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ORIGINAL RESEARCH

Investigation of a Mask Fitness Test Based on Self-Efficacy and Diversified Training in the Assessment System for Nosocomial Infection Training

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Objective: To explore a mask fitness test based on self-efficacy and diversified training in the assessment system for nosocomial infection training.

Methods: From March 15 to April 5, 2022, 442 staff members (272 male and 170 female) of the Third People's Hospital of Shenzhen who planned to enter the quarantine ward for secondary protection skill training assessment were selected. They comprised 56 doctors, 31 medical technicians, 72 nurses, and 283 property logistics staff. During the mask fitness test, a diversified training model based on self-efficacy was adopted to observe the passing status, the identification and selection of mask models, the method of mask-wearing, the fit between the mask and the face, and the changes in self-efficacy.

Results: In the assessment system for nosocomial infection training, the passing rate of the mask fitness test was correlated with the identification and selection of mask models, the method of wearing masks, the fit between the mask and the face, and the diversified training, and the differences were statistically significant ($P < 0.05$). The difference in the self-efficacy in the test takers between those before and after the mask fitness test was statistically significant ($P < 0.05$).

Conclusion: In the assessment system for nosocomial infection training, the mask fitness test based on self-efficacy and diversified training might improve the passing rate, the rate of correct mask model identification and selection, the rate of correct mask-wearing, and the degree of facial fit, thus to enhance the awareness of protection and improve self-efficacy.

Keywords: self-efficacy, mask fitness test, training mode

Introduction

According to the data concerning the coronavirus disease 2019 (COVID-19) issued by the World Health Organization (WHO) as of February 22, 2022, there have been more than 424 million confirmed cases of COVID-19 infection worldwide, resulting in 5,890,312 deaths.[1] Respiratory droplets and close contact are the main transmission routes of the virus leading to COVID-19.[2] Previous meta-analysis have provided the latest state-of-art evidence on the efficacy of masks in preventing the transmission of COVID-19 and reducing the risk of infection. The protective effects of masks against COVID-19 were not only significant for healthcare workers, but also population.[3,4] However, protective masks are effective respiratory protective equipment. The fitness of this protective equipment directly determines the protective effect on the respiratory tract.[5]

It is required by WHO, the United States, and the European Union that a fitness test should be conducted when wearing respiratory protective equipment. Studies from abroad have shown that in the absence of the fitness test, the

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average exposure rate of the test takers is reduced to 33% of the environmental level. While through the fitness test, the protection obtained is much higher than that from the normally expected level (the average exposure rate is reduced to 4% of the environmental level).[6] Currently, China also has relevant national and industry standards, which clearly stipulate the requirements for the fitting of the mask to the face as well as the measurement of the fitness of respiratory protective equipment and medical protective masks.[7,8]

In actual clinical practice, front-line medical staff generally wear masks directly provided by the hospitals, with a lack of relevant training on fitness and relevant testing methods.[9] Facing the global pandemic of Omicron mutants, the dynamic zero-clearing policy faces huge challenges in China.[10–13] To cope with the dual requirements of the wartime state of the epidemic and the normalization of epidemic prevention and control, a mask fitness tester was adopted by the staff in this study during the mask fitness test assessment.[14] The tests of self-efficacy, objective mask fitness, and diversified training modes were adopted to improve protection skills and achieved satisfactory results.

Study Subjects

From March 15 to April 5, 2022, 442 staff members (272 male and 170 female) who would be working at the designated hospital for the treatment of patients with COVID-19 in the Third People's Hospital of Shenzhen and would enter the quarantine ward for the second-level protection skill training assessment were enrolled. There were 56 doctors, 31 medical technicians, 72 nurses, and 283 property logistics staff (Table 1).

Table 1 The General Data of the Staffs Who Planned to Enter the Quarantine Ward for the Training and Assessment of Secondary Protection Skills (n=442)

Category	Items	The Number of Cases	Percentage (%)
Age (Year)	26–35	155	35.07
	36–45	141	31.9
	46–55	88	19.91
	≤25	52	11.76
	>55	6	1.36
Gender	Female	170	38.46
	Male	272	61.54
Educational background	Technical secondary school /Senior high school and below	210	47.51
	Junior college	72	16.29
	Undergraduate	132	29.86
	Postgraduate and above	28	6.33
Occupation	Medical technician	31	7.01
	Doctor	56	12.67
	Nurse	72	16.29
	Property logistics staff	283	64.03
Length of service (Year)	1–5	127	28.73
	6–10	100	22.62
	<1	82	18.55
	>10	133	30.09
Number of times of training participation	3–5	120	27.15
	6–10	53	11.99
	<3	243	54.98
	>10	26	5.88
Number of times of personal training (n=433)	10–20	74	17.09
	<10	297	68.59
	>20	62	14.32

The inclusion criteria were as follows: (1) staff in good health, including those who were asymptomatic and with stable underlying diseases (hypertension, diabetes mellitus, cardiovascular disease, etc.) and those without respiratory infectious diseases (tuberculosis, influenza, COVID-19, etc.); (2) staff who were not pregnant; (3) staff without beards; (4) staff who had not smoked within 30 min before the test; (5) staff who had participated in theoretical knowledge training, simulated scene training, and nosocomial infection and secondary protection theory assessment in the skills training center and had achieved 100 points; (6) staff who had completed three doses of the novel coronavirus vaccine for at least 14 d; and (7) staff who voluntarily signed a commitment and entered the quarantine ward.

The exclusion criteria were as follows: (1) staff with symptomatic disease or a history of other serious medical conditions, (2) staff with a height <145 or >185 cm, (3) staff with a weight < 35 or >95 kg, or (4) staff who were illiterate.

Methods

Assessment Team Training

The team consisted of 34 staff from the Infection Control Department, the Nursing Department, the Medical Department, the General Affairs Department, and the Skills Training Center. They were divided into the infection control supervision team, the scenario-based simulation team, the teaching guidance team, the logistics support team, the assessment team, and the appointment review team (Figure 1). All members were included after passing the examinations for the homogenized secondary protection skill training. The members were very familiar with the theoretical knowledge of nosocomial infection and secondary protection, operation procedures, mask fitness test, pipeline disinfection, and training methods.

Secondary Protection Skill Training and Assessment Process

According to the "Guidelines for the Usage Scope of Common Medical Protective Equipment in the Prevention and Control of COVID-19 (Trial)",[15] the "Secondary Protection Skill Assessment Form" was formulated (Figure 2), and those with an assessment score of 100 points were considered as qualified. The assessed person should scan the code on the mobile terminal to make an appointment in advance, scan the site code to punch in the card on the day of the assessment, fill in the paper version of the assessment form, and receive onsite operation training, guidance, and practice of the secondary protection skill.

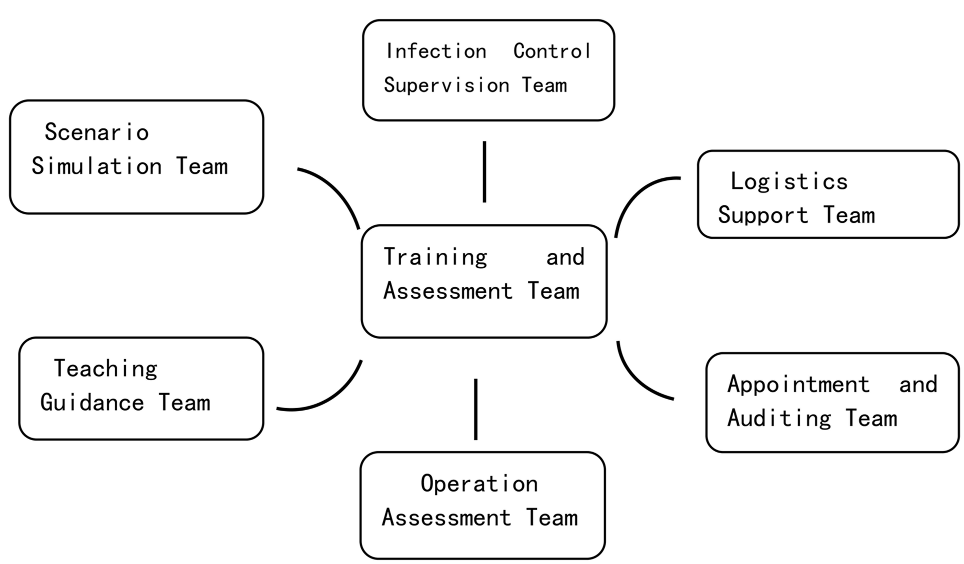

Figure 1 The structure diagram of the training and assessment team.

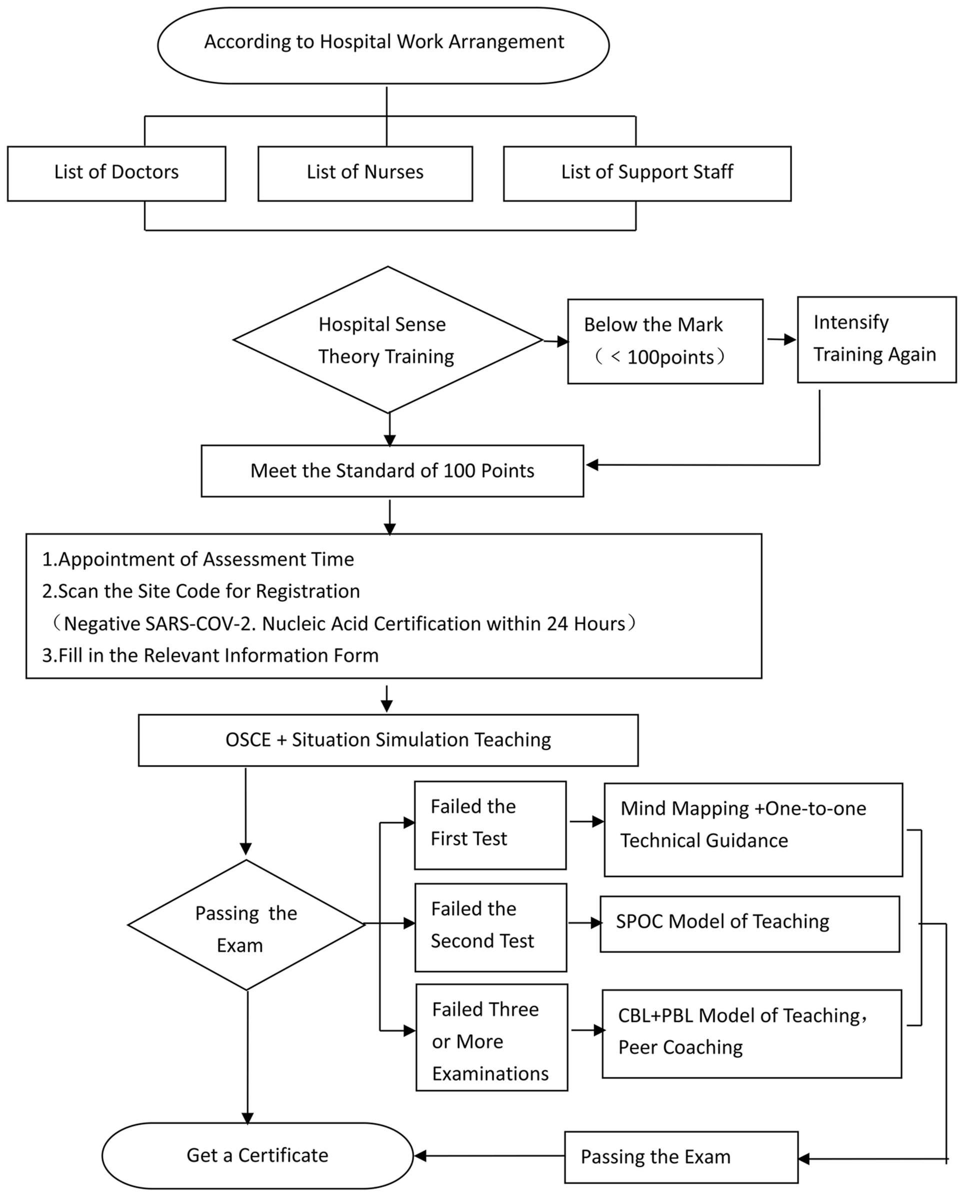

Figure 2 Flow chart of the training and assessment procedures for the secondary protection skills.
Abbreviations: OSCE, objective structured clinical examination; SPOC, Small Private Online Course; CBL, case-based learning; PBL, problem-based learning.

Diversified Training Mode

The scenario-based simulation teaching mode of the objective structured clinical examination (OSCE) was adopted before the assessment of the mask fitness test. The OSCE is a tool for the evaluation of clinical practice ability and scenario-based simulation, which may provide the trainees with a simulated real practice scene, allowing them to complete tasks during the process of experiencing the role.[16] First, the scenario-based simulation team completed the onsite arrangement under the guidance of the infection control supervision team. Then the scenario was set as follows: (1) hand hygiene, selection of protective equipment, donning, and doffing; (2) emergency management of occupational exposure after contact with a patient with COVID-19; and (3) protective equipment removal and medical waste disposal. The student would undergo onsite training and drills in sequence, and the instructor would make a preliminary evaluation according to the secondary protection skill assessment form and provide targeted guidance.

Those who failed the first assessment of the mask fitness test would be trained by drawing a mind map and one-on-one skill guidance mode. Mind mapping is an approach of visualizing human thinking. With the adoption of the technique of paying equal attention to both pictures and text, hierarchical diagrams or mutual affiliation are used to express themes at all levels.[17] First, the assessment team would provide feedback to the teaching guidance team regarding the secondary protection skill assessment form and the reasons for failing the test. The teaching team would help the student draw a mind map according to the problems found, as follows: (1) determine the central keywords; (2) disperse multiple knowledge points according to the keywords; and (3) one-on-one skill guidance to strengthen the weak points and easily overlooked parts, thereby enhancing self-confidence.

For those who failed the second assessment of the mask fitness test, a teaching mode of a small-scale restricted online course was adopted. This mode was to organically combine online courses with modern classroom teaching, while using flipped classroom teaching to improve the teaching quality.[18] The teaching guidance team would send the strengthening operation video to the student through WeChat. The video comprised narration, action decomposition, assessment standard explanation, error-prone analysis, and an online interaction section. The teaching team would demonstrate errors on the spot and raise questions to the student, asking them to answer the mistaken points and explain emergencies to strengthen standardized operation memory and improve their ability to deal with emergencies.

For those who failed the mask fitness test three or more times, case-based learning and problem-based learning[19] combined with peer-to-peer teaching were adopted. Students were divided into groups by the teaching team, with 2–3 subjects in each group. The teaching group arranged occupational exposure cases in the quarantine ward according to the specific problems. The group members would discuss and analyze the cases, and the teaching group would answer the questions. Team members acted as examiners for each other and conducted scenario-based simulation for specific problems to guide each other and strengthen the knowledge points. The teaching team would provide appropriate psychological adjustments according to the psychological status and occupational characteristics of the examinees to improve their enthusiasm and self-identity.

Mask Fitness Test

During the assessment of conventional secondary protection skills, all the assessed personnel routinely wore N95 masks of the same brand, following the training requirements. These were that the assessed personnel chose the type of mask they considered being suitable and wore it according to the conventional method of wearing masks, which involved the index fingers of both hands pressing the metal strip along the upper edge of the mask onto the bridge of the nose and adjusting the tightness of the strap. The test method was to cover the mask with both hands and then exhale vigorously. If air came from the edge of the mask, this indicated improper wearing, and the strap and metal strip on the bridge of the nose should be adjusted until no air escaped when exhaling vigorously. During the test, no one was given guidance or instruction. In this study, in addition to the routine mask-wearing by the examinees, the mask fitness test was conducted with the adoption of the TSI 8048 type respirator fitness tester. The specific operation procedures were as follows:

Dual air tubes and the power supply were installed before starting the instrument, and TSI FitPro Ultra software was installed on the computer;

The system was powered on and routine quality control testing was conducted;

The mask sampling probe was installed on the N95 mask and tightly connected with the dual airline interface;

The examinee was instructed to follow the animation displayed on the screen to complete the testing actions in sequence: bend deeply for 30s, speak loudly for 30s, swing head left and right for 30s, look up and down for 30s, with the total test time of 2.5 min;

When the test was completed, the software interface would display green to indicate success and red to indicate failure. For those who failed, the tester helped them analyze the reasons for the failure, such as whether the mask model was suitable, whether the method of mask-wearing was correct, as well as the face shape, etc. The teaching team would provide them with different training modes to conduct improved training, and re-test as required until they passed.

After each student completed the test, the mask and sampling probe were unplugged from the dual gas pipeline, and then a special pipeline sterilizer was adopted to sterilize the dual gas pipeline and quickly dry it for repeated use.

Observation Indicators

The observation indicators were mask model identification and selection, mask-wearing method, facial fitness, passing status of the mask fitness test, and evaluation of self-efficacy.

Statistic Methods

Double entry was adopted for data input and SPSS™ Statistics v25.0 software was used for statistical analysis. The measurement data were expressed as means ± standard deviations ($(\bar{x} \pm s)$) and tested for normality and homogeneity of variance. The *t*-test was adopted for data that conformed with the normal distribution. The countable data were expressed as the number of cases (n) (percentages %), and the χ^2-test was adopted for comparison between groups. A value of $P < 0.05$ was considered statistically significant.

Results

Comparison of the Results of Mask Fitness Test with Diversified Training

The passing status of the mask fitness test was correlated with the identification and selection of mask models, the method of mask-wearing, and the fit between the mask and the face, and the differences were statistically significant ($P < 0.05$) (Table 2).

Table 2 Comparison of the Results of Mask Fitness Test with Diversified Training

Item	The Number of Tests (%)			χ^2	p
	After 1 Test	After 2 Tests	After 3 and More Tests		
Error in mask model identification					
No	122(27.60)	434(98.19)	442(100.00)	809.379	0.000**
Yes	320(72.40)	8(1.81)	0(0.00)		
Error in mask model selection					
No	262(59.28)	378(85.52)	434(98.19)	226.233	0.000**
Yes	180(40.72)	64(14.48)	8(1.81)		
Error in metal sheet pressing					
No	317(71.72)	412(93.21)	442(100.00)	186.658	0.000**
Yes	125(28.28)	30(6.79)	0(0.00)		
Back tie rolling					
No	320(72.40)	434(98.19)	442(100.00)	238.318	0.000**
Yes	122(27.60)	8(1.81)	0(0.00)		
Too loose/too tight of the rear strap					
No	394(89.14)	442(100.00)	442(100.00)	99.606	0.000**
Yes	48(10.86)	0(0.00)	0(0.00)		
Too high/too low of the rear strap					
No	397(89.82)	441(99.77)	442(100.00)	89.226	0.000**
Yes	45(10.18)	1(0.23)	0(0.00)		
Too high/too low of the mask					
No	416(94.12)	442(100.00)	442(100.00)	53.04	0.000**
Yes	26(5.88)	0(0.00)	0(0.00)		
Unfitness between the mask and face					
No	280(63.35)	388(87.78)	413(93.44)	150.091	0.000**
Yes	162(36.65)	54(12.22)	29(6.56)		
Inexperienced in wearing a mask					
No	368(83.26)	424(95.93)	440(99.55)	98.195	0.000**
Yes	74(16.74)	18(4.07)	2(0.45)		
Failed the test					
No	239(54.07)	355(80.32)	405(91.63)	176.62	0.000**
Yes	203(45.93)	87(19.68)	37(8.37)		

Note: ** p<0.01.

Table 3 Comparison of General Self-Efficacy Before and After the Mask Fitness Test(n=442)

The Level of Self-Efficacy	The Level of Self-Efficacy			χ^2	p
	Low (10–20 Points)	Medium (21–30 Points)	High (31–40 Points)		
Before	25(5.66)	230(52.04)	187(42.31)	286.121	0.000**
After	0(0.00)	22(4.98)	420(95.02)		
Total	25(2.83)	252(28.51)	607(68.67)		

Note: ** p<0.01.

Comparison of the Self-Efficacy of the Test Takers Before and After the Mask Fitness Test Based on the Self-Efficacy Theory

The general self-efficacy scale (GSES) was prepared by Schwarzer et al,[20] with a total of 10 items and adoption of the Likert four-point scale, ranging from completely incorrect (one point) to completely correct (four points) for the assessment. According to the score, it could be divided into three levels: low (10–20 points), medium (21–30 points), and high (31–40 points). The higher the score, the higher the self-efficacy. The Cronbach's alpha coefficient of the internal consistency was 0.81. The comparison of the self-efficacy of the test takers before and after the mask fitness test is shown in Table 3.

Discussion

Improve Self-Efficacy

Self-efficacy theory was first proposed by American psychologist Bandura[21] in 1977. It refers to an individual's subjective evaluation of whether he/she can complete a certain task or job, and it can also be considered as the belief or judgment of organizational and executive ability of an individual's behavioral process for completing a given behavioral goal.[22] Strengthening self-efficacy is of great significance to work motivation enhancement and work attitude improvement,[23] and is helpful for changing behavior.[24] In the present study, the difference in the GSES scores before and after the mask fitness test was statistically significant ($P < 0.05$). The mask fitness test could quickly evaluate the protective effect and safety of the tested subject regarding correct mask-wearing. The diversified training could strengthen the application of protection knowledge and the proficiency in protection skills of the students. The self-efficacy of the students became higher with reduced tension, a more positive work attitude, and enhanced confidence in completing the task, therefore better protecting the physical and mental health of staff. During this investigation, positive feedback and recognition from the test takers was continuously received.

Mask Fitness Test

The mask fitness test relies on the instrument to detect whether there is air leakage around the contact between the mask and face. It does not rely on personal subjective feelings and judgments, thus has better accuracy and authenticity. During the fitness test, it was found that when the students completed various tests according to the instructions, the selection of mask model, whether hemmed, the position and tightness of the strap, the position of the mask, and the proficiency in mask-wearing all affected the passing rate to varying degrees. Therefore, the training and assessment team was committed to continuously improving the mask-wearing and mask-removing skills, the proficiency, and protection awareness of the students through a diversified training mode to continuously improve their protection skills and the test passing rate. During the process, the self-efficacy of the test takers was improved, and they adapted better to work in the quarantine ward. It was found in the present study that the more working experience in the quarantine ward and duration of training and practice, the stronger the awareness of protection, the higher the proficiency, and the easier it was for the students to pass the mask fitness test.

The Mask Tightness Test

The fitness test is to detect the sealing performance between the edge of the mask and the wearer's face. It mainly depends on whether the shape, size, nose clip, and mask strap of the mask matches the wearer's face.[25,26] As illustrated in Table 2, before the mask fitness test in this study, 72.4% of the test takers did not know how to distinguish the mask model, and 40.72% of them did not know which type of mask was suitable for them to wear. Combined with the reasons for the failure of the students in each fitness test, it was conducted again after applying diversified training. Therefore, all the test takers knew how to distinguish the mask model and could determine the mask model that was suitable for themselves. Studies have shown that different testers had great differences in the fitness test of the same type of protective mask.[27] With the help of the mask fitness test under the diversified training mode, the medical staff could choose the most suitable type of protective mask for personal use, and the test takers could master the correct methods and the details concerning mask-wearing. As demonstrated in Table 2, before the fitness test in this study, 28.28% of the test takers did not use the index fingers of both hands to press the metal piece along the upper edge of the mask onto the bridge of the nose but used their thumb and index finger, making an acute angle of the metal piece, and the mask could not be completely attached to the face, which resulted in air leakage, thereby reducing the fitness of the mask. In addition, 6.56% of the test takers passed the fitness test after multiple attempts even though the mask was worn correctly; details are shown in Table 2. The reason might be due to the fixed specifications of the mask, and it was impossible to make the mask fit perfectly with each subject's face, resulting in insufficient facial fitness with reduced protective performance.[28] In the present study, the same brand of mask was adopted for each student, so there are certain limitations.

Disinfection Management in the Mask Fitness Test

When the test takers completed the mask fitness test, the pipeline in the test instrument was sterilized before further use. However, currently, there is no dedicated pipeline sterilizer on the market. During the test, the mask was connected to the environment inside the pipeline. With normal breathing, there would be residual viruses transmitted through the respiratory tract in the pipeline, and there was a risk of cross-infection in the case of repeated use without disinfection. In the present study, the application of a pipeline sterilizer was explored, and the pipelines were perfused and sterilized with 75% alcohol and dried quickly to ensure they were quickly sterilized one at a time with a reduction in the risk of cross-infection.

Sampling Probe

In addition, a sampling probe should be installed on the test mask when conducting the mask fitness test, and the test mask should not be worn anymore. Considering the cost of testing equipment and test masks together with the workforce required to complete the test, it was recommended that during the process of high-risk aerosol exposure environments and operations (pathogenic microorganism laboratories, respiratory infectious disease areas, viral nucleic acid sampling, dust environments, etc.), attention should be paid to the mask fitness test based on self-efficacy and diversified training mode to ensure the health and safety of staff.

Conclusion

In summary, in the assessment system for nosocomial infection training, the mask fitness test based on self-efficacy and diversified training could improve the correct rate of mask model identification and selection, the correct rate of mask-wearing, and the facial fit for the staff, thereby enhancing the protection awareness and strengthening the protection skills with higher self-efficacy and good effect.

Data Sharing Statement

The data used to support the findings of this study are available from the corresponding author upon request.

Ethics Approval and Consent to Participate

This study was conducted with approval from the Ethics Committee of the Third People's Hospital of Shenzhen. This study was conducted in accordance with the declaration of Helsinki. Written informed consent was obtained from all participants.

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Disclosure

The authors declare that they have no competing interests in this work.

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