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Original Research Article

Knowledge about, attitude and acceptance towards, and predictors of intention to receive the COVID-19 vaccine among cancer patients in Eastern China: A cross-sectional survey

Jing Hong [a,b,1], Xiao-wan Xu [b,1], Jing Yang [c], Jing Zheng [d], Shu-mei Dai [e], Ju Zhou [f], Qing-mei Zhang [g], Yi Ruan [a,b,*], Chang-quan Ling [a,b,*]

[a] School of Traditional Chinese Medicine, Naval Medical University, Shanghai 200433, China
[b] Department of Integrative Oncology, Changhai Hospital, Naval Medical University, Shanghai 200433, China
[c] Department of Oncology, The First Affiliated Hospital, Bengbu Medical College, Bengbu 233010, Anhui Province, China
[d] Department of Nursing, Fuyang Cancer Hospital, Fuyang 236000, Anhui Province, China
[e] Department of Cardiac Rehabilitation, Shanghai First Rehabilitation Hospital, Shanghai 200090, China
[f] Department of Radiation Oncology, Anhui Chest Hospital, Hefei 230022, Anhui Province, China
[g] Department of Anesthesiology, Chaohu Hospital, Anhui Medical University, Hefei 238000, Anhui Province, China

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ABSTRACT

Objective: The coronavirus disease 2019 (COVID-19) pandemic has had a serious impact on health all over the world. Cancer patient, whose immunity is often compromised, faces a huge challenge. Currently, some COVID-19 vaccines are being developed and applied on general population; however, whether cancer patients should take COVID-19 vaccine remains unknown. Our study aimed to explore the knowledge, attitude, acceptance, and predictors of intention to receive the COVID-19 vaccine among cancer patients in Eastern China.

Methods: A cross-sectional study was conducted in Eastern China from June 17th to September 3rd, 2021. Patients were selected using a convenience sampling method. A self-report questionnaire was developed to assess knowledge about the COVID-19 vaccine, attitude towards the vaccine and acceptance of the vaccine; following a review of similar studies previously published in the scientific literature, multivariate logistic regression analysis was used to determine the predictors associated with COVID-19 vaccine acceptance.

Results: A total of 2158 cancer patients were enrolled in this study. The rate of vaccine hesitancy was 24.05% (519/2158); further, among the participants of vaccine acceptance, 767 had taken COVID-19 vaccine (35.54%), and 872 were willing to get vaccinated (40.01%). A total of 24 variables including demographic characteristics, clinical status of cancer, impact of COVID-19 pandemic on study participants, patients' knowledge about the COVID-19 vaccine, and attitude towards the vaccine, had significant differences between the "vaccine hesitancy" population and "vaccine acceptance" population. Multivariate logistic regression analysis indicated that parameters including alcohol consumption (odds ratio [OR] = 1.849; 95% confidence interval [CI]: 1.375–2.488; P-reference [P-Ref] < 0.001 vs non-drinkers), income impacted by COVID-19 pandemic (OR = 1.930, 2.037 and 2.688 for mild, moderate, and severe impact, respectively; all P-Ref < 0.01 vs no impact), knowledge of how the vaccine was developed (OR = 1.616; 95% CI: 1.126–2.318; P-Ref = 0.009 vs unknown), believing in the safety of the vaccine (OR = 1.502; 95% CI: 1.024–2.203; P-Ref = 0.038 vs denying the safety of vaccine), willingness to pay for the vaccine (OR = 3.042; 95% CI: 2.376–3.894; P-Ref < 0.001 vs unwilling), and willingness to recommend families and friends to get vaccinated (OR = 2.744; 95% CI: 1.759–4.280; P-Ref < 0.001 vs do not recommend) were contributors to vaccine acceptance. While such as being retired (OR = 0.586; 95% CI: 0.438–0.784; P-Ref < 0.001 vs unemployed), undergoing multiple therapies of cancer (OR = 0.408; 95% CI: 0.221–0.753; P-Ref = 0.004 vs no ongoing treatment), and worrying that the vaccine might deteriorate the prognosis of cancer (OR = 0.393; 95% CI: 0.307–0.504; P-Ref < 0.001 vs might not) were contributors to vaccine hesitancy.

* Corresponding authors at: School of Traditional Chinese Medicine, Naval Medical University, Shanghai 200433, China. Department of Integrative Oncology, Changhai Hospital, Naval Medical University, Shanghai 200433, China

E-mail addresses: ruanyi@smmu.edu.cn (Y. Ruan), changquanling@smmu.edu.cn (C.Q. Ling).

[1] Jing Hong and Xiao-wan Xu contributed equally to this work.

Conclusion: This study provided preliminary estimates of the rates of vaccine acceptance and vaccine hesitancy among cancer patients in Eastern China. The intention to receive the COVID-19 vaccine was impacted by factors such as patient occupation, alcohol consumption, and some parts of knowledge about and attitude towards COVID-19 vaccine. It is recommended to develop individualized vaccination plans that meet the healthcare needs of cancer patients.

1. Introduction

Currently, the prevalence of coronavirus disease-19 (COVID-19) is a serious threat to socio-economic development and public health worldwide [1]. As of September 19th, 2021, globally, the reported cumulative number of COVID-19 cases exceeded 228 million, and the number of deaths was almost 4.6 million [2]. The World Health Organization (WHO) declared the COVID-19 outbreak to be a pandemic on 11 March 2020 [3,4].

When the COVID-19 outbroke in China at the beginning of 2020, the Chinese government took urgent action to control its prevalence. During this battle, traditional Chinese medicine (TCM), as an important part of the complementary and alternative medicine, played a vital role in China: it was adopted as one of the main therapies in the treatment plan announced by the National Health Commission of the People's Republic of China [5], and applied on 90% of Chinese COVID-19 patients [6]. Practice has proved that the combination of TCM and Western medicine is the most powerful weapon for the prevention and treatment of COVID-19, providing a new idea and new method for the global fight against this epidemic [7–9]. A meta-analysis showed that TCM not only can promote the recovery of patients in mild stage, but also is an important auxiliary treatment method for those in severe and extremely severe stage [10]. A retrospective study also proved that TCM could help Western medicine treatments to reduce the negative conversion time of fecal nucleic acid and the duration of negative conversion of pharyngeal-fecal nucleic acid [11].

Although TCM has been proved to be a good way to cure COVID-19 patients, it is believed that vaccination is still the only way to ultimately control the prevalence of COVID-19 pandemic [12]. Since the genetic sequence of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which caused COVID-19, was published, many vaccines have been developed [13–16], and, as of the writing of this manuscript, the WHO has approved two Chinese vaccines for emergency use against COVID-19 [17].

The cancer patient population is a special group of people who are at high risk of serious and lethal complications from COVID-19 [18,19]. Due to a lack of data on the safety and efficacy of vaccines in cancer patients [20–22], there is still no clinical guideline on whether cancer patient should take COVID-19 vaccine. On April 27, 2021, the European Society for Medical Oncology launched an initiative to prioritize the vaccination of patients with cancer, based on the extrapolation of safety and effectiveness data for other vaccines among cancer patients and COVID-19 vaccination in non-cancer patients; however, they also affirmed the necessity to monitor side effects [23]. The United States (US) National Comprehensive Cancer Network recommended that patients with active cancer and those under treatment should be prioritized for vaccination and should be immunized when any vaccine had been authorized for use by the US Food and Drug Administration [24]. Further, a prospective observational study suggested that cancer patients should receive the second dose of COVID-19 vaccine earlier than the general population [25]. Some researchers believed that, among cancer patients, the benefits of vaccination would outweigh the risks [26].

Vaccination is an important tool for reducing the spread of an infectious disease through a population, but hesitancy in vaccination has been one of the biggest obstacles to controlling the COVID-19 pandemic. "Vaccine hesitancy" refers to the reluctance or refusal to receive a vaccination despite the availability of a vaccine, and the WHO identified it as one of the top ten health threats in the world [27].

Recently, several studies have explored the attitudes of cancer patients towards receiving the COVID-19 vaccine. A French cross-sectional study showed that about 16.6% of cancer patients were unwilling to get vaccinated at the beginning of the vaccination campaign [28]. In Italy, it was reported that 11.2% of cancer patients refused vaccination [29]. In Poland, up to 23.46% of cancer patients refused to get vaccinated, while 16.22% were undecided about whether they should receive the vaccine [30]. The rate of vaccination hesitancy is higher among cancer patients than among the general population. For example, a Chinese cross-sectional survey reported that only 8.7% of healthy adults were unwilling to receive the vaccine [31]; in Australia, 6% of the population refused the vaccine [32], and in Japan, 11.0% of respondents refused to take the COVID-19 vaccine [33]. Lack of faith in the efficacy and safety of vaccines is often cited as a main factor in vaccine hesitancy in various countries [34–38]. Some researchers pointed out that gender, age, race, level of education, marital status, and knowledge about COVID-19 may also be associated with vaccine acceptance [39–41].

To promote the global COVID-19 vaccination programs, it is critical to understand the concerns and hesitancy about the COVID-19 vaccine among cancer patients. However, until now, no data addressing this question for cancer patients in China had been published.

Eastern China, covering provinces of Shanghai, Jang Su, Zhejiang, Anhui, Jiangxi, Shangdong, and Fujian, is one of the regions with the high incidence and mortality of cancer in China [42]; it is also among the areas that have high incidence of COVID-19 in China [43]. Therefore, we conducted an online survey among cancer patients in Eastern China, to document this population's knowledge about and attitude towards the COVID-19 vaccine; we also evaluated the rate of vaccine acceptance, and analyzed parameters that were predictive of a cancer patient's willingness to receive the COVID-19 vaccine.

2. Methods and materials

2.1. Study design and participants

A cross-sectional, web-based, anonymous survey was conducted among cancer patients in Eastern China, from June 17th

to September 3rd, 2021. The study was conducted using the "Questionnaire Star," a paid website that helps generate, distribute, and retrieve electronic questionnaires for mobile platforms [44]. Cancer patients over the age of 18 years were invited to participate in the study, and those with cognitive disabilities were excluded.

This study was approved by the Institutional Review Board of Changhai Hospital, Naval Medical University, China (CCHEC2013-119) and Chaohu Hospital, Anhui Medical University, China (KYXM-20210501). All participants were informed about the purpose of the study, the study procedures, and their rights. Furthermore, all participants were informed that only anonymized data would be used in this study. The written informed consent of all participants was obtained.

2.2. Questionnaire

The self-report questionnaire was developed to assess knowledge about the COVID-19 vaccine, attitude towards the vaccine and acceptance of the vaccine, following a review of similar studies previously published in the scientific literature [30,44–49]. The questionnaire was developed in English and then translated into Chinese. Subsequently, it was translated back into English to check for compatibility.

The questionnaire included four parts. (1) Basic information: the demographic characteristics (gender, age, body mass index, education, average monthly income, marital status, residence, occupation, current smoking status, and current drinking status), clinical status of cancer (cancer type, time since cancer diagnosis, presence of metastasis, family history of cancer, ongoing treatment, and complications), and the impact of COVID-19 pandemic on participants (whether the daily life and income are influenced by COVID-19, whether the regular medical treatment of cancer is hampered by COVID-19, and the risk of COVID-19 infection). (2) The intention to receive vaccination: participants were first asked to report whether they had taken COVID-19 vaccines; then, if the answer was no, they were asked whether they were willing to receive a COVID-19 vaccination; participants who had received the COVID-19 vaccine or were willing to be vaccinated were considered to belong to the "vaccine acceptance" group, and those who had not received the vaccine or were unwilling to be vaccinated were considered to be part of the "vaccine hesitancy" group. (3) Knowledge about COVID-19 vaccines: participants were asked to report their trusted information sources about COVID-19 vaccines, how long it takes for the COVID-19 vaccine to start working after vaccination, how the COVID-19 vaccines were developed, how safe the COVID-19 vaccines are, and whether they thought that COVID-19 vaccines would trigger allergies. (4) Attitude towards COVID-19 vaccine: participants were asked to respond to the following prompts: "is the COVID-19 vaccine effective," "will you encourage your parents and friends to get vaccinated," "are you willing to get the COVID-19 vaccine, even if you have to pay for it," "will the COVID vaccine worsen the prognosis of cancer," and "is it necessary to wear a mask after getting COVID-19 vaccine."

2.3. Data analyses and sample size estimation

Data analyses were performed using SPSS version 22.0 (SPSS Inc, Chicago, Illinois, USA). Socio-demographic characteristics and responses to the questionnaire were treated as categorical data and presented as numbers and percentages. A chi-squared test was used to evaluate the relationships between the independent variables (basic information, knowledge about the COVID-19 vaccine, and attitude towards the COVID-19 vaccine) and the outcome variable (the intention to receive vaccination). Variables with a *P* value < 0.1 in the univariate analysis (chi-squared test) were

included in the multivariate logistic regression analyses to identify variables that were correlated with a participant's intention to receive the COVID-19 vaccine. For these variables, the odds ratio (OR) and 95% confidence interval (CI) were reported, and a *P* value < 0.05 was considered to be statistically significant.

According to the Sample Size Guidelines for Logistic Regression from Observational Studies with Large Population [50], a minimum sample size of 500 is necessary to properly conduct a logistic regression; further, when considering the number of independent variables in the final model of logistic regression (i), the minimum sample size (n) can be estimated as: $n = 100 + 50i$. In this study, as indicated in section 2.3, the maximum number of potential independent variables in the final logistic regression model is 30, including 20 basic information variables and 10 attitude and knowledge variables; the question about trusted sources of COVID-19 vaccine information was intended to understand the participants' information sources and was not included in the analysis of predictors. Therefore, in this survey, the minimum necessary sample size was estimated to be 1600, and a greater sample size would add to the robustness of the results.

To balance the time limitation and the accuracy of statistics, the study was implemented as follows: during a two-week period, the study populations were initially recruited using a convenience sampling method in 28 hospitals located in Eastern China (each province of Eastern China had at least one hospital); next, the study population was broadened via patient-patient spreading. If, at this point, we received more than 1600 valid questionnaire responses, data collection for the study would be considered complete. Otherwise, another two-week period would have been allocated to recruit more participants.

3. Results

3.1. The characteristic of participants and COVID-19 vaccination status

A total of 2170 cancer patients were invited to participate in this online survey; of these, 12 participants returned incomplete questionnaires. Ultimately, 2158 cancer patients completed the study, and the overall effective response rate of this survey was 99.4%.

As shown in Fig. 1, among the 2158 participants, 519 were unwilling to receive the COVID-19 vaccine. Therefore, the rate of vaccine hesitancy was 24.05% (519/2158). Among the participants willing to be vaccinated, 767 had already received the COVID-19 vaccine (35.54%), and 872 were willing to be vaccinated (40.41%).

The demographic characteristics of participants showed that there were significant between-group differences ("vaccine hesitancy" group *vs* "vaccine acceptance" group) in the variables of age, marital status, education level, occupation, and current drinking status (all $P \leq 0.001$, Table 1). Among cancer patients over 40 years of age, married, with less than a high-school education, retired, and non-drinking, the proportion of vaccine hesitancy was higher than that of vaccine acceptance.

Among the six variables of clinical cancer status, the majority of both the "vaccine hesitancy" (435/519; 83.82%) and "vaccine acceptance" (1362/1639; 83.10%) participants were free of cancer-related complications ($P = 0.736$, Table 2), while significant between-group differences were observed in the proportions of cancer type, time since cancer diagnosis, ongoing treatment, family history of cancer, and metastasis (all $P < 0.01$, Table 2). Percentage of vaccine hesitancy was greater than that of vaccine acceptance among patients who reported suffering from digestive tract cancer, gynecologic cancer, and multiple types of cancer. When referred to ongoing treatment, participants undergoing TCM or multiple therapies held a higher percentage of vaccine hesitancy than vaccine
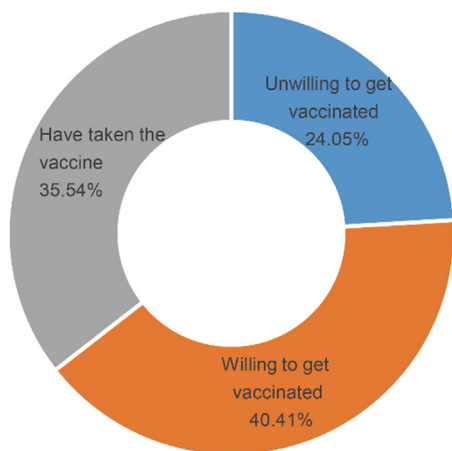
Fig. 1. The acceptance status of coronavirus disease 2019 vaccines among cancer patients in Eastern China (N = 2158).

acceptance, while those undergoing other therapies or without any treatment were more likely to accept vaccine. Besides, participants having been diagnosed with cancer more than one year prior to the

questionnaire, with a family history of cancer or metastasis also tended to be vaccine hesitancy.

As shown in Table 3, the impact of the COVID-19 pandemic had effects on participants: the majority participants reported that they were at low to high risk of infection (1747/2158; 80.95%), and that the COVID-19 pandemic had a mild to severe impact on their regular medical treatment for cancer (1877/2158; 86.98%), their daily life (1918/2158; 88.88%), and their income (1626/2158; 75.35%). The degree of risk and impact that participants reported experiencing were significantly different between "vaccine hesitancy" and "vaccine acceptance" groups (all $P \leq 0.001$, Table 3). Among participants who believed they were at risk of COVID-19 infection and who reported pandemic-related impacts on their lives, a greater proportion belonged to the "vaccine acceptance" group than the "vaccine hesitancy" group. Among participants who believed that they had not been impacted by the COVID-19 pandemic or that their regular medical treatment had not been interrupted, there were lower proportion of vaccine acceptance and greater proportion of vaccine hesitancy; when the degree of impact was mild, the proportion of vaccine acceptance overwhelmed vaccine hesitancy; however, when the degree was moderate or severe, the proportion was similar among the two intentions.

Table 1
Demographic characteristics of participants.

Item	All participants (N = 2158)	Intention to receive COVID-19 vaccine		
		Vaccine hesitancy (n = 519)	Vaccine acceptance (n = 1639)	P value
Age (year)				< 0.001
< 40	357 (16.54%)	46 (8.86%)	311 (18.97%)	
40–70	1443 (66.87%)	365 (70.33%)	1078 (65.77%)	
> 70	358 (16.59%)	108 (20.81%)	250 (15.25%)	
Gender				0.546
Female	1103 (51.11%)	259 (49.90%)	844 (51.49%)	
Male	1055 (48.89%)	260 (50.10%)	795 (48.51%)	
BMI (kg/m^2)				0.729
< 18.5	233 (10.80%)	59 (11.37%)	174 (10.62%)	
$\geq$ 18.5, < 24	1257 (58.25%)	303 (58.38%)	954 (58.21%)	
$\geq$ 24, < 28	530 (24.56%)	129 (24.86%)	401 (24.47%)	
$\geq$ 28	138 (6.39%)	28 (5.39%)	110 (6.71%)	
Marital status				0.001
Unmarried	160 (7.41%)	18 (3.47%)	142 (8.66%)	
Married	1889 (87.53%)	469 (90.37%)	1420 (86.64%)	
Divorced	47 (2.18%)	15 (2.89%)	32 (1.95%)	
Widowed	62 (2.87%)	17 (3.28%)	45 (2.75%)	
Residence				0.202
Rural	910 (42.17%)	206 (39.69%)	704 (42.95%)	
Urban	1248 (57.83%)	313 (60.31%)	935 (57.05%)	
Education level				0.001
$\leq$ Senior high school	1507 (69.83%)	393 (75.72%)	1114 (67.97%)	
College degree	319 (14.78%)	69 (13.29%)	250 (15.25%)	
$\geq$ Bachelor's degree	332 (15.38%)	57 (10.98%)	275 (16.78%)	
Occupation				< 0.001
Unemployed	819 (37.95%)	176 (33.91%)	643 (39.23%)	
Employed	623 (28.87%)	84 (16.18%)	539 (32.89%)	
Retired	716 (33.18%)	259 (49.90%)	457 (27.88%)	
Average monthly income (CNY)				0.652
< 3000	1204 (55.79%)	293 (56.45%)	911 (55.58%)	
3000–8000	753 (34.89%)	183 (35.26%)	570 (34.78%)	
> 8000	201 (9.31%)	43 (8.29%)	158 (9.64%)	
Current smoking status				0.571
No	1726 (79.98%)	420 (80.92%)	1306 (79.68%)	
Yes	432 (20.02%)	99 (19.08%)	333 (20.32%)	
Current drinking status				< 0.001
No	1609 (74.56%)	420 (80.92%)	1189 (72.54%)	
Yes	549 (25.44%)	99 (19.08%)	450 (27.46%)	

Data are presented as number (percentage). P values were calculated via chi-squared tests between the "vaccine hesitancy" and "vaccine acceptance" groups. Participants who had already received the COVID-19 vaccine or were willing to be vaccinated were included in the "vaccine acceptance" group, and those who had not received or were unwilling to receive the COVID-19 vaccine were included in the "vaccine hesitancy" group. BMI: body mass index; CNY: China Yuan; COVID-19: coronavirus disease 2019.

Table 2
Clinical status of participants.

Item	All participants (*N* = 2158)	Intention to receive COVID-19 vaccine		
		Vaccine hesitancy (*n* = 519)	Vaccine acceptance (*n* = 1639)	*P* value
Type of cancer				< 0.001
Head and neck cancer	203 (9.41%)	44 (8.48%)	159 (9.70%)	
Respiratory and thoracic cancer	579 (26.83%)	136 (26.20%)	443 (27.03%)	
Digestive tract cancer	703 (32.58%)	194 (37.38%)	509 (31.06%)	
Urogenital caner	136 (6.30%)	25 (4.82%)	111 (6.77%)	
Gynecologic cancer	325 (15.06%)	84 (16.18%)	241 (14.70%)	
Other type of cancer	152 (7.04%)	15 (2.89%)	137 (8.36%)	
Multiple types of cancer	60 (2.78%)	21 (4.05%)	39 (2.38%)	
Time since cancer diagnosis (year)				0.002
< 1	1085 (50.28%)	223 (42.97%)	862 (52.59%)	
≥ 1, < 3	692 (32.07%)	192 (36.99%)	500 (30.51%)	
≥ 3, < 5	186 (8.62%)	52 (10.02%)	134 (8.18%)	
≥ 5	195 (9.04%)	52 (10.02%)	143 (8.72%)	
Ongoing treatment				< 0.001
None	176 (8.16%)	17 (3.28%)	159 (9.70%)	
Surgery*	420 (19.46%)	63 (12.14%)	357 (21.78%)	
Radiotherapy	82 (3.80%)	17 (3.28%)	65 (3.97%)	
Chemotherapy	330 (15.29%)	77 (14.84%)	253 (15.44%)	
Immunological and molecular-targeted therapy	67 (3.10%)	15 (2.89%)	52 (3.17%)	
Traditional Chinese medicine	144 (6.67%)	43 (8.29%)	101 (6.16%)	
Other therapy	20 (0.93%)	3 (0.58%)	17 (1.04%)	
Multiple therapies	919 (42.59%)	284 (54.72%)	635 (38.74%)	
Family history of cancer				0.005
No	1895 (87.81%)	437 (84.20%)	1458 (88.96%)	
Yes	263 (12.19%)	82 (15.80%)	181 (11.04%)	
Complication				0.736
No	1797 (83.27%)	435 (83.82%)	1362 (83.10%)	
Yes	361 (16.73%)	84 (16.18%)	277 (16.90%)	
Metastasis				0.001
No	1609 (74.56%)	358 (68.98%)	1251 (76.33%)	
Yes	549 (25.44%)	161 (31.02%)	388 (23.67%)	

Data are presented as number (percentage). *P* values were calculated via chi-squared tests between the "vaccine hesitancy" and "vaccine acceptance" groups. Participants who had received or were willing to receive the COVID-19 vaccine were included in the "vaccine acceptance" group, and those who had not received or were unwilling to receive the COVID-19 vaccine were included in the "vaccine hesitancy" group. * Surgery including procedures such as excision, transarterial chemoembolization, and microwave ablation. COVID-19: coronavirus disease 2019.

Table 3
Impact of COVID-19 pandemic on study participants.

Item	All participants (*N* = 2158)	Intention to receive COVID-19 vaccine		
		Vaccine hesitancy (*n* = 519)	Vaccine acceptance (*n* = 1639)	*P* value
Risk of COVID-19 infection				0.001
Unknown	411 (19.05%)	130 (25.05%)	281 (17.14%)	
Low	893 (41.38%)	194 (37.38%)	699 (42.65%)	
Medium	440 (20.39%)	105 (20.23%)	335 (20.44%)	
High	414 (19.18%)	90 (17.34%)	324 (19.77%)	
Impact of COVID-19 pandemic on regular medical treatment of cancer				< 0.001
None	281 (13.02%)	97 (18.69%)	184 (11.23%)	
Mild	517 (23.96%)	96 (18.50%)	421 (25.69%)	
Moderate	627 (29.05%)	153 (29.48%)	474 (28.92%)	
Severe	733 (33.97%)	173 (33.33%)	560 (34.17%)	
Impact of COVID-19 pandemic on daily life				< 0.001
None	240 (11.12%)	92 (17.73%)	148 (9.03%)	
Mild	526 (24.37%)	99 (19.08%)	427 (26.05%)	
Moderate	693 (32.11%)	169 (32.56%)	524 (31.97%)	
Severe	699 (32.39%)	159 (30.64%)	540 (32.95%)	
Impact of COVID-19 pandemic on income				< 0.001
None	532 (24.65%)	208 (40.08%)	324 (19.77%)	
Mild	539 (24.98%)	103 (19.85%)	436 (26.60%)	
Moderate	542 (25.12%)	113 (21.77%)	429 (26.17%)	
Severe	545 (25.25%)	95 (18.30%)	450 (27.46%)	

Data are presented as number (percentage). *P* values were calculated via chi-squared tests between the "vaccine hesitancy" and "vaccine acceptance" groups. Participants who had received or were willing to receive the COVID-19 vaccine were included in the "vaccine acceptance" group, and those who had not received or were unwilling to receive the COVID-19 vaccine were included in the "vaccine hesitancy" group. COVID-19: coronavirus disease 2019.

3.2. Knowledge about and attitude towards the COVID-19 vaccine

For the participants in this study, the most-trusted sources of information about the COVID-19 vaccine were media (1649/2158; 76.41%), followed by government agencies (1433/2158; 66.40%), and friends and families (1178/2158; 54.59%), while only a small proportion of participants had learned about the COVID-19 vaccine from medical staff (885/2158, 41.01%) or ward mates (533/2158; 24.70%, Fig. 2).

As shown in Table 4, participants' knowledge about and attitude towards the COVID-19 vaccine had significant differences between the "vaccine hesitancy" and "vaccine acceptance" groups ($P \leq 0.001$ for each of the ten relevant questions). In terms of knowledge, only 39.30% of participants clearly knew the onset time of COVID-19 vaccine after vaccination (848/2158), and the majority did not know how the COVID-19 vaccine was developed (1767/2158; 81.88%). Comfortingly, more than half participants thought the COVID-19 vaccine was safe (1833/2158; 84.94%) and could be useful in controlling this pandemic (1497/2158; 69.37%). The proportions of positive and passive answers to the question "will the COVID-19 vaccine trigger allergy?" was close among all participants (47.82% vs 52.18%). In terms of attitude, the majority of participants believed that the COVID-19 vaccine was effective (1882/2158, 87.21%), thought that the vaccine would not worsen prognosis of cancer (1475/2158, 68.35%), and believed that a mask was still needed after getting the COVID-19 vaccine (1600/2158, 74.14%). Approximately 69.09% of participants were willing to pay for the vaccine (1491/2158), and 92.35% of participants were willing to recommend their families and friends to get vaccinated (1993/2158).

The proportion of vaccine hesitancy was higher than that of vaccine acceptance among the participants who did not know the onset time of enhanced immunity following the COVID-19 vaccine rightly, did not know the process by which the vaccine had been developed, regarded the vaccine as unsafe, ineffective, or useless in controlling the panic, thought that the vaccine could trigger allergy or worsen the prognosis of cancer, thought the vaccination could not release them from mask use, were reluctant to pay for vaccination, or were not willing to recommend vaccination to their friends and families.

3.3. Predictors of COVID-19 vaccine attitude

A total of 24 variables with P values < 0.1 were present in the univariate analysis (chi-squared test, Tables 1–4). The multivariate logistic regression analyses of these 24 variables (Table 5) showed that, after adjusting for the other variables, nine variables contributed significantly to the participants' intention towards receiving the COVID-19 vaccine (all P-Log < 0.05), including "occupation," "current drinking status," "ongoing treatment of cancer," "impact of COVID-19 pandemic on income," "do you know about how the COVID-19 vaccine was developed," "is the COVID-19 vaccine safe," "will you encourage your friends and family to get vaccinated," "will the COVID vaccine worsen the prognosis of cancer," and "are you willing to get the COVID-19 vaccine, even if you have to pay for it."

As these nine variables suggested (Table 5), cancer patients who consumed alcohol (OR = 1.849; 95% CI: 1.375–2.488, P-reference [P-Ref] < 0.001 vs non-drinkers), whose incomes were impacted by the COVID-19 pandemic (OR = 1.930, 2.037 and 2.688 for mild, moderate and severe impact; all P-Ref < 0.01 vs no impact), knew how the vaccine was developed (OR = 1.616; 95% CI: 1.126–2.318; P-Ref = 0.009 vs unknown), believed in the safety of the vaccine (OR = 1.502; 95% CI: 1.024–2.203; P-Ref = 0.038 vs denying the safety of vaccine), were willing to pay for the vaccine (OR = 3.042; 95% CI: 2.376–3.894; P-Ref < 0.001 vs unwilling), and would rec-

ommend families and friends to get vaccinated (OR = 2.744; 95% CI: 1.759–4.280; P-Ref < 0.001 vs do not recommend) were more likely to accept the COVID-19 vaccine.

However, being retired (OR = 0.586; 95% CI: 0.438–0.784; P-Ref < 0.001 vs unemployed), undergoing multiple treatments for cancer (OR = 0.408; 95% CI: 0.221–0.753; P-Ref = 0.004 vs no ongoing treatment), and worrying that the vaccine might worsen the prognosis of cancer (OR = 0.393; 95% CI: 0.307–0.504; P-Ref < 0.001 vs might not) were the catalyst for vaccine hesitancy (Table 5).

4. Discussion

With all the difficulty in managing COVID-19 pandemic worldwide, it is undeniable that TCM as a unique therapy contributed a lot during the quick and effective control of COVID-19 prevalence in China—during the past two years, TCM was deeply involved in the whole process of diagnosis and treatment of patients with COVID-19, and exerted superior advantage in promoting the treating effects when combined with Western medicine, which was regarded as a perfect anti-COVID-19 "combined punch" in China [51–53].

Despite the success of TCM application in the pandemic control in China, vaccination is still an inevitable way to wind up the COVID-19 pandemic. The National Health Commission of the Peoples' Republic of China published a technical guideline for the inoculation with COVID-19 vaccines on March 29, 2021 [54]. Since then, the Chinese government has actively promoted vaccination campaigns, encouraging people to get the COVID-19 vaccine as soon as possible.

This study preliminarily revealed the predictors of intention to receive COVID-19 vaccine among cancer patients in Eastern China. Based on the results of this study, the following suggestions are recommended to be considered before making vaccination plans for cancer patients.

4.1. Clarifying the impact of COVID-19 vaccine on cancer progression is the premise of advocating vaccination for cancer patients

Eastern China is an area with a high cancer incidence as well as being strongly affected by the COVID-19 pandemic. In this study, among the 2158 cancer patients from Eastern China, 24.05% were "vaccine hesitancy" towards the COVID-19 vaccine (Fig. 1). The multivariate logistic regression analyses indicated that the concern that the COVID-19 vaccine could worsen the prognosis of their cancer treatment was one of the main predictors for vaccine hesitancy (Table 5). These results are similar to data from other countries: in Tunisia, 15.5% cancer patients thought the COVID-19 vaccine could impact cancer treatment outcomes or treatment efficacy [55]; in the US, among cancer patients who refused to take the COVID-19 vaccine, 56.3% reported being concerned about the compatibility of the COVID-19 vaccine and their cancer treatment [56].

Further, this study found that 69.37% of cancer patients believed that the COVID-19 vaccine would effectively control the COVID-19 epidemic. However, the acceptance rate was much lower than a previous anonymous cross-sectional survey among adults conducted in China (89.5%) [31]. Actually, the distrust towards the COVID-19 vaccine seems to be a worldwide phenomenon: in Korea, among cancer patients who were willing to take the COVID-19 vaccine, only 46.7% trusted its effectiveness [57]; in Poland, 44.4% of cancer patients questioned the usefulness of COVID-19 vaccines [58].

The efficacy of the vaccine is critical to controlling the epidemic and has caused widespread concern. A previous cross-sectional
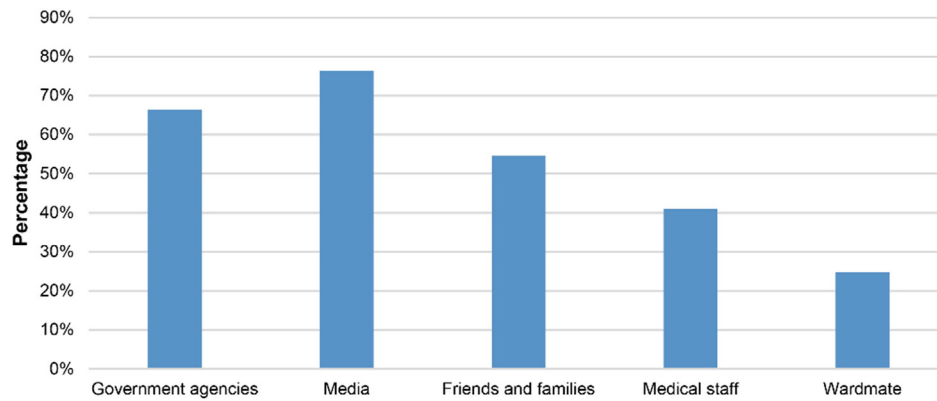
Fig. 2. The sources of trusted information about coronavirus disease 2019 vaccines (N = 2158).

Table 4
Participants' knowledge about and attitude towards the COVID-19 vaccine.

Item	All participants (N = 2158)	Intention to receive COVID-19 vaccine		
		Vaccine hesitancy (n = 519)	Vaccine acceptance (n = 1639)	P value
When does the COVID-19 vaccine start working after vaccination?				< 0.001
Unknown	696 (32.25%)	233 (44.89%)	463 (28.25%)	
Immediately after the first dose	269 (12.47%)	43 (8.29%)	226 (13.79%)	
Immediately after the second dose	345 (15.99%)	65 (12.52%)	280 (17.08%)	
Fourteen days after the second dose	848 (39.30%)	178 (34.30%)	670 (40.88%)	
Do you know about how the COVID-19 vaccine was developed?				< 0.001
No	1767 (81.88%)	466 (89.79%)	1301 (79.38%)	
Yes	391 (18.12%)	53 (10.21%)	338 (20.62%)	
Will the COVID-19 vaccine be useful in controlling the COVID-19 pandemic?				< 0.001
No	661 (30.63%)	216 (41.62%)	445 (27.15%)	
Yes	1497 (69.37%)	303 (58.38%)	1194 (72.85%)	
Is the COVID-19 vaccine safe?				< 0.001
No	325 (15.06%)	127 (24.47%)	198 (12.08%)	
Yes	1833 (84.94%)	392 (75.53%)	1441 (87.92%)	
Will the COVID-19 vaccine trigger allergy?				0.001
No	1126 (52.18%)	239 (46.05%)	887 (54.12%)	
Yes	1032 (47.82%)	280 (53.95%)	752 (45.88%)	
Is the COVID-19 vaccine effective?				< 0.001
No	276 (12.79%)	95 (18.30%)	181 (11.04%)	
Yes	1882 (87.21%)	424 (81.70%)	1458 (88.96%)	
Will you encourage your parents and friends to get vaccinated?				< 0.001
No	165 (7.65%)	86 (16.57%)	79 (4.82%)	
Yes	1993 (92.35%)	433 (83.43%)	1560 (95.18%)	
Will the COVID vaccine worsen prognosis of cancer?				< 0.001
No	1475 (68.35%)	266 (51.25%)	1209 (73.76%)	
Yes	683 (31.65%)	253 (48.75%)	430 (26.24%)	
Is it necessary to wear a mask after getting the COVID-19 vaccine?				< 0.001
No	558 (25.86%)	107 (20.62%)	451 (27.52%)	
Yes	1600 (74.14%)	412 (79.38%)	1188 (72.48%)	
Are you willing to get the COVID-19 vaccine, even if you must pay for it?				< 0.001
No	667 (30.91%)	279 (53.76%)	388 (23.67%)	
Yes	1491 (69.09%)	240 (46.24%)	1251 (76.33%)	

Data are presented as number (percentage). P values were calculated via chi-squared tests between the "vaccine hesitancy" and "vaccine acceptance" groups. Participants who had received or were willing to receive the COVID-19 vaccine were included in the "vaccine acceptance" group, and those who had not received or were unwilling to receive the COVID-19 vaccine were included in the "vaccine hesitancy" group. COVID-19: coronavirus disease 2019.

study including the general population, medical students, and healthcare workers showed that approximately 41.2% of the study population was willing to receive a COVID-19 vaccine with an efficacy of 50% or more, 60.6% with an efficacy of 70% or more, and 79.6% with an efficacy of 90% or more [59]. Similar results were found in low- and middle-income countries [60].

Therefore, although the safety and efficacy of COVID-19 vaccines seem to be acknowledged by the general population, among cancer patients the support is less enthusiastic. In fact, the risk of vaccine about COVID-19 infection has been partially focused: a study of the mass vaccination in Israel found that the BNT162b2 vaccine was not associated with an elevated risk of most of the adverse events considered, but the risk of potentially serious adverse events was significantly increased after SARS-COV-2 infection [61].

Cancer patients comprise a special group, whose immune function and health status are different from those of the general public. Since most cancer patients are middle-aged or elderly, their reactivity to the vaccine may also be different. A retrospective study of 326 cancer patients found that although the BNT162b2 vaccine was safe and effective in cancer patients undergoing regular treatment, the antibody titers of these patients were significantly lower than in the general population, especially among those undergoing chemotherapy [62].

Therefore, considering the intention of cancer patients to receive the COVID-19 vaccine and the effectiveness and safety of

Table 5
Predictors of intention to receive the COVID-19 vaccine among cancer patients.

Variable	Intention to receive COVID-19 vaccine		OR (95% CI)	P-Ref	P-Log
	Vaccine hesitancy (n = 519)	Vaccine acceptance (n = 1639)			
Age (year)					0.329
< 40	46	311	Ref	/	
40–70	365	1078	0.715 (0.456–1.122)	0.144	
> 70	108	250	0.761 (0.449–1.292)	0.313	
Marital status					0.239
Unmarried	18	142	Ref	/	
Married	469	1420	0.634 (0.333–1.207)	0.165	
Divorced	15	32	0.383 (0.150–0.980)	0.045	
Widowed	17	45	0.549 (0.223–1.353)	0.193	
Education level					0.783
≤ Senior high school	393	1114	Ref	/	
College degree	69	250	0.965 (0.671–1.387)	0.847	
≥ Bachelor's degree	57	275	0.861 (0.566–1.310)	0.485	
Occupation					< 0.001
Unemployed	176	643	Ref	/	
Employed	84	539	1.446 (0.995–2.102)	0.053	
Retired	259	457	0.586 (0.438–0.784)	< 0.001	
Current drinking status					< 0.001
No	420	1189	Ref	/	
Yes	99	450	1.849 (1.375–2.488)	< 0.001	
Type of cancer					0.401
Other type of cancer	15	137	Ref	/	
Head and neck cancer	44	159	0.712 (0.346–1.467)	0.357	
Respiratory and thoracic cancer	136	443	0.631 (0.323–1.232)	0.177	
Digestive tract cancer	194	509	0.592 (0.307–1.140)	0.117	
Urogenital caner	25	111	1.048 (0.472–2.329)	0.908	
Gynecologic cancer	84	241	0.641 (0.321–1.282)	0.209	
Multiple types of cancer	21	39	0.682 (0.275–1.692)	0.410	
Time since cancer diagnosis (year)					0.577
< 1	223	862	Ref	/	
≥ 1, < 3	192	500	0.962 (0.736–1.258)	0.777	
≥ 3, < 5	52	134	1.136 (0.742–1.741)	0.557	
≥ 5	52	143	1.267 (0.836–1.920)	0.265	
Ongoing treatment for cancer					0.001
None	17	159	Ref	/	
Surgery*	63	357	0.863 (0.449–1.658)	0.658	
Radiotherapy	17	65	0.544 (0.234–1.266)	0.158	
Chemotherapy	77	253	0.567 (0.294–1.096)	0.091	
Immunological and molecular-targeted therapy	15	52	0.585 (0.243–1.410)	0.232	
Traditional Chinese medicine	43	101	0.583 (0.282–1.207)	0.146	
Other therapy	3	17	0.883 (0.203–3.843)	0.868	
Multiple therapies	284	635	0.408 (0.221–0.753)	0.004	
Family history of cancer					0.719
No	437	1458	Ref	/	
Yes	82	181	0.939 (0.668–1.321)	0.719	
Metastasis of cancer					0.160
No	358	1251	Ref	/	
Yes	161	388	0.828 (0.636–1.077)	0.160	
Risk of COVID-19 infection					0.716
Unknown	130	281	Ref	/	
Low	194	699	1.047 (0.750–1.463)	0.786	
Medium	105	335	1.219 (0.826–1.799)	0.319	
High	90	324	1.172 (0.784–1.752)	0.438	
Impact of COVID-19 pandemic on regular medical treatment of cancer					0.320
None	97	184	Ref	/	
Mild	96	421	1.306 (0.751–2.271)	0.345	
Moderate	153	474	0.875 (0.490–1.563)	0.651	
Severe	173	560	1.002 (0.559–1.796)	0.994	
Impact of COVID-19 pandemic on daily life					0.485
None	92	148	Ref	/	
Mild	99	427	1.116 (0.635–1.963)	0.702	
Moderate	169	524	0.802 (0.436–1.475)	0.478	
Severe	159	540	0.945 (0.503–1.777)	0.861	
Impact of COVID-19 pandemic on income					< 0.001
None	208	324	Ref	/	
Mild	103	436	1.930 (1.325–2.81)	0.001	
Moderate	113	429	2.037 (1.382–3.002)	< 0.001	
Severe	95	450	2.688 (1.791–4.035)	< 0.001	
When does the COVID-19 vaccine start working after vaccination?					0.080
Unknown	233	463	Ref	/	
Immediately after the first dose	43	226	1.524 (1.002–2.317)	0.049	
Immediately after the second dose	65	280	1.468 (1.016–2.120)	0.041	
Fourteen days after the second dose	178	670	1.277 (0.966–1.689)	0.086	

Table 5 (*continued*)

Variable	Intention to receive COVID-19 vaccine		OR (95% CI)	P-Ref	P-Log
	Vaccine hesitancy (*n* = 519)	Vaccine acceptance (*n* = 1639)			
Do you know about how the COVID-19 vaccine was developed?					0.009
No	466	1301	Ref	/	
Yes	53	338	1.616 (1.126–2.318)	0.009	
Will the COVID-19 vaccine be useful in controlling the COVID-19 pandemic?					0.439
No	216	445	Ref	/	
Yes	303	1194	1.116 (0.845–1.474)	0.439	
Is the COVID-19 vaccine safe?					0.038
No	127	198	Ref	/	
Yes	392	1441	1.502 (1.024–2.203)	0.038	
Will the COVID-19 vaccine trigger allergy?					0.062
No	239	887	Ref	/	
Yes	280	752	0.791 (0.617–1.012)	0.062	
Is the COVID-19 vaccine effective?					0.422
No	95	181	Ref	/	
Yes	424	1458	0.847 (0.564–1.271)	0.422	
Will you encourage your parents and friends to get vaccinated?					< 0.001
No	86	79	Ref	/	
Yes	433	1560	2.744 (1.759–4.280)	< 0.001	
Will the COVID vaccine worsen the prognosis of cancer?					< 0.001
No	266	1209	Ref	/	
Yes	253	430	0.393 (0.307–0.504)	< 0.001	
Is it necessary to wear a mask after getting the COVID-19 vaccine?					0.053
No	107	451	Ref	/	
Yes	412	1188	0.731 (0.532–1.003)	0.053	
Are you willing to get the COVID-19 vaccine, even if you must pay for it?					< 0.001
No	279	388	Ref	/	
Yes	240	1251	3.042 (2.376–3.894)	< 0.001	

P-Log: the *P* value indicates whether the variable contributes significantly to the occurrence of "vaccine acceptance"; *P*-Ref: the *P* value indicates whether the adjusted OR of particular sub-category is significant when compared with the reference category. * Surgery including procedures such as excision, transarterial chemoembolization, and microwave ablation. COVID-19: coronavirus disease 2019; OR: odds ratio; CI: confidence interval; Ref: reference category.

the vaccine itself, clarifying the impact of COVID-19 vaccine on the progression of cancer is the premise of advocating vaccination for this special population.

4.2. Individualized vaccination plans/recommendations should be drawing up for cancer patients with different demographic and health characteristics

According to the results from this study, cancer patients' occupation, the nature of their ongoing treatment, the impact of the COVID-19 pandemic on their income, and their individual knowledge about and attitude towards the COVID-19 vaccine are all factors that impact their intention to receive the vaccine (Table 5). The vaccination intention of cancer patients is the real reflection of their vaccine demand. Therefore, individualized recommendations are more suitable for convincing cancer patients to get vaccinated.

Firstly, for retired cancer patients living in areas with low risk of COVID-19 infection, vaccination does not need to be recommended with urgency, since their risk of infection is low while the adverse impact of COVID-19 vaccine may overwhelm its benefits in this population.

Secondly, for patients in the stable phase of cancer management, who are still working, and live in an area with a high risk of COVID-19 exposure, and meanwhile have no allergic diseases, vaccination should be prioritized. For these individuals, vaccination could provide protection from COVID-19 infection, and there are few chances of vaccination negatively impacting their cancer treatment.

In addition, for cancer patients who want to be vaccinated due to the impact of the COVID-19 pandemic on their life and income, a comprehensive evaluation of the cancer progression and the risk of COVID-19 infection is necessary before receiving the vaccination. When the benefit of COVID-19 vaccination overwhelms its poten-

tial risk to cancer progression, vaccination is recommended, otherwise vaccination should be delayed.

4.3. Public information and guidance are important ways to attract eligible patients to complete vaccination

At present, the Chinese government regularly releases information about COVID-19 infections and vaccination rates, promotes vaccination decisions, and provides free vaccines to Chinese citizens. Numerous media outlets also actively publicize the benefits of vaccination. The COVID-19 epidemic has been brought under control in China, and the number of daily confirmed cases is very small.

This shows that government guidance plays an important role in elevating the vaccination willingness of the general public, improving the vaccination rate and controlling the spread of the COVID-19 epidemic.

In this study, we found that for cancer patients, the most reliable sources of information about the COVID-19 vaccine were the media (76.41%), government agencies (66.40%), and discussions with friends and family (54.59%). These findings suggested that appropriate publicity and guidance from the government and media could help cancer patients to accept the COVID-19 vaccine. In fact, cancer patients are a special group. Whether individual patients should be vaccinated needs to be comprehensively evaluated by the physicians and clinicians who manage cancer progression, rather than relying on the decisions of the patients themselves. In this regard, developing a system for caregivers to determine the suitability of COVID-19 vaccination for individual cancer patients will be of more use to this population than the general public health guidelines supplied by the government and echoed by the media.

Globally, the knowledge about the COVID-19 vaccine itself, especially its formulation and manufacture, is an important ele-

ment that may affect the acceptance of the vaccine. With the development of the global pandemic, the COVID-19 vaccine has a huge market demand. Many new manufacturers have entered the market, and the development of vaccines has become the focus of global attention. In our study, only 18.12% of the respondents said they were aware of the process behind the development of the COVID-19 vaccines (Table 4), which was much lower than in Ethiopia (73.6%) [47]. Further logistic regression analysis shows that whether an individual understands the vaccine development process and whether an individual believes the vaccine is safe are two of the main factors that affect the vaccination intention of a cancer patient (Table 5). This shows that although the Chinese government and media are actively publicizing the advantages of the COVID-19 vaccine and advocating the general public to get vaccinated as soon as possible, the content and depth of the publicity need to be strengthened. In future publicity and guidance, providing comprehensive and systematic information about the source of the vaccine and its production process should be emphasized, to improve vaccination acceptance.

4.4. Multi-population, multi-region surveys with large sample size will help to better plan vaccination

Although this was the first survey in China to investigate the knowledge, attitude, and intention to receive the vaccination among cancer patients, due to the limitations of time, manpower and material resources, this study still has some deficiencies. First, due to the short time-window for questionnaire development, the questionnaire used in our study was only partially validated through a small-scale pilot study. Second, this survey was only conducted among cancer patients in Eastern China, and therefore may not represent the status of cancer patients all over China. Third, the research was a cross-sectional study which could not infer the causality. Further longitudinal studies are needed to verify any causalities. Fourth, the online survey we used did not include individuals who could not access to the internet, like the old and the poor. Fifth, our research was conducted only in China, which limits the ability to extrapolate our findings to the global population. Fortunately, our findings were similar to those in other recent studies conducted in other countries [30]. Sixth, given the rapid and unpredictable progression of the COVID-19 pandemic, the willingness of cancer patients to accept the COVID-19 vaccine may change over time. Seventh, due to the time limitation, our study was based on convenience sampling method, and therefore, the sample size may not uniformly distributed among all the seven provinces of Eastern China. Finally, the data collected from this self-reported questionnaire may not fully reflect the attitudes of this population towards the COVID-19 vaccines.

Despite the above shortcomings, this study revealed willingness of cancer patients to receive the COVID-19 vaccine and exposed some of the factors that contributed to their attitudes. Thus, it has value for developing future vaccination initiatives for cancer patients in China. As a research precedent, this study proposed that a multi-population, multi-region survey with large sample size will be helpful to the correct planning and implementation of vaccination programs and should be undertaken.

5. Conclusion

Our study revealed the knowledge about, attitude towards, and intention to receive the COVID-19 vaccine among cancer patients in Eastern China: the rate of vaccine hesitancy was 24%; the main contributors to vaccine hesitancy were being retired, undergoing multiple treatments for cancer, and worrying that the vaccine might worsen the prognosis of one's cancer treatment; however,

alcohol consumption, having one's income impacted by the COVID-19 pandemic, knowing how the vaccine was developed, believing in the safety of vaccine, being willing to pay for the vaccine, and being willing to recommend that friends and family receive the vaccine were contributors to vaccine acceptance.

When advocating for vaccination among cancer patients, we recommend incorporating the specific details of each patient and their personal needs into the development of an individualized vaccination plan, balancing the public health needs of controlling the COVID-19 pandemic against the best clinical practices for managing the progression of disease in cancer patients.

Author contributions

CQL, JH and YR designed the study. YR and JH performed the study and their analyses. XWX, JY, JZ, SMD, JZ and QMZ were responsible for data collection. YR performed data analyses. All authors participated in data interpretation, manuscript review and writing. YR and JH were responsible for preparation of the Tables and Figures. All authors contributed to the scientific discussion of the data and of the manuscript.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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