8 million worldwide (WHO, 2024). Vaccination has been recommended to control the spread of the infectious diseases (Orenstein and Ahmed, 2017). However, there has been hesitancy to receive the vaccine in spite of the evidence that vaccination reduces transmission and chances of severe infection (Harris *et al*, 2010; Institute of Medicine (US) Immunization Safety Review Committee, 2004). In 2019,

the World Health Organization (WHO) declared vaccine hesitancy as a major hurdle to disease control (WHO, 2019).

The WHO Strategic Advisory Group of Experts (SAGE) and Working Group (WG) on Vaccine hesitation define vaccine hesitancy as a delay in acceptance or refusal to receive a vaccine despite the presence of vaccination facilities (WHO, 2019; Goldstein *et al*, 2015).

Pakistan has reported challenges in vaccine distribution and acceptance (Butt *et al*, 2020). COVID-19 infected school-going children can spread COVID-19 at home and school (Perveen *et al*, 2022). In Pakistan, where many families are large and may include members at greater risk

of complications due to COVID-19, vaccination may reduce the risk of these at-risk persons from contracting severe COVID-19 (Perveen *et al*, 2022).

Several reasons have been reported for vaccine hesitancy in Pakistan, such as: fear of vaccine side effects, lack of confidence in the health sector and false information about the disease or the vaccine being disseminated on social media (Perveen *et al*, 2022).

There is little data regarding vaccine hesitancy in Pakistan (Ataullahjan *et al*, 2021). Previous studies regarding vaccine hesitancy have been conducted primarily among adults, healthcare personnel and the elderly (Ataullahjan *et al*, 2021), not on school-age children who may be potential vectors for transmission of infection. If the causes of vaccine hesitancy remain unknown, they are difficult to overcome (Ataullahjan *et al*, 2021).

As of May 2024, Pakistan had 1.6 million reported COVID-19 cases with more than 30,000 deaths (Countryeconomy, 2024). More than

200 million doses of the COVID-19 vaccine have been dispensed in Pakistan with 55% of adults having been fully vaccinated (Gulf News, 2022).

Pakistan faced challenges in achieving vaccination coverage targets for school-age children (Ataullahjan *et al*, 2021; UNICEF, 2021).

We used the 3Cs model of vaccine hesitancy from the WHO-SAGE (Goldstein *et al*, 2015) and an assessment of subject knowledge about COVID-19 and the COVID-19 vaccine to evaluate vaccine hesitancy. The 3Cs of the 3Cs model are: subject confidence (subject trust in the efficacy and safety of the COVID-19 vaccine and trust in healthcare professionals and policymakers endorsing the vaccine), vaccine convenience (subject perceived ease of receiving the COVID-19 vaccine) and subject complacency (subject perceived risk for contracting COVID-19 and perceived necessity of receiving the COVID-19 vaccine) (MacDonald, 2015).

In this study we aimed to compare the efficacy of a school-based intervention program with a previously employed brochure about COVID-19 and the COVID-19 vaccine in reducing COVID-19 vaccine hesitancy among 9th and 10th grade students in Balochistan, Pakistan in order to inform efforts to improve vaccine uptake in the study population.

MATERIALS AND METHODS

Study subject selection

In this cluster randomized trial, inclusion criteria for study subjects were being a student in either 9th or 10th grades in any one of 30 study schools and being willing to participate in the study. Exclusion criteria for study subjects were, being unwilling to participate in the study or attending a non-study school.

Thirty schools were randomly selected to be included in the study. The district head of the Education Department provided a list of public and private schools that had 9th and 10th grade students and

the study schools were randomly selected from this list. The selected study schools were then randomly placed in either an intervention or a control group. Fifteen schools (9 public and 6 private) were randomly placed in the intervention group and the remaining 15 (5 public and 10 private schools) were placed in the control group (Fig1).

The minimum number of subjects needed for the study was calculated based on having a minimum difference of 0.09 for differences in knowledge, confidence, convenience, and complacency scores between the intervention and control groups, with a 95% confidence interval and 80% power. An intra-class correlation coefficient (ICC) of 0.001 was assumed. The minimum number of subjects needed for the study was estimated to be 780 (390 in the intervention and 390 in the control group). We aimed to recruit 26 subjects from each of the 30 study schools (Fig 2).

The study was conducted during September 2023 - February 2024.

Study instrument

Each subject was asked to complete a questionnaire assessing subject knowledge, subject confidence, vaccine convenience and subject complacency regarding COVID-19 and the COVID-19 vaccine prior to the starting the study and 8 weeks after the first questionnaire. The questionnaire

was adapted from an earlier study (Sheikh *et al*, 2023) and consisted of 4 sections:

The first section asked about subject age, whether they attended a government or private school and whether they were in the 9th or 10th grades.

The second section assessed subject knowledge about COVID-19

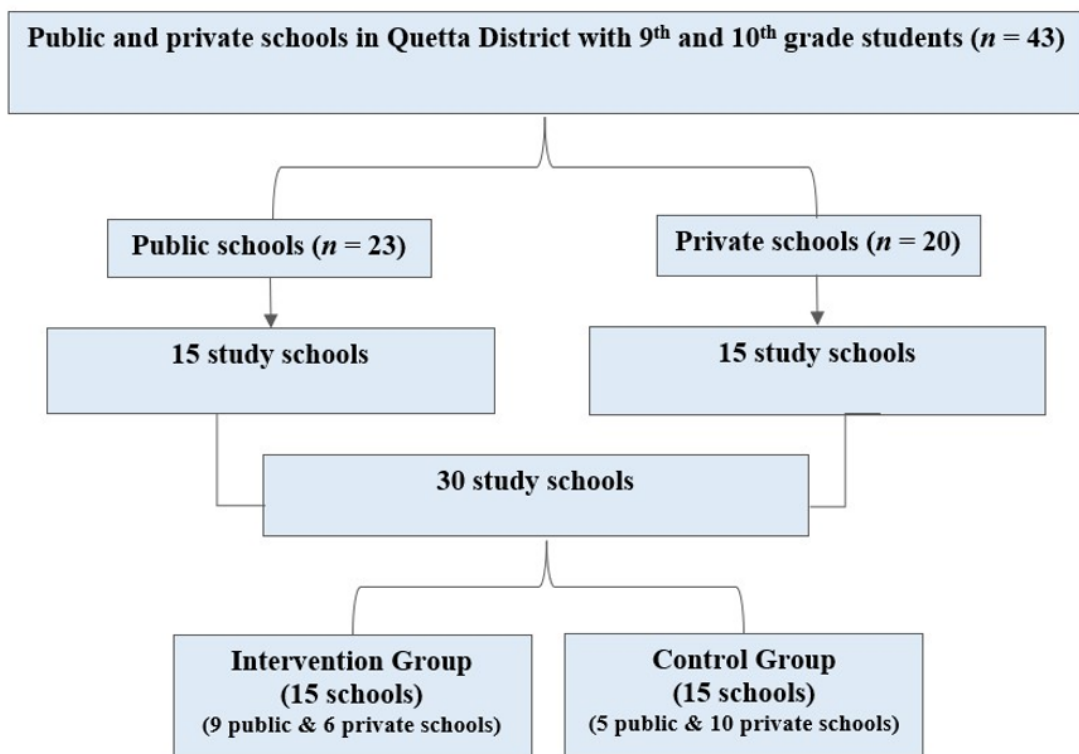


Fig 1 - Selection of study schools

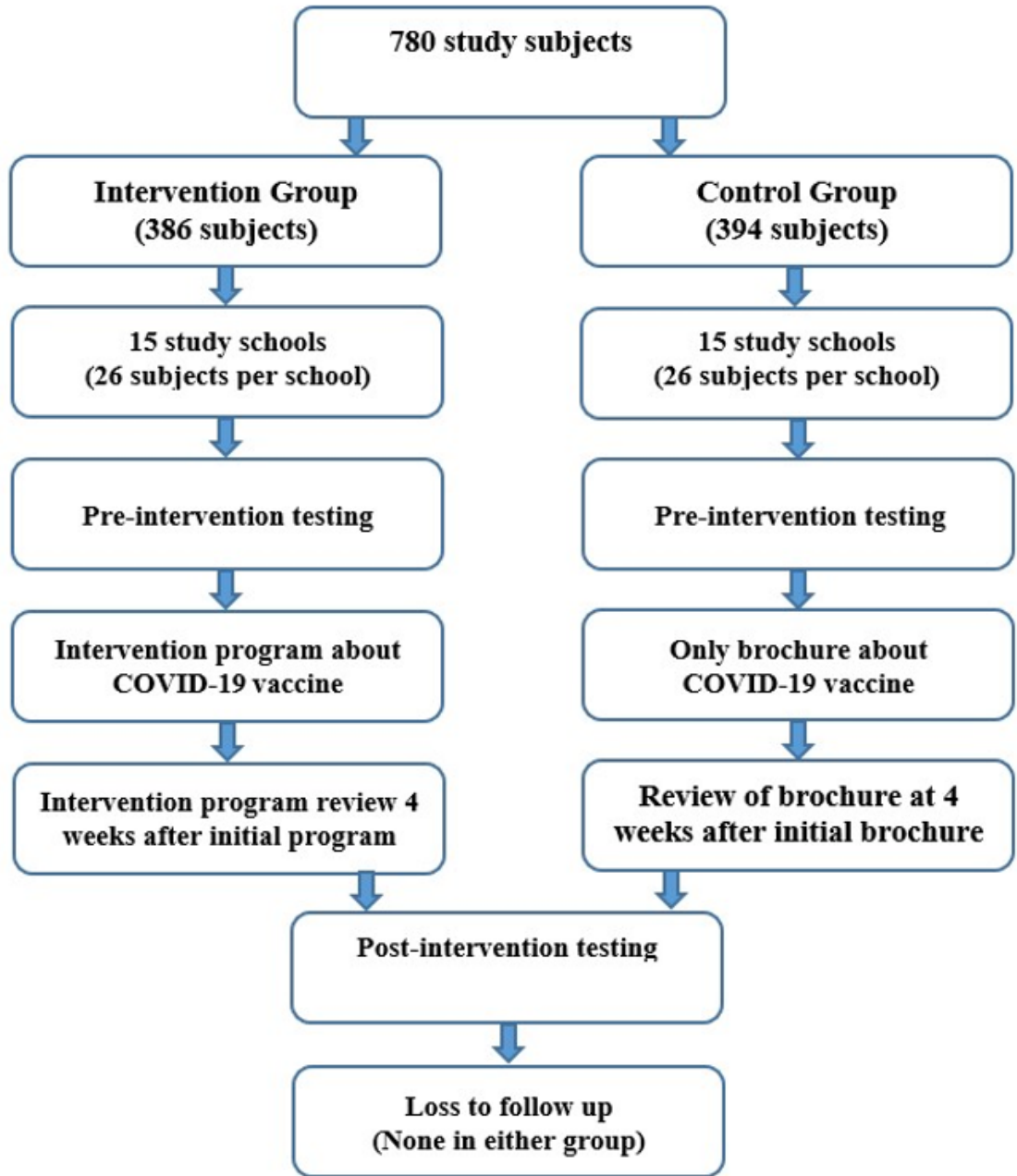


Fig 2 - Study flowchart

and the COVID-19 vaccine. It consisted of 15 Yes/No questions where a correct answer was given 1 point, and an incorrect answer was given 0 points. The total knowledge score ranged from 0 to 15 points. The mean scores were categorized as having low subject knowledge (<34th percentile), medium subject knowledge (34th-66th percentile) and high subject knowledge (>66th percentile) (Sheikh *et al*, 2023).

The third section assessed factors associated with COVID-19 vaccine hesitancy based on the 3C model of vaccine hesitancy and was divided into 3 parts: subject confidence, vaccine convenience and subject complacency. Answers to these questions were scored using a 5-point Likert scale with 1 being “strongly disagree” and 5 being “strongly agree”. The mean scores were categorized as being low (<34th percentile), medium (34th-66th percentile) and high (>66th percentile) (Sheikh *et al*, 2023). The confidence section contained 15 items with a possible score ranging from 15 to 75 points.

The convenience section contained 12 items with a possible score ranging from 12 to 60 points. The complacency section contained 12 items with a possible score ranging from 12 to 60 points. The mean scores were categorized as being low (<34th percentile), medium (34th-66th percentile) and high (>66th percentile). For complacency, higher score indicated lower complacency.

The fourth section asked a single Yes/No question, as to whether the subject would be willing to receive the COVID-19 vaccine or not.

The questionnaire was developed in English, translated into Urdu, the language most subjects were proficient in. Subjects were assured their answers would be kept confidential.

The intervention

Subjects in the control group were given a brochure about COVID-19 and the COVID-19 vaccine. They were given the same brochure again 4 weeks later.

Subjects in the intervention

group attended a 30-minute education program about COVID-19 and the COVID-19 vaccine that consisted of a presentation, posters and booklets. The same session was repeated again 4 weeks later.

Data analysis

Data were entered into the statistical package for social sciences (SPSS), version 22 (IBM Corp, Armonk, NY) and analysis was done using both SPSS and the statistical package STATA, version 18 (StataCorp, College Station, TX).

Frequencies were calculated to describe categorical variables, and significance was calculated with the Chi-square test. Means and standard deviations were calculated to describe quantitative variables. Pre- and post-intervention questionnaire score results for subject knowledge, confidence, convenience and complacency were compared using paired *t*-tests. Mean scores were compared between intervention and control groups using the independent *t*-test.

We conducted univariate

analysis to determine variables potentially associated with receiving the COVID-19 vaccine. Those variables with a *p*-value <0.25 on univariate analysis were included in a multilevel logistic regression analysis model. The appropriateness of the final model was assessed using the AIC and BIC goodness-of-fit tests.

We used multilevel logistic regression analysis to determine a significant association between the intervention and willingness to receive the vaccine. The factors included in the model were demographic characteristics and subject knowledge, confidence, convenience, and complacency scores. The results are presented as odds ratios (OR) with 95% confidence intervals (CI). All analyses were conducted with two-sided *p*-values, with statistical significance defined as a *p*-value of <0.05, except for univariate analysis, as mentioned above.

The primary outcome of the study was subject willingness to receive the COVID-19 vaccine.

The intervention program was the primary exposure.

Ethical approval

This study was approved by the Mahidol University Public Health Ethics Committee (MUPH 2023-092). Ethical approval for the study was also obtained from the Provincial Research Ethics Committee, Health Department, Government of Balochistan (No.2/PDSRU/FELTP/2023/45638-55). Written, informed consent was obtained from each subject prior to inclusion in the study.

RESULTS

A total of 780 subjects were included in the study: 386 (49.5%) (with 59.3% males) in the intervention group and 394 (50.5%) (with 56.6% males) in the control group. The mean (\pm standard deviation (SD)) ages of intervention and control subjects were: 16 (\pm 1.3) (range: 10-19) and 15.6 (\pm 1.3) (range: 10-19) years, respectively (Table 1).

The mean (\pm SD) knowledge

scores in the intervention and control groups increased significantly ($p=0.001$ and $p=0.001$, respectively) from before intervention (8.7 (\pm 2.9) and 9.0 (\pm 2.7), respectively) to after the intervention (11.7 (\pm 2.5) and 9.6 (\pm 2.3), respectively). The mean (\pm SD) subject knowledge scores in the intervention and control groups prior to the intervention were not significantly different from each other ($p=0.120$). The mean subject knowledge score in the intervention group after the intervention was significantly higher ($p<0.001$) than the control group after the intervention (Table 2).

The mean (\pm SD) subject confidence score in the intervention group decreased significantly ($p<0.001$) from before the intervention (41.4 (\pm 6.4)) to after the intervention (40.5 (\pm 6.5)) and the mean (\pm SD) subject confidence score in the control group increased significantly ($p<0.001$) from before the intervention (41.0 (\pm 6.3)) to after the intervention (42.8 (\pm 6.2)). The mean subject confidence scores in the intervention and control groups

before the intervention were not significantly different from each other ($p=0.330$). The mean subject confidence score in the intervention group was significantly lower than

the control group ($p<0.001$) after the intervention (Table 3).

The mean (\pm SD) vaccine convenience score in the intervention group increased

Table 1
Sociodemographic characteristics of study subjects by group

Characteristics	Frequency, <i>n</i> (%)		<i>p</i> -value
	Intervention group (N = 386)	Intervention group (N = 386)	
Type of school			<0.001 ^b
Government	229 (59.3)	154 (39.1)	
Private	157 (40.7)	240 (60.9)	
Sex			
Male	202 (52.3)	223 (56.6)	0.231 ^b
Female	184 (47.7)	171 (43.4)	
Age groups			
10-15 years	200 (51.8)	198 (50.3)	0.663 ^b
16-19 years	186 (48.2)	196 (49.7)	
Mean (\pm SD) years	15.5 (\pm 1.3)	15.6 (\pm 1.3)	0.457 ^c
Grade in school			
9 th	200 (51.8)	181 (45.9)	0.101 ^b
10 th	186 (48.2)	213 (54.1)	

^aUnless otherwise stated; ^bChi-square test used to compare the difference between study groups; ^cindependent t-test to compare of mean difference between study groups

SD: standard deviation

Table 2

Results for evaluating of COVID-19 vaccine knowledge before and after intervention among study subjects by group

Knowledge items	Pre-test, <i>n</i> (%)		Post-test, <i>n</i> (%)		<i>p</i> -value
	Intervention (N=394)	Control (N=386)	Intervention (N=386)	Control (N=394)	
Have you heard of COVID-19 before?					<0.001
Yes	316 (81.9)	275 (69.8)	361 (93.5)	339 (86.0)	0.001
No	70 (18.1)	119 (30.2)	25 (6.5)	55 (14.0)	
Can you name at least 3 COVID-19 symptoms?					<0.001
Yes	336 (87.0)	299 (75.9)	363 (94.0)	328 (83.2)	
No	50 (13.0)	95 (24.1)	23 (6.0)	66 (16.8)	
Do you know how COVID-19 spreads?					0.445
Yes	315 (81.6)	313 (79.4)	373 (96.6)	345 (87.6)	<0.001
No	71 (18.4)	81 (20.6)	13 (3.4)	49 (12.4)	
Are you aware of the importance of wearing a mask to prevent the spread of COVID-19?					0.153
Yes	364	380 (96.4)	374 (96.9)	305 (77.4)	<0.001
No	22	14 (3.6)	12 (3.1)	89 (22.6)	
Have you received information about the COVID-19 vaccine?					0.436
Yes	309 (80.1)	324 (82.2)	358 (92.7)	257 (65.2)	<0.001
No	77 (19.9)	70 (17.8)	28 (7.3)	137 (34.8)	

Table 2 (cont)

Knowledge items	Pre-test, <i>n</i> (%)		<i>p</i> -value	Post-test, <i>n</i> (%)		<i>p</i> -value
	Intervention (N=386)	Control (N=394)		Intervention (N=386)	Control (N=394)	
Do you know how vaccines work to protect against diseases?			0.069			<0.001
Yes	164 (42.5)	193 (49.0)		325 (84.2)	284 (72.1)	
No	222 (57.5)	201 (51.0)		61 (15.8)	110 (27.9)	
Are you familiar with the COVID-19 vaccines available?			0.416			0.288
Yes	148 (38.3)	140 (35.5)		231 (59.8)	221 (56.1)	
No	238 (61.7)	254 (64.5)		155 (40.2)	173 (43.9)	
Do you know the possible side effects of the COVID-19 vaccine?			0.022			0.033
Yes	148 (38.3)	183 (46.4)		231 (59.8)	206 (52.3)	
No	238 (61.7)	211 (53.6)		155 (40.2)	188 (47.7)	
Do you know the recommended COVID-19 vaccine age groups?			0.016			0.253
Yes	121 (31.3)	156 (39.6)		199 (51.6)	187 (47.5)	
No	265 (68.7)	238 (60.4)		187 (48.4)	207 (52.5)	
Do you think getting vaccinated against COVID-19 is important?			0.015			<0.001
Yes	116 (30.1)	151(38.3)		319 (82.6)	221(56.1)	
No	270 (69.9)	243 (61.7)		67 (17.4)	173 (43.9)	

Table 2 (cont)

Knowledge items	Pre-test, <i>n</i> (%)		Post-test, <i>n</i> (%)		<i>p</i> -value
	Intervention (N=386)	Control (N=394)	Intervention (N=386)	Control (N=394)	
Have you or anyone you know been vaccinated against COVID-19?					<0.001
Yes	172 (44.6)	184 (46.7)	296 (76.7)	207 (52.5)	
No	214 (55.4)	210 (53.3)	90 (23.3)	187 (47.5)	
Are you familiar with the concept of herd immunity and its role in controlling the spread of COVID-19?					0.039
Yes	119 (30.8)	173 (43.9)	189 (49.0)	164 (41.6)	
No	267 (62.2)	221 (56.1)	197 (51.0)	230 (58.4)	
Have you actively engaged in discussions or activities related to COVID-19 in school or at home?					<0.001
Yes	170 (44.0)	198 (50.3)	281 (72.8)	234 (59.4)	
No	216 (56.0)	196 (49.7)	105 (27.2)	160 (40.6)	
Would you like to learn more about COVID-19 and the vaccine?					<0.001
Yes	304 (78.8)	324 (82.2)	323 (83.7)	287 (72.8)	
No	82 (21.2)	70 (17.8)	63 (16.3)	107 (27.2)	

Note: Chi-square test was used to compare proportion difference between study groups.

COVID-19: coronavirus disease 2019

Table 3

Results for evaluating COVID-19 vaccine confidence before and after intervention among study subjects by group

Items about vaccine confidence	Mean (\pm SD) pre-intervention score*		p-value	Mean (\pm SD) post-intervention score*		p-value
	Intervention (n = 386)	Control (n = 394)		Intervention (n = 386)	Control (n = 394)	
I am worried about the side effects of the COVID-19 vaccine.	2.6 (\pm 1.5)	2.6 (\pm 1.5)	0.980	4.0 (\pm 1.1)	3.4 (\pm 1.4)	<0.001
The COVID-19 vaccine will protect me from getting COVID-19.	3.3 (\pm 1.3)	3.6 (\pm 1.2)	0.003	3.6 (\pm 1.4)	3.5 (\pm 1.3)	0.147
The COVID-19 vaccine is safe to give to pregnant and breastfeeding women.	2.6 (\pm 1.4)	2.6 (\pm 1.3)	0.885	3.1 (\pm 1.4)	3.1 (\pm 1.3)	0.687
The COVID-19 vaccine will help life to return to normal.	3.0 (\pm 1.3)	3.2 (\pm 1.3)	0.027	3.5 (\pm 1.3)	3.4 (\pm 1.2)	0.060
The COVID-19 vaccine causes infertility.	2.6 (\pm 1.2)	2.3 (\pm 1.2)	0.009	2.1 (\pm 1.3)	1.9 (\pm 1.2)	0.148
The COVID-19 vaccine can cause autism.	2.6 (\pm 1.1)	2.5 (\pm 1.1)	0.054	2.0 (\pm 1.3)	2.3 (\pm 1.4)	0.002
The COVID-19 vaccine can cause autoimmune disease.	2.8 (\pm 1.4)	2.8 (\pm 1.4)	0.691	1.8 (\pm 1.3)	2.5 (\pm 1.5)	<0.001
The COVID-19 vaccine can cause allergic reactions.	2.9 (\pm 1.2)	3.1 (\pm 1.3)	0.059	2.0 (\pm 1.4)	2.6 (\pm 1.5)	<0.001

Table 3 (cont)

Items about vaccine confidence	Mean (\pm SD) pre-intervention score*		p-value	Mean (\pm SD) post-intervention score*		p-value
	Intervention (n = 386)	Control (n = 394)		Intervention (n = 386)	Control (n = 394)	
I am concerned that receiving the COVID-19 vaccine could infect me with the virus.	2.8 (\pm 1.5)	2.8 (\pm 1.6)	0.476	2.0 (\pm 1.4)	2.6 (\pm 1.6)	<0.001
The COVID-19 vaccine can cause me to die.	2.1 (\pm 1.4)	1.9 (\pm 1.3)	0.012	1.6 (\pm 1.1)	3.2 (\pm 1.6)	<0.001
The COVID-19 vaccine is more dangerous than COVID-19.	2.6 (\pm 1.4)	2.2 (\pm 1.4)	<0.001	2.4 (\pm 1.5)	2.8 (\pm 1.5)	<0.001
I do not think the COVID-19 vaccine is safe because it was created too quickly.	2.8 (\pm 1.3)	2.7 (\pm 1.3)	0.303	1.9 (\pm 1.4)	2.4 (\pm 1.5)	<0.001
The COVID-19 vaccine should only be given to the elderly and those at high risk for complications due to COVID-19.	3.0 (\pm 1.3)	2.7 (\pm 1.3)	0.008	3.0 (\pm 1.6)	2.6 (\pm 1.6)	<0.001
Children can receive the COVID-19 vaccine.	2.4 (\pm 1.4)	2.5 (\pm 1.3)	0.366	3.5 (\pm 1.5)	2.7 (\pm 1.7)	<0.001
I have enough information to decide about receiving the COVID-19 vaccine.	3.3 (\pm 1.4)	3.4 (\pm 1.4)	0.400	3.8 (\pm 1.2)	3.7 (\pm 1.3)	0.073

*The score is from a Likert Scale of 1-5 with 1 meaning low confidence and 5 meaning high confidence.

COVID-19: coronavirus disease 2019; SD: standard deviation

significantly ($p < 0.001$) from before the intervention (38.5 (± 7.6)) (to after the intervention (40.1 (± 6.2)) but the mean (\pm SD) vaccine convenience score in the control group decreased significantly ($p < 0.001$) (from before the intervention (37.9 (± 7.1)) to after the intervention (35.8 (± 5.3)). The mean vaccine convenience scores were not significantly different between the intervention and control groups before the intervention. The mean vaccine convenience score was significantly higher ($p < 0.001$) in the intervention group after the intervention than in the control group after the intervention (Table 4).

The mean (\pm SD) subject complacency score in the intervention group increased significantly ($p = 0.006$) in the intervention group from before the intervention (30.6 (± 6.4)) to after the intervention (34.2 (± 0.7)) and the mean (\pm SD) subject complacency score in the control group increased significantly ($p = 0.006$) from before the intervention (31.5 (± 5.8)) to after the intervention (35.5 (± 5.8)).

The mean subject complacency scores in the intervention and control groups before the intervention were not significantly different from each other ($p = 0.034$). The mean subject complacency score after the intervention was significantly higher in the intervention than the control group ($p = 0.006$), indicating lower complacency and greater recognition of COVID-19 risks and need for vaccination in the intervention group (Table 5).

Table 6 compares the overall scores of knowledge, confidence, convenience and complacency at pre- and post-intervention among the study subjects. It shows that after the intervention, those scores in the intervention group and control group were significantly different.

Significantly more (adjusted odds ratio (aOR) = 3.716; 95% confidence interval (CI): 1.323-10.443; $p = 0.013$) subjects in the intervention (51.0%) than the control group (35.0%) stated they would be willing to receive the COVID-19 vaccine after the intervention (Table 7).

Table 4

Results for evaluating COVID-19 vaccine convenience before and after intervention among study subjects by group

Items about vaccine convenience	Mean (\pm SD) pre-intervention score*		Mean (\pm SD) post-intervention score*		<i>p</i> -value
	Intervention (<i>n</i> = 386)	Control (<i>n</i> = 394)	Intervention (<i>n</i> = 386)	Control (<i>n</i> = 394)	
I will only get vaccinated if the access to the vaccination site is convenient for me.	2.9 (\pm 1.4)	2.9 (\pm 1.4)	2.2 (\pm 1.5)	2.0 (\pm 1.4)	0.059
I will get vaccinated if the government recommends it.	3.2 (\pm 1.4)	3.1 (\pm 1.4)	3.6 (\pm 1.4)	2.7 (\pm 1.4)	<0.001
I will get vaccinated if my family members are vaccinated and recommends it.	3.3 (\pm 1.4)	3.2 (\pm 1.4)	3.8 (\pm 1.3)	3.7 (\pm 1.3)	0.404
I will get vaccinated if the government officials are themselves vaccinated.	3.7 (\pm 1.3)	3.3 (\pm 1.3)	3.9 (\pm 1.1)	3.8 (\pm 1.1)	0.029
I will get vaccinated if it is recommended by a healthcare professional.	3.7 (\pm 1.2)	3.6 (\pm 1.3)	3.9 (\pm 1.1)	3.8 (\pm 1.2)	0.403
I will get vaccinated if it is recommended by the head of my religion	3.3 (\pm 1.3)	3.1 (\pm 1.3)	3.9 (\pm 1.1)	3.9 (\pm 1.1)	0.634

Table 4 (cont)

Items about vaccine convenience	Mean (\pm SD) pre-intervention score*		p-value	Mean (\pm SD) post-intervention score*		p-value
	Intervention (n = 386)	Control (n = 394)		Intervention (n = 386)	Control (n = 394)	
I will get vaccinated if my friends get vaccinated and express satisfaction with the experience.	3.5 (\pm 1.4)	3.4 (\pm 1.4)	0.380	3.7 (\pm 1.2)	2.2 (\pm 1.4)	<0.001
I will get vaccinated if a vaccination certificate is required by my employer.	3.4 (\pm 1.4)	3.3 (\pm 1.5)	0.240	3.7 (\pm 1.3)	3.5 (\pm 1.4)	0.048
I will get vaccinated if a vaccination proof is required for travel.	3.5 (\pm 1.3)	3.6 (\pm 1.3)	0.354	3.7 (\pm 1.2)	2.6 (\pm 1.5)	<0.001
I will get vaccinated because I belong to a group that has a high risk of exposure to COVID-19.	2.4 (\pm 1.3)	2.4 (\pm 1.4)	0.836	2.2 (\pm 1.4)	3.3 (\pm 1.5)	<0.001
I will get vaccinated because I live with someone who has a high risk of exposure to COVID-19.	2.7 (\pm 1.5)	2.8 (\pm 1.5)	0.661	1.9 \pm 1.3	2.0 (\pm 1.4)	0.105
I will get vaccinated because my decision will benefit the community.	3.1 (\pm 1.3)	3.2 (\pm 1.2)	0.107	3.7 \pm 1.3	2.3 (\pm 1.5)	<0.001

*The score is from a Likert Scale of 1-5 with 1 meaning low convenience and 5 meaning high convenience.

COVID-19: coronavirus disease 2019; SD: standard deviation

Table 5

Results for evaluating of COVID-19 vaccine complacency before and after intervention among study subjects by group

Items	Mean (\pm SD) pre-intervention score ^a		<i>p</i> -value	Mean (\pm SD) post-intervention score ^a		<i>p</i> -value ^c
	Intervention (<i>n</i> = 386)	Control (<i>n</i> = 394)		Intervention (<i>n</i> = 386)	Control (<i>n</i> = 394)	
Vaccine complacency						
COVID-19 is not serious and it should be treated like a normal flu.	2.7 (\pm 1.6)	2.7 (\pm 1.7)	0.869	2.4 (\pm 1.5)	3.4 (\pm 1.5)	<0.001
The media has given COVID-19 unnecessary hype.	3.0 (\pm 1.5)	3.3 (\pm 1.5)	0.005	3.5 (\pm 1.3)	3.4 (\pm 1.4)	0.884
If I get COVID-19 I do not need to get the COVID-19 vaccine.	3.2 (\pm 1.3)	3.2 (\pm 1.4)	0.749	2.8 (\pm 1.5)	3.8 (\pm 1.2)	<0.001
If I get the COVID-19 vaccine I will not have to follow social distancing or any other pandemic restrictions.	2.9 (\pm 1.5)	3.1 (\pm 1.4)	0.218	2.4 (\pm 1.5)	3.3 (\pm 1.4)	<0.001
Getting the COVID-19 vaccine does not guarantee I will not get COVID-19.	2.7 (\pm 1.3)	2.7 (\pm 1.3)	0.686	3.2 (\pm 1.4)	3.0 (\pm 1.5)	0.114
I wear mask regularly.	2.8 (\pm 1.6)	2.9 (\pm 1.6)	0.647	3.5 (\pm 1.4)	3.8 (\pm 1.4)	0.005
I take precautionary measures, like avoiding large crowds.	2.9 (\pm 1.4)	2.7 (\pm 1.5)	0.127	3.4 (\pm 1.4)	2.2 (\pm 1.4)	<0.001

Table 5 (cont)

Items	Mean (±SD) pre-intervention score ^a		p-value	Mean (±SD) post-intervention score ^a		p-value ^c
	Intervention (n = 386)	Control (n = 394)		Intervention (n = 386)	Control (n = 394)	
Vaccine complacency						
I avoid close contact with people, such as shaking hands	2.4 (±1.4)	2.8 (±1.6)	0.001	3.2 (±1.6)	3.0 (±1.6)	0.197
I isolate myself when I or my family members developed cough or fever.	2.4 (±1.5)	2.6 (±1.5)	0.017	3.2 (±1.5)	3.1 (±1.6)	0.466
I avoided going to family functions if I have COVID-19 symptoms.	2.6 (±1.4)	2.7 (±1.5)	0.558	3.3 (±1.5)	2.9 (±1.7)	0.001
I strictly follow WHO recommendations regarding COVID-19 restrictions.	2.9 (±1.4)	2.8 (±1.4)	0.763	3.3 (±1.4)	3.5 (±1.4)	0.028
Vaccination acceptance						
Are you willing to receive the COVID-19 vaccine?						
Yes	166 (43.0)	138 (35.0)	0.022 ^b	197 (51.0)	139 (35.3)	<0.001 ^c
No	220 (57.0)	256 (65.0)		189 (49.0)	255 (64.7)	

^aThe score is from a Likert Scale of 1-5 with 1 meaning low confidence and 5 meaning high confidence;

^bChi-square test was used to compare proportion difference between study groups, ^cindependent t-test was used to compare of mean difference between study groups

COVID-19: coronavirus disease-2019; SD: standard deviation; WHO: World health Organization.

Table 6
Comparison of knowledge, confidence, convenience and complacency overall scores at pre- and post-intervention among study subjects

Items	Pre-test score, mean (\pm SD)			Post-test score, mean (\pm SD)			<i>p</i> -value
	Intervention group (<i>n</i> = 386)	Control group (<i>n</i> = 394)	Difference (Intervention-Control)	Intervention group (<i>n</i> = 386)	Control group (<i>n</i> = 394)	Difference (Intervention-Control)	
Knowledge	8.7 (\pm 2.9)	9.0 (\pm 2.7)	-0.3 (\pm 0.2)	11.7 (\pm 2.5)	9.6 (\pm 2.3)	2.0 (\pm 0.2)	<0.001
Confidence	41.4 (\pm 6.4)	41.0 (\pm 6.3)	0.4 (\pm 0.5)	40.5 (\pm 6.5)	42.8 (\pm 6.2)	-2.3 (\pm 0.5)	<0.001
Convenience	38.5 (\pm 7.6)	37.9 (\pm 7.1)	0.7 (\pm 0.5)	40.1 (\pm 6.2)	35.8 (\pm 5.3)	4.3 (\pm 0.4)	<0.001
Complacency	30.6 (\pm 6.4)	31.5 (\pm 5.8)	-0.9 (\pm 0.4)	34.2 (\pm 0.7)	35.5 (\pm 5.8)	-1.3 (\pm 0.5)	0.006

Note: An un-paired t-test was used to calculate the *p*-value for two independent samples.
SD: standard deviation

In the intervention group, there was a significant positive association between being willing to have the COVID-19 vaccine and having a high knowledge score (aOR = 6.085; 95% CI: 2.523-14.676; $p < 0.001$), having a high vaccine convenience score (aOR = 4.899; 95% CI: 1.984-12.094; $p = 0.001$) and having a high subject complacency score (aOR = 4.521; 95% CI: 1.887-10.828; $p = 0.001$) (Table 7).

Table 7 also shows that female subjects in the intervention group, but not in the control group, were significantly more likely to receive the COVID-19 vaccine than male subjects (aOR = 4.761; 95% CI: 1.711-13.251; $p = 0.001$). Prior to the intervention, 43.0% of subjects in the intervention group and 35.0% of subjects in the control group were willing to receive the COVID-19 vaccine ($p = 0.022$). After the intervention, 51.0% of subjects in the intervention group and 35.5% of subjects in the control group ($p < 0.001$) were willing to receive the vaccine. The percentage of subjects in the intervention group

who were willing to receive the vaccine after the intervention increased significantly ($p < 0.001$) and the percentage of subjects in the control group who were willing to receive the vaccine after the intervention also increased significantly ($p < 0.001$) but to a lower extent.

DISCUSSION

Our results show the school-based intervention significantly improved subject knowledge and subject convenience and decreased subject complacency and subject confidence about receiving the COVID-19 vaccine.

In our study, subject knowledge about COVID-19 and the COVID-19 vaccine significantly increased in both intervention and control groups, but knowledge scores were higher in the intervention group. Other studies also reported educational interventions improved COVID-19 knowledge scores among school children (Sheikh *et al*, 2023; Rehman, 2021).

Table 7

Multilevel logistic regression analysis of selected factors associated with willingness to receive the COVID-19 vaccine

Study group	Characteristics	Crude OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Time	Intervention	5.0 (1.82-13.732)	0.002	3.716 (1.323-10.443)	0.013
	Control	Ref			
Time	Pre-intervention	Ref			
	Post-intervention	1.711 (1.091-2.684)	0.019		
Knowledge scores	Low	Ref			
	Medium	2.007 (0.973-4.141)	0.059	1.662 (0.802-3.44)	0.172
	High	10.992 (4.527-26.691)	<0.001	6.085 (2.523-14.676)	<0.001
Confidence scores	Low	Ref			
	Medium	0.624 (0.296-1.318)	0.216		
	High	0.533 (0.218-1.306)	0.169		
Convenience scores	Low	Ref			
	Medium	3.29 (1.518-7.132)	0.003	2.88 (1.311-6.325)	0.008
	High	6.407 (2.666-15.396)	<0.001	4.899 (1.984-12.094)	0.001

Table 7 (cont)

Characteristics	Crude OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Complacency scores				
Low	Ref			
Medium	1.83 (0.836-4.008)	0.131	1.456 (0.675-3.139)	0.338
High	6.614 (2.729-16.031)	<0.001	4.521 (1.887-10.828)	0.001
Gender				
Male	Ref			
Female	4.761 (1.711-13.251)	0.003		
Age group				
10-15 years	Ref			
16-19 years	0.853 (0.312-2.333)	0.757		
Grade in school				
9 th	Ref			
10 th	3.591 (1.266-10.189)	0.016		
School type				
Government	0.619 (0.216-1.77)	0.371		
Private	Ref			

Note: Knowledge, confidence, convenience and complacency scores are categorized as follows - Low: <34th percentile; Medium: 34th-66th percentile; High: >67th percentile.

CI: confidence interval; COVID-19: coronavirus disease 2019; OR: odds ratio; Ref: reference

However, in our study intervention group subject confidence scores significantly decreased after the intervention but not in the control group. This shows the intervention was inferior to the previously used brochure for improving subject confidence. This decrease in confidence could be due to exposure to information that caused the subjects to be worried about the vaccine. This was seen in previous similar studies (Sheikh *et al*, 2023; Dubé *et al*, 2015).

This component of the intervention needs to be changed to better go along with what was written in the brochure used for the control group. Further study is needed to find out the exact reasons for the difference between the control and intervention groups in this area and how to improve it.

The subject vaccine convenience scores significantly increased after the intervention in the intervention group, but not in the control group in our study. This suggests that the educational intervention was more successful in improving

the participants' perception of convenience compared to the brochure. Numerous studies have highlighted the role that convenience has to play in vaccine uptake especially among adolescents (Dubé *et al*, 2015; Thompson *et al*, 2021).

In our study, after the intervention, complacency scores increased significantly in both intervention and the control groups but the complacency score was higher in intervention group, showing less complacency, indicating the intervention group had better perception of the risk of COVID-19 and the need for vaccination. This agrees with previous similar studies showing educational interventions can reduce complacency when misinformation is debunked and the gravity of vaccine-preventable diseases is emphasized (Sheikh *et al*, 2023; Rehman, 2021).

In our study, after the intervention significantly more subjects in the intervention group were willing to receive the vaccine showing the intervention improved

both knowledge and willingness to receive the vaccine. Previous studies have also reported greater knowledge, convenience and complacency decrease vaccine hesitancy (Larson *et al*, 2014; Thompson *et al*, 2021).

In our study, females were more willing to receive COVID vaccination. This is consistent with a previous study which reported finding females were more likely to exhibit health seeking behavior and are more responsive to health education interventions (Seale *et al*, 2021).

Strengths and weaknesses of the study

Our study was confined to high school students in one region, so cannot be applicable to other populations. Another limitation was the significant difference knowledge scores between the control and intervention groups. This could be due proportions of private- and public-school students varied between the control and intervention groups. This difference in baseline scores was not known

until the study was already started and could not be controlled for. A higher proportion of private school subjects in the intervention group may have resulted in a greater baseline knowledge score in this population. In retrospect, this should have been accounted for by having the proportions of public and private school subjects the same. Our study was retrospective so was subject to recall bias. The short study period might have also interfered with scores among subjects. Finally, limited resources interfered with choosing a larger study population.

In summary, we found that both the previously used brochure and the intervention both improved subject knowledge about COVID-19 and the COVID-19 vaccine but more people in the intervention group said they would be willing to receive the COVID-19 vaccine, which was the main goal of the intervention. The proportion of subjects who said they would be willing to receive the vaccine was still low, at only 51%. We conclude

the intervention was effective but there is still room for improvement. Further studies are needed to determine what other factors are involved in vaccine hesitancy in the study population and how to improve the proportion of subjects who would be willing to receive the vaccine.

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CONFLICT OF INTEREST DISCLOSURE

The authors declare no conflicts of interest.

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