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ORIGINAL RESEARCH

Acceptance of COVID-19 Vaccine Among High-Risk Occupations in a Port City of China and Multifaceted Strategies for Increasing Vaccination Coverage: A Cross-Sectional Study

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Purpose: Considering high risk of imported epidemic in port cities, it is necessary to estimate COVID-19 vaccine acceptability and to promote vaccination coverage of high-risk occupations.

Methods: A cross-sectional survey was carried out among the occupations in Yantai city, China, using an online questionnaire service platform. Targeted strategies were developed based on the survey results. In addition, periodic monitoring of the vaccination rate was provided in order to evaluate the effectiveness of the strategies.

Results: A total of 2231 (73.22%) of 3047 participants were willing to accept the vaccine, while 2.53% refused and 24.25% were not sure. Frontline port workers (133/152, 87.50%) and healthcare workers (999/1155, 86.49%) had higher intentions to accept, while public places and commercial service staff (584/1011, 57.76%) had the lowest. The reasons for refusal and hesitation were mainly "doubt of safety or effectiveness" (661/816, 81.00%) and "hearing previous news about vaccines" (455/816, 55.76%). Multilevel strategies such as adequate organizations, health education and promotion, and easy access to vaccination were promoted by local authorities in collaboration with schools, hospitals, enterprises and institutions. The study showed a significant increase in vaccination rate among these occupations after the implementation of these strategies ($p<0.001$), reaching 87.96%.

Conclusion: COVID-19 vaccine acceptability among high-risk occupations was unsatisfactory before the stage of emergency vaccination. An advanced understanding of vaccine attitudes and acceptance can aid in the development of focused immunization promotion programs. It is worth emphasizing that wide strategies with the strong support and enthusiastic cooperation of the government and the industry executive can contribute to increasing occupations' acceptance of the ongoing COVID-19 immunization project.

Keywords: COVID-19, vaccine, willingness, occupation, public health policy

Introduction

The Coronavirus Disease 2019 (COVID-19) pandemic has imposed unprecedented challenges not only for human health but for social and economic systems of the countries.[1,2] To curb the spread of the epidemic, different containment efforts have been undertaken by the authorities, such as wearing face masks in public, keeping a social distance, and washing hands frequently.[3] Notably, vaccines are regarded as the most effective way of controlling the spread of disease, and an increasing number of COVID-19 vaccines have been developed and used worldwide.[4] To prevent spread in the community, a sufficient rate of immunization will be required to reach herd immunity.[5]

The vaccination strategy in China follows a "two-step" approach.[6] The first step is to build an immune barrier mainly for high-risk populations, such as front-line port workers, healthcare workers, transportation industry staff, and fresh market staff. The second step is to build an immune barrier in the entire population with a gradual increase in vaccine production and uptake. High-risk occupations are considered high-priority groups for vaccine administration because they are at high risk of exposure to the virus as well as at risk of transmitting the virus to others, including their family

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members.[7] Healthcare workers are considered to have higher infection risks, since they directly expose to the patients.[8,9] However, a number of other occupations may also be at an increased risk because they are facing a high risk of infection under the pandemic with a high chance of direct exposure to the public and contaminated cold chain goods, and the virus is more easily spread due to the high population density of their work environment, such as public places and commercial service staff, blue-collar workers in labour-intensive enterprises, transportation industry staff, and front-line port workers in contact with cold chain goods.[10–12]

In the present study, we estimated knowledge, attitude and practice towards COVID-19 vaccine as well as the reasons not to accept vaccination among different occupation groups in the initial stage of vaccine emergency use. Based on the results of the survey, we identified the influencing factors of vaccine acceptability in order to develop focused intervention strategies for promoting vaccine acceptability during the immunization campaign.[13] In addition, periodic monitoring of the vaccination rate will be provided, which can be used to evaluate the effectiveness of the strategies.

Materials and Methods

Study Design and Participants

From December 1 to December 9, 2020, a cross-sectional online survey was conducted on the largest online questionnaire service platform in China: Wen Juan Xing (https://www.wjx.cn/, Changsha Ranxing Information Technology Co., Ltd., Hunan, China). It is one of the largest online survey platforms in China, which can provide questionnaire creation, release, and management services for enterprises or individuals. The study was carried out in Yantai city, a port city located in the eastern coastal area of China. According to the statistical data issued by Yantai Municipal Statistical Bureau in 2020, the average age of the residents was 41.96 years old (the male to female ratio is 1.03:1). 19.86% of the residents had a bachelor's degree or above. Gross Regional Product of Yantai city was CNY 781,642 million and the yearly wage of an employed person was approximately CNY 88,339 in 2020. The target population was six different occupational groups: (1) public places and commercial service staff who work in malls, fresh markets, restaurants and hotels; (2) blue-collar workers in labour-intensive enterprises; (3) transportation industry staff; (4) front-line port workers in contact with cold chain food; (5) healthcare workers; and (6) teachers. The registered institutions of these occupations were randomly selected, and then the questionnaires were sent out to the administrators of the selected institutions. The sample size calculation, based on the assumptions that 40% of the occupations are hesitant to receive vaccination with 95% confidence levels, a 3% margin of error, and 10% missing rate showed that a total of 1173 subjects were needed.[14] After the administrators of the target occupations completed the questionnaire, they were encouraged to share the survey link with members of their working groups randomly.

Measurements

We designed the questionnaire based on expertise and previous research in the field.[8] The questionnaire was evaluated for critical appraisal and content validity by a team of five experts with expertise in epidemiologic and population surveys. A pilot study was conducted with 54 participants (the six target groups) to test the reliability of the questions (test-retest). The inclusion criteria were (1) ≥18 years old, (2) Chinese as a primary or native language, and (3) participants who lived in Yantai city. Participants who had retired were not included. The developed questionnaire contained six sections: (1) socio-demographic characteristics (age, sex, schooling level, occupation, personal income); (2) knowledge of COVID-19 and COVID-19 vaccines (pathogeny, source of infection, incubation period, transmission, types of COVID-19 vaccines); (3) perceived risk (perceived risk of COVID-19 infection while on the job; perceived current situation of the COVID-19 epidemic); (4) perceived likelihood of controlling the COVID-19 epidemic by vaccination; (5) vaccination history, such as influenza vaccination in the last 3 years; and (6) willingness to receive COVID-19 vaccination when it is available (accept, refuse, not sure). Those who refused and did not decide to accept COVID-19 vaccination were asked to select their reason from six options: "Doubt of COVID-19 vaccine safety", "Doubt of COVID-19 vaccine effectiveness", "Previous negative news about vaccines", "Having no time to vaccinate on weekdays", "Believing the epidemic is under control, vaccination is unnecessary" and "Others, please specify" with an open-ended question. The final questionnaire was reported in Supplementary Document. Electronic consent was obtained from the participants before the survey. This

study was conducted in accordance with the declaration of Helsinki and approved by the ethics committee of Yantai Preventive Medicine Association (YYLS2020-01).

The Implementation of Strategies

The COVID-19 vaccination program among high-risk occupations in Yantai city has been implemented since December 15, 2020, and a wide and multilevel strategies of vaccination campaign was instituted during the immunization campaign, which were offered to local authorities by the disease control agency based on the survey results (Figure 1). With planning based on organizations, health education and promotion, incentives, and easy access to vaccination, the campaign was promoted by local authorities in collaboration with schools, hospitals, enterprises and institutions. The program consisted of the following components:

Organizations

Up-bottom management was carried out during the immunization campaign. Staff member managers were responsible for organizing their personnel to be vaccinated. Moreover, on-site vaccination was performed, which meant immunization doctors and nurses were available throughout the vaccination program in schools, hospitals, enterprises and institutions to offer COVID-19 vaccinations to employees. Daily availability and prolonged vaccination times were carried out at each vaccination site.

Education and Communication

Information regarding the present epidemic, the risk of infection while on the job, the safety and effectiveness of COVID-19 vaccination, vaccine contraindications and the vaccination site was provided via different media and tools,

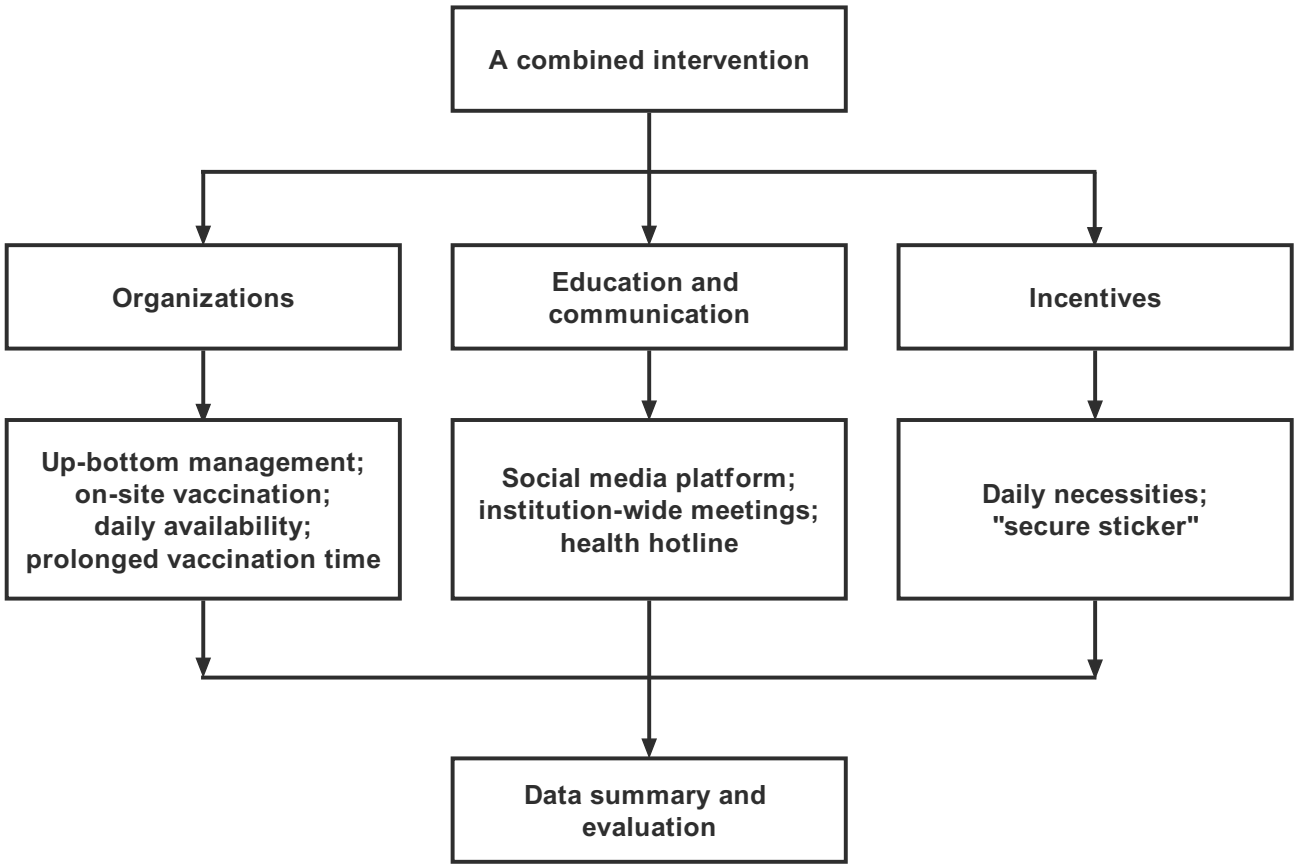

Figure 1 The wide and multilevel strategies were instituted during the COVID-19 immunization campaign. With planning based on organization, health education and communication, incentives, the campaign was promoted by local authorities in collaboration with schools, hospitals, enterprises and institutions.

such as posters, internet, television, radio, and mobile apps. With the support of administrators, vaccination promotion was delivered at various institution-wide meetings. Health hotlines aiming to help with the public's enquiries and offer recommendations were set up by local authorities.

Incentives

A "secure sticker" was developed for placement on the entrances of malls, fresh markets, restaurants and hotels in which all staff had already received at least one dose of COVID-19 vaccine. Daily necessities, such as food and personal protective equipment, were provided for those who came for vaccination to motivate employees to get vaccinated.

Database and Reporting

A database was developed to record all staff employed during the program. A listing of total staff and the number of vaccinations was obtained from staff member managers and was revised to ensure that all staff, including externs and temporary workers, were enrolled. Public health agencies summarized data and evaluated vaccination rates regularly and provided feedback to authorities in a timely manner.

Statistical Analysis

Kappa coefficients were calculated for categorical variables and intra-class correlation coefficients for continuous variables, which were used to examine test-retest reliability. Descriptive analysis was used to evaluate the willingness to receive the COVID-19 vaccine based on different survey characteristics. Categorical data were summarized as frequencies and proportions. For each cross-tabulation, the chi-squared test or Fisher's exact test was used to evaluate the categorical variables. Multiple multinomial logistic regression was applied to examine the association between intention to receive COVID-19 vaccination and occupation, knowledge of COVID-19 and COVID-19 vaccines, perceived risk of COVID-19 infection while on the job, perceived current situation of the COVID-19 epidemic, perceived likelihood of controlling the COVID-19 epidemic by vaccination, and previous acceptance of influenza vaccination, with adjustments for sex, schooling level and personal income. There were five knowledge items about COVID-19 and COVID-19 vaccine. Score 3–5 was regarded as good knowledge, and score of <3 was regarded as poor knowledge. The adjusted odds ratio (aOR) and 95% confidence interval (95% CI) was used to estimate the association. Reasons for refusal and hesitancy of COVID-19 vaccination and vaccination rate were summarized by the occupation types of the participants. In addition, we performed the Cochrane-Armitage test for trends to determine whether the vaccination rate of employees changed over time. A value of $p<0.05$ was considered statistically significant. The data were analyzed using R version 3.6.1.

Results

Sample Characteristics

The results demonstrated a good content validity of the questionnaire based on qualitative interviews, and excellent test-retest reliability (The Kappa coefficients and intra-class coefficients ranged between 0.8 and 0.9). A total of 3057 questionnaires were recovered in the survey. Each item of the questionnaire was set up for mandatory responses; otherwise, the questionnaire could not be submitted. Ten invalid questionnaires were eliminated because the respondents disagreed with the survey. Thus, a total of 3047 valid questionnaires were collected. The effective questionnaire recovery rate was 99.67%.

Regarding occupations, 1011 (33.18%) of respondents were public places and commercial service staff, 394 (12.93%) were blue-collar workers, 108 (3.54%) were transportation industry staff, 152 (4.99%) were front-line port workers, 1155 (37.91%) were healthcare workers and 227 (7.45%) were teachers. The mean age was 37.19 ± 8.85 (range, from 18 to 65 years old) in the survey. Table 1 showed the associated sociodemographic and epidemiological characteristics of the different occupations.

Table 1 Characteristics of Different Occupations Who Were Enrolled in the Study

Subjects Characteristics	Public Places and Commercial Service Staff (%)	Blue-Collar Workers (%)	Transportation Industry Staff (%)	Front-Line Port Workers (%)	Healthcare Workers (%)	Teachers (%)
Age						
18–29	14.84	11.42	11.11	40.13	29.44	10.57
30–39	38.77	48.22	45.37	39.47	41.12	36.12
40–49	33.53	27.41	34.26	14.47	21.39	37.44
50+	12.86	12.95	9.26	5.93	8.05	15.87
Sex						
Male	12.36	66.24	87.04	90.13	24.50	23.35
Female	87.64	33.76	12.96	9.87	75.50	76.65
Schooling level						
High school or below	80.12	47.72	37.04	18.42	6.32	2.64
Associates degree	15.92	32.23	26.85	26.97	31.08	13.22
Bachelor degree	3.66	19.29	33.33	49.34	54.89	56.83
Post-graduate degree	0.30	0.76	2.78	5.27	7.71	27.31
Personal income (CNY/year)						
<50,000	84.37	43.15	14.81	11.84	45.54	16.30
50,000–100,000	13.25	53.55	77.78	67.11	49.78	71.81
>100,000	2.38	3.30	7.41	21.05	4.68	11.89
Knowledge score about COVID-19 and COVID-19 vaccine						
Poor	44.31	40.61	26.85	22.37	19.74	23.35
Good	55.69	59.39	73.15	77.63	80.26	76.65
Perceived risk of COVID-19 infection while on the job						
High	67.95	46.95	67.59	75.00	70.13	45.37
Fair	26.21	43.40	30.56	23.68	27.62	48.02
Low	5.84	9.65	1.85	1.32	2.25	6.61
Perceived current situation of the COVID-19 epidemic						
Very dangerous	86.55	89.09	93.52	90.13	85.97	88.55
Moderately dangerous	11.97	9.64	6.48	9.21	13.77	11.01
Not dangerous	1.48	1.27	0.00	0.66	0.26	0.44
Perceived likelihood of controlling COVID-19 epidemic by vaccine						
Very likely	63.80	73.35	82.41	87.50	84.42	75.77
Somewhat likely	6.43	4.57	4.63	5.26	5.28	7.05
Not likely	0.89	0.76	0.00	0.00	0.17	0.88
Not sure	28.88	21.32	12.96	7.24	10.13	16.30
Other vaccines uptake in the last 3 years						
Yes	8.90	7.11	5.56	7.24	34.55	23.35
No	91.10	92.89	94.44	92.76	65.45	76.65
Total	100.00	100.00	100.00	100.00	100.00	100.00

Acceptance, Preferences and Influencing Factors of COVID-19 Vaccination

Overall, 2231 (73.22%) of 3047 participants stated that they were willing to be vaccinated against COVID-19, while 77 (2.53%) of them refused COVID-19 vaccination and 739 (24.25%) of them stated that they were not sure they wished to get vaccinated. For occupations, 584 (57.76%) of 1011 public places and commercial service staff, 272 (69.04%) of 394 blue-collar workers, 86 (79.63%) of 108 transportation industry staff, 133 (87.50%) of 152 front-line port workers, 999 (86.49%) of 1155 healthcare workers, and 157 (69.16%) of 227 teachers were willing to be vaccinated (Table 2).

From the univariate analysis (Table 2), the willingness to receive COVID-19 vaccination was found to be associated with sex, schooling level, occupation, personal income, knowledge score about COVID-19 and COVID-19 vaccines,

Table 2 Willingness to Accept COVID-19 Vaccine by Different Characteristics of Participants

	Willingness to Accept COVID-19 Vaccine						*p* value[a]
	Accept		Refuse		Not Sure		
	n	%	n	%	n	%	
Age							
18–29	477	75.47	16	2.53	139	21.99	0.381
30–39	886	70.99	34	2.72	328	26.28	
40–49	618	73.75	20	2.39	200	23.87	
50+	250	75.99	7	2.13	72	21.88	
Sex							
Male	773	81.11	24	2.52	156	16.37	<0.001
Female	1458	69.63	53	2.53	583	27.84	
Schooling level							
High school or below	722	63.06	40	3.49	383	33.45	<0.001
Associates degree	579	77.51	14	1.87	154	20.62	
Bachelor degree	806	81.66	20	2.03	161	16.31	
Post-graduate degree	124	73.81	3	1.79	41	24.40	
Occupation							
Public places and commercial service staff	584	57.76	36	3.56	391	38.67	<0.001
Blue-collar workers	272	69.04	12	3.05	110	27.92	
Transportation industry staff	86	79.63	1	0.93	21	19.44	
Front-line port workers	133	87.50	1	0.66	18	11.84	
Healthcare workers	999	86.49	25	2.16	131	11.34	
Teachers	157	69.16	2	0.88	68	29.96	
Personal income (CNY/year)							
<50,000	1110	68.52	44	2.72	466	28.77	<0.001
50,000–100,000	987	77.78	30	2.36	252	19.86	
>100,000	134	84.81	3	1.90	21	13.29	
Knowledge score about COVID-19 and COVID-19 vaccine							
Poor	627	65.86	35	3.68	290	30.46	<0.001
Good	1604	76.56	42	2.00	449	21.43	
Perceived risk of COVID-19 infection while on the job							
High	1488	75.46	46	2.33	438	22.21	<0.05
Fair	646	69.24	25	2.68	262	28.08	
Low	97	68.31	6	4.23	39	27.46	
Perceived current situation of the COVID-19 epidemic							
Very dangerous	1960	73.74	61	2.29	637	23.97	<0.05
Moderately dangerous	257	70.60	14	3.85	93	25.55	
Not dangerous	14	56.00	2	8.00	9	36.00	
Perceived likelihood of controlling COVID-19 epidemic by vaccine							
Very likely	1903	82.63	36	1.56	364	15.81	<0.001
Somewhat likely	103	59.54	8	4.62	62	35.84	
Not likely	7	43.75	2	12.50	7	43.75	
Not sure	218	39.28	31	5.59	306	55.14	
Other vaccines uptake in the last 3 years							
Yes	498	84.84	6	1.02	83	14.14	<0.001
No	1733	70.45	71	2.89	656	26.67	
Total	2231	73.22	77	2.53	739	24.25	

Notes: [a] *p* value is calculated by Chi-square test or Fisher's exact test.

perceived risk of COVID-19 infection while on the job, perceived current situation of the COVID-19 epidemic, perceived likelihood of controlling the COVID-19 epidemic by vaccination, and other vaccines had been received in the last 3 years. These factors were used as covariates in the multiple multinomial regression examining the change in the willingness of participants to accept the vaccine.

In the multiple multinomial logistic regression (Table 3), male participants were more likely to accept the vaccine (aOR: 1.71, 95% CI: 1.31–2.23). Regarding schooling level, those with a high school education or below were more likely to accept the vaccine. Healthcare workers were more likely to accept the vaccine (aOR: 2.51, 95% CI: 1.71–3.68), while public places and commercial service staff were less likely to accept it (aOR: 0.57, 95% CI: 0.37–0.89). Moreover,

Table 3 Factors Associated with Intentions to Accept COVID-19 Vaccination When It is Available

("Not Sure" as Reference)	Willingness to Accept COVID-19 Vaccine			
	Accept		Refuse	
	aOR	95% CI	aOR	95% CI
Sex				
Male	1.71	(1.31, 2.23)	1.86	(0.97, 3.57)
Female	Reference		Reference	
Schooling level				
High school or below	1.99	(1.19, 3.34)	2.19	(0.51, 9.37)
Associates degree	1.59	(0.98, 2.56)	1.35	(0.34, 5.37)
Bachelor degree	1.52	(0.97, 2.36)	1.60	(0.43, 5.85)
Post-graduate degree	Reference		Reference	
Occupation				
Public places and commercial service staff	0.57	(0.37, 0.89)	2.50	(0.49, 12.78)
Blue-collar workers	0.78	(0.50, 1.24)	2.20	(0.42, 11.46)
Transportation industry staff	1.00	(0.53, 1.89)	0.87	(0.07, 10.97)
Front-line port workers	1.55	(0.82, 2.94)	1.02	(0.08, 12.61)
Healthcare workers	2.51	(1.71, 3.68)	1.18	(0.59, 2.36)
Teachers	Reference		Reference	
Personal income (CNY/year)				
<50,000	0.59	(0.34, 1.02)	0.53	(0.14, 2.03)
50,000–100,000	0.54	(0.32, 0.92)	0.70	(0.19, 2.54)
>100,000	Reference		Reference	
Knowledge score about COVID-19 and COVID-19 vaccine[1]				
Poor	0.91	(0.74, 1.11)	1.34	(0.81, 2.21)
Good	Reference		Reference	
Perceived risk of COVID-19 infection while on the job				
High	1.08	(0.70, 1.66)	0.80	(0.31, 2.09)
Fair	0.74	(0.48, 1.14)	0.64	(0.24, 1.69)
Low	Reference		Reference	
Perceived current situation of the COVID-19 epidemic				
Very dangerous	1.07	(0.42, 2.71)	0.40	(0.08, 2.00)
Moderately dangerous	0.82	(0.31, 2.15)	0.60	(0.11, 3.24)
Not dangerous	Reference		Reference	
Perceived likelihood of controlling COVID-19 epidemic by vaccine				
Very likely	5.91	(4.74, 7.36)	0.84	(0.49, 1.42)
Somewhat likely	1.91	(1.31, 2.80)	1.21	(0.52, 2.80)
Not likely	1.67	(0.56, 5.00)	2.16	(0.41, 11.51)
Not sure	Reference		Reference	
Other vaccines uptake in the last 3 years				
Yes	1.54	(1.16, 2.04)	0.53	(0.21, 1.30)
No	Reference		Reference	

those with an annual income of CNY 50,000–100,000 ($7,912–15,823) were less likely to accept the vaccine (aOR: 0.54, 95% CI: 0.32–0.92). Those who thought that the COVID-19 epidemic was very likely or somewhat likely to be controlled by vaccination were more likely to accept the vaccine. Those who had received other vaccines in the last 3 years were more likely to accept the vaccine (aOR: 1.54, 95% CI: 1.16–2.04).

Reasons for COVID-19 Vaccine Refusal or Hesitancy

Participants were asked about their reasons for COVID-19 vaccine refusal or hesitancy (Table 4). A total of 661 (81.00%) participants had doubts about the vaccine's safety, 455 (55.76%) had doubts about its effectiveness, 320 (39.22%) were against vaccination because of previous negative news about vaccines, 156 (19.12%) had no time to go to the clinic for vaccination on weekdays and 60 (7.35%) believed that vaccination was unnecessary because the epidemic was under control. In addition, some participants worried that they had vaccine contraindications. Significant differences among occupations were found for all reasons. Regarding occupations, most of them had doubts about the vaccine's safety and effectiveness, and 40.91–45.67% of transportation industry staff, blue-collar workers and public places and commercial service staff worried about previous negative news about vaccines. A total of 42.31% of healthcare workers had no time to vaccinate on weekdays.

Vaccination Rate

Local authorities have mainly pushed forward the vaccination of front-line port workers, transportation industry staff and healthcare workers since December 15, 2020. In the initial stage of vaccination, front-line port workers had the highest vaccination rate (62.64%), followed by healthcare workers (52.12%) by the end of January (Figure 2). With the strengthening of combined strategies among public places and commercial service staff since March 2021, blue-collar workers in labour-intensive enterprises and teachers, the vaccination rates of other occupations have gradually increased. By end of May 2021, the vaccination rates of all occupations had reached over 85%. In the trend test analysis, the vaccination rates of all occupations significantly increased over time (p for trend<0.05). At the end of May 2021, 870,978 high-risk occupations (87.96%) received the vaccine with a significant increase from the period before the adoption of strategies (p<0.001). This statistically significant difference among occupations was found as well (p<0.001). A comparison between the period before and after adoption of strategies by occupations was shown in Table 5.

Discussion

Our investigation was conducted in Yantai city, a port city of China, during the fifth wave of the epidemic in China, while there were no cases in Yantai city during the period of the survey.[15] Epidemiological investigations revealed that the risk of imported epidemics in port cities was high, and high-risk occupations were more likely to be infected and cause the spread of the epidemic.[16] Since different COVID-19 vaccines have been marketed, countries around the world have

Table 4 Reasons for COVID-19 Vaccine Refusal or Hesitancy Among Different Occupations

Occupations	Doubt of COVID-19 Vaccine Safety (n,%)[a]	Doubt of COVID-19 Vaccine Effectiveness (n,%)[a]	Previous Negative News About Vaccines (n,%)[a]	Having no Time to Vaccinate on Weekdays (n,%)[a]	Believing the Epidemic is Under Control, Vaccination is Unnecessary (n,%)[a]	Total (n,%)
Public places and commercial service staff	350 (81.97)	250 (58.55)	195 (45.67)	52 (12.18)	29 (6.79)	427 (100.00)
Blue-collar workers	101 (82.79)	78 (63.93)	52 (42.62)	16 (13.11)	11 (9.02)	122 (100.00)
Transportation industry staff	18 (81.82)	12 (54.55)	9 (40.91)	6 (27.27)	1 (4.55)	22 (100.00)
Front-line port workers	15 (78.95)	7 (36.84)	6 (31.58)	7 (36.84)	3 (15.79)	19 (100.00)
Healthcare workers	113 (72.44)	68 (43.59)	36 (23.08)	66 (42.31)	12 (7.69)	156 (100.00)
Teachers	64 (94.11)	40 (57.14)	22 (31.43)	9 (12.86)	4 (5.71)	70 (100.00)
p value[b]	<0.001	<0.001	<0.001	<0.001	<0.001	
Total	661 (81.00)	455 (55.76)	320 (39.22)	156 (19.12)	60 (7.35)	816 (100.00)

Notes: [a] The number and percentage of those who choose that option. [b] p value is calculated by Chi-square test or Fisher's exact test.

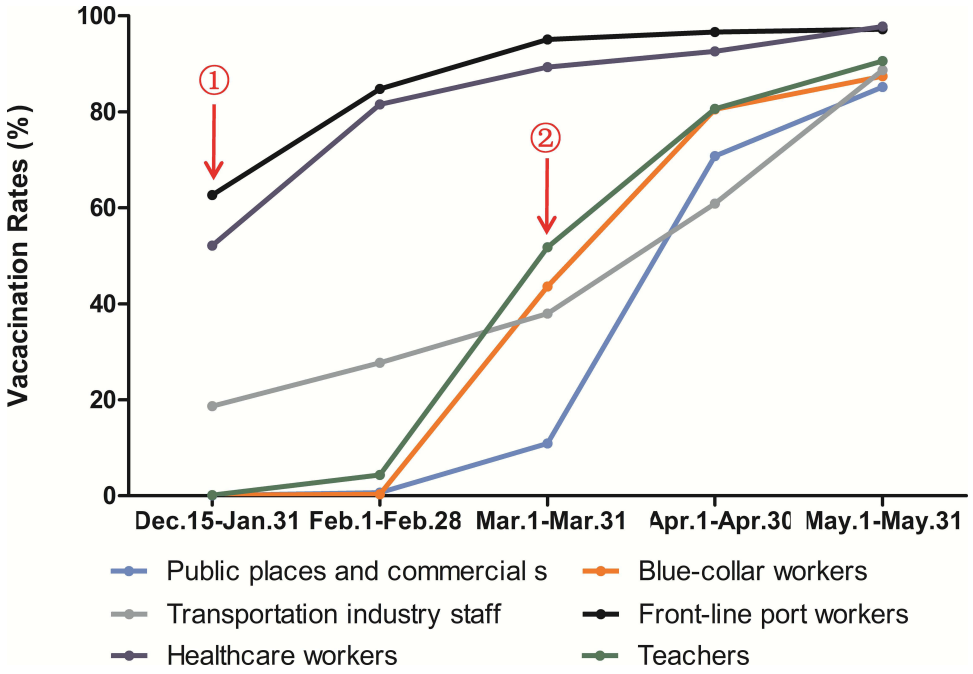

Figure 2 The vaccination rates of all occupations significantly increased over time (p for trend<0.05). 1, Local authorities mainly pushed forward the vaccination of front-line port workers, transportation industry staff and healthcare workers since December 15, 2020. 2, The vaccination of public places and commercial service staff, blue-collar workers in labour-intensive enterprises and teachers were vigorously promoted since March 2021 with multifaceted strategies.

formulated different vaccination strategies and priority is generally given to high-risk groups, such as medical workers and public service workers.[17,18] Thus, we chose different occupations who faced a higher risk of infection as the target population in this research. Despite the serious situation of the epidemic, a high proportion of high-risk occupations who refused to accept COVID-19 vaccination or were not sure about accepting vaccination was found in the survey, which might be partially due to the previous stable status of the epidemic. The findings of our research revealed that 65.7% of the participants were willing to accept COVID-19 vaccination, which was higher than previous Chinese (60.4%) and Japanese (62.1%) studies and lower than an Australian study (83.7–89.0%).[14,19,20] The reasons for refusal and hesitation were mainly "doubt of safety or effectiveness" and "hearing previous news about vaccines". During the ongoing pandemic, the anti-vaccine movement and raging new COVID-19 variants (eg, Delta and Omicron) have fueled skepticism towards the possibility of a worldwide vaccine-induced herd immunity. However, it is worth emphasizing that increasing vaccination coverage was the most important contributing factor in reducing hospitalizations and deaths.[21,22] Therefore, more effort should be invested in promoting the COVID-19 vaccine among the population.

Table 5 COVID-19 Vaccination Uptake Among Different Occupations Before and After the Strategies

Occupation	Before the Strategies[a]		After the Strategies[b]		p value
	Total Staff	Vaccinated Staff (%)	Total Staff	Vaccinated Staff (%)	
Public places and commercial service staff	409,327	2620 (0.64)	411,915	350,951 (85.20)	<0.001
Blue-collar workers	358,473	1112 (0.31)	356,195	311,314 (87.40)	<0.001
Transportation industry staff	29,196	5460 (18.70)	29,114	25,815 (88.67)	<0.001
Front-line port workers	19,231	12,047 (62.64)	18,560	18,040 (97.20)	<0.001
Healthcare workers	89,115	46,447 (52.12)	95,013	92,923 (97.80)	<0.001
Teachers	79,824	3457 (4.33)	79,399	71,935 (90.60)	<0.001
Total	985,166	71,143 (7.22)	990,196	870,978 (87.96)	<0.001

Notes: [a] The statistical data of transportation industry staff, front-line port workers and healthcare workers were as of January 31, 2021. Public places and commercial service staff, blue-collar workers and teachers were as of February 28, 2021. [b] The statistical data of all the occupations were as of May 31, 2021.

Differences in acceptance of COVID-19 vaccination and the influencing factors were found among different occupations. Overall, participants who perceived that vaccination was likely to control the COVID-19 epidemic were more willing to be vaccinated, suggesting that having a positive attitude towards vaccination is a significant predictor of COVID-19 vaccine uptake intentions.[23] Furthermore, participants who had received other vaccines, such as seasonal influenza vaccine, in the last 3 years were more willing to accept the COVID-19 vaccine, suggesting that a secure vaccination experience was sufficient to make individuals more confident about being vaccinated.[24] Moreover, according to previous studies, risk perception played an important role in the choice of getting vaccinated, increasing the willingness to accept the COVID-19 vaccine even for the more hesitant populations.[25] Thus, we chose "perceived risk of COVID-19 infection while on the job" and "perceived current situation of the COVID-19 epidemic" as the possible influencing factors. The univariate analysis results showed that the willingness to receive COVID-19 vaccination was associated with these factors, confirming the hypothesis that risk perception played a key role in the choice of getting vaccinated.

Regarding occupations, front-line port workers had the highest willingness to accept COVID-19 vaccination (87.5%). Epidemiological investigation revealed that contaminated cold-chain food products caused a recurrence of COVID-19 cases.[26] Thus, China has intensified the supervision of imported frozen food, and front-line port workers have been included on the priority list of occupations for COVID-19 vaccinations.[12] Our study found that healthcare workers had greater acceptance than the other groups of workers (86.49%, OR: 2.44, 95% CI: 1.66–3.58), which is similar to the findings of research in Indonesia.[27] Healthcare workers have more knowledge about COVID-19 and vaccines and perceived a high risk of COVID-19 infection while on the job and high self-protection awareness have been drivers of vaccination in previous studies.[28,29] It is worth noting that doctors' recommendations are important facilitators for vaccine confidence and acceptance;[30] therefore, it is important to promote the uptake of vaccination for healthcare workers. However, public places and commercial service staff had the lowest willingness to accept COVID-19 vaccination compared to others (52.69%, aOR: 0.44, 95% CI: 0.28–0.70), which is similar to research findings in Hong Kong.[31] Our results showed that these respondents had more doubt about COVID-19 vaccine safety and vaccine effectiveness, which might be due to a lower schooling level. However, public places and commercial service staff are exposed to higher risks of COVID-19 infection and are more likely to transmit the virus to others because they have a higher frequency of contact with crowds. They also have longer working hours and lower socioeconomic status and thus have little access to publicity and education about the COVID-19 vaccination.[11] We found that the willingness of blue-collar workers in labour-intensive enterprises and teachers to be vaccinated was less than 70%. Due to the large population densities in labour-intensive enterprises and schools, viruses spread easily. In addition, the willingness of teachers to be vaccinated will affect that of their students.

Our results indicated that the "doubt of COVID-19 vaccine safety" (81.00%) and "doubt of COVID-19 vaccine effectiveness" (55.76%) were the main reasons for reluctance or hesitance to be vaccinated. Public concern about vaccine safety and effectiveness has been reported as the major obstacle to vaccination uptake, especially for newly introduced vaccines.[32–34] Furthermore, our findings confirmed that a substantial portion of the participants' willingness to be vaccinated was affected by previous negative news reports about vaccines. Public acceptance and implementation of vaccination programs are essential to prevent infectious diseases. In recent years, China has had several vaccine-related scandals that severely diminished the public's trust in the quality and effectiveness of domestically manufactured vaccines.[35–38] Although Chinese pharmaceutical companies are now taking a leading position in the race to develop and manufacture the COVID-19 vaccine, the long-term vaccine crisis has had a significantly negative influence on the public's willingness to obtain domestic vaccines.[39] This is in line with a previous study's findings that anxiety about vaccine safety reduces the public's willingness of COVID-19 vaccine uptake before marketing.[40]

Considering the management mode of the occupations, we carried out "up-bottom" organizational strategy. The managers in different industries responded to the government's call to promote the motivation of employees to receive vaccinations, organized the registration and vaccination process, and reasonably arranged the time for vaccination. Moreover, government and employers continuously delivered knowledge of vaccine safety and effectiveness and promoted trust such as publicity and education on social media platforms and at the work site. To address the issue of

having no time to vaccinate, on-site vaccination and prolonged vaccination time was performed. For example, for healthcare workers with tight working hours, vaccination sites were set up in hospitals to administer vaccinations daily and extend the vaccination hours to ensure that this staff could receive vaccinations in a timely manner. To promote the uptake of vaccination among public places and commercial service staff who had lowest willingness to vaccination, we developed a "secure sticker" for placement on the entrances of malls, fresh markets, restaurants and hotels in which all staff had already received COVID-19 vaccine, which could ensure customers that the site was secure. The result showed that the vaccination rates substantially successfully improved with our multifaceted strategies over time, especially among those who initially had a lower willingness to accept vaccination.

To the best of the author's knowledge, only a few studies have investigated the vaccination willingness of different occupations, thus far, especially among high-risk occupations. There were some limitations in our research. Firstly, our study is that a convenience sample via the online questionnaire service platform was recruited, and the numbers of participants from some occupations were lower, which may cause selection bias and doubtful representativeness. Secondly, with more available information on the safety and effectiveness of COVID-19 vaccines and the unpredictable evolution of the epidemic, individuals might change their stance regarding COVID-19 vaccination. Thirdly, in this survey, 62.09% of participants had received education at high school level or below. It is possible that they could not understand the questions in the questionnaire, which could increase information bias. Lastly, during the immunization campaign, information was not available and therefore was not collected with regard to the socio-demographic characteristics and internal policy of their workplace, leading to the possible presence of confounders that we were not able to control. Moreover, our survey did not take into account the medical conditions of the subjects. Further investigations may be required to better understand these relationships. We described an observational cross-sectional design study, an ecological study, therefore there was no possibility to determine direct causation between our strategies and the increased vaccination rate. However, the strength of our study design was the temporality that suggested that the strategies had impacted on the outcome, which could indicate that these measures were effective in improving the vaccination rate.

Conclusion

Although COVID-19 vaccine acceptability among high-risk occupations was unsatisfying in the early stage of emergency vaccination, based on the results of survey, targeted strategies involving organization, health education and promotion, incentives were developed, which could be considered good practices to help promoting immunization rates among these occupations.

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Disclosure

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