

Original Article

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# Perceptions and Opinions of New Respiratory Protection Program and Policies: Results of a Questionnaire Survey

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**Purpose:** Article 277-1 of the *Rules Governing Occupational Safety and Health Facilities* (Article 277-1), amended on April 30, 2019 by the Ministry of Labor, states that when employees are required to use respirators, the employer shall assign a designated person to implement respiratory protective measures and establish a record. This amendment came into effect on January 1, 2020 and greatly impacts on businesses.

**Methods:** A questionnaire was developed to survey workers' perceptions of the respiratory protection measures listed in Article 277-1 and their implementation.

**Results:** Based on the results of the questionnaire that was completed by 430 workers, 70.5% are at risk of exposure to respiratory hazards in the workplace. Among them, 80.9% reported lack of regular respirator fitting tests. Regarding who should perform respirator fitting tests, 65.7% of respondents preferred commissioned certified third-party tester and 20.5% preferred first-party (users' company) tester. Only 13.8% of respondents believe that second-party (respirator supplier) tester is adequate. This lack of preference for second-party tester may be due to the potential for a conflict of interest. Moreover, 68.8% of respondents believe that testers should be able to produce a third-party testing certificate; 72.3% believe that fitting test items should be accredited; 88.1% believe that testing equipment should be annually calibrated, and 86.3% believe that the operator should have relevant training and certification. It is common practice to commission second-party suppliers to conduct fitting tests due to economic considerations, resulting in inconsistencies in the quality of test results.

**Conclusion:** According to the results of this study, a classification system based on business size and promotion of measures to prevent and control respiratory hazards in high-risk industries are suggested. The labor rights of, and impact on, those who are unable to use respirators after medical evaluation, require further discussion. Moreover, it is recommended that government agencies formulate relevant guidelines or technical manuals for the implementation of respiratory protection measures to enable businesses to better understand and comply with regulatory standards. Finally, the amendment of Article 277-1 is timely as it came into effect at the start of the COVID-19 pandemic.

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## Introduction

Paragraph 1, Article 5 of the *Occupational Safety and Health Act* [1] specifies that “work assigned to laborers by the employers shall be within a reasonable and feasible scope, with necessary preventative equipment or measures taken to prevent laborers from being involved in occupational accidents.” Article 6 of the same Act stipulates that “The employers shall have the necessary safety and health equipment and measures that comply with regulations to prevent the risks of injuries posed by raw materials, materials, gases, vapors, dusts, solvents, chemicals, toxic substances, oxygen-deficient air.” Therefore, businesses should have preventive policies in place to protect workers from hazards and effectively control risks to respiratory health.

There may be different types of harmful substances in the air. Hazard prevention involves engineering control, health management, and administrative management. Administrative management reduces workers’ exposure by modifying manufacturing processes or procedures (e.g., adding liquid or water before mixing powder to prevent dust suspension), adjusting exposure time (e.g., shifts), education and training, standard operating procedures (SOP), emergency response plans, environmental measurements, respirators, and facility maintenance [2]. In general, only when the concentration of harmful substances in the air cannot be controlled at an acceptable level is the use of respirators considered. Here, respirators are the last line of protection from exposure to harmful substances in the air. In addition, medical professionals may be susceptible to infection from medical equipment or procedures. For example, electrocautery is often used in operating rooms to cut tissue and stop bleeding. The smoke that is generated contains harmful substances such as carcinogenic polycyclic aromatic hydrocarbons, formaldehyde, benzene, hydrogen cyanide, nanoparticles, and bioaerosols. It can induce discomfort such as nausea and coughing, and chronic exposure is potentially deleterious. Although medical professionals understand that surgical smoke is harmful, their knowledge of harmful substances in smoke and awareness of respiratory protective methods are lacking [3].

According to US federal regulations [4], when

a worker is assigned to an environment where a tight-fitting positive or negative pressure respirator must be worn, fitting test must be performed for the selected respirator before he/she starts work, on a regular basis and whenever needed, and the fit factor must be above a certain level. In the third year after the promulgation of the Standards 29 CFR 1910.134 law (also known as the Respiratory Protection Program) [5] in the US, only 9.4% of private establishments had implemented a respiratory protection program in full compliance with these standards. More than half (54%) of private establishments had more than 5 violations [6], including lack of filter replacement schedule (78.1%), failure to set the correct air supply pressure (77.2%), lack of instructions for using respirator (65.5%), lack of regular evaluation of the performance of respirator (64.3%), and lack of fitting tests (51.2%).

To ensure the protective effects of respirators, businesses should properly select respirators and develop and implement respiratory protection programs. In June 2018, Rhode Island became the first US state to legally regulate surgical smoke exposure, requiring all hospitals to use a local evacuator during surgical procedures that generate cauterized smoke [7]. Domestically, the Joint Commission of Taiwan included surgical smoke as one of the criteria for hospital accreditation in 2020. Specifically, operating room management should include a policy for reviewing measures to reduce and eliminate surgical smoke and provide staff with respirators, such as N95 masks or above, as needed [8]. In 2016, ISO published ISO/TS 16975-1:2016 Respiratory protective devices — Selection, use and maintenance, which contains the essential requirements for establishing and implementing a complete respiratory protection program in line with established standards. These guidelines also include information on risk assessment, selection procedure, training, use, and maintenance [9]. On April 30, 2019, the Ministry of Labor amended Article 277-1 of the *Rules Governing Occupational Safety and Health Facilities* (Article 277-1) [10]: When the employer requests employees to use respirators, the employer shall assign a designated person to implement the following respiratory protective actions and establish a record, which shall be kept for

three years: (1) Hazard identification and exposure assessment; (2) choice of respirators; (3) utilization of respirators; (4) maintenance and management of respirators; (5) respiratory protection education and training; and (6) effectiveness evaluation and improvement.

For businesses with 200 or more employees, employers should develop respiratory protection programs according to relevant guidelines published by the central authorities. For businesses with fewer than 200 employees, implementation records or documents can serve as an alternative. The amendment to Article 277-1 took effect on January 1, 2020 and has had a major impact on businesses. Therefore, a questionnaire was developed to survey participants' perceptions of respiratory protection measures and their implementation in various types of workplaces for future reference.

## Materials and Methods

This survey of perceptions and opinions of new respiratory protection program and policies is based on a questionnaire approved by the Occupational Safety and Health Administration, Ministry of Labor and includes respondents' basic information, perceptions of new respiratory protection program and policies and implementation of respiratory protection measures and relevant difficulties in the workplace. The questionnaires were collected using Google Forms with anonymous identity authentication. Statistical analyses were carried out with IBM SPSS Statistics 19, including descriptive statistics, cross-tabulation, Chi-Square test of independence, and logistic regression.

## Results

The response period was May 1, 2019 to September 18, 2019. A total of 436 responses were received. Among them, 6 questionnaires from unemployed respondents were excluded, for a total of 430 (98.6%) valid questionnaires. Before use, the questionnaire was validated by experts and evaluated by and discussed with representatives of the Occupational Safety and Health Administration,

Ministry of Labor multiple times. In addition, the fact-based questionnaire is suitable for testing via the test-retest reliability method. However, as it was necessary to test the same questionnaire twice, which may have affected responses, reliability analysis was not performed, which is a limitation of this study.

### *Basic Information of Respondents*

As shown in Table 1, 44.4% of the respondents work in northern Taiwan, 26.5% in central Taiwan, 25.8% in southern Taiwan, and only 3.3% in eastern Taiwan. The majority (39.8%) of the respondents work for medium-sized enterprises, followed by small-to-medium-sized enterprises (33.0%), and large enterprises (27.2%). As for industries, 45.6% are in manufacturing and 16.0% are in healthcare and social work services. Moreover, 54.0% of the respondents are safety and health personnel and 20.7% are in management. It is worth noting that for 70.5% of the respondents there are potential respiratory hazards in the workplace.

### *Perceptions of Respiratory Protection Measures*

A majority (59.5%) of the respondents had comprehensive understanding of respiratory protection programs and the remaining 40.5% had slight to no understanding. Regarding the assignment of a designated person to implement the respiratory protection program, 41.2% responded that this should be a safety and health professional with relevant training. As to the physiological evaluation of respirator users, most (45.8%) preferred the evaluator to be a trained doctor, followed by a trained nurse practitioner (33.2%). Additionally, 65.7% of the respondents considered commissioned third-party certified tester the most appropriate to perform respirator fitting test, while 20.5% preferred first-party tester and 13.81% preferred second-party (respirator supplier) tester. For a third party tester, testing equipment should be regularly calibrated (88.1%), fitting test items should be accredited (72.3%), third-party testing certificate should be produced (68.8%), and certification should be obtained under a laboratory quality management system (60.9%). Regarding the qualifications of fitting test operator, he/she should receive relevant training and certification (86.3%), such as by

**Table 1. Descriptive statistics.**

Dimension	Item	Frequency	%	valid %
Basic information	Region of business			
	Northern Taiwan (Taipei City, New Taipei City, Yilan County, Taoyuan City, Hsinchu County & Hsinchu City, Keelung City)	191	44.4	44.4
	Central Taiwan (Miaoli County, Taichung City, Changhua County, Nantou County, Yunlin County)	114	26.5	26.5
	Southern Taiwan (Kaohsiung City, Chiayi County & Chiayi City, Tainan City, Pingtung County, Penghu County)	111	25.8	25.8
	Eastern Taiwan (Hualien County, Taitung County)	14	3.3	3.3
Basic information	Business size			
	Small-to-medium-sized enterprise	142	33.0	33.0
	Medium-sized enterprise	171	39.8	39.8
	Large enterprise	117	27.2	27.2
Basic information	Industry			
	Construction, plumbing/electricity, natural gas, mining	43	10.0	10.0
	Manufacturing	196	45.6	45.6
	Indoor worker	52	12.1	12.1
	Outdoor worker	25	5.8	5.8
	Healthcare and social work service	69	16.0	16.0
	Other service	45	10.5	10.5
Basic information	Whether there are workers with duties potentially hazardous to respiratory health			
	No	127	29.5	29.5
	Yes	303	70.5	70.5
Basic information	Position			
	Management	89	20.7	20.7
	General worker	59	13.7	13.7
	Safety and health personnel	232	54.0	54.0
	Medical personnel	50	11.6	11.6
Perception	Whether understands respiratory protection program/ degree of understanding			
	No	174	40.5	40.5
	Yes	256	59.5	59.5

Perception	Who should be responsible for respiratory protection duties			
	Trained safety and health professional	175	40.7	41.2
	Trained department heads	124	28.8	29.2
	Anyone with training	126	29.3	29.6
	Others	5	1.2	
Perception	Who is appropriate to perform physiological evaluations			
	Trained doctors	192	44.7	45.8
	Trained nurse practitioners	139	32.3	33.2
	Trained safety and health personnel	88	20.5	21.0
	Others	11	2.6	
Implementation	Whether there are worker health service personnel			
	None	119	27.7	27.7
	Both doctors and nurse practitioners	214	49.8	49.8
	Doctors	15	3.5	3.5
	Nurse practitioners	82	19.1	19.1
Implementation	Whether respirator fitting test is regularly performed			
	No	359	83.5	83.5
	Yes	71	16.5	16.5
Implementation	Which kind of fitting test is performed			
	Qualitative	36	8.4	52.2
	Quantitative	8	1.9	11.6
	Both, as appropriate	25	5.8	36.2
	Missing value	361	84.0	
Perception	Who is more appropriate and credible to perform fitting test			
	Third-party certified tester	276	64.2	65.7
	Second-party supplier	58	13.5	13.8
	First-party self-testing	86	20.0	20.5
	Others	10	2.3	
Implementation	Whether there is respiratory protection training			
	No	148	34.4	35.3
	Yes	166	38.6	39.6
	No, but external training is allowed	105	24.4	25.1
	Missing value	11	2.6	

Implementation	Who conducts respiratory protection training			
	None	52	12.1	12.9
	External professional teacher	48	11.2	11.9
	Respirator supplier	69	16.0	17.1
	Safety and health personnel	203	47.2	50.4
	Medical personnel	31	7.2	7.7
	Others	27	6.3	
Implementation	Whether a respiratory protection program has been implemented or there are records or documents			
	No	226	52.6	52.8
	Yes	202	47.0	47.2
	Missing value	2	.5	
Implementation	Frequency of evaluating program or implementation records or documents			
	Never	58	13.5	27.8
	Once every half year	16	3.7	7.7
	Once a year	90	20.9	43.1
	Once every 2 years	9	2.1	4.3
	Once every 3 or more than 3 years	36	8.4	17.2
	Missing value	221	51.4	

the equipment supplier (57.4%) or under quality management system (44%).

#### *Implementation of Respiratory Protection Measures*

Items in the questionnaire related to the difficulties businesses face when implementing respiratory protection program, in order of frequency, are: physiological evaluation (61.6%), fitting test (59.3%), air quality monitoring of supplied respirators (45.3%), planning and evaluation (40.9%), choice of respirators (33%), education and training (22.8%), utilization of respirators (21.4%), cleaning and maintenance (19.5%), and none of the above (only 4.9%). Among the respondents, 49.8% worked for businesses with worker health service personnel (including doctors and nurses) and 27.7% did not. Only 16.5% reported that regular respiratory fitting test was performed in the workplace, with 52.2% noting that testing was qualitative and 11.6% noting that testing was quantitative. For 36.2% of respondents, qualitative

or quantitative testing in the workplace depended on the situation. There were 39.6% of respondents who reported that respiratory protection education and training are regularly held in the workplace, while 25.1% reported that such training is not available in the workplace but can be completed externally and 35.3% have no access to relevant training. Training courses are mainly held by the internal safety and health personnel of the business (47.2%), followed by the respirator supplier (16%). Overall, 52.6% of respondents reported that their place of employment had developed respiratory protection program or had implementation records or documents, while 47% did not. Regarding the frequency of program evaluation, the majority (43.1%) reported once a year, followed by never (27.8%).

#### **Discussion**

**Table 2. Chi-Square test results of business size and perception.**

		Business size			Total	$\chi^2$ (p-value)	
		Small-to-medium-sized enterprise	Medium-sized enterprise	Large enterprise			
Whether understands respiratory protection program/degree of understanding							
No understanding, slight understanding	Frequency	48	76	50	174	3.991 (0.136)	
	%	33.8%	44.4%	42.7%	40.5%		
Rough understanding, full understanding	Frequency	94	95	67	256		
	%	66.2%	55.6%	57.3%	59.5%		
Total	Frequency	142	171	117	430		
	%	100.0%	100.0%	100.0%	100.0%		
Who should be in charge of respiratory protection duties							
Trained safety and health professional	Frequency	67	68	40	175		14.734** (0.005)
	%	47.2%	40.2%	35.1%	41.2%		
Trained department head	Frequency	38	60	26	124		
	%	26.8%	35.5%	22.8%	29.2%		
Anyone with training	Frequency	37	41	48	126		
	%	26.1%	24.3%	42.1%	29.6%		
Total	Frequency	142	169	114	425		
	%	100%	100%	100%	100%		
Who is appropriate to perform physiological evaluations							
Trained doctors	Frequency	59	79	54	192	6.225 (0.183)	
	%	42.1%	47.3%	48.2%	45.8%		
Trained nurse practitioners	Frequency	42	57	40	139		
	%	30.0%	34.1%	35.7%	33.2%		
Trained safety and health personnel	Frequency	39	31	18	88		
	%	27.9%	18.6%	16.1%	21.0%		
Total	Frequency	140	167	112	419		
	%	100%	100%	100%	100%		
Who is more appropriate and credible to perform fitting test							
Third-party notarized tester	Frequency	107	98	71	276		10.770* (0.029)
	%	75.9%	59.0%	62.8%	65.7%		
Second-party supplier	Frequency	14	29	15	58		
	%	9.9%	17.5%	13.3%	13.8%		
First-party self-testing	Frequency	20	39	27	86		
	%	14.2%	23.5%	23.9%	20.5%		
Total	Frequency	141	166	113	420		
	%	100%	100%	100%	100%		

**Table 3. Chi-Square test results of business size and implementation.**

		Business size			Total	$\chi^2$ (p-value)	
		Small-to-medium-sized enterprise	Medium-sized enterprise	Large enterprise			
Whether there are worker health service personnel							
None	Frequency	98	13	8	119	197.392** (0.000)	
	%	69.0%	7.6%	6.8%	27.7%		
Both doctors and nurse practitioners	Frequency	20	105	89	214		
	%	14.1%	61.4%	76.1%	49.8%		
Doctors	Frequency	3	9	3	15		
	%	2.1%	5.3%	2.6%	3.5%		
Nurse practitioners	Frequency	21	44	17	82		
	%	14.8%	25.7%	14.5%	19.1%		
Total	Frequency	142	171	117	430		
	%	100%	100%	100%	100%		
Whether respirator fitting test is regularly performed							
No	Frequency	128	143	88	359		10.372** (0.006)
	%	90.1%	83.6%	75.2%	83.5%		
Yes	Frequency	14	28	29	71		
	%	9.9%	16.4%	24.8%	16.5%		
Total	Frequency	142	171	117	430		
	%	100%	100%	100%	100%		
Whether there is regular respiratory protection training							
No	Frequency	60	60	28	148	18.462** (0.001)	
	%	43.2%	35.7%	25.0%	35.3%		
Yes	Frequency	37	71	58	166		
	%	26.6%	42.3%	51.8%	39.6%		
No, but external training is allowed	Frequency	42	37	26	105		
	%	30.2%	22.0%	23.2%	25.1%		
Total	Frequency	139	168	112	419		
	%	100%	100%	100%	100%		
Who conducts respiratory protection training							
None	Frequency	23	15	14	52	24.098** (0.002)	
	%	17.0%	9.2%	13.3%	12.9%		
External professional teacher	Frequency	25	15	8	48		
	%	18.5%	9.2%	7.6%	11.9%		
Respirator supplier	Frequency	16	33	20	69		
	%	11.9%	20.2%	19.0%	17.1%		



Safety and health personnel	Frequency	65	90	48	203	
	%	48.1%	55.2%	45.7%	50.4%	
Medical personnel	Frequency	6	10	15	31	24.098** (0.002)
	%	4.4%	6.1%	14.3%	7.7%	
Total	Frequency	135	163	105	403	
	%	100%	100%	100%	100%	
Whether a respiratory protection program or implementation						
No	Frequency	89	94	43	226	
	%	63.6%	55.0%	36.8%	52.8%	
Yes	Frequency	51	77	74	202	18.932** (0.000)
	%	36.4%	45.0%	63.2%	47.2%	
Total	Frequency	140	171	117	428	
	%	100%	100%	100%	100%	

### Business Size

Regarding differences in the perceptions of respiratory protection program and policies among respondents working for companies of various sizes, Table 2 shows that there are significant differences in terms of “who should be in charge of respiratory protection duties” and “who is appropriate and credible to perform fitting test”. Those working in small-to-medium-sized enterprises (47.2%) and medium-sized enterprises (40.2%) expected trained safety and health professionals to oversee respiratory protection programs, while those working in large enterprises were accepting of anyone with relevant training regardless of background. No matter the size of the business they worked in, respondents considered third-party fitting test to be most appropriate and credible. However, those working in large enterprises had a slightly higher preference (23.9%) for first-party testing. This suggests that large enterprises take economy of scale and cost-effectiveness into consideration and invest in equipment and human resources for internal testing. In Table 3, there were significant differences in the “size of the company” in terms of “whether there are worker health service personnel”, “whether respirator fitting test is regularly performed”, “whether there is regular respiratory protection training”, “who conducts respiratory protection training”, and “whether a respiratory protection program has been implemented or there are records or documents”. In

addition, 69% of small-to-medium-sized enterprises did not have worker health service personnel, while the majority of large enterprises (76.1%) and medium-sized enterprises (61.4%) had doctor and/or nurse on staff. Although the majority of businesses of all sizes did not perform respirator fitting tests on a regular basis (small-to-medium-sized enterprises 90.1%, medium-sized enterprises 83.6%, and large enterprises 75.2%), a higher percentage (24.8%) of large enterprises regularly performed fitting tests. In addition, “whether respiratory protection training is regularly held” is positively correlated with the size of the company; the larger the business, the more likely such training is regularly held (small-to-medium-sized enterprises 26.6%, medium-sized enterprises 42.3%, and large enterprises 51.8%).

### Type of Industry

As shown in Table 4, the perceptions of respondents from various industries only exhibited significant differences in terms of who should be in charge of respiratory protection duties. Respondents from most industries preferred that their employer assign a safety and health professional with relevant training to carry out respiratory protection duties (construction 48.8%, indoor workers 59.6%, healthcare and social work service 41.2%, and other service industries 56.8%) but those in manufacturing preferred trained department head (37.6%), while 41.7% of outdoor workers considered anyone with relevant

**Table 4. Chi-Square test results of industry and perception.**

	Industry						Total	X <sup>2</sup>	(p-value)
	Construction, plumbing/ electricity, natural gas, mining	Manufacturing	Indoor worker	Outdoor worker	Healthcare and social work service	Other service			
<b>Whether understands respiratory protection program/degree of understanding</b>									
No understanding, slight understanding	Frequency 17	76	19	10	37	174			
	% 39.5%	38.8%	36.5%	40.0%	53.6%	40.5%			
Rough understanding, full understanding	Frequency 26	120	33	15	32	256			6.492 (0.261)
	% 60.5%	61.2%	63.5%	60.0%	46.4%	59.5%			
Total	Frequency 43	196	52	25	69	430			
	% 100%	100%	100%	100%	100%	100%			
<b>Who should be in charge of respiratory protection duties</b>									
Trained safety and health professional	Frequency 21	64	31	6	28	175			
	% 48.8%	33.0%	59.6%	25.0%	41.2%	41.2%			
Trained department heads	Frequency 9	73	9	8	18	124			
	% 20.9%	37.6%	17.3%	33.3%	26.5%	29.2%			25.623** (0.004)
Anyone with training	Frequency 13	57	12	10	22	126			
	% 30.2%	29.4%	23.1%	41.7%	32.4%	29.6%			
Total	Frequency 43	194	52	24	68	425			
	% 100%	100%	100%	100%	100%	100%			
<b>Who is appropriate to perform physiological evaluations</b>									
Trained doctors	Frequency 18	86	22	12	31	192			
	% 41.9%	45.5%	42.3%	48.0%	47.0%	45.8%			
Trained nurse practitioners	Frequency 15	67	16	6	24	139			
	% 34.9%	35.4%	30.8%	24.0%	36.4%	33.2%			5.434 (0.860)
Trained safety and health personnel	Frequency 10	36	14	7	11	88			
	% 23.3%	19.0%	26.9%	28.0%	16.7%	21.0%			
Total	Frequency 43	189	52	25	66	419			
	% 100%	100%	100%	100%	100%	100%			
<b>Who is more appropriate and credible to perform fitting test</b>									
Third-party notarized tester	Frequency 33	110	38	16	45	276			
	% 76.7%	57.9%	73.1%	66.7%	66.2%	65.7%			
Second-party supplier	Frequency 6	33	3	2	10	58			
	% 14.0%	17.4%	5.8%	8.3%	14.7%	13.8%			15.800 (0.106)
First-party self-testing	Frequency 4	47	11	6	13	86			
	% 9.3%	24.7%	21.2%	25.0%	19.1%	20.5%			
Total	Frequency 43	190	52	24	68	420			
	% 100%	100%	100%	100%	100%	100%			

training acceptable. As shown in Table 5, there were significant differences among industries in terms of “whether there are worker health service personnel”, “whether there is regular respirator fitting test”, “whether there is regular respiratory protection training”, “who conducts respiratory protection training”, and “whether a respiratory protection program has been implemented or there are records or documents”. A pattern emerged in which industries with higher percentages of both doctors and nurses on staff (healthcare and social work service 71% and manufacturing 54.1%) also had higher percentages of respiratory protection training programs (47-50%) and implementation of respiratory protection program or keeping of records or documents (54-64%). Conversely, some industries with high percentages of neither doctor nor nurse on staff (construction 51.2% and indoor workers 61.5%) tended to be less active in carrying out respiratory protection training (only 20-32%) and implementing protection program or keeping records or documents (only 28-32%). No firefighters responded to the questionnaire. As firefighters are government employees, they are not included in the scope of Article 277-1, even though respiratory protection programs are very important in their line of work.

### *Respondents' Position*

As shown in Table 6, there were significant differences among respondents in different positions in terms of “whether understands respiratory protection program/degree of understanding”, “who should oversee respiratory protection duties”, “who is appropriate for performing physiological evaluations”, and “who is appropriate and credible for performing fitting test”. Article 277-1 specifies that when the employer requests employees to use respirators, the employer shall assign a designated person to implement respiratory protective measures and establish recordkeeping. It can be seen from the survey results that a high percentage of managers, workers, and medical personnel believe that this should be performed by safety and health personnel. However, 36.2% of the respondents who are themselves safety and health professionals considered anyone with relevant training acceptable. In addition, 32.8% believe department heads

should receive relevant training and take on the responsibility, while 31% are willing to take on these duties in addition to their current responsibilities. The use of respirators may cause additional physiological burden on operators. Consequently, the physiological condition of the user needs to be evaluated. As shown in Table 7, there are significant differences in who should perform physiological evaluation in relation to the presence of worker health service personnel. There were 88 respondents who prefer that the evaluator be a trained safety and health professional, among whom 38 (43.2%) were in a workplace without medical personnel and 50 (56.8%) were in a workplace with medical personnel. Therefore, when an employer assigns a designated person, in accordance with Article 277-1, the distribution of responsibilities and human resources has to be taken into consideration.

### *Others*

As shown in Table 8, there were significant differences in the incidence of potential respiratory health risks in relation to industry. Respondents in manufacturing had the highest risk (84.2%) of exposure to respiratory hazards, followed by respondents in healthcare and social work services (78.3%). According to the literature [3], more than a dozen international professional associations and governmental organizations have proposed policies or methods for reducing the exposure of medical personnel to surgical smoke. Among them, enhanced ventilation in the operating room and standard surgical procedures, including the wearing of surgical masks or replacement of masks at regular intervals, are recommended [7]. As shown in Table 9, respondents had significantly different perceptions of whether there are potential respiratory health hazards and whether fitting test is performed regularly in their workplace. Among the 303 respondents who answered questions about respiratory hazards in the workplace, 80.9% noted that respirator fitting test was not performed regularly. As shown in Table 10, respondents had significantly different perceptions of “having difficulties implementing fitting test” and “whether fitting test is regularly performed.” Among the 255 respondents who noted difficulties in implementation of fitting test in their workplace,

**Table 5. Chi-Square test results of industry and implementation.**

	Industry						Total	X <sup>2</sup> (p-value)
	Construction, plumbing/ electricity, natural gas, mining	Manufacturing	Indoor worker	Outdoor worker	Healthcare and social work service	Other service		
<b>Whether there are worker health service personnel</b>								
None	Frequency 22 51.2%	40 20.4%	32 61.5%	6 24.0%	5 7.2%	14 31.1%	119 27.7%	
Both doctors and nurse practitioners	Frequency 14 32.6%	106 54.1%	14 26.9%	17 68.0%	49 71.0%	14 31.1%	214 49.8%	
Doctors	Frequency 1 2.3%	9 4.6%	0 .0%	0 .0%	2 2.9%	3 6.7%	15 3.5%	76.825** (0.000)
Nurse practitioners	Frequency 6 14.0%	41 20.9%	6 11.5%	2 8.0%	13 18.8%	14 31.1%	82 19.1%	
Total	Frequency 43 100%	196 100%	52 100%	25 100%	69 100%	45 100%	430 100%	
<b>Whether respirator fitting test is regularly performed</b>								
No	Frequency 37 86.0%	165 84.2%	50 96.2%	23 92.0%	45 65.2%	39 86.7%	359 83.5%	
Yes	Frequency 6 14.0%	31 15.8%	2 3.8%	2 8.0%	24 34.8%	6 13.3%	71 16.5%	24.677** (0.000)
Total	Frequency 43 100%	196 100%	52 100%	25 100%	69 100%	45 100%	430 100%	
<b>Whether there is regular respiratory protection training</b>								
No	Frequency 15 36.6%	67 34.9%	21 42.0%	13 52.0%	16 24.2%	16 35.6%	148 35.3%	
Yes	Frequency 9 22.0%	95 49.5%	10 20.0%	8 32.0%	31 47.0%	13 28.9%	166 39.6%	38.023** (0.000)
No, but external training is allowed	Frequency 17 41.5%	30 15.6%	19 38.0%	4 16.0%	19 28.8%	16 35.6%	105 25.1%	
Total	Frequency 41 100%	192 100%	50 100%	25 100%	66 100%	45 100%	419 100%	
<b>Who conducts respiratory protection training</b>								
None	Frequency 6 15.8%	13 6.8%	12 24.0%	7 29.2%	5 8.3%	9 22.0%	52 12.9%	102.270** (0.000)
External professional teacher	Frequency 4 10.5%	10 5.3%	9 18.0%	4 16.7%	8 13.3%	13 31.7%	48 11.9%	

Respirator supplier	Frequency	9	33	9	4	11	3	69
	%	23.7%	17.4%	18.0%	16.7%	18.3%	7.3%	17.1%
Safety and health personnel	Frequency	19	122	19	9	19	15	203
	%	50.0%	64.2%	38.0%	37.5%	31.7%	36.6%	50.4%
Medical personnel	Frequency	0	12	1	0	17	1	31
	%	.0%	6.3%	2.0%	.0%	28.3%	2.4%	7.7%
Total	Frequency	38	190	50	24	60	41	403
	%	100%	100%	100%	100%	100%	100%	100%
Whether a respiratory protection program or implementation records or documents have been established								
No	Frequency	28	90	37	17	25	29	226
	%	68.3%	45.9%	71.2%	68.0%	36.2%	64.4%	52.8%
Yes	Frequency	13	106	15	8	44	16	202
	%	31.7%	54.1%	28.8%	32.0%	63.8%	35.6%	47.2%
Total	Frequency	41	196	52	25	69	45	428
	%	100%	100%	100%	100%	100%	100%	100%

**Table 6. Chi-Square test results of position and perception.**

		Position				Total	$\chi^2$ (p-value)	
		Management	General worker	Safety and health personnel	Medical personnel			
<b>Whether understands respiratory protection</b>								
No understanding, slight understanding	Frequency	33	29	81	31	174	14.865** (0.002)	
	%	37.1%	49.2%	34.9%	62.0%	40.5%		
Rough understanding, full understanding	Frequency	56	30	151	19	256		
	%	62.9%	50.8%	65.1%	38.0%	59.5%		
Total	Frequency	89	59	232	50	430		
	%	100%	100%	100%	100%	100%		
<b>Who should supervise respiratory protection</b>								
Trained safety and health professional	Frequency	37	32	71	35	175		37.049** (0.000)
	%	42.5%	54.2%	31.0%	70.0%	41.2%		
Trained department heads	Frequency	31	9	75	9	124		
	%	35.6%	15.3%	32.8%	18.0%	29.2%		
Anyone with training	Frequency	19	18	83	6	126		
	%	21.8%	30.5%	36.2%	12.0%	29.6%		
Total	Frequency	87	59	229	50	425		
	%	100%	100%	100%	100%	100%		
<b>Who is appropriate for performing physiological evaluations</b>								
Trained doctors	Frequency	37	26	102	27	192	17.613** (0.007)	
	%	43.0%	44.1%	45.5%	54.0%	45.8%		
Trained nurse practitioners	Frequency	25	14	89	11	139		
	%	29.1%	23.7%	39.7%	22.0%	33.2%		
Trained safety and health personnel	Frequency	24	19	33	12	88		
	%	27.9%	32.2%	14.7%	24.0%	21.0%		
Total	Frequency	86	59	224	50	419		
	%	100%	100%	100%	100%	100%		
<b>Who is more appropriate and credible for performing fitting test</b>								
Third-party notarized tester	Frequency	52	43	143	38	276		12.847* (0.046)
	%	59.8%	74.1%	63.6%	76.0%	65.7%		
Second-party supplier	Frequency	11	8	30	9	58		
	%	12.6%	13.8%	13.3%	18.0%	13.8%		
First-party self-testing	Frequency	24	7	52	3	86		
	%	27.6%	12.1%	23.1%	6.0%	20.5%		
Total	Frequency	87	58	225	50	420		
	%	100%	100%	100%	100%	100%		

**Table 7. Chi-Square test results of physiological evaluations and presence of worker health service personnel.**

		Whether there are worker health service personnel				Total	$\chi^2$ (p-value)
		None	Both doctors and nurse practitioners	Doctors	Nurse practitioners		
Who should perform physiological evaluations	Trained doctors	Frequency	48	103	8	33	192
		%	25.0%	53.6%	4.2%	17.2%	100%
	Trained nurse practitioners	Frequency	32	68	3	36	139
		%	23.0%	48.9%	2.2%	25.9%	100%
	Trained safety and health personnel	Frequency	38	37	3	10	88
		%	43.2%	42.0%	3.4%	11.4%	100.0%
Total	Frequency	118	208	14	79	419	
	%	28.2%	49.6%	3.3%	18.9%	100%	

**Table 8. Chi-Square test results of industry and presence of potential respiratory hazards.**

		Industry					Total	$\chi^2$ (p-value)	
		Construction, plumbing/electricity, nature gas, mining	Manufacturing	Indoor worker	Outdoor worker	Healthcare and social work service			Other service
Potential respiratory hazard	No	Frequency	19	31	28	9	15	25	127
		%	44.2%	15.8%	53.8%	36.0%	21.7%	55.6%	29.5%
	Yes	Frequency	24	165	24	16	54	20	303
		%	55.8%	84.2%	46.2%	64.0%	78.3%	44.4%	70.5%
Total	Frequency	43	196	52	25	69	45	430	
	%	100%	100%	100%	100%	100%	100%	100%	

**Table 9. Chi-Square test results of potential respiratory hazards and regular fitting test.**

		Regular fitting test		Total	$\chi^2$ (p-value)
		No	Yes		
Whether there are workers with duties potentially hazardous to respiratory health	No	Frequency	114	13	127
		%	89.8%	10.2%	100.0%
	Yes	Frequency	245	58	303
		%	80.9%	19.1%	100.0%
Total	Frequency	359	71	430	
	%	83.5%	16.5%	100.0%	

**Table 10. Chi-Square test results of difficulties in implementing fitting test and regular fitting test.**

		Regular fitting test			Total	$\chi^2$ (p-value)
		No	Yes			
Difficulties in implementing fitting test	No	Frequency	131	44	175	13.233** (0.000)
		%	74.9%	25.1%	100%	
	Yes	Frequency	228	27	255	
		%	89.4%	10.6%	100%	
Total	Frequency	359	71	430		
	%	83.5%	16.5%	100%		

**Table 11. Logistic regression results of predictor variables.**

Predictor variable	B	S.E.	Wals	Significance	Exp(B)
b1 Potential respiratory hazard	0.293	0.352	0.696	0.404	1.341
c1 Whether understands respiratory protection program	0.007	0.305	0.000	0.982	1.007
b4_1 Whether there is respiratory protection training	0.801	0.304	6.955	0.008**	2.227
b6 Whether a respiratory protection program has been implemented or there are records or documents	1.525	0.346	19.418	0.000**	4.594
Constant	-3.185	0.412	59.743	0.000	0.041

\* $p < .05$ , \*\* $p < .01$

89.4% did not receive regular respirator fitting test. As shown in Table 11, “whether there is regular respiratory protection training” and “whether a respiratory protection program has been implemented or there are records or documents” are two important variables for predicting and explaining “whether respirator fitting test is regularly performed.” The odds ratios can be further explained as follows: the probability of a workplace having regular fitting test in which there is regular respiratory protection training is 2.23 times that of a workplace in which there is no respiratory protection training. In addition, the probability of performing fitting test in a workplace that has implemented a respiratory protection program or keeps records or documents is 4.59 times that for a workplace that has not implemented a respiratory protection program or does not keep records or documents. These results were similar to

those of an OSHA study in 2013, in which the most-cited violation was medical evaluation, followed by establishment and implementation of a respiratory protection program, fitting test, permitting employees to voluntarily use respirators, and identifying and evaluating respiratory hazards [11].

## Conclusion

Article 277-1 took effect on January 1, 2020. From the survey results, 70.5% of respondents are at risk of exposure to respiratory hazards in the workplace, 80.9% of whom do not receive regular respiratory fitting test. This may be due to an awareness among laborers that they may be exposed to respiratory hazards. However, their employers do not comply with Article 277-1 or ignore potential health hazards. Regarding who is to perform fitting test, 65.7% of



respondents considered commissioned third-party certified tester the most appropriate, while 20.5% preferred first-party (user's own business) tester and 13.8% preferred second-party (respirator supplier) tester. As second-party testing may involve a conflict of interest, it was not considered appropriate by most respondents. In addition, 68.8% of respondents believe that the tester should be able to produce a third-party testing certificate, 72.3% believe that fitting test items should be accredited, 88.1% believe that testing equipment should be regularly calibrated, and 86.3% believe that the operator should have relevant training and certification. However, common industry practice is to commission second-party suppliers for fitting test due to economic considerations, resulting in inconsistent quality of test results. Considering that businesses of different sizes may encounter different problems when implementing respiratory protection programs, regarding the implementation of the amended Article 277-1 regulations, relevant government agencies should develop a classification system based on business size and further promote the prevention and control of respiratory hazards in high-risk industries. Moreover, use and testing of respirators must comply with relevant standards (e.g., CNS 14258 Z3035 [12] and US 42 CFR part 84 [13]). Fitting test should be performed by first-party designated tester or commissioned third-party certified tester. Testing equipment should also be regularly calibrated and the operator should receive relevant training and certification. Physiological evaluation and the labor rights of and impact on those who are unable to use respirators following physiological evaluation require further discussion. Moreover, it is recommended that government agencies set relevant guidelines or produce technical manuals for the implementation of respiratory protection measures for businesses to better understand and follow regulatory standards. Due to the start of the COVID-19 pandemic, amendments to Article 277-1 were made just in time for employers to request employees to use respirators correctly and to take respiratory protective action including hazard identification and exposure assessment, choice of respirators, utilization of respirators, maintenance and management of respirators, respiratory protection education and training, and effective evaluation and

improvement.

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## Competing interests

The authors declare that they have no competing interests, financial or otherwise.

## Table Legends

Table 1. Descriptive statistics.

Table 2. Chi-Square test results of business size and perception.

Table 3. Chi-Square test results of business size and implementation.

Table 4. Chi-Square test results of industry and perception.

Table 5. Chi-Square test results of industry and implementation.

Table 6. Chi-Square test results of position and perception.

Table 7. Chi-Square test results of physiological evaluation and presence of worker health service personnel.

Table 8. Chi-Square test results of industry and presence of potential respiratory hazards.

Table 9. Chi-Square test results of potential respiratory hazards and regular fitting test.

Table 10. Chi-Square test results of difficulties in implementing fitting test and regular fitting test.

Table 11. Logistic regression results of predictor variables.

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