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Impact of Booster Vaccination on Infection and Hospitalization Rates During the Mass Vaccination in Mongolia

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Objective: Our study aims to evaluate the effectiveness of booster vaccination in preventing new COVID-19 infections and related hospitalizations among groups that received the primary vaccination series. **Methods:** Booster vaccination started on August 31, 2021, at recruitment in May 2022. By May 2022, 64% of the Mongolian population had received two primary doses of a COVID-19 vaccine, and 31% had received a booster dose. We followed 1,251 participants (459 males and 792 females, with a mean age of 41.5 ± 14.5 years [18–93], and a median age of 39.0 years) over six months, from the start of booster immunization on September 1, 2021, to February 28, 2022. We compared infection and hospitalization rates among vaccinated groups using logistic regression and calculated vaccine effectiveness (VE) for booster recipients with the formula: VE = 1 – (vaccinated rate/unvaccinated rate) × 100. **Results:** All participants received two doses of one of four vaccines used in the nationwide campaign. During the study period, we identified 449 new infection cases, accounting for 35.9% of all participants, and 150 subsequent hospitalizations, or 12.0% of the total. Participants who did not receive a booster demonstrated significantly higher infection rates compared to those who did. Booster vaccination provided notably better protection against new infections among frontline workers and reduced hospitalizations in high-risk groups. No significant differences were found in VE when comparing participants based on seroconversion after initial vaccination or the type of booster vaccine used.
Conclusion: Therefore, we concluded that COVID-19 booster vaccinations effectively enhanced protection against new SARS-CoV-2 infections among frontline healthcare workers, government employees, and individuals at higher risk for severe disease, thereby reducing their risk of hospitalization.

Keywords: Booster vaccination, Effectiveness, Infection, Hospitalization

Introduction

The first case of COVID-19 was reported in our country on November 11, 2020. As of 2023, a total of 869,385 cases and 2,128 deaths have been recorded nationwide. The World

Health Organization's (WHO) has advised low-income member states to prioritize vaccinating healthcare workers and other high-risk populations vulnerable to severe illness and death from COVID-19. The primary objective of the coronavirus vaccination program is to prevent infection, complications, and death among priority target groups, including healthcare workers and other populations at high risk of severe illness. The effectiveness of the vaccination is measured by its ability to reduce the risk of disease, hospitalization, and death from COVID-19-related complications among vaccinated individuals. The nationwide vaccination campaign in Mongolia began on February 23, 2021.[1] It uses four types of vaccines that are listed on the World Health Organization's Emergency Use List. These vaccines include: the non-replicating viral vector vaccine AstraZeneca (ChAdOx1-S), the mRNA-based vaccine Pfizer-BioNTech (BNT162b2), the inactivated virus vaccine Sinopharm BBIBP-CorV, and the non-replicating viral vector vaccine Sputnik V.[2] The Government of Mongolia identified three priority groups for mass immunization based on a strategic approach: 1) Frontline employees, including healthcare workers and government personnel who are directly involved in managing pandemics; 2) Individuals at increased risk of developing severe disease; and 3) The general adult population aged 18 to 59 years who do not fall into the first two categories.[3]

A booster dose of the vaccine was administered to the target population nationwide starting August 31, 2021. The timing was in line with the WHO's recommendation to administer the booster dose, which is 3-6 months after the primary vaccination.

Booster vaccination began on August 31, 2021, at recruitment (May 2022). As of May 2022, 64% of the total Mongolian population had received two priming doses of a COVID-19 vaccine, and 31% had received a booster dose.[4]

The primary goal of the coronavirus infection vaccination program is to prevent severity and mortality in the target population. The effectiveness and impact of immunization are assessed by how it reduces the risk of illness, hospitalization, and death from COVID-19 complications among vaccinated individuals.

In this study, we aim to evaluate the effectiveness of booster vaccination in preventing new COVID-19 cases and related hospitalizations among populations that received the primary vaccination series.

Materials and Methods

Study Population

This follow-up study was conducted over 80 weeks, at weeks 12, 24, and 48, from February 23, 2021, to December 31, 2022. The study was conducted over a period of 1.5 years (80 weeks) following the administration of the first two doses of the COVID-19 vaccine. This study involved those who received booster vaccinations, and we followed from September 1, 2021, to February 28, 2022.

Data were collected from participants at three time points: before vaccination, after the second dose, and after the booster dose. A structured questionnaire comprising seven sections and 49 questions was used to collect the data.

Booster vaccination started on August 31, 2021, at recruitment (May 2022). By May 2022, 64% of the entire Mongolian population had received two primary doses of a COVID-19 vaccine, and 31% had received a booster dose. We examined 1,251 participants (459 males and 792 females, with a mean age of 41.5 ± 14.5 years [range 18–93] and a median age of 39.0 years) over six months, from the start of booster immunization on September 1, 2021, to February 28, 2022. All participants received two doses of one of four vaccines used in the nationwide campaign. They had not undergone natural infection before receiving the booster and were not infected with SARS-CoV-2 within four weeks after the booster dose. All participants tested negative for anti-SARS-CoV-2 RBD-IgG antibodies before their initial vaccination. Of the 744 individuals who measured antibody titers 21 to 28 days after the second dose, 577 (77.6%) showed a positive antibody response (seroconversion). The frontline employee (FE) group included 602 (48.1%) participants, the increased risk population (IRP) group had 333 (26.6%) participants, and the general adult population (GAP) group included 316 (25.3%) participants. A total of 830 participants (66.3%) received the Sinopharm BBIBP-CorV vaccine, 272 (21.7%) received the Pfizer-BioNTech vaccine, 92 (7.4%) received the AstraZeneca ChadOx1 vaccine, and 57 (4.6%) received the Sputnik V vaccine for their initial series.

A total of 596 participants (47.6%) received the third dose of the vaccine. Among them, 520 individuals (87.2%) received a different type of vaccine from the initial series. Specifically, 511 participants (85.7%) received the Pfizer BioNTech vaccine, 48 participants (8.1%) received the Sinopharm BBIBP-CorV vaccine, 34 participants (5.7%) received the AstraZeneca ChadOx1

vaccine, and only 3 participants (0.5%) received the Sputnik V vaccine.

Data Collection

Data on vaccinations, infections, hospitalizations, fatal outcomes, and booster vaccinations were obtained from national health registry operators using participants' national registration IDs. We accessed individual data with the necessary permissions, including vaccination status information from the National Center for Communicable Diseases of Mongolia (https://vis.health.gov.mn/), and hospital admission dates, PCR-confirmed infection diagnoses, and outcomes from the national health database of the Center for Health Development (https://hdc.gov.mn). Hospital services were provided following the "Interim Guidelines for the Diagnosis and Treatment of Coronavirus Infections (COVID-19)" issued by the Ministry of Health in Mongolia, which were developed based on WHO recommendations.[5]

Statistical Analysis

The statistical analyses were performed using SPSS for Windows, version 26.0. The overall risk of infection or hospitalization was assessed using logistic regression, which employed Fisher's exact test, odds ratio (OR), and relative risk (RR). The infection hospitalization rate (IHR) was calculated as the percentage of hospitalization cases among new infection cases.[6] We calculated vaccine effectiveness (VE) for participants who received a booster vaccination using the formula: VE = 1 – (vaccinated rate / unvaccinated rate)x100.[7]

Ethical Statement

The study protocol and consent forms were reviewed and approved by the Ethical Review Committee of the Ministry of Health, under resolutions 216, 217, and 219 dated April 6, 2021.

This study received ethics approval from the Mongolian National University of Medical Science in Ulaanbaatar, Mongolia (2024/3-05).

Results

Table 1 shows the mean age of 41.5 ± 14.5 years (18–93), and the median age was 39.0 years. A total of 596 participants (47.6%) received the third dose of the vaccine. Among them, 520 individuals (87.2%) received a different type of vaccine from the initial series. Specifically, 511 participants (85.7%) received the Pfizer BioNTech vaccine, 48 participants (8.1%) received the Sinopharm BBIBP-CorV vaccine, 34 participants (5.7%) received the AstraZeneca ChadOx1 vaccine, and only 3 participants (0.5%) received the Sputnik V vaccine.

Table 1. Study population characteristics

Variable	Frequency n (%)
Sex, n (%)	
Male	459 (36.7)
Female	792 (63.3)
Age (years)	
Mean, M±SD	41.5±14.5 (39.0)
Booster vaccination by vaccine type	596 (47.6)
Pfizer/BioNTech (BNT162b2)	511(85.7)
Sinopharm (BBIBP-CorV)	48 (8.1)
AstraZeneca (ChAdOx1-S)	34 (5.7)
Sputnik V (Gam-COVID-Vac)	3 (0.5)

Abbreviations: SD, standard deviation; M, median

Table 2 shows during the observation period, we identified 449 new infection cases, accounting for 35.9% of all participants, and 150 subsequent hospitalizations, representing 12.0% of all participants. This results in an infection hospitalization rate of 33.4%. Participants who did not receive booster vaccination demonstrated a dramatically increased infection rate compared to participants who received booster vaccination.

Table 1. Study population characteristics

Population groups	Infection state	Booster vaccine state			OR	RR	VE	*p* value
		Received	Not received	Total				
		n (%)	n (%)	n (%)				
Infection rate	No infection	410 (68.8)	392 (59.8)	802 (64.1)				
	Infection	186 (31.2)	263 (40.2)	449 (35.9)	1.5(1.2-1.9)	1.2(1.1-1.4)	22.0%	<0.005
	Total	596 (100)	655 (100)	1251 (100)				
Hospitalization rate	No hospitalization	524 (87.9)	577 (88.1)	1101 (88.0)				>0.05
	Hospitalization	72 (12.1)	78 (11.9)	150 (12.0)				
	Total	596 (100)	655 (100)	1251 (100)				

OR = Odds Ratio; (OR > 1 indicates the exposure is associated with higher odds of outcome in participants who did not receive booster doses);
RR = Relative Risk (RR > 1 suggests a fold-increased risk of the outcome in participants who did not receive booster doses);
VE = Vaccine Effectiveness (VE indicates the percentage reduction in the incidence of infection among a vaccinated group compared to an unvaccinated group);
Statistically significant at the p > 0.05 level (Fisher's exact test)

Discussion

In our study, we observed a modest vaccine effectiveness (VE) of 22%. Our findings align with global data from the Omicron era, which showed that VE against infection declined to approximately 20–30% within a few months after receiving the booster, largely due to waning immunity and the immune escape characteristics of the variant.[8-10] This highlights the continued need for updated vaccines and boosting high-risk groups to sustain protection, as similar studies in Qatar, Brazil, and China observed comparable short-lived VE against Omicron infection despite substantial protection against severe disease.[8-12]

COVID-19 booster vaccinations have been shown to enhance protection against SARS-CoV-2 infection and severe outcomes. Booster doses of the mRNA vaccine showed high effectiveness in preventing both disease and death, as demonstrated in clinical trials and real-world settings.[13] The effectiveness of a booster dose of the inactivated SARS-CoV-2 vaccine against Omicron infection emphasizes the importance of boosters in enhancing protection.[14] A systematic review and meta-analysis reported that mRNA booster doses (Pfizer-BioNTech and Moderna) provided high vaccine effectiveness (VE) against COVID-19 hospitalization, with pooled VE estimates ranging from 84% to 86%.[15]

Figure 1 shows that the booster vaccination showed a significantly greater protective effect against new infections in FEs and IRP (Fig. 1A) and reduced hospitalizations in IRP (Fig. 1B).

A monovalent mRNA booster dose offered significant protection against COVID-19 for U.S. healthcare personnel who had already received two mRNA doses. The vaccine effectiveness (VE) was evaluated during periods when the Delta and Omicron variants were predominant. The findings showed considerable protection; however, effectiveness decreased over time.[16] Booster vaccination had a life-saving impact on healthcare workers in New York City, highlighting the importance of booster doses for maintaining protection against COVID-19 in high-risk occupational settings.[17]

In our results, Primary immunization effectively prevented the risk of new infections for up to 24 weeks. Receiving a booster dose 3 to 6 months later further reduced the risk of infection. Health care workers' hospitalization rates ranged from 17.3% to

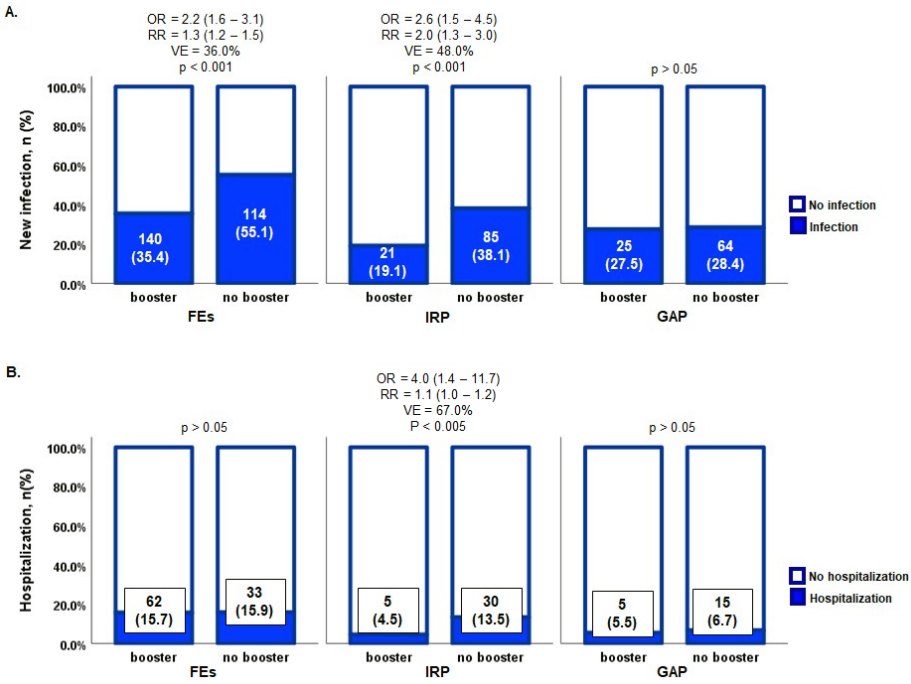

Figure 1. COVID-19 impacts among population groups prioritized by the immunization strategy based on their booster vaccination attendance. (A) Distribution of new infection cases among population groups. (B) Distribution of hospitalization cases among population groups. OR- Odds Ratio; RR- Relative Risk, VE- Vaccine Effectiveness (Statistically significant at the p> 0.05 level (Fisher's exact test), Fes -frontline employees, IRP-increased risk population, GAP=general adult population aged 18 – 59 years

22.1%, indicating that the vaccine helped reduce complications requiring hospitalization.

There were no significant differences in infection and hospitalization rates based on seroconversion after the initial vaccine series, regardless of whether participants received booster doses, changed vaccine types for booster vaccination, or used different types of vaccines for booster doses.

Limitations

During our subsequent period, there was a lack of comprehensive evaluation and research on immunization outcomes in Mongolia, which limits the comparative assessment. We encountered challenges in collecting health data, particularly due to the limited availability of large-scale databases that comprehensively aggregated information on key factors such as the demographics and socioeconomic status of infected individuals, infection incidence, disease progression, and outcomes. It is necessary to establish an extensive database that integrates health-related information, including demographic and socioeconomic data of the infected population, as well as information on infections, diseases, their course, and outcomes among the immunized population.

Conclusion

COVID-19 booster shots effectively improved protection against new SARS-CoV-2 infections among frontline healthcare workers and government employees. While the overall reduction in hospitalizations was not statistically significant, a protective trend was seen in high-risk groups, especially among people at greater risk.

Conflict of Interest

The authors state no conflict of interest.

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Authors Contribution

Dashpagam Otgonbayar: conceptualization, methodology, investigation, writing original draft preparation, visualization
Burenjargal Batmunkh: contributed to data collection, preliminary analyses,
Davaalkham Dambadarjaa: conceptualization, formal analysis, visualization, writing review and editing, supervision.
Khorolsuren Lkhagvasuren: reviewed the paper and contributed to the framing and recommendations.
Batbaatar Gunchin: reviewed the paper and contributed to the framing and recommendations.
Tsogtsaikhan Sandag: supervised the project, provided methodological guidance, and critically reviewed the manuscript
All authors have read and agreed to the published version of the manuscript.

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