

The interference of protective masks on teachers' sensation of vocal effort, voice use, self-reported vocal quality, and vocal signs and symptoms

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ABSTRACT

Purpose: to analyze possible interferences of face masks on teachers' sensation of vocal effort, voice use, self-reported vocal quality, and vocal signs and symptoms.

Methods: an observational cross-sectional study with 212 teachers (175 women; 37 men; mean age of 47 years), working at different education levels. They were contacted from the database of a previous study and completed an online questionnaire upon returning to in-person classes during the COVID-19 pandemic. Association analyses between aspects of mask use and other variables were performed using Fisher's exact test, Kruskal-Wallis H test, and Student's t test, with a 5% significance level.

Results: 85% of participants wore masks in class, mainly surgical and FFP2/N95 ones. They reported increased vocal effort, difficulty in being understood, general fatigue, and the need to speak louder; 54% removed the mask to facilitate communication. Those who did not wear a mask had worse vocal quality and more hoarseness. The mask type was not relevant; reporting negative interference from the mask was associated with vocal signs and symptoms.

Conclusion: the mask interfered with these teachers' communication, further hindering occupational voice use where the occurrence of dysphonia is already high.

Keywords: Voice; COVID-19; Faculty; N95 Respirators; Containment of Biohazards



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INTRODUCTION

COVID-19, the infectious disease caused by the SARS-CoV-2, spread rapidly globally and was classified as a pandemic in 2020 by the World Health Organization¹. Measures were implemented to contain the spread of the disease, considering the lack of vaccines and effective treatments at the time. Among the practices to control the exponential transmission of the virus, social distancing and the use of personal protective face masks became standard measures².

However, they brought about significant changes in people's lives, particularly in the way many professionals work – including teachers^{3,4}, whose occupational performance depends on effective communication, and who were forced to adapt to emergency remote teaching.

This professional group is at a higher risk of developing voice changes and symptoms than the general population⁵⁻⁷. This happens due to several factors, such as the organizational and environmental teaching conditions, incorrect voice use due to lack of knowledge and preparation, and aspects related to health and lifestyle⁶⁻⁸.

In the literature, the prevalence of vocal disorders in teachers is quite variable: between 9% and 37% when self-reported considering the specific moment, between 15% and 80% self-reported considering the last 12 months, and between 17% and 57% when clinically evaluated⁷. Dysphonia has a direct and indirect impact on these professionals' quality of life, and vocal fatigue appears as the most prevalent symptom⁹.

In Brazil, in-person activities in educational institutions returned gradually after the period of stricter social distancing, as vaccinations to combat COVID-19 advanced. Hence, certain adaptations and changes were necessary. The use of personal protective masks was maintained to minimize the transmission of the disease, due to their effect of suppressing the spread of aerosols and droplets that can carry the virus^{10,11}.

Despite their protective aspect, masks interfere with verbal communication by making it difficult to clearly and accurately understand the spoken message and by preventing orofacial reading, which can lead to increased vocal effort^{5,12-15}. Face masks may also compromise respiratory flow during inhalation and exhalation and cause uncoordinated breathing and speech^{12,14,15}. Therefore, there may be discomfort, vocal fatigue^{10,11,14,16}, and psychosocial and socioemotional difficulties¹³. All these factors can contribute to the occurrence of dysphonia, especially in professionals

such as teachers who are historically at high risk¹². The impact of wearing a mask may be even greater for teachers who have dysphonia.

Furthermore, the interference of the mask in communication between teachers and students can hinder the teaching-learning process^{5,17}.

When studying the impact of wearing protective masks on teachers' communication, it is also important to consider the differences between them in terms of composition, filter, type of fit, and thickness¹⁴. Recent studies have indicated that surgical masks present the lowest attenuation of sound frequency and intensity, followed by KN95/N95, fabric masks, and lastly faceshields^{11,18}. Therefore, surgical masks would be the most recommended for teachers to use at work¹¹.

Although masks were widely used when in-person activities resumed during the COVID-19 pandemic, many teachers maintain this practice when viral infections occur (whether they, colleagues, or students are the ones infected) and when reports indicate an increase in COVID-19 and influenza cases in their region. Some teachers continue to wear masks during classes, regardless of explicit risks. Therefore, speech-language-hearing care for teachers' voice and communication should incorporate guidelines and practices for the use of this personal protective equipment (PPE) to facilitate communication and avoid inadequate adjustments directly related to dysphonia.

Thus, this study aimed to analyze the impact caused by the use and type of facial protection masks on teachers' vocal effort, amount of voice use, self-reported vocal quality, and vocal signs and symptoms.

METHODS

This observational cross-sectional study was approved by the Ethics Committee for Analysis of Research Projects of the Clinics Hospital of the Medical School of the Universidade de São Paulo, SP, Brazil, under evaluation report number 4.614.973 and CAAE number 32876820.8.0000.0068. Teachers were invited to participate in the study in March 2022, when the number of COVID-19 cases was still rather high, and they were in in-person activities with mandatory indoor mask use.

All teachers participating in a previous study were contacted by email⁴. The inclusion criteria were being an active teacher and teaching in-person classes at the time of data collection, regardless of age, sex, type of school, number of schools, education levels (kindergarten, elementary school, middle school, high

school, and university), and subjects they taught at the time. The exclusion criteria were being a retired teacher or not teaching during the period of social distancing caused by the COVID-19 pandemic for some other reason.

Those who agreed to participate signed an informed consent form and answered a questionnaire prepared on Google Forms specifically for this research. The questions addressed the teachers' perception of the impact of wearing a respiratory protection mask on their vocal effort (whether their vocal effort was greater, lesser, or equal to what it was before the pandemic), how much they were using their voice when they returned to work in person, how much they used it during social isolation, and how much they used it before the pandemic (on a 4-point scale from 0 [little use] to 4 [much use]), self-reported vocal quality (very poor, poor, fair, good, and very good), and the presence of vocal signs and symptoms when they returned to work in person; the type of mask, the frequency of use, and whether they perceived any negative interference from wearing the mask in their communication at work. The number of respondents for each block of questions could vary.

Of the 1,253 teachers contacted (1,025 women – 81.8%; 228 men – 18.2%; mean age of 43.1 years), 212 (16.9%) were interested in and willing to participate, all meeting the inclusion and exclusion criteria. Of the 212 study participants, 175 (82.5%) were women and 37 (17.4%) were men, aged 26 to 74 years (mean of 47.1 years), from 10 different Brazilian states (Bahia, Goiás, Mato Grosso do Sul, Minas Gerais, Paraíba, Pernambuco, Rio de Janeiro, Rio Grande do Sul, Santa Catarina, and São Paulo). The mean self-reported length of service was 20 years, with a minimum of 3 and a maximum of 50 years. The majority (56%) reported 5 to 8 hours of classes per day, and 94.8% did not use a microphone. Around 90% did not smoke. Of the total, 174 (82.1%) reported only teaching in-person classes,

30 (14.2%) taught in-person and online classes at different times, and nine (4.2%) taught simultaneous online and in-person classes. There were teachers from public and private schools and different education levels; around 10% of them had classes with more than 40 students.

Association analyses were performed between mask use, mask type, and negative interference from mask use and the following variables: vocal effort, amount of voice use, self-reported vocal quality, and vocal signs and symptoms upon returning to in-person classes. The analysis used the Statistical Package for the Social Sciences (SPSS), version 28.0 (IBM Corp., Armonk, NY, USA). The Fisher's exact test, Kruskal-Wallis H test, and Student's t-test were applied with a bias-corrected and accelerated bootstrap sampling method based on 1,000 samples; the bias-corrected and accelerated method based on 1,000 bootstrap samples was used to calculate the 95% confidence intervals. Statistical significance was set at 5% ($p \leq 0.05$).

RESULTS

Most teachers reported wearing masks during work activities when they returned to in-person classes; however, approximately 15% did not continue wearing them, even though they were mandatory. The most used masks were the FFP2/N95 (39.0%) and the surgical mask (38.4%). The majority (76.7%) perceived that masks negatively interfered with communication during work, with a greater impact on speech comprehension, vocal effort, the need to repeat speech, and fatigue; and a lesser impact on students' attention focus and learning. While wearing masks, teachers felt the need to use their voices louder than usual (pre-pandemic), and just over half of those who responded (93 of 172; 54%) reported removing the mask to improve communication. A large proportion (57.8%) attributed the worsening of their voices to returning to in-person work (Table 1).

Table 1. Descriptive data on teachers' mask use and its possible interference with their voices and return to in-person activities

Variables	Categories	Absolute frequency (N)	Relative frequency (%)
Mask use	No	32	15.7
	Yes	172	84.3
Mask type	Surgical mask	66	38.4
	Fabric mask	26	15.1
	FFP2/N95	67	39.0
	Others	13	7.5
Negative interference from the mask	No	40	23.3
	Yes	132	76.7
Students' learning	No	173	81.2
	Yes	40	18.8
Speech comprehension	No	69	32.4
	Yes	144	67.6
Students' attentional focus	No	152	71.4
	Yes	61	28.6
Need to repeat	No	85	39.9
	Yes	128	60.0
Fatigue	No	101	47.4
	Yes	112	52.6
Vocal effort	No	81	38.0
	Yes	132	62.0
Voice intensity wearing a mask	Same as usual	37	21.5
	Stronger than usual	135	78.5
Removing the mask for better communication	No	79	45.9
	Yes	93	54.0
Effect of returning to in-person work on the voice	The voice worsened	118	57.8
	The voice remained the same	77	37.8
	The voice improved	9	4.4

Captions: N = number; % = percentage

Among the teachers who said they removed their masks during class to improve communication, it was observed that the majority considered their voice to be terrible, bad or average (70 - 75% versus 55 - 69.6% of those who did not remove the mask); indicated frequent vocal fatigue (80 - 86.0% versus 60 - 75.9% of those who did not remove the mask) and noticed voice flaws (42 - 45.2% versus 27 - 34.2% of those who did not remove the mask).

Those who did not wear a mask rated their voice as very poor/poor/fair more often and complained more about hoarseness than those who wore a mask. Vocal effort, amount of voice use, and other signs and symptoms were not associated with mask use (Table 2).

No difference was found in vocal effort, voice use, or self-reported vocal quality between mask types (Table 3).

Table 2. Association between variables of interest and mask use by teachers

Variables	Categories	Mask use						p-value
		No		Yes		Total		
		N	%	N	%	N	%	
Greater vocal effort than usual	No	8	25.0	38	22.1	46	22.5	0.818 ^a
	Yes	24	75.0	134	77.9	158	77.5	
Amount of voice use	0 – little use	0	0.0	0	0.0	0	0.0	0.106 ^b
	1	0	0.0	1	0.6	1	0.5	
	2	0	0.0	4	2.3	4	2.0	
	3	2	6.2	27	15.7	29	14.2	
	4 – much use	30	93.8	140	81.4	170	83.3	
Self-reported vocal quality	very poor / poor / fair	13	40.6	52	30.20	65	31.9	< 0.001 ^{a*}
	good / very good	19	59.4	120	69.8	139	68.1	
Vocal signs and symptoms								
Breathy voice	No	29	90.6	152	88.4	181	88.7	> 0.999 ^a
	Yes	3	9.4	20	11.6	23	11.3	
Fatigued voice	No	12	37.5	63	36.7	75	36.8	> 0.999 ^a
	Yes	20	62.5	109	63.3	129	63.2	
Sore throat	No	20	62.5	111	64.5	131	64.2	0.843 ^a
	Yes	12	37.5	61	35.5	73	35.8	
Speaking loudly	No	7	21.9	66	38.4	73	35.8	0.107 ^a
	Yes	25	78.1	106	61.6	131	64.2	
Voice failures	No	19	59.4	103	59.9	122	59.8	> 0.999 ^a
	Yes	13	40.6	69	40.1	82	40.2	
Dry throat	No	12	37.5	65	37.8	77	37.8	> 0.999 ^a
	Yes	20	62.5	107	62.2	127	62.2	
Shouting	No	22	68.8	130	75.6	152	74.5	0.507 ^a
	Yes	10	31.2	42	24.4	52	25.5	
Clearing the throat	No	20	62.5	127	73.8	147	72.0	0.202 ^a
	Yes	12	37.5	45	26.2	57	28.0	
Hoarseness	No	12	37.5	103	59.9	115	56.4	0.021 ^{a*}
	Yes	20	62.5	69	40.1	89	43.6	

Fisher's exact test (^a), Kruskal-Wallis H-test (^b)Captions: N = number; % = percentage; * statistically significant value at 5% ($p \leq 0.05$)**Table 3.** Association between variables of interest and the type of mask used by teachers

Variables	Categories	Mask type								p-value
		Surgical		Fabric		FFP2/N95		Total		
		N	%	N	%	N	%	N	%	
Greater vocal effort than usual	No	16	24.2	7	26.92	12	17.91	35	22.01	0.524 ^a
	Yes	50	75.8	19	73.08	55	82.09	124	77.99	
Amount of voice use	0 – little use	0	0.00	0	0.00	0	0.00	0	0.00	0.613 ^b
	1	1	1.5	0	0.00	0	0.00	1	0.63	
	2	2	3.0	0	0.00	1	1.49	3	1.89	
	3	10	15.2	3	11.54	11	16.42	24	15.09	
	4 – much use	53	80.3	23	88.46	55	82.09	131	82.39	
Self-reported vocal quality	Very poor	0	0.0	0	0.0	1	1.4	1	0.6	0.293 ^b
	Poor	4	6.0	1	3.8	2	3.0	7	4.4	
	Fair	17	25.8	8	30.9	15	22.4	40	25.2	
	Good	33	50.0	14	53.8	30	44.8	77	48.4	
	Very good	12	18.2	3	11.5	19	28.4	34	21.4	

Fisher's exact test (^a) and Kruskal-Wallis H-test (^b)

Captions: N = number; % = percentage

Reporting negative interference of the mask on communication was statistically significantly associated with greater presence of voice fatigue, sore throat, speaking loudly, voice failures, dry throat, throat

clearing, and hoarseness (Table 4). The mean number of vocal signs and symptoms was higher among teachers who indicated negative interference of mask use on communication (Table 5).

Table 4. Association between vocal signs and symptoms and the negative interference of the mask

Variables	Categories	Negative interference of the mask						p-value
		No		Yes		Total		
		N	%	N	%	N	%	
Breathy voice	No	37	92.5	115	87.1	152	88.4	0.573
	Yes	3	7.5	17	12.9	20	11.6	
Fatigued voice	No	23	57.5	40	30.3	63	36.6	0.003*
	Yes	17	42.5	92	69.7	109	63.4	
Sore throat	No	35	87.5	76	57.6	111	64.5	0.001*
	Yes	5	12.5	56	42.4	61	35.5	
Speaking loudly	No	23	57.5	43	32.6	66	38.4	0.006*
	Yes	17	42.5	89	67.4	106	61.6	
Voice failure	No	34	85.0	69	52.3	103	59.9	< 0.001*
	Yes	6	15.0	63	47.7	69	40.1	
Dry throat	No	24	60.0	41	31.1	65	37.8	0.001*
	Yes	16	40.0	91	68.9	107	62.2	
Shouting	No	35	87.5	95	72.0	130	75.6	0.058
	Yes	5	12.5	37	28.0	42	24.4	
Clearing the throat	No	38	95.0	89	67.4	127	73.8	< 0.001*
	Yes	2	5.0	43	32.6	45	26.2	
Hoarseness	No	35	87.5	68	51.5	103	59.9	< 0.001*
	Yes	5	12.5	64	48.5	69	40.1	

Fisher's exact test

Captions: N = number; % = percentage; * Statistically significant value at 5% ($p \leq 0.05$)

Table 5. Association between the number of vocal signs and symptoms and the negative interference of the mask

Variable	Negative interference of the mask	N	Mean	SD	Median	Min.	Max.	p-value
Number of vocal signs and symptoms	No	40	1.90	1.98	1.00	0.00	6.00	0.001*
	Yes	132	4.18	2.09	4.00	0.00	9.00	

Student's t-test for independent samples

Captions: N = number; SD = standard deviation; Min. = Minimum; Max. = Maximum; *Statistically significant value at 5% ($p \leq 0.05$)

DISCUSSION

The COVID-19 pandemic has brought the use of face masks into classrooms upon the return to in-person teaching. Although much less frequent today, they are still used in more specific situations, making it even more important to better understand the relationship between mask use and teachers'

communicative efficiency and incorporate this topic into health promotion/vocal improvement actions.

Most teachers in the study reported wearing masks in in-person classes. Their use was mandatory indoors at the time of data collection, meaning that all teachers would be expected to be wearing this PPE. The negative impact of masks on communication, mentioned by most teachers, possibly hindered this adherence and

caused other teachers to remove their masks during classes to facilitate communication with students. This impact was clear as it was associated with seven of the nine vocal symptoms studied. Other studies agree with these findings, since masks increased vocal effort and difficulties in speech intelligibility and in breathing/speech coordination^{13,14} – which also increase vocal fatigue, as observed in this study.

Vocal effort is one of the main risk factors for developing behavioral dysphonia in this professional category, whose vocal problems are significantly higher than in the general population^{5,6,9,19}, and for which vocal fatigue is the main symptom^{5,11}. Furthermore, it was observed that more than 80% of those who did not use the mask had negatively rated their voice – i.e., they possibly had vocal changes/difficulties even before being challenged to communicate in the classroom wearing protective masks.

Besides not all participants wearing masks, half of the teachers who did wear them said they took them off to facilitate communication, exposing themselves to the risk of viral transmission so as not to disrupt classes and student learning. This type of attitude shows how difficult it is for teachers not to know how to deal with communication difficulties that arise at work – “a need to communicate at any cost”¹⁷, which is quite worrying. They did not wear or remove the mask or reduce voice use. University professors reported that the mask reduces communicative effectiveness and makes it difficult for students to understand¹⁷. On the other hand, this attitude may have reduced the chance of these teachers presenting compensatory adjustments such as increasing voice intensity and frequency and laryngeal tension^{13,14}. Thus, it was impossible to establish an association between mask use and vocal effort, voice use, and self-reported vocal quality.

Most teachers noticed that their voices worsened when they returned to in-person work. Whereas other studies on voice use during the pandemic found improvements in voices during emergency remote teaching compared to pre-pandemic in-person teaching^{4,20,21}, it would be expected that this return would bring back the difficulties of in-person teaching – particularly due to the noise, which was much more easily controlled in remote teaching²². In addition, some teachers taught online and in-person classes simultaneously, increasing the communication challenge.

Another very relevant finding was that teachers who did not wear masks had worse vocal quality and greater presence of hoarseness, which reinforces the

hypothesis that those teachers who perceived their voice as having good or very good quality felt safer to continue using PPE. Those who reported worse voices and greater presence of hoarseness possibly had previous vocal difficulties, which led them to not maintain regular mask use. A study with university professors found an association between greater difficulty in communicating while wearing a protective mask and a history of inadequate vocal adjustments and vocal signs and symptoms¹⁷.

Mask use also interferes with the teacher's hydration routine, who drinks less water so as not to remove the mask all the time¹². It is known that systemic hydration is essential for proper voice use. Hence, lacking hydration leads to more signs and symptoms such as hoarseness, throat clearing, discomfort in the throat, and greater vocal effort¹².

Face masks, regardless of the type, act as a barrier to sound propagation, and their material and thickness determine the listener's perception characteristics^{11,23}. The types most used by teachers in this study were the surgical mask and the FFP2/N95, both considered adequate against the spread of the virus. Surgical masks are considered to reduce speech intelligibility by 20%, equivalent to hearing loss at high frequencies²⁴. The vocal effort did not differ between mask types, although the FFP2/N95 may attenuate the sound a little more than the surgical mask^{11,18}. Moreover, teachers did not change their voice use due to the type of mask, and there was no difference in self-reported vocal quality. However, these three aspects had quite high levels of change in this study. Thus, regardless of the type of mask used, there was significant vocal overload.

Research that investigated how the use of surgical masks¹⁹ and other types of masks²⁵ could affect the voice and verbal communication of adults found no difference in vocal and acoustic aspects. However, other studies^{11,18,26} found that surgical masks have less effect on speech sound properties than FFP2. An important fact to consider is the different levels of density in classrooms depending on how they are occupied, which interferes with the way sound waves are absorbed and distributed. Very crowded classrooms can completely absorb these waves before they reach the ends of the room; a teacher wearing a mask and positioned at the front of the room will have to perform vocal projection very efficiently for everyone to understand them and for them not to strain their voice¹².

Most vocal signs and symptoms investigated and the largest number of signs and symptoms were

associated with the negative interference of the mask on the voice, reinforcing that this PPE increases the perception of effort, leads to loss of communicative efficiency, and overload adjustments, increasing vocal problems and the risk of dysphonia^{4,13,14,17}. A literature review on the effects of mask use on the voice identified that individuals who wore masks in their various professional activities perceived significant symptoms of voice problems such as vocal fatigue, discomfort, and effort¹¹. Furthermore, the occurrence of vocal problems reported by teachers doubled after they started wearing masks¹². Vocal effort can cause loss of intensity, attenuate high frequencies, and lead to difficulty in understanding the teacher and in the sensory feedback, as it is affected¹².

A summary of the main changes in voice production due to mask use includes the obstruction of the upper airways (even if partial, changing the amount of air inhaled), possibly compensated, such as by increasing the frequency of inhalations (interfering with the respiratory pattern and breathing-speech coordination, worsened with allergic rhinitis, deviated septum, and so on); speaking louder than usual because they think it is difficult for others to hear them (causing vocal effort and fatigue); difficulties in conveying their message, especially due to the absence of nonverbal cues such as facial expressions to facilitate understanding; the need to frequently repeat what they say, which worsens vocal fatigue and general exhaustion. These aspects combined with prolonged noise, room occupancy and size, difficulties with reverberation and sound absorption, lower systemic hydration, and so forth set a perfect situation for establishing hyperfunctional dysphonia due to the enormous overload on the laryngeal muscles¹³.

Another point to be considered is the possible changes in teaching or in the work routine that teachers can make to alleviate some of the communication difficulties they face. Most teachers did not use this type of compensatory strategy such as more frequent breaks, talking less, hydrating more, using a microphone, etc.¹⁷. However, among those who sought to make some compensation, women invested slightly more than men in group activities in the classroom and took more breaks to rest their voices. In another study, even though teachers had increased the use of microphone amplification, they continued to perceive the need for vocal effort and reduced hydration, and thus reported an increase in all vocal problems¹²; studies should address the use of this type of equipment. The

continuation of this study must analyze these strategies and observe mask use in classrooms.

In other cultures, mask use has been part of people's routine since before the COVID-19 pandemic, and they noticed these communication difficulties.

For teachers, communication difficulties are an additional factor in a reality of great physical and mental illness. In addition, during the pandemic there was a greater workload, a lot of stress regarding the need to acquire new skills for the teaching-learning process, changes in relationships with students, peers, and the institution, difficulty in limiting work and rest hours, and fear and anxiety resulting from the pandemic³.

The sample included men and women, different ages and education levels, public and private schools, and a certain homogeneity in the number of hours of class per day, number of students in the classroom, and smoking. Nevertheless, one must consider the importance of aspects other than mask use (e.g., the physical environment, work relationships, pre-existing diseases, use of medications, and so on), which may interfere with the use of the teacher's voice. This study did not control such aspects, which may be explored in future research.

Furthermore, the return to in-person teaching faced several difficulties in reestablishing all the necessary school dynamics after so many months of confinement. This placed even greater demands on teachers in terms of the need to welcome children and young people and reestablish the necessary limits.

Monitoring participants longitudinally is desirable, adopting practices that help them perform teaching activities, especially given the many complaints related to voice and the high occurrence of vocal signs and symptoms. Although mask use is less frequent at this time, actions for vocal improvement or rehabilitation should consider their occasional use and how to minimize their interference in the communication of a population that encompasses so many risk factors.

CONCLUSION

For most study participants, voices worsened upon returning to in-person activities during the COVID-19 pandemic.

Furthermore, some teachers did not wear masks constantly, even though they were mandatory, and half of those who did wear masks took them off in class to improve communication.

Teachers who did not wear masks had worse vocal quality and more frequent hoarseness. Greater vocal

effort, excessive use of the voice and altered vocal quality were frequent and were not associated with the type of mask used.

The negative interference of the mask was associated with vocal fatigue, sore throat, speaking loudly, voice failures, dry throat, throat clearing, hoarseness, and more vocal signs and symptoms.

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Authors' contributions:

ITS: Conceptualization; Data analysis; Writing - Original draft.

MSZ: Conceptualization; Data analysis; Supervision; Writing - Review and editing.

SBB: Visualization; Writing - Review and editing.

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Data sharing statement:

We declare that the research data will not be shared.