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Short communication

Vaccine effects on COVID-19 infection with bivalent boosting by age group

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A R T I C L E I N F O

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A B S T R A C T

This paper examines time-series vaccine effectiveness on COVID-19 infection with/without a bivalent booster dose by 6 age groups such as 18–29, 30–49, 50–64, 65–79, 80+, and all_ages respectively. CDC's COVID data on rates of COVID-19 cases and deaths by updated (bivalent) booster status was used in this study. This result concludes that there is no difference between vaccines with or without a bivalent booster dose for preventing COVID-19 infection in 6 age groups 18–29, 30–49, 50–64, 65–79, 80+, and all_ages. Vaccination is effective in two age groups of 65-79 and 80+ for preventing COVID-19 infection. However, vaccine effectiveness against COVID-19 infection has not been confirmed in the 18–29 and 30–49 age groups.

Vaccine efficacy is a constant, measured in controlled clinical trials, and vaccine effectiveness is a variable, a measure of how well a vaccine works in the real world. Vaccine effectiveness wanes over time (Pérez-Alós et al., 2022; Feikin et al., 2022; Pooley et al., 2023).

Efficacy or effectiveness of the bivalent vaccines was demonstrated (Tenforde et al., 2022; Link-Gelles et al., 2023). However, their results only showed a snapshot constant. Snapshot constants cannot show the course or transition of vaccine effects.

This paper examines time-series vaccine effectiveness on COVID-19 infection with/without a bivalent booster dose over time. CDC's COVID data on rates of COVID-19 cases and deaths by updated (bivalent) booster status (CDC, 2023a, 2023b) was used for investigating time-series vaccine effectiveness on COVID-19 infection with/without a bivalent booster dose by age group. The effects of three types of vaccination (unvaccinated, vaccinated without a bivalent booster dose, and vaccinated with a bivalent booster dose) were studied over time from Oct. 1, 2021 to Dec. 1, 2022 by 6 age groups such as 18–29, 30–49, 50–64, 65–79, 80+, and all_ages respectively.

The time-series vaccine COVID-19 infection rate for the vaccinated population without a bivalent booster dose was calculated by dividing the number of vaccinated cases with outcomes by the vaccinated population without a bivalent booster dose over time. Similarly, the COVID-19 infection rate for the bivalent booster population was calculated by dividing the number of bivalent booster cases with outcomes by the vaccinated population with a bivalent booster dose. The time-series COVID-19 infection rate for unvaccinated population was calculated by dividing the number of unvaccinated cases with outcomes by the unvaccinated population.

The result with vuc4.py shows Figs. 1 to 1–1–6 for 6 age groups such as 18–29, 30–49, 50–64, 65–79, 80+, and all_ages respectively. Each figure includes three graphs: a thick dotted line for unvaccinated, a thin dotted line for vaccinated with a bivalent booster dose, and a solid line for vaccinated without a bivalent booster dose.

In other words, in Figs. 1–1–1–6, the vertical axis indicates the vaccine effect of three types: unvaccinated, vaccinated without a bivalent booster dose, and vaccinated with a bivalent booster dose. All figures indicate that bivalent booster doses have little or no effect. In Figs. 1–5 for those over 80 years of age, there is only a small difference between those vaccinated with and without the bivalent booster dose, while the other figures show no difference. Vaccines are effective on preventing COVID-19 infection in age groups of 65–79 and 80+. However, vaccine effects on preventing COVID-19 infection are not rarely observed in age groups of 18–29 and 30–49.

The Python program vuc4.py is attached in APPENDIX. The program automatically downloads the latest data from the CDC site over the Internet, creates and saves the result of an age group among 6 age groups.

This result concludes that there is no difference between vaccines with or without a bivalent booster dose for preventing COVID-19 infection in 6 age groups 18–29, 30–49, 50–64, 65–79, 80+, and all_ages. Vaccination is effective in two age groups of 65–79 and 80+ for preventing COVID-19 infection. However, vaccine effectiveness against COVID-19 infection has not been confirmed in the 18–29 and 30–49 age groups.

Johnson et al. showed that booster vaccination with bivalent vaccine reduced the number of deaths among persons 65 years of age and older

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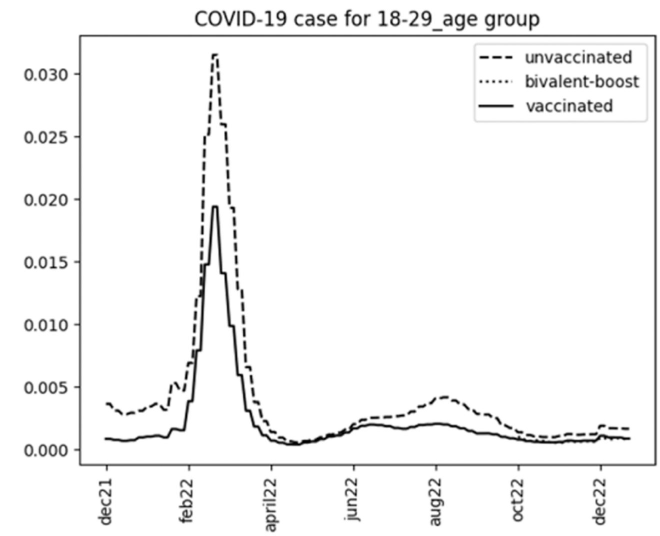

Fig. 1–1. COVID-19 case for 18–29 age group.

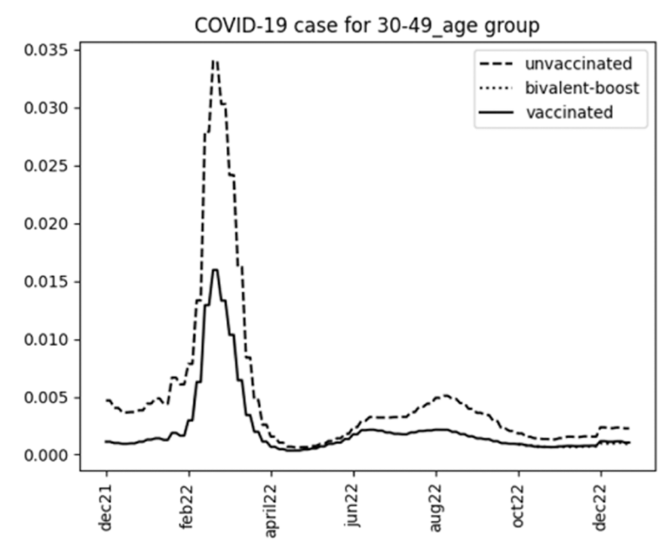

Fig. 1–2. COVID-19 case for 30–49 age group.

(CDC, 2023c). However, Johnson et al. did not show any effects of booster vaccination with the bivalent vaccine in two age groups: 18–29 and 30–49. Poukka et al. addressed that among the chronically ill aged 18–64 years bivalent vaccination did not reduce the risk of severe COVID-19 outcomes (Poukka et al., 2023).

This study found that the efficacy of booster doses of the bivalent vaccine varies by age group. The results suggest that optimizing the age and frequency of bivalent vaccine booster doses based on scientific analysis could reduce social costs. Overall, the effectiveness of booster vaccination with bivalent vaccines differs by age group.

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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.

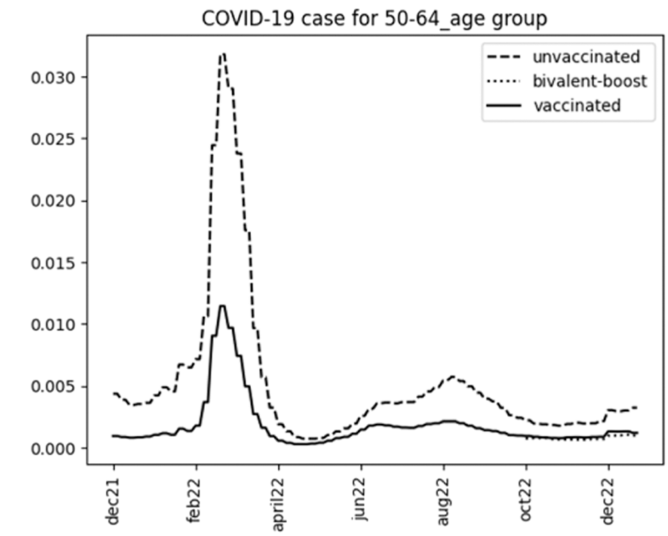

Fig. 1–3. COVID-19 case for 50–64 age group.

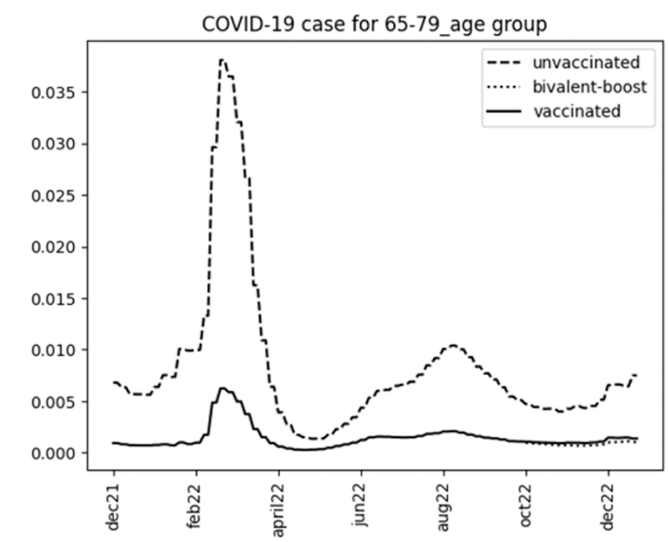

Fig. 1–4. COVID-19 case for 65–79 age group.

Appendix: Python program vuc4.py

```
# To run this program, type "python vuc4.py all_ages" after installing Python.
# "python vuc4.py 18–29" for calculating the vaccine effectiveness of the 18–29 age group.
import pandas as pd.
import sys.
import subprocess as sp.
sp.call('wget -nc https://data.cdc.gov/api/views/54ys-qyzm/rows.csv',shell=True).
d=pd.read_csv('rows.csv').
months=d.mmwr_week.unique().
#months=d.month.unique().
if len(sys.argv)= =1:
  print('18–29,30–49,50–64,65–79,80 +,all_ages').
  sys.exit(0).
else:
  age=sys.argv[1].
  #age= 'all_ages'.
  #vaccination_statust=sys.argv[1].
```

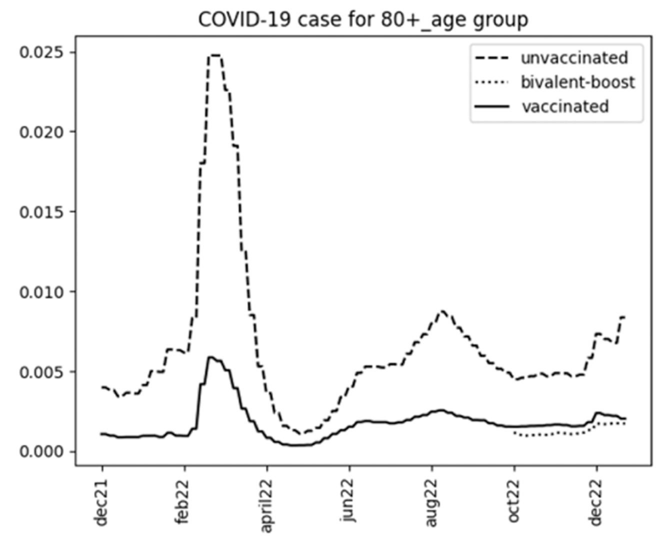

Fig. 1–5. COVID-19 case for 80+ age group.

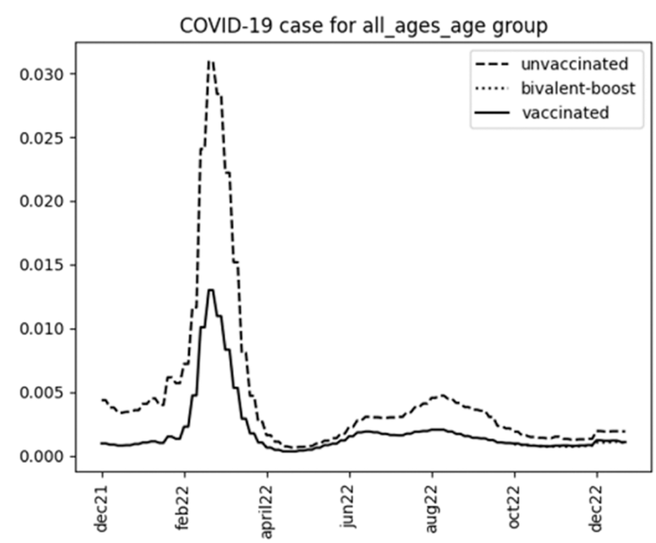

Fig. 1–6. COVID-19 case for all_age group.

```
  # vaccinated, vax with updated booster.
import numpy as np.
for i in months:
  b1=d.loc[(d.outcome=='case') & (d.vaccination_status=='vaccinated') & (d['age_group']==age),'vaccinated_with_outcome'].
  bp1=d.loc[(d.outcome=='case') & (d.vaccination_status=='vaccinated') & (d['age_group']==age),'vaccinated_population'].
  v1=b1/bp1.
  bb=d.loc[(d.outcome=='case') & (d.vaccination_status=='vax with updated booster') & (d['age_group']==age),'vaccinated_with_outcome'].
  bp2=d.loc[(d.outcome=='case') & (d.vaccination_status=='vax with updated booster') & (d['age_group']==age),'vaccinated_population'].
  v2=bb/bp2.
  uo=d.loc[(d.outcome=='case') & (d['age_group']==age),'unvaccinated_with_outcome'].
  up=d.loc[(d.outcome=='case') & (d['age_group']==age),'unvaccinated_population'].
  u=uo/up.
v1=np.array(v1).
v2=np.array(v2).
vv1=np.zeros(128).
vv2=np.zeros(128).
for i in range(64):
  vv1[i * 2]=v1[i].
  vv1[i * 2 + 1]=v1[i].
  vv2[i * 2]=v2[i].
  vv2[i * 2 + 1]=v2[i].
print(len(months),len(v1),len(v2),len(u)).
import matplotlib.pyplot as plt.
import numpy as np.
fig,ax1=plt.subplots().
plt.plot(range(128),u,'–k').
plt.plot(range(128),vv2,':k').
plt.plot(range(128),vv1,'-k').
ax1.set_xticklabels(['oct21','dec21','feb22','april22','jun22','aug22','oct22','dec22'],rotation=90).
plt.legend(('unvaccinated','bivalent-boost','vaccinated')).
plt.title('COVID-19 case for '+age+'_age group').
plt.savefig('bivalent_'+age+'.png',bbox_inches='tight').
plt.show().
plt.close().
```

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