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The protective effect of emergency fourth-dose vaccination issued to county-level hospital nurses against the Omicron infection peak: evidence from China

Lanyue Zhang[1†], Lei Yang[2†], Wuping Zhou[1] and Weiyan Jian[1*]

Abstract

Background County-level hospitals are the main providers of health services in rural areas in China. On the eve of the Chinese government's plan to lift the Zero-COVID policy, a number of healthcare workers in county-level hospitals received emergency fourth-dose vaccination against COVID-19. This study aims to evaluate the extent to which these rapid emergency fourth-dose vaccination administered to county-level hospital nurses have provided protection against the Omicron infection wave affecting Mainland China.

Methods A total of 3,302 clinical nurses from 40 county-level hospitals in mainland China participated in this study. The control group was set to comprise nurses who had not received a fourth dose within the past month or indeed any dose of the COVID-19 vaccine within the previous 6 months. The intervention group was set to comprise nurses who received emergency fourth-dose vaccine doses within the month preceding the lifting of the Zero-COVID policy and those who had not received such a fourth-dose within the prior month but who had received a dose of the COVID-19 vaccine within the previous 6 months. Regression methods were used to analyze the factors associated with the probability of symptoms, duration, recovery time and hospitalization rates.

Results About 13.1% of the nurses surveyed reported having received the emergency fourth-dose vaccination. It emerged that those nurses had a lower risk of developing clinical symptoms such as fever and diarrhea. Where they did experience symptoms, the duration of these tended to be shorter, with an accompanying and significant reduction in hospitalization rates. It was also found that emergency vaccination was associated with significantly shorter recovery time.

Conclusions The emergency fourth-dose COVID-19 vaccination has had a significant protective effect. At a broader level, reducing hesitancy towards booster shots is an important part of protecting the health of healthcare workers and thereby reducing the impact of the pandemic on the healthcare system and maintaining its resilience.

Keywords Emergency vaccination, Healthcare workers, COVID-19 vaccine, Rural China

†Lanyue Zhang and Lei Yang are contributed equally to the work.

*Correspondence:
Weiyan Jian
jianweiyan@bjmu.edu.cn

[1]Department of Health Policy and Management, School of Public Health, Peking University, No. 38 Xueyuan Road, Haidian District, Beijing 100191, China
[2]Henan Honliv Hospital, Changyuan City, Henan Province 453400, China

Background

Following the relaxing of the "Zero-COVID" policy on December 7, 2022, China experienced a peak in Omicron virus infections at the end of year and into 2023, with populous provinces such as Henan and Sichuan reporting infection rates of over 85% [1, 2]. During this time, Chinese hospitals have faced tremendous pressure, due not only to the sudden increase in patients seeking medical treatment for COVID-19, but also to rising infection rates and ill health among healthcare workers [3, 4].

In China, over 509 million residents live in the rural areas, comprising 36.11% of the population [5]. Although county-level hospitals are the main providers of health services for such individuals, they have been observed to suffer from relatively scarce healthcare resources compared with what is offered in urban areas [6, 7]. Given the weak healthcare systems in place in rural areas, protecting their healthcare workers so as to maintain normal delivery of healthcare services is of paramount importance in efforts to minimize the effects of the Omicron variant of COVID-19.

On the eve of the Chinese government's plan to lift the Zero-COVID policy, several healthcare workers received emergency vaccination of second COVID-19 vaccine booster (a fourth vaccine dose) in mainland China. Although mounting evidence has demonstrated the reduced effectiveness of COVID-19 vaccines against infection by the Omicron variant, the vaccines, especially booster doses, are still strongly associated with prevention of serious illness, hospitalization and death [8–13]. Besides China, certain high-income countries have also made available fourth-doses of COVID-19 vaccines to healthcare workers and vulnerable population, including Israel, Germany, the United Kingdom and Canada [14, 15]. Emergency vaccination also sees common use in responses to outbreaks of infections more generally. For example, the American Centers for Disease Control and Prevention implemented emergency vaccine implementation to enhance health security in the face of the need to ensure the rapid containment of cholera outbreaks in Haiti after Hurricane Matthew in October 2016 [16]. In terms of COVID-19, existing studies provide evidence that the rapid vaccination program was essential for mitigating deaths and hospitalization rates in the US in the year of 2021 [17]. There is also evidence pointing to the importance of the emergency vaccination of healthcare workers against infectious disease as a means of ensuring the continuity of healthcare services during outbreaks. For example, existing studies provide evidence of the importance of rapid prophylactic vaccination of healthcare workers in the face of the Ebola outbreak as a means of providing direct protection and maintaining healthcare capacity [18].

This study aims to evaluate whether the rapid emergency vaccination of furth-dose COVID-19 vaccine to county-level hospital nurses can provide protection during the high Omicron infection wave in mainland China. The results of this study are likely to be of interest to countries beyond China in relation to the question of how to best respond to similar public health crises.

Methods

Study design

Among the participants, the control group (Over 6 months ago) comprised nurses who had not received any dose of the COVID-19 vaccine within the previous 6 months. Two intervention groups were also established: one group whose members received their fourth dose of the COVID-19 vaccine within the month preceding the lifting of the Zero-COVID policy (Within 1 month), and another group whose members had not received the fourth dose within the prior month but had received the COVID-19 vaccine in the previous 6 months (1 to 6 months ago). Participants were asked to report symptoms occurring between 2 weeks and 6 months after receiving their fourth-dose vaccination, a timeframe selected based on clinical evidence showing that vaccine-induced immunity typically peaks around 2 weeks post-vaccination and gradually wanes after 6 months [19–21].

Data sources

This research was conducted with a focus on Chinese rural areas, where medical resources are relatively scarce. Hospitals were selected based on the classification standards of regions in Mainland China as defined by the China National Bureau of Statistics, which categorizes regions into four areas: eastern, central, western, and northeast regions. This stratified random sampling method ensured that our sample represented regions with varying levels of economic development. Hospitals were categorized into strata according to these standards, and from each stratum, hospitals were randomly chosen to participation. The survey was distributed through the China National Alliance of Respiratory and Critical Care (CNARCC) —— a nationwide professional network comprising nurses and healthcare institutions across all 31 provinces, autonomous regions, and municipalities in mainland China. The research team used WeChat (the most popular social media and communication platform in China) to promote and circulate the survey link among CNARCC network members. Hospital administrators and department heads within the CNARCC were asked to forward the survey invitation to all eligible clinical nurses in the selected hospitals. The inclusion criteria for participants were as follows: respondents must be employed as a clinical nurse at a county-level hospital with a bed capacity of 500 to 1,000 during the study period (January–March 2023), must have been directly involved in patient care during the Omicron infection peak and willing to report their vaccination history, have beensymptom severity, and treatment choices.

Sample size and questionnaire design

We have calculated the sample size with a series of preset parameters in advance. The acceptance rate (p) ranged from 50 to 99%, along with an α of 0.05 and a two-sided confidence interval width of 0.1p. To be statistically reliable, at least 1537 respondents were needed. A total of 3,302 clinical nurses from 40 county-level hospitals, each with a capacity of 500 to 1,000 beds, participated in the study. Nurses were selected using stratified random sampling based on the size and departmental distribution within each hospital. A total of 3,586 questionnaires were distributed, and after excluding incomplete or incorrect responses, we obtained 3,302 valid samples, resulting in an effective response rate of 92.08%.

The survey consisted of questions that assessed: (1) Vaccination timing: Documentation of the timing of emergency fourth-dose COVID-19 vaccination (e.g., within one month prior to the lifting of the Zero-COVID policy); (2) Symptom profiles: Characterization of self-reported symptoms experienced during Omicron infection (e.g., fever, cough, fatigue); (3) Symptom duration: Recording of the duration of symptoms (in days) from onset to resolution; (4) Treatment pathways: Assessment of treatment options utilized during infection, including home rest, outpatient care, emergency care, or hospitalization. The full questionnaire is provided as supplemental material (Appendix A). The study was conducted over a three-month period, spanning early January 2023 to the end of March 2023, to capture outcomes across the Omicron infection peak.

Statistical models

This study focuses on the following research outcomes: the probability of experiencing different symptoms, the duration of these symptoms, the probability of hospitalization, the time it takes for symptoms to disappear following infection by COVID-19, and the time it takes for nurses as patients, to be regarded as cured. The dependent variables in this study included the probability of symptoms, symptoms duration, hospitalization rate, times to symptom disappearance and recovery time. The independent variables included vaccination time, which was categorized into three groups: nurses who had not received the fourth dose of the COVID-19 vaccine within the previous month or any dose within the previous six months (Control Group), nurses who received their fourth dose of the COVID-19 vaccine within the month preceding the lifting of the Zero-COVID policy (Intervention Group 1), and nurses who had not received the fourth dose of the COVID-19 vaccine within the prior month but had received any dose within the previous six months (Intervention Group 2). Control variables included gender (male or female), as reported in the demographic section of the questionnaire; age; and underlying health conditions (comorbidities).

Given these considerations, the following statistical models were selected for use:

Logistic regression was used to analyze the impact on the probability of experiencing symptoms following infection by COVID-19 in terms of vaccination timing, gender, age and underlying health conditions (such as diabetes, hypertension). The specific model is:

$$logit\,(P) = ln\left(\frac{P}{1} - P\right) = \beta_{\,0} + \beta_{\,1}Time + \beta_{\,2}Gender + \beta_{\,3}Age + \beta_{\,3}Comorbidity$$

Given the relatively low probability of hospitalization (1.7%), Poisson regression was applied to identify the associated factors. The Cox proportional hazards model was used to analyze the degree of affect on the duration of various symptoms in terms of the impact of vaccination timing, gender, age, and underlying health conditions. The specific models are as follows:

$$\mathrm{h}_{(t,x)} = \mathrm{h}_{(0)}\,(t)\,e^{\beta_{\,1}Time+\beta_{\,2}Gender\beta_{\,3}Age+\beta_{\,3}Comorbidity}$$

In this model, $\mathrm{h}_{(0)}\,(t)$ represents the baseline hazard function for the persistence of symptoms at time t. In our study, this corresponds to the duration of symptoms in individuals who have not been vaccinated. $\mathrm{h}_{(t,x)}$ represents the actual hazard function at time t, corresponding in our study to the duration of symptoms in vaccinated individuals. The ratio $\mathrm{h}_{(t,x)}/\,\mathrm{h}_{(0)}\,(t)$ is the relative risk (RR) value, representing the proportional hazard and reflecting the protective effect of vaccination. Other control variables are used to adjust for sociodemographic characteristics between the vaccinated and unvaccinated groups, as well as the correlation between underlying diseases and the duration of symptoms.

Finally, a generalized linear model was constructed to quantitatively analyze the duration of symptoms:

$$Y = \beta_{\,0} + \beta_{\,1}Time + \beta_{\,2}Gender+\beta_{\,3}Age+\beta_{\,3}Comorbidity$$

In this model, given the need to ascertain percentage differences, Y represents the logarithm of the duration of symptoms. In the aforementioned regression analysis, standard errors were clustered at the hospital level. Data analysis was performed using Stata 15.0 SE version.

Results

Basic information on the sample

The basic characteristics of the study sample are summarized in Table 1. Approximately 96.8% of the respondents were female. In terms of age structure, as all the respondents were clinical nurses, more than 80% of them were under 40 years old. Most of the respondents were in good health, with only 4.94% having underlying health conditions. The vast majority of nurses had already completed their three-dose COVID-19 vaccination before the lifting of the Zero-COVID policy. The proportion of those whose last dose of the vaccine was received more than 6 months ago was the greatest, at 80.7%, while the proportion of those who received the vaccine between 1 and 6 months ago was the smallest, at 6.21%. Among the participants, 13.1% nurses reported having received the emergency fourth-dose vaccination. See Table 1.

Impact of emergency fourth-dose vaccination on symptoms

With those who had not received a vaccine in the past 6 months being taken as the control group, logistic regression analysis showed that, following the emergency delivery of the fourth-dose of the vaccine, the incidence of fever decreased by 45.8%, and the incidence of diarrhea decreased by 34.5%. The incidence of loss of smell/taste, shortness of breath, cough, muscle aches and nausea/vomiting were also relatively low (28.1%, 27.6%, 26.3%, 20.1%, and 18.9% lower than the control group, respectively). The incidence of runny nose symptoms was higher

Table 1 Basic information of the sample

Variables		*N*	(%)
Total sample		3302	100
Age	< 30 years old	1206	36.5
	31–40 years old	1511	45.8
	41–50 years old	475	14.4
	51–60 years old	110	3.3
Gender	Male	3197	96.8
	Female	105	3.2
Having underlying diseases		163	4.94
Duration since last dose of vaccine (preceding lifting of Zero-COVID policy)	Within 1 month (30 days)	431	13.1
	1 to 6 months ago (30 to 180 days)	205	6.21
	Over 6 months ago	2666	80.7
Symptom type	Fever	3091	93.6
	Highest body temperature: above 40℃	163	4.9
	39℃-40℃	1433	43.4
	38℃-39℃	1338	40.5
	below 38℃	157	4.8
	Cough	3172	96.1
	Fatigue	2977	90.2
	Muscle aches	2889	87.5
	Expectoration	2835	85.9
	Dizziness or headache	2774	84.0
	Sore throat	2444	74.0
	Runny nose	2689	81.4
	Loss of smell/taste	1778	53.8
	Shortness of breath	1497	45.3
	Nausea and vomiting	1171	35.5
	Diarrhea	837	25.3
	Blurred vision	383	11.6
Number of symptoms during the infection	No symptom	3	0.1
	1–3 symptom	47	1.4
	4–6 symptom	444	13.4
	7–10 symptom	2063	62.5
	Above 10 symptoms	745	22.6
Treatment ways	Home rest	2744	83.1
	Outpatient care	400	12.1
	Emergency care	103	3.1
	Hospitalization care	55	1.7

in the intervention group than in the control group. None of the other symptoms were associated with a statistically significant difference between the two groups.

It was found that, compared to the respondents who last dose of vaccine was more than 6 months, nurses who received the vaccine between 1 and 6 months ago before the lifting of the Zero-COVID policy experienced a lower risk of fever (OR = 0.444, $P < 0.01$) but a higher risk of blurred vision (OR = 1.678, $P < 0.01$).

The risks associated with experiencing a cough, expectoration, a sore throat, headaches or dizziness, nausea and vomiting, runny nose symptoms, and shortness of breath were all generally lower in male nurses compared to all the surveyed individuals ($P < 0.01$ for all). On the other hand, as age increased, the probability of experiencing headaches or dizziness decreased, while the likelihood of blurred vision gradually increased. The 31–50 age group also emerged as being associated with a higher probability of experiencing shortness of breath and loss of taste/smell, but fewer symptoms relating to a fever, a cough and a sore throat. Individuals with underlying respiratory system diseases had the highest risk of experiencing shortness of breath (OR = 6.765, $P < 0.01$), although the risk of experiencing headaches or dizziness was not significant. See Table 2.

Impact of emergency fourth-dose vaccination on symptom duration

Regarding the impact of emergency fourth-dose vaccination on symptom duration, the results of the Cox regression analysis showed that nurses who received emergency fourth-dose of the vaccine benefitted from experiencing a shorter duration of symptoms relating to fever, fatigue, a runny nose and shortness of breath, with the probability of symptoms disappearing in the same time period being 1.21 times, 1.24 times, 1.19 times, and 1.33 times higher than those ascertained for the control group (nurses who had not received the vaccine within 6 months). The duration of other symptoms was similar to that of the control group.

Regarding the duration of symptoms after infection, as compared with the control group the probability of fever symptoms disappearing in the same time period was 1.099 times higher in surveyed individuals who received the vaccine within 6 months. However, the duration of sore throat and nausea or vomiting symptoms was shorter (sore throat: HR, 0.824; $P < 0.05$; nausea: HR, 0.815; $P < 0.1$).

In the case of those who had underlying diseases, individuals with circulatory system diseases experienced fever and cough symptoms for a longer period following infection with COVID-19; those with endocrine system diseases experienced muscle aches for long; and those with respiratory system diseases experienced coughing and nausea or vomiting for longer. See Table 3.

Impact of emergency fourth-dose vaccination on recovery time and hospitalization rates

It should be noted that, overall, emergency fourth-dose vaccination is significantly associated with a reduction in the risk of hospitalization among nurses after infection. As shown in Table 4, the Poisson regression results showed that the risk of hospitalization after infection was 0.114 times lower for the emergency vaccination group compared with the control groups ($P < 0.05$). In addition, the recovery time was 12.8% shorter for the emergency vaccination group than for the control groups ($P < 0.01$).

Among all the surveyed individuals, the male nurses generally that their symptoms disappeared faster after COVID-19 infection than their female counterparts, with a difference of 20.1% ($P < 0.01$). In terms of the effect of age, the duration of symptom persistence is found to increase. It was also found that the duration of self-perceived symptoms in the 31–40 age group, 41–50 age group, and 51–60 age group was 15.1%, 20.7%, and 25.2% longer than that in the control groups (30 years old) ($P < 0.01$). See Table 4.

Discussion

This is the first study on the protective effect of the fourth-dose COVID-19 vaccine on healthcare workers in Mainland China. The results reported here reveal that such vaccination of healthcare workers has been effective as a means of protecting them in the context of the Omicron infection peak following the lifting of the Zero-COVID policy. Based on the sample examined here, the proportion of healthcare workers who received fourth-dose vaccination was not high (13.1%). This may be because the large-scale COVID-19 vaccination plan for the second booster (fourth vaccine dose) was implemented on December 14, 2022, one week after the announcement of relaxing "Zero-COVID" policy [22]. However, at this time, a large number of healthcare workers were infected, and there was no time to organize a widespread fourth-dose vaccination program, since all nurses were working in the face of a significant level of pressure due to the surge in COVID-19 patients. It should also be highlighted that a study on the fourth-dose vaccination of Israeli healthcare workers also shows that the overall fourth-dose vaccination rate was only 19%, a rate considerably lower than that associated with the nearly universal uptake of the third-dose vaccine among healthcare workers [23]. This difference is likely to be due at least in part to healthcare workers' doubts about the necessity of a second booster.

Regarding the protective effect of emergency fourth-dose vaccination, the picture that emerges is that they

Table 2 Logistic regression results of the probability of symptoms after infection among nurses

	Fever	Cough	Expectoration	Sore throat	Headache or dizziness	Muscle aches	Fatigue	Diarrhea	Nausea and vomiting	Loss of smell or taste	Blurred vision	Runny nose	Shortness of breath
Last dose of vaccine over 6 months ago (reference)													
Emergency fourth-dose vaccination within 1 month	0.542***	0.873	0.737**	0.852	1.006	0.799**	0.965	0.655***	0.811*	0.719**	1.131	1.425**	0.724**
Last dose of vaccine 1 to 6 months ago	0.444***	0.672	1.011	1.137	0.961	1.012	0.970	0.932	1.076	1.034	1.678***	0.926	1.145
Female (reference)													
Male	1.504	0.236***	0.506***	0.634***	0.492***	0.537**	0.689	0.943	0.450***	0.927	0.537*	0.582***	0.580***
< 30 years old (reference)													
31–40 years old	0.634***	0.563**	0.836*	0.823**	0.838*	1.340**	1.128	1.001	0.952	1.177***	1.552***	0.761**	1.247**
41–50 years old	0.649**	0.719	0.571***	0.716**	0.572***	0.940	1.310	1.182	0.751**	1.273**	1.623**	0.730	1.437***
51–60 years old	0.536	1.474	0.697	0.788	0.319***	0.679	1.714	1.219	1.039	0.822	2.112***	0.561**	0.943
No underlying disease (reference)													
Endocrine system	1.062	1.782	1.458	1.059	3.217**	0.716	1.595	1.064	0.806	1.551	1.718	1.683	1.836**
Respiratory system	1.742	0.564	4.530	1.226	2.732	1.776	2.737	1.261	0.986	0.710	1.367	1.981	6.765***
Circulatory system	2.916	1.612	3.925*	1.034	2.298*	2.993	1.893	0.917	0.847	1.529	1.483	1.794	1.261
Other system	1.728	—	1.578	1.256	2.351*	1.037	1.661	1.715*	1.169	0.813	1.922	0.813	1.756

Note: The table shows OR values

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 3 Cox regression results of the symptom duration after infection among nurses received emergency fourth-dose vaccination

	Fever	Cough	Expectoration	Sore throat	Headache or dizziness	Muscle aches	Fatigue	Diarrhea	Nausea and vomiting	Loss of smell or taste	Blurred vision	Runny nose	Short-ness of breath
Last dose of vaccine over 6 months ago (reference)													
Emergency fourth-dose vaccination within 1 month	1.210***	1.068	0.970	1.018	1.048	1.048	1.237***	1.056	0.960	0.987	1.055	1.192**	1.331**
Last dose of vaccine 1 to 6 months ago	1.099**	1.118	1.038	0.824**	0.954	0.957	0.963	0.827	0.815*	0.924	0.956	1.072	1.116
Female (reference)													
Male	0.971	1.246	1.038	0.884	0.958	0.791*	0.976	1.090	0.900	0.926	0.0991***	0.953	0.792
< 30 years old (reference)													
31–40 years old	1.052	0.850**	0.921	0.928*	0.825***	0.782***	0.706***	0.942	0.859**	0.789***	0.788*	0.928	0.800***
41–50 years old	1.044	0.872	1.039	1.058	0.851**	0.910	0.553***	1.176	0.860*	0.774***	0.637**	1.093	0.678***
51–60 years old	0.936	0.903	0.972	1.032	0.839	0.732***	0.547***	1.065	1.136	0.881	0.570*	0.968	0.713
No underlying disease (reference)													
Endocrine system	0.912	0.967	0.935	1.018	0.952	0.763*	0.854	0.961	1.232	0.839	1.605	0.842	0.870
Respiratory system	1.050	0.627	0.632	0.951	1.199	0.829	0.737	0.709	0.587**	1.379	0.788	0.939	1.028
Circulatory system	0.820**	0.384***	0.844	1.019	0.926	0.829	0.803	0.796	0.869	1.238	0.799	0.788	0.905
Other system	0.963	0.984	0.739	0.979	0.996	0.909	0.778	1.310	1.012	1.039	0.449	1.027	0.935

Note: The table shows Hazard Ratio

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 4 Results of Poisson regression of hospitalization rate and loglinear regression of recovery time after infection

	Hospitalization rate	Recovery time
Last dose of vaccine over 6 months ago (reference)		
Emergency fourth-dose vaccination within 1 month	0.114**	-0.128***
Last dose of vaccine 1 to 6 months ago	0.499	-0.032
Female (reference)		
Male	0.540	-0.201***
< 30 years old (reference)		
31–40 years old	0.707	0.151***
41–50 years old	0.941	0.207***
51–60 years old	0.000***	0.252***
No underlying disease (reference)		
Endocrine system	1.321	0.064
Respiratory system	0.000***	0.227
Circulatory system	3.306	0.027
Other system	4.037**	0.106*

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

have been very helpful. In 30-day period preceding the lifting of the Zero-COVID policy, healthcare workers who received fourth-doses had a lower risk of developing clinical symptoms such as fever and diarrhea. Where they did experience symptoms, the duration of these tended to be shorter, with an accompanying and significant reduction in hospitalization rates. This is consistent with previous research results. In the researches of the efficacy of the fourth booster vaccine among healthcare workers, most infected healthcare workers were found to report negligible symptoms and shorter durations of these symptoms [24–26].

At the same time, in addition to the specific factors related to COVID-19, many healthcare workers have been absent from work due to illness, compounding operational pressure and indirectly harming patients who depend on the healthcare system or other long-term medical services. Given this, the survey results reported here and the analyses of these also provide evidence relevant to the role of preventative emergency booster vaccination among healthcare workers [27, 28]. Although there is still no consensus on whether healthcare workers should receive a second-booster immunization due to the low efficacy of the vaccine against infection, the results reported here suggest that emergency second-booster vaccination have significantly shortened the recovery time of the selected nursing population [29, 30]. During the wave of the Omicron outbreak in Mainland China after reopening, shorter recovery times mean that healthcare workers can return to work and provide services to patients faster. In this way, emergency fourth-dose vaccination for healthcare workers can be considered an important means of guaranteeing the functionality of the healthcare system at a time of high levels of operational pressure. Given the weak healthcare systems with shortage of healthcare workers in rural China, protecting their healthcare workers in order to maintain normal delivery of healthcare services is critical importance in efforts to mitigate the effects of the Omicron variant of COVID-19.

The results also demonstrate that nurses who received the vaccine between 1 and 6 months ago constituted a relatively special group. Due to the special physical characteristics of the members of this group, including their suffering of allergies, they are not suitable for receiving the vaccine during regular vaccination periods, so the results are unlikely to be stable over the longer term [31].

Previous studies that emphasized the effectiveness of the booster dose of inactivated vaccines in mainland China, specifically Sinopharm (BBIBP-CorV) and Sinovac (CoronaVac), against Omicron infection. Research has shown that receiving the booster dose of these inactivated vaccines is associated with a significantly lower risk of Omicron infection. However, it's also important to note that evidence for protection was observed among young adults, but not as clearly detected among older age groups. As of August 2022, the full vaccination coverage for individuals aged over 60 years in China was 85.6%, while the booster vaccination coverage for the elderly was only 67.8% (29). This lower rate of booster vaccination among the elderly, who are a more vulnerable group with higher risks of severe illness and death, can lead to increased infection risks and workload pressures for healthcare workers, especially in rural areas.

The analysis offered here is likely to be of interest to policymakers working both in the China's context and internationally. In the fight against COVID-19, there is a clear need to address vaccine hesitancy among healthcare workers [32]. Although the second booster may not provide long-term protection against infection by Omicron, emergency prophylactic vaccination for medical staff can reduce their symptoms in the event of infection and thereby mitigate shortages of critical healthcare workers. For low- and middle-income countries, where gaps in healthcare infrastructure amplify these risks, emergency booster vaccination of healthcare workers is not merely a clinical intervention but a safeguard for frontline service delivery [33]. By reducing symptom severity and duration, fourth-dose campaigns can mitigate workforce attrition, ensuring continuity of care even during infection peaks.

The results reported here also underscore the importance of advance notification and deployment of booster shot policies. It is crucial that decision-makers have the correct information to set out appropriate timelines before the changes of preventive measures and to conduct preventive emergency vaccination with healthcare workers and other high-risk groups [34]. Healthcare workers form the backbone of epidemic response, yet their ability to deliver high-quality care depends fundamentally on their own health. During the Omicron wave, widespread healthcare workers absenteeism due to illness or overwork from extended shifts severely strained healthcare systems, particularly in rural and resource-limited settings where workforce shortages can precipitate systemic collapse. In future epidemics, these lessons underscore the need to prioritize healthcare workers not just as beneficiaries of vaccines but as pillars of health system resilience.

Limitations

This study only investigated vaccination in terms of frequency and did not examine the impact of vaccine types (protein subunit, inactivated, non replicating viral vector, etc.) on protective effectiveness. In addtion, due to the lack of routine PCR testing during the infection peak, self-reported symptoms were used as a proxy for COVID-19 infection. While this approach reflects real-world clinical constraints during crises, symptom reporting may be influenced by recall bias. Third, unmeasured confounders such as prior COVID-19 infections, variable work environments, and exposure levels during the outbreak could influence outcomes. Future studies should incorporate these factors when feasible.

Conclusion

Prior to the peak of the Omicron variant, a number of Mainland Chinese healthcare workers received an emergency fourth-dose COVID-19 vaccination. The research findings suggest that fourth-dose vaccination was associated with reduced symptom burden among healthcare workers during the Omicron wave following Zero-COVID policy discontinuation, though this finding requires confirmation through PCR-confirmed infection data. In the face of the pressure caused by large-scale infection outbreak in the general population, preservation of the functionality of the health system is crucial. Given this, reducing hesitancy towards booster shots is an important part of task of protecting the health of healthcare workers as part of the larger project of reducing the impact on the healthcare system and maintaining its resilience.

Abbreviations

OR	Odds ratio
HR	Hazard ratio

Supplementary Information

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Supplementary Material 1

Acknowledgements

Not applicable.

Author contributions

The conceptualization was carried out by LZ and LY. Data curation was handled by WZ. The original draft was written by LZ, LY, and WJ, who also performed review writing and editing. The manuscript was reviewed by WZ and WJ. All authors have read and agreed to the published version of the manuscript.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The research strictly followed the ethical principles outlined in the Declaration of Helsinki and its subsequent amendments. The Peking University Institutional Review Board approved the study, and the ethical approval number was IRB00001052-18005. We confirm that all methods were carried out in accordance with relevant guidelines and regulations. And we confirm that informed consent was obtained from all subjects.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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