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Time-series vaccine effects on preventing COVID-19 infection and death among adults aged 50–64 and 65+

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Dear Editor

In geriatric research, a retrospective cohort study is pivotal in investigating the long-term effects of COVID-19 vaccinations. This importance is underscored by the emergence of new COVID-19 variants and the potential waning of vaccine efficacy over time. The vaccine efficacy reported by manufacturers represents a momentary snapshot, while the real-world effectiveness evolves over time. Data science technology can effectively illustrate the time-series effectiveness, but it's crucial to utilize reliable datasets for the analysis. The most trusted datasets are available from CDC, which stands for the Centers for Disease Control and Prevention, is the national public health agency of the United States.

The dataset unveiled by the CDC on June 9, 2023, is globally recognized as the most exhaustive and trustworthy data source. It encompasses jurisdictions that represent 72 % of the U.S. population across all ten Health and Human Services Regions from March to September 2022. Data on cases and fatalities among individuals who received additional or booster doses were reported by 31 and 30 jurisdictions, respectively. Of these, 28 jurisdictions reported cases and 26 reported fatalities among those who received at least two additional doses. The list is expected to grow with the participation of more jurisdictions.

This study using the trusted federal CDC dataset (CDC.GOV, 2024) included individuals who were among adults aged 50–64 and 65+ and had received at least one COVID-19 vaccine dose between January 2021 and March 2023. The efficacy of vaccines tends to diminish over time, and this is further complicated by the emergence of new variants. This study examines the time-series efficacy of Pfizer, Moderna, and Janssen vaccines and their boosters in preventing COVID-19 infection and death.

Participants were followed up for up to 6 months after their last vaccine dose. The study found that vaccines were effective against COVID-19 infection, but no booster effect was observed for Pfizer, Moderna, and Janssen vaccines. Being fully vaccinated was found to be the most effective in preventing COVID-19 infection. The second booster was identified as the most effective in preventing COVID-19 death. The findings suggest that the second booster is the most effective vaccine regimen in preventing COVID-19 death. However, no booster effect was observed for Pfizer, Moderna, and Janssen in preventing COVID-19 infection.

Pfizer-BioNTech reported an overall vaccine efficacy of 91 % against infection and 97 % against severe disease 6 months after vaccination with BNT162b2 (Thomas et al., 2021). The overall efficacy of Moderna vaccine against symptomatic laboratory-confirmed COVID-19 was 92.7 % [https://www.cdc.gov/vaccines/acip/recs/grade/bla-covid-19-moderna-etr.html]. Vaccine efficacy of Janssen against all-cause death was 75 % and the overall efficacy against symptomatic, laboratory-confirmed COVID-19 was 66.3 % (CDC.GOV, 2023).

This paper investigates the time-series effects of two types of protection: COVID-19 infection and COVID-19 death using CDC dataset of "rates of COVID-19 cases or deaths by age group and vaccination status and second booster Dose" (CDC.GOV, 2022). The dataset provided by the CDC is among the most reliable and extensive ones available.

From March 1, 2022, to September 1, 2022, the time series effects of the second booster, the first booster, fully vaccinated, and unvaccinated between Janssen, Moderna and Pfizer vaccines were examined for COVID-19 infection and death protection. Infection and mortality rates are derived from the number of infections and deaths per population, respectively. Specifically, the infection rate is computed by dividing the total number of infections by the total population. Similarly, the mortality rate is calculated by dividing the total number of deaths by the total population, expressed in millions. This normalization allows for a fair comparison of rates between populations of varying sizes.

There are four types of vaccines: the second booster, the first booster, fully vaccinated and unvaccinated among adults aged 50–64 and 65+. There are three vaccine products such as Pfizer, Moderna and Janssen. The Python open-source program vuc3.py [https://github.com/y-takefuji/safety_vaccine/raw/main/vuc3.py] is used to calculate infection and mortality rates for three vaccines and four vaccination states. The open-source program, vuc3.py was converted to vuc3 PyPI application and validated via Code Ocean (Takefuji, 2023). The vuc3 PyPI tool, having been downloaded 2459 times, serves as a testament to its practicality and the credibility of the tool we've proposed.

The study categorizes individuals into four groups: unvaccinated, first booster, second booster, and fully vaccinated. It uses three vaccines:

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Pfizer, Moderna, and Janssen. It also uses two aged groups such as 50–64 and 65+ for geriatric research. In all the generated figures, the y-axis signifies a normalized metric, either the infection rate or mortality rate. This metric is computed by dividing the total number of COVID-19 cases or fatalities by the respective population, whether vaccinated, unvaccinated, the first booster (1-boost) or the second booster (2-boost). The x-axis, on the other hand, displays the time period spanning from March 1, 2022, to September 1, 2022. Figs. 1–1, 1-2, 1–3 show that being fully vaccinated offers the best protection against COVID-19 infection, with no observed booster effects across all three vaccines.

Fig. 1–4 illustrates infection protection among adults aged 50–64 across all vaccines, while Fig. 1–5 depicts infection protection among adults aged 65+ using the same vaccines. Data from both figures consistently shows that full vaccination offers the strongest protection against COVID-19 infection, particularly for adults aged 65 and over. This finding highlights the significant benefit of vaccination for older adults.

Figs. 2–1, 2-2, 2–3 indicate that the second booster provides the highest protection against COVID-19 death. However, there's no significant difference in death protection between fully vaccinated individuals and those who received boosters. Additionally, Fig. 2–4 presents death protection data for adults aged 50–64 across all vaccines, and Fig. 2–5 displays the corresponding death protection information for adults aged 65+ across all vaccines.

Fig. 1–4 demonstrates that among individuals aged 50–64, fully vaccinated protection surpasses both the second booster and the initial booster, in that order. Fig. 1–5 exhibits a comparable trend to that depicted in Fig. 1–4, with the exception that the fully vaccinated group and the second booster group demonstrate similar outcomes for adults aged 65+.

Fig. 2–4 illustrates that among individuals aged 50–64, fully vaccinated, first booster, and second booster exhibit similar effects during the initial three months. However, after that period, the second booster demonstrates the most favorable outcomes. Fig. 2–5 indicates that among adults aged 65 and older, the second booster outperforms both fully vaccinated and first booster, in that sequence.

This study, utilizing a dataset from the CDC, examined the time-series effects of COVID-19 vaccinations from March 1, 2022, to September 1, 2022. The focus was on the protection against infection and death offered by the second booster, first booster, full vaccination, and no vaccination, across three vaccines: Janssen, Moderna, and Pfizer. The study categorized individuals into four groups and considered two age groups (50–64 and 65+) for geriatric research.

The results showed that full vaccination offers the best protection against infection across all three vaccines, with no observed booster effects. However, the second booster provided the highest protection against death, except for the Janssen vaccine, where there was no significant difference in death protection between fully vaccinated individuals and those who received boosters.

The study also compared infection and death protection among adults aged 50–64 and 65+ across all vaccines. Among individuals aged 50–64, full vaccination provided better protection than both the second and first boosters. For adults aged 65+, the fully vaccinated group and the second booster group showed similar outcomes. However, after the initial three months, the second booster demonstrated the most

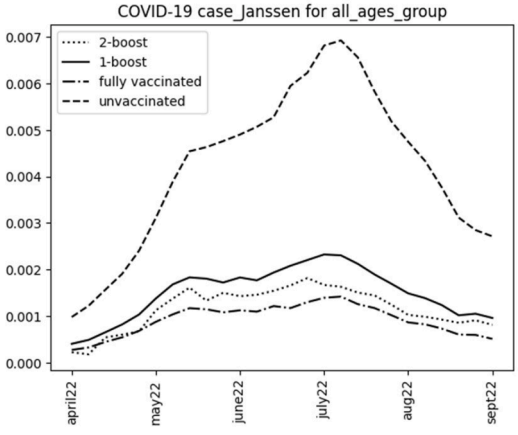

Fig. 1–1. Infection protection with Janssen.

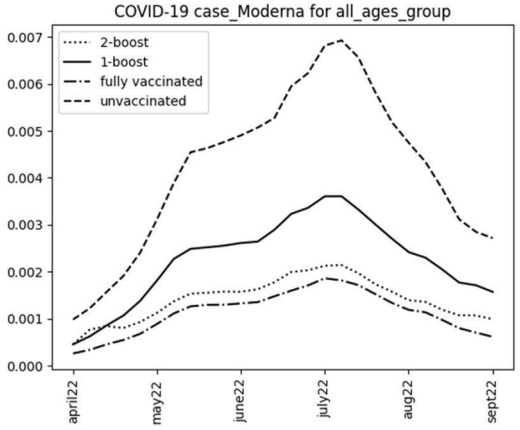

Fig. 1–2. Infection protection with Moderna.

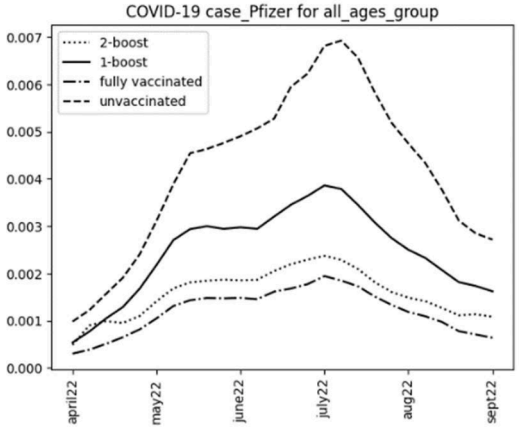

Fig. 1–3. Infection protection with Pfizer.

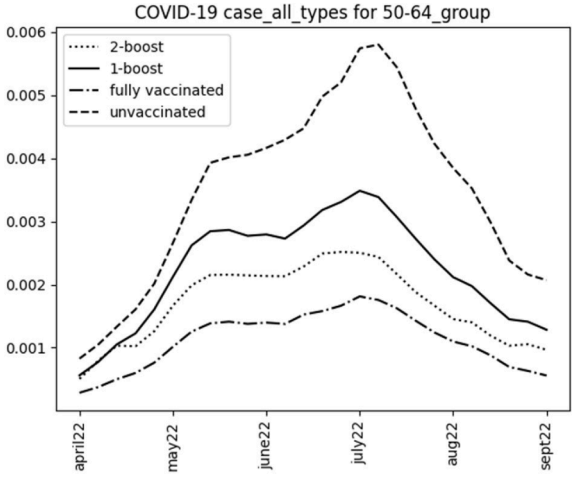

Fig. 1–4. Infection protection among adults aged 50–64 across all vaccines.

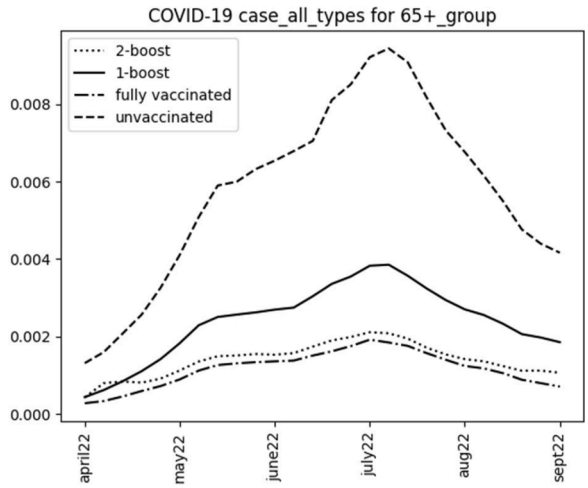

Fig. 1–5. Infection protection among adults aged 65+ across all vaccines.

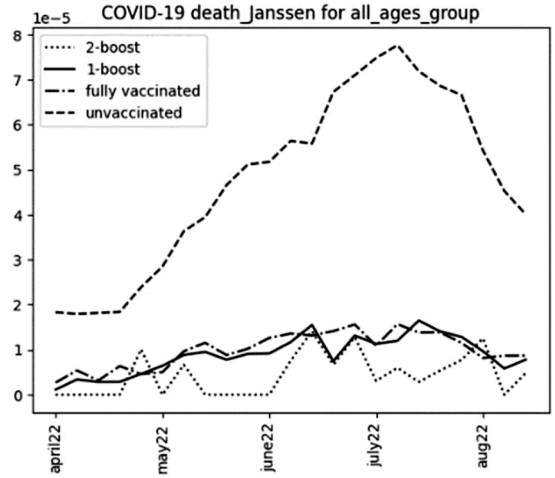

Fig. 2–1. Death protection with Janssen.

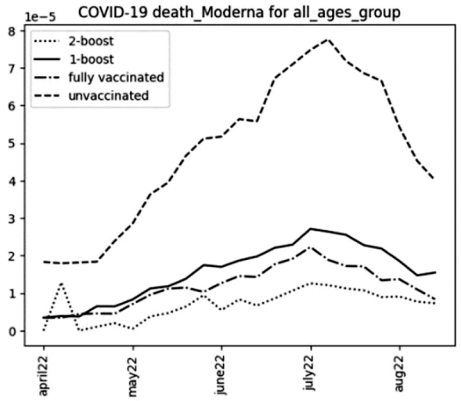

Fig. 2–2. Death protection with Moderna.

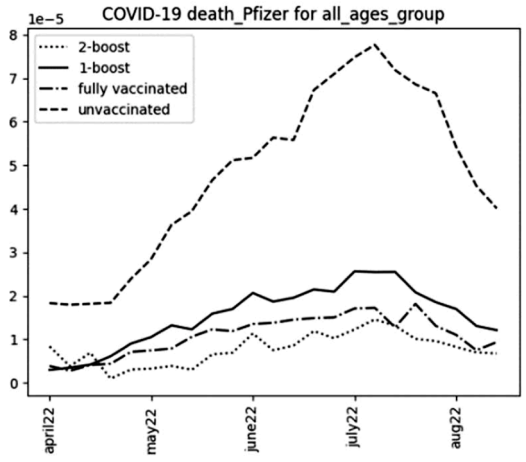

Fig. 2–3. Death protection with Pfizer.

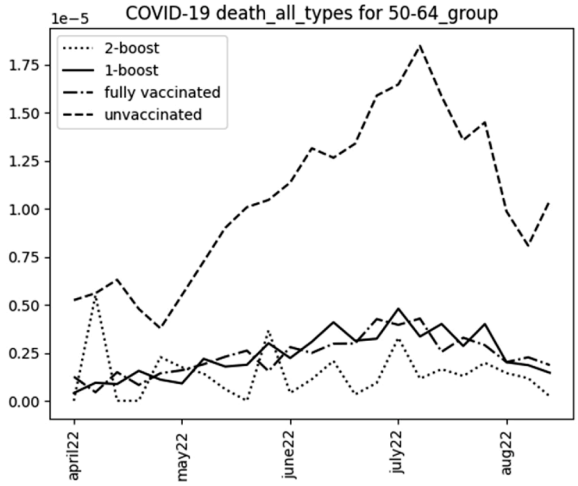

Fig. 2–4. Death protection among adults aged 50–64 across all vaccines.

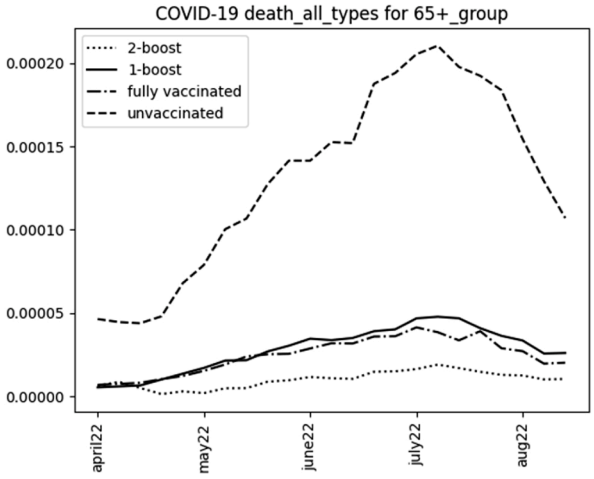

Fig. 2–5. Death protection among adults aged 65+ across all vaccines.

favorable outcomes for individuals aged 50–64. Among adults aged 65 and older, the second booster outperformed both full vaccination and the first booster.

The research indicates that vaccines are effective in combating COVID-19 infection. However, the booster shots of Pfizer, Moderna, and Janssen did not show any additional protective effect against the infection. Full vaccination was found to offer the highest protection against the infection.

Interestingly, the second booster shot emerged as the most effective measure in preventing fatalities due to COVID-19, suggesting that this regimen could be the most effective in reducing COVID-19 mortality.

The data also provides insights into the level of protection against

infection and death for adults aged 50–64 and 65+ across all vaccines. For individuals aged 50–64, full vaccination provides better protection than both the second booster and the initial booster. However, for adults aged 65+, full vaccination and the second booster shot provide similar outcomes.

In the initial three months, full vaccination, the first booster, and the second booster show similar effects among individuals aged 50–64. But after this period, the second booster shows the most favorable outcomes. For adults aged 65 and older, the second booster outperforms both full vaccination and the first booster.

In summary, while vaccines are effective against infection, no booster effect is observed. The second booster is most effective in preventing COVID-19 death. The effectiveness of the first booster is less than that of being fully vaccinated. It's also important to note that vaccine effectiveness varies depending on age groups.

The data does not contain any information on COVID-19 variants. However, the peer-reviewed paper (Ma et al., 2023) reported that throughout 2022, the Omicron variant's BA.1.1 lineage dominated in January, succeeded by BA.2 in late March, and later by BA.2.12.1 and BA.5 in May and July respectively, while the latter half of the year saw the circulation of BA.2, BA.4, and BA.5 sublineages, some of which independently developed similar spike protein substitutions linked to immune evasion (Ma et al., 2023).

This study analyzed data on COVID-19 vaccines (Pfizer, Moderna, Janssen) from March to September 2022. While all vaccines offered protection against infection, full vaccination provided the best defense. Interestingly, booster shots did not significantly increase protection against infection. However, the second booster emerged as the most effective strategy for preventing COVID-19 deaths across all age groups. This finding suggests a booster strategy could significantly reduce mortality rates. The study also revealed age-related variations in vaccine effectiveness. For adults aged 50–64, full vaccination offered superior protection compared to both boosters. In contrast, adults aged 65+ showed similar protection between full vaccination and the second booster.

Overall, vaccination remains crucial in combating COVID-19. While boosters may not significantly impact infection rates, the second booster offers the strongest defense against death, especially for older adults. Public health strategies should prioritize vaccination and consider age-specific booster recommendations to maximize protection against both infection and death from COVID-19.

While this study using CDC data suggests full vaccination offers the best protection against infection and the second booster is most effective against death, limitations exist. The retrospective design introduces selection bias, the timeframe is short to assess long-term effects, using rates doesn't account for confounding variables, only three vaccines are considered, and just two age groups are analyzed. These limitations call for further research with a longer timeframe, more age groups, and a wider range of vaccines to confirm the effectiveness of boosters on infection and mortality rates.

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CRediT authorship contribution statement

Yoshiyasu Takefuji: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

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.

Data availability

The authors do not have permission to share data.

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