


Original Research

Cite this article: Gao X, Li H, He W, Zeng W. COVID-19 vaccine hesitancy among medical students: The next COVID-19 challenge in Wuhan, China. *Disaster Med Public Health Prep*. doi: <https://doi.org/10.1017/dmp.2021.291>.

Keywords: COVID-19; medical students; vaccine hesitancy

Corresponding author: Wen Zeng, Email: zengwen2030@163.com.

COVID-19 Vaccine Hesitancy Among Medical Students: The Next COVID-19 Challenge in Wuhan, China

Xudong Gao¹ , Haiyan Li², Wenjie He³ and Wen Zeng⁴

¹College of Medicine and Health Science, Wuhan Polytechnic University, Wuhan, China; ²Emergency Room, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, China; ³Gastrointestinal Department, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, China and ⁴Department of Scientific research and Teaching, The Central Hospital of Shaoyang, Shaoyang, China

Abstract

Objective: The purpose of this study was to explore the level of coronavirus disease 2019 (COVID-19) vaccine hesitancy among medical students in Wuhan, China, and to identify the factors and barriers associated with their vaccination decision.

Methods: A cross-sectional survey was launched with 612 medical students recruited by convenience sampling from 6 universities. Data collection measures mainly included a demographic questionnaire, COVID-19 vaccine knowledge questionnaire, and the vaccine hesitancy scale.

Results: A total of 58.2% of medical students reported vaccine hesitancy. The most common reasons for this were worrying about the side effects of vaccines (44.4%), uncertainty about vaccine safety (40.4%), and underestimating the risk of exposure to COVID-19 (27.9%). The main factors associated with COVID-19 vaccine hesitancy among participants were their knowledge about COVID-19 vaccine, training related to COVID-19 vaccines, family address, and education level ($P < 0.05$).

Conclusions: The government, health department and universities in China need to work together and actively communicate with vaccine-hesitant students, establish a standardized COVID-19 vaccine course, and provide on-campus vaccination services.

Background

Since the coronavirus disease 2019 (COVID-19) was first reported in Wuhan, China in late 2019, no consensus treatment has been developed or accepted in the world.^{1–4} The arrival of COVID-19 vaccines was regarded as the key to ending the pandemic. As of August 7, 2021, more than 4 billion doses of the COVID-19 vaccine had been administered globally, with an average vaccination rate of 52 doses for 100 people.^{5,6} However, there is great inequity in the distribution of the COVID-19 vaccines in developed countries and developing countries.^{7–10} COVID-19 vaccination is a great challenge to the government of China, a country with a population of 1.4 billion.^{11–15}

Initially, due to the scarcity of COVID-19 vaccines, the public was usually eager to get vaccinated.¹⁶ However, with the COVID-19 vaccine production being ramped up, vaccine hesitation is becoming a new obstacle in the COVID-19 pandemic. Considering that the COVID-19 vaccine is 1 of the fastest vaccines ever developed, citizens from many countries have expressed their skepticism about its safety, efficacy, and side effects.^{17–19} With an increasing number of negative reports about COVID-19 vaccines being published, many people have been expressing hesitancy about vaccination, or even refusing to be vaccinated.^{20,21} Vaccine hesitancy is defined as the reluctance or refusal to vaccinate despite its accessibility.^{22,23} Studies have shown that COVID-19 vaccine hesitation is a widespread phenomenon worldwide.^{24,25} By implementing strict border controls, contact tracing, and personal protection measures, China has become 1 of the countries to control the spread of COVID-19 successfully.²⁶ The number of COVID-19 infections in China was relatively small from May 2020.²⁶ Therefore, Chinese people generally believe they are safe, making them less willing to get vaccinated,^{27,28} however, COVID-19 vaccine hesitancy is a serious barrier to achieve herd immunity.

As medical students work as frontline health care workers, they are at a greater risk for COVID-19 exposure. Once COVID-19 vaccines become widely available, a high vaccination rate must be achieved for this group. Medical students are future health care workers and important influencers among laypeople and their communities. That is, they will be trusted by vaccine-hesitant people to provide recommendations and counseling on COVID-19 vaccines. At present, research on COVID-19 vaccine hesitancy has mainly focused on health care workers, ethnic minority groups, religious believers, and black Americans.^{29–37} To our knowledge, there

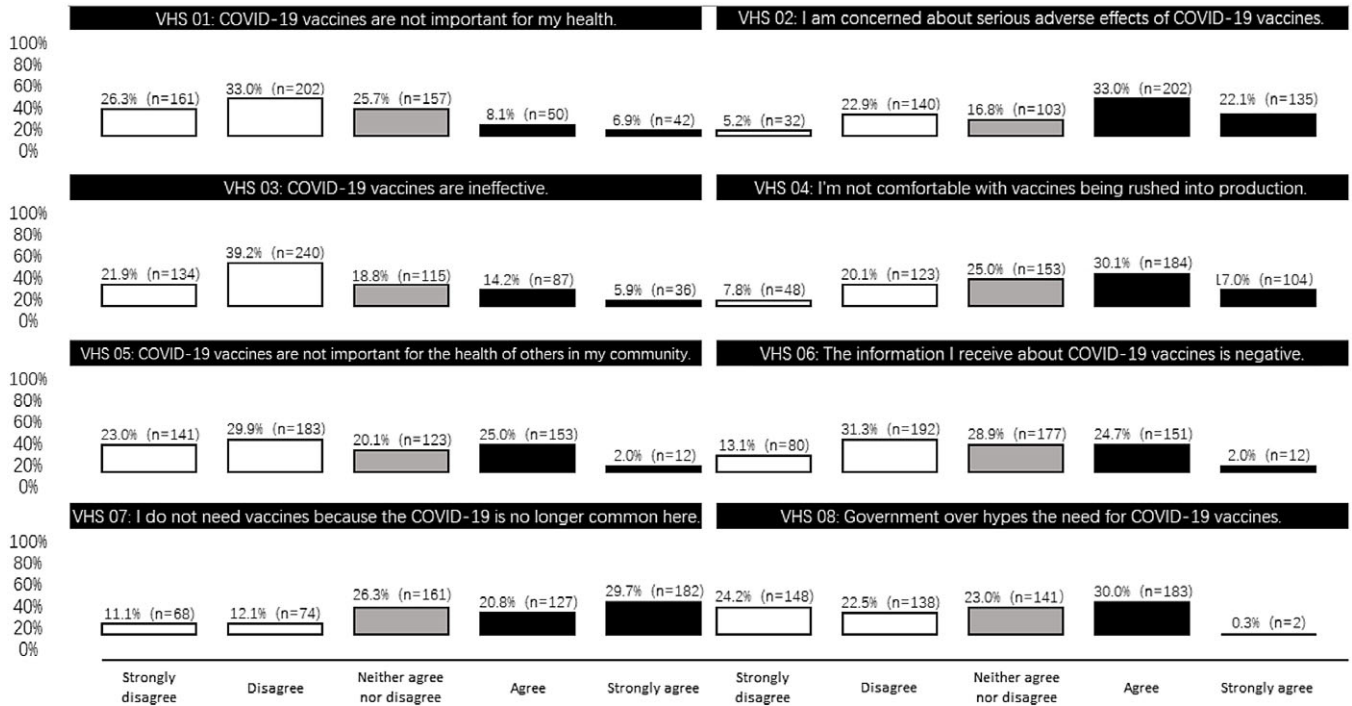


Figure 1. Distribution of answers to the 8 items of vaccine hesitancy scale ($n = 612$).

*Annotation: Black bars indicate answers that are reflecting a negative attitude to vaccination, white as positive attitude and gray as doubtful ("neither agree nor disagree").

have been no studies of COVID-19 vaccine hesitancy among medical students in China, therefore, our study aimed to fill this gap by exploring the level of COVID-19 vaccine hesitancy among Chinese medical students and identifying the factors and barriers associated with decision to vaccinate.

Methods

Study design and participants

We conducted a cross-sectional survey using an online questionnaire. Medical students from 6 universities in Wuhan were selected to participate through convenience sampling. We chose a teacher from each university as a liaison for our study. Questionnaires were distributed to students' cell phones through the liaisons. Prior to the study, the liaisons provided them with an electronic informed consent form. All students received information about the study purpose, and they were told that participation was voluntary and anonymous. This study was approved by the Institutional Review Board at [blinded for review].

Inclusion criteria were participants who, (a) were medical undergraduates or postgraduates in Wuhan, (b) were eligible for COVID-19 vaccines, and (c) had volunteered to participate in this study. Exclusion criteria were participants who, (a) were infected with COVID-19, (b) were pregnant or breastfeeding women, and (c) were diagnosed with diseases that prevented them from receiving the COVID-19 vaccines. In total, 711 medical students completed our questionnaire from February to March 2021. The government of Wuhan has been providing COVID-19 vaccines for college students since April 2021. Thus, none of the participants in this study have received COVID-19 vaccines. In total, 99 incomplete questionnaires were excluded, and finally 612 questionnaires were analyzed.

Survey questionnaire

The survey questionnaire contained 3 parts, and it took the students approximately 6 minutes to complete the survey.

Demographic characteristics

Medical students' demographic characteristics were collected, these included gender (male, female), nation (non-minority, minority), monthly household income (less than \$780, \$780 – \$1561, more than \$1561), family address (in Wuhan, not in Wuhan), education level (undergraduate, postgraduate), training related to COVID-19 vaccines (trained, untrained), college (clinical medicine, nursing, preventive medicine, pharmacy, basic medicine), history of respiratory diseases in the past year (yes, no), history of influenza vaccination (vaccinated, unvaccinated), religious belief (non-religious, religious). Household income in our questionnaire was recorded in Chinese currency (less than 5000 RMB, 5000 – 10000 RMB, more than 10000 RMB) and converted to U.S. dollars for reporting purposes.

Knowledge about COVID-19 vaccine

A self-design, 14-item questionnaire was employed to evaluate the medical students' knowledge about COVID-19 vaccine (e.g., types of vaccines, vaccination eligibility, common side effects, and precautions after vaccination). The questionnaire was developed through a literature review and group discussion. After 2 rounds of expert consultation, the pre-test questionnaire was developed. A total of 126 medical students were pilot tested. The results show that the Cronbach's α coefficient was 0.743. The content validity index was 0.961, and the reliability index was 0.788. When a question was answered correctly, the student received 1 point while incorrect answers were not scored. The scores on all questions were summed to obtain the total score. Higher total scores indicate a

better understanding of COVID-19 vaccines. Furthermore, we investigated the sources of students' knowledge about COVID-19 vaccine.

Vaccine hesitancy scale

Zhang established the Vaccine Hesitancy Scale (VHS) in 2020.³⁸ Participants were asked to answer 8 questions related to their vaccine hesitancy on a 5-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree). The scores on the 8 questions were summed to obtain the total score; higher total scores indicated higher vaccine hesitancy. The Cronbach's α coefficient of the scale was 0.705. The content validity index was 0.830, and the reliability index was 0.696. Furthermore, the reasons hindering COVID-19 vaccination among medical students were also investigated (e.g., side effects of vaccine, vaccine safety, convenience, vaccine efficacy, and underestimating the risk of exposure to COVID-19).

Statistical methods

We used IBM SPSS Statistics 26.0 (IBM Corp., Armonk, New York) for statistical analysis. The Kolmogorov Smirnov analysis was applied, and the result showed that VHS was normal distribution.^{39,40} Multicollinearity was measured by the variance inflation factor (VIF). After testing, values of VIF were all lower than 10, so there is no multicollinearity. The correlation between COVID-19 vaccine knowledge and VHS was analyzed using Pearson correlation analysis. The comparison of different demographic medical students' COVID-19 vaccine hesitancy was analyzed by univariate analysis. Multiple-factor analysis of VHS was analyzed using multiple regression analysis. The value of $P < 0.05$ was considered statistically significant.

Results

Scores of COVID-19 vaccine hesitancy

The average VHS score among medical students was 22.81 ± 5.91 , and the mean score rate was 57.0%. The maximum score of VHS was 36, and the minimum was 12. A total of 58.2% of medical students scored at least 24 points on the VHS. As shown in Figure 1, only 15% of students agreed that 'COVID-19 vaccines are not important for my health' (Question 1). More than half of the students reported concern regarding the adverse effects of COVID-19 vaccines (Question 2). Moreover, 47.1% of the students agreed with the statement that 'I am uncomfortable getting a vaccine that was rushed into production' (Question 4). About 50% of the students agreed with the statement that 'I do not need vaccines because COVID-19 is no longer widespread locally' (Question 7). For all questions, "neither agree nor disagree" is not the most selected option.

Medical students' knowledge about COVID-19 vaccine

The average COVID-19 vaccine knowledge score among medical students was 9.82 ± 2.83 , with an average accuracy rate of 70.1%. The maximum score of COVID-19 vaccine knowledge was 14, and the minimum was 6. The COVID-19 vaccine knowledge score was negatively correlated with VHS score ($P < 0.01$). As shown in Table 1, medical students' primary sources of knowledge about COVID-19 vaccine were the Internet (67.3%), campus publicity (36.4%), and medical staff (29.7%).

Table 1. Sources of medical students' knowledge about COVID-19 vaccine ($n = 612$)

Source	n	%
Internet	412	67.3%
Campus publicity	223	36.4%
TV	114	18.6%
Medical staff	182	29.7%
Other	167	27.3%

Medical students' demographic characteristics associated with COVID-19 vaccine hesitancy

As shown in Table 2, COVID-19 vaccine hesitancy among medical students in Wuhan were significantly associated with their family address, education level, training related to COVID-19 vaccines, and history of influenza vaccination ($P < 0.05$).

Multiple-factor analysis of COVID-19 vaccine hesitancy among medical students

As shown in Table 3, the main factors associated with medical students' COVID-19 vaccine hesitancy were their knowledge about COVID-19 vaccine, training related to COVID-19 vaccines, family address, and education level. Therefore, the negative factors were lack of knowledge about COVID-19 vaccine, lack of related training, not living in Wuhan, and lower education level.

Barriers to COVID-19 vaccination among medical students

As shown in Table 4, the most common reasons hindering COVID-19 vaccination among medical students in Wuhan were worrying about the side effects of vaccines (44.4%), uncertainty about the safety of vaccines (40.4%), and underestimating the risk of exposure to COVID-19 (27.9%).

Discussion

Vaccination is an effective way to prevent and control COVID-19. However, there are still many people in some countries who continue to refuse or delay vaccination.²⁴ Medical students are often ignored in the promotion of COVID-19 vaccines, hence to the best of our knowledge, this study is the first to investigate COVID-19 vaccine hesitancy among medical students in China.

COVID-19 vaccine hesitancy among medical students

Typically, a VHS score of 24 or higher indicates vaccine hesitancy.³⁸ In our survey, 58.2% of the medical students scored at least 24 points on the VHS, indicating that a large proportion of Chinese medical students are hesitant to receive COVID-19 vaccines. We inferred 4 reasons that may explain this phenomenon. First, it is possible that some medical students underestimated the risk of the COVID-19 pandemic. Since January 2020, China has adopted a series of effective prevention and control measures and successfully controlled the spread of the epidemic.⁴¹ Apart from some imported cases of COVID-19, there have been very few domestic infections in China since May 2020.²⁶ Furthermore, to protect the safety of students, almost all universities in Wuhan implemented closed management, whereby outsiders were prohibited from entering campuses without special permission. Therefore, many medical students believed that their probability of being infected with COVID-19 was very low. Second, several vaccine incidents might affect medical students' trust in Chinese vaccines. In recent

Table 2. Medical students' demographic characteristics associated with COVID-19 vaccine hesitancy ($n = 612$)

Factor	n (%)	VHS total points ($\bar{x} \pm S$)	F	P	Factor	n (%)	VHS total points ($\bar{x} \pm S$)	F	P
Gender			2.575	0.109	College			1.620	0.168
Male	225 (36.8)	23.31 \pm 6.39			Clinical medicine	149 (24.3)	23.22 \pm 5.89		
Female	387 (63.2)	22.52 \pm 5.60			Nursing	252 (41.2)	22.23 \pm 5.52		
Nation			3.588	0.059	Preventive medicine	83 (13.6)	22.43 \pm 6.03		
Non-minority	568 (92.8)	22.68 \pm 5.96			Pharmacy	76 (12.4)	23.83 \pm 5.90		
Minority	44 (7.2)	24.43 \pm 4.89			Basic Medicine	52 (8.5)	23.52 \pm 7.30		
Monthly household income			2.255	0.106	Suffered from respiratory diseases in the past year			1.211	0.272
< \$780,	181 (29.6)	22.65 \pm 6.03			Yes	139 (22.7)	22.32 \pm 5.26		
\$780-\$1,561	252 (41.2)	23.37 \pm 5.93			No	473 (77.3)	22.95 \pm 6.08		
> \$1,561	179 (29.2)	22.17 \pm 5.71			History of influenza vaccination			9.737	0.002
Family address			22.242	0.000	Vaccinated	51 (8.3)	20.35 \pm 6.80		
In Wuhan	178 (29.1)	21.08 \pm 6.17			Unvaccinated	561 (91.7)	23.03 \pm 5.77		
Not in Wuhan	434 (70.9)	23.52 \pm 5.65			Religious belief			0.573	0.449
Education level			16.725	0.000	Non-religious	521 (85.1)	22.73 \pm 5.61		
Postgraduate	207 (33.8)	21.46 \pm 6.76			Religious	91 (14.9)	23.24 \pm 7.41		
Undergraduate	405 (66.2)	23.50 \pm 5.30			Training related to COVID-19 vaccines			31.329	0.000
Training related to COVID-19 vaccines			31.329	0.000	Trained	197 (32.2)	20.91 \pm 5.69		
Trained	197 (32.2)	20.91 \pm 5.69			Not trained	415 (67.8)	23.71 \pm 5.80		
Not trained	415 (67.8)	23.71 \pm 5.80							

Annotation: VHS= Vaccine Hesitancy Scale

Table 3. Multiple-factor analysis of COVID-19 vaccine hesitancy among medical students in Wuhan, China ($n = 612$)

Independent variable	Regression coefficient	Standardized regression coefficient	t	P
Constant	19.539	—	12.164	< 0.001
Knowledge about vaccine	- 0.515	- 0.247	- 6.472	< 0.001
Training related to COVID-19 vaccines	2.222	0.176	4.589	< 0.001
Family address	1.452	0.112	2.884	0.004
Education level	1.271	0.102	2.661	0.008

Annotation: $R^2 = 0.147$, adjusted $R^2 = 0.142$, $F = 26.208$, $P < 0.05$

Table 4. Barriers of COVID-19 vaccination among medical students in Wuhan, China ($n = 612$)

Barriers	n	%
Have concerns about side effects of vaccines	272	44.4
Have concerns about vaccines safety	136	22.2
Vaccination is not convenient	247	40.4
Do not believe that vaccines work	108	17.6
COVID-19 has been well controlled in China; vaccination is not necessary	171	27.9
Have concerns about the mutation of the virus and make vaccines ineffective	84	13.7
Other	96	15.7

years, several vaccine incidents have emerged in China, such as the DPT vaccine incident in Wuhan, tetanus vaccine incident in Changchun, and influenza vaccine incident in Shandong.^{42,43} In the DPT vaccine incident that occurred in 2017, the Wuhan Institute of Biological Products did not follow the production regulation and produced a batch of invalid DPT vaccines. These invalid vaccines were administered to approximately 144000 people. The Wuhan Institute of Biological Products is also 1 of the 3 leading manufacturers of COVID-19 vaccines in China.⁴⁴ As medical students are usually familiar with these vaccine incidents. It is likely that this negative information influenced their unwillingness to be vaccinated. Third, vaccination is not convenient for most medical students. In China, most vaccination services are provided by community health centers.⁴⁵ However, community health centers are mainly located in urban areas, while most universities in Wuhan are in suburb areas, which have fewer community health centers. Consequently, access to vaccines was not very convenient for many medical students. Finally, 1 year after the COVID-19 outbreak, China's research institutions and enterprises have been developing and producing COVID-19 vaccines on a large scale.⁴⁴ Unlike the typical duration for producing traditional vaccines, COVID-19 vaccines were developed in the shortest period. Therefore, many medical students were worried about the safety, side effects, and effectiveness of COVID-19 vaccines. Although medical students understood the importance of being vaccinated, some students planned to wait for a while to observe the effectiveness of the vaccines on others.

Factors associated with COVID-19 vaccine hesitancy among medical students

Our study demonstrated that the main factors associated with medical students' COVID-19 vaccine hesitancy were their knowledge about

COVID-19 vaccine, training related to COVID-19 vaccines, family address, and education level. First, medical students' knowledge about COVID-19 vaccine was closely related to their vaccine intention. Previous study also demonstrated that people who knew more about COVID-19 vaccines were more likely to get vaccinated.⁴⁶ Since the target group of this survey was medical students, we expected that they would have better knowledge of vaccines. However, participants' average accuracy of COVID-19 vaccine knowledge in this study was merely 70.1%, indicating that knowledge about COVID-19 vaccine is not provided in the current medical curriculum. Second, we found that medical students who had received relevant training were more willing to receive COVID-19 vaccines. Previous studies have also demonstrated that relevant training can improve students' adherence, attitude, and knowledge about vaccinations.^{47–49} Nevertheless, in our survey, only 32.2% of the students had received relevant training. Training related to COVID-19 vaccines should be offered to medical students as soon as possible. Third, medical students who lived in Wuhan were more willing to receive COVID-19 vaccines compared to those who were not living in Wuhan. This is likely because Wuhan residents experienced the rapid spread of COVID-19 in the first quarter of 2020. Thus, their awareness of epidemic prevention was generally high. Finally, we found that undergraduate students were more likely than postgraduate students to hesitate about vaccination. This may be because postgraduates have more medical knowledge than undergraduates, so they understand the importance of COVID-19 vaccines better. Moreover, according to the graduation requirements of universities in China, medical postgraduates are generally required to complete 1 year or more in professional practice in hospitals, center for disease control and prevention, or other medical institutions. Postgraduates know that they are at a higher risk of exposure to COVID-19 and are, thus, more likely to receive the vaccine.

Limitations

This study has several limitations. First, considering the limited number of universities that participated in this study, our sample was relatively small. Thus, our findings must be further verified using a larger sample size. Second, the VHS uses standardized questions and a Likert scoring format, which make it easy to analyze data. However, it masks the heterogeneity of the students. Future study should employ other methods, such as interviews, that can explore potential motivations in greater depth. Third, as a cross-sectional survey, our study only evaluated the status of COVID-19 vaccine hesitancy at a specific time point without conducting a follow-up observation of the medical students. Finally, in addition to the factors included in this study, there may also be other factors associated with medical students' COVID-19 vaccine hesitancy.

Recommendations

Considering these findings, we suggest the following to improve medical students' intention to vaccinate. First, prior to conducting vaccine training or awareness campaigns, health department should conduct surveys on students' intention to vaccinate against the COVID-19. Universities should actively communicate with vaccine-hesitant students, and identify the reasons hindering their intent to vaccinate, based on which targeted measures should be taken. Second, given that the COVID-19 pandemic will last for a long time, medical students' hesitation about vaccines may also

continue. Thus, universities should establish and promote a standardized COVID-19 vaccine course. This course can also be disseminated via TikTok, Twitter, and online public classes. Third, governments should supply on-campus vaccination services to improve students' accessibility to COVID-19 vaccines.

Conclusion

In the past year, there have been very few COVID-19 infections in China, which has resulted in gross underestimation of infection risk among Chinese people.²⁷ Our study is the first to focus on COVID-19 vaccine hesitancy among medical students in China. More than half of the medical students reported COVID-19 vaccine hesitancy, and the main factors associated with vaccine hesitancy were knowledge about COVID-19 vaccine, training related to COVID-19 vaccines, family address, and education level. Once most countries achieve herd immunity and resume trade and tourism, many vaccine-hesitant medical students in China may be exposed to a greater risk for infection. The government, health department, and universities in China need to work together and actively communicate with vaccine-hesitant students, establish a standardized COVID-19 vaccine course, and provide vaccination services on campus.

Author contributions. Xudong Gao and Wen Zeng conceived and designed the subject. Haiyan Li and Wenjie He collected and analyzed data. Xudong Gao, Haiyan Li, Wenjie He and Wen Zeng were involved in writing the paper. All authors read and approved the final version of the manuscript.

Funding statement. The study was funded by Hubei Higher Education Teaching Reform Research Project (2020509).

Conflict(s) of interests. The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical standards. Ethical approval was granted from the Institutional Review Board of Wuhan Polytechnic University.

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