



[1] Vaccination and Omicron update

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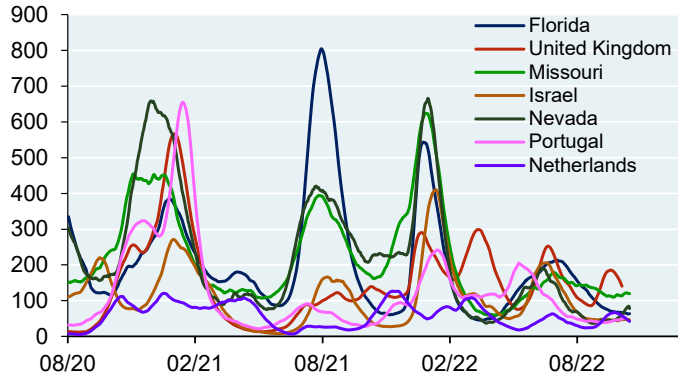
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Update on Omicron: antigenic drift, immunity escape, vaccine efficacy and Omicron booster testing

A few countries and US states are now experiencing a breakout in COVID hospitalizations linked to Omicron BA.4/5. So far, this increase is modest compared to prior waves since there is a large degree of seroprevalence in many places due to prior infection, vaccination or both.

**Omicron hospitalization breakout**

Current hospitalizations, # per mm, smoothing = 7 days

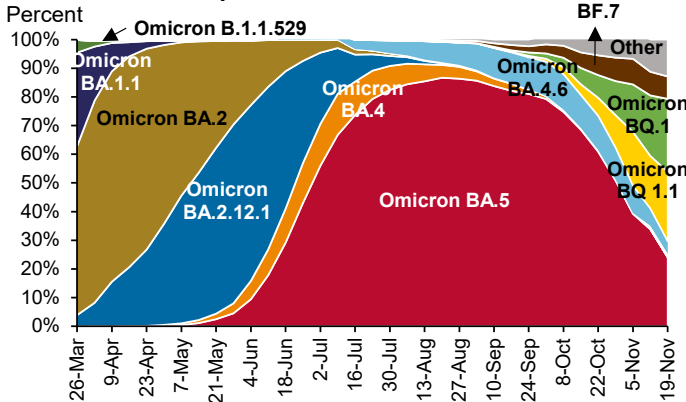


Source: HHS, various country sources, IMF, JPMAM. Nov 14, 2022.

Summary

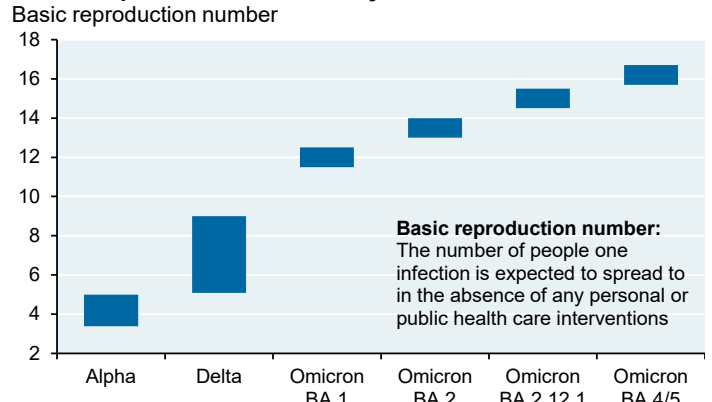
- BA.4/5 exhibits the highest observed degree of infectiousness of SARS Cov-2 variants to date (see chart)
- Some studies find that BA.4/5 exhibits higher potential immunity escape than prior variants (i.e., greater susceptibility to the virus despite vaccination or prior infection) but this is not a universal finding. In other words, recent infections may still be primarily first-time infections rather than reinfections
- For BA.1 and BA.2, 3-shot vaccine efficacy vs hospitalization is still high; there are conflicting observations as to the drop-off in efficacy with only 2 shots. The large population of previously infected/unvaccinated people with some immunity may be exaggerating some measures of the vaccine efficacy decline
- Omicron-specific boosters are under development, and show improvements vs the existing booster shots

**US COVID variant prevalence**



Source: CDC, JPMAM. November 19, 2022.

**COVID reproduction number by variant**



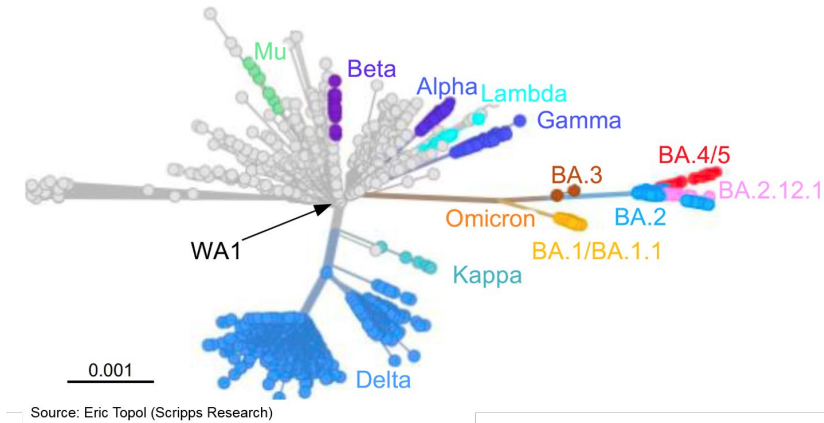
Source: Univ S Australia, Univ Tokyo, Umea Univ, Crotty (LJI), JPMAM. 2022.

**Basic reproduction number:**  
The number of people one infection is expected to spread to in the absence of any personal or public health care interventions



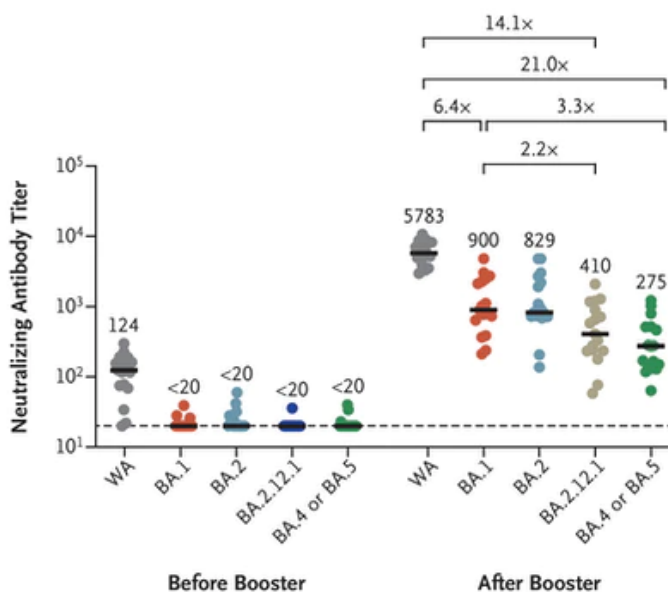
**Any immunity escape exhibited by BA.4/5 can be traced to its antigenic drift vs prior strains.** BA.4/5 variants have evolved substantially from the original Omicron variant (B.1.1.529, shown in below in orange) and are even more genetically distant from prior variants and the original Wuhan strain (WA1). BA.5 in particular has substantial mutations outside the spike protein.

### Genetic Distance of SARS-CoV-2 Variants

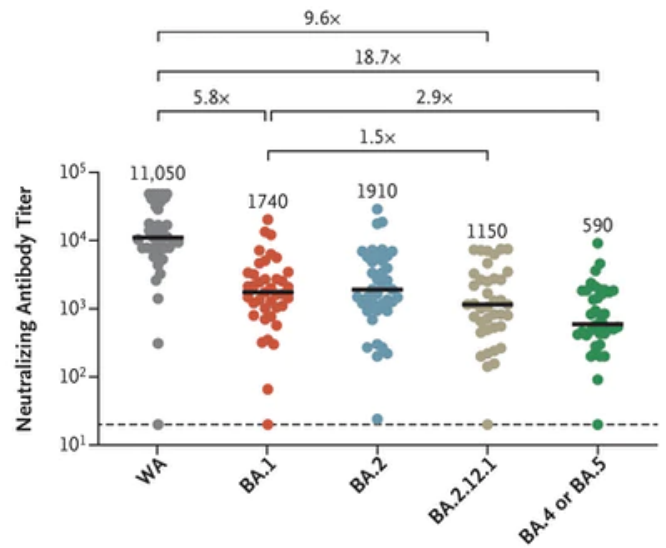


**Evidence is mixed as to whether Omicron BA.4/5 has a materially higher tendency to escape natural or acquired immunity.** A study from Beth Israel in Boston found the potential for higher immunity escape by BA.4/5. The two charts below show lower antibody responses for vaccinated or previously infected people when exposed to Omicron BA.4/5 variants than prior Omicron variants. However, a separate study from the University of Glasgow’s Center for Virus Research found no material difference between Omicron variant immunity escape. To be clear, these are in-vitro studies of the behavior of cells when exposed to the virus, and not field measurements of actual antibody responses.

**B Vaccinated Participants before and after Booster Dose**



**C Infected Participants with BA.1 or BA.2 Subvariant**

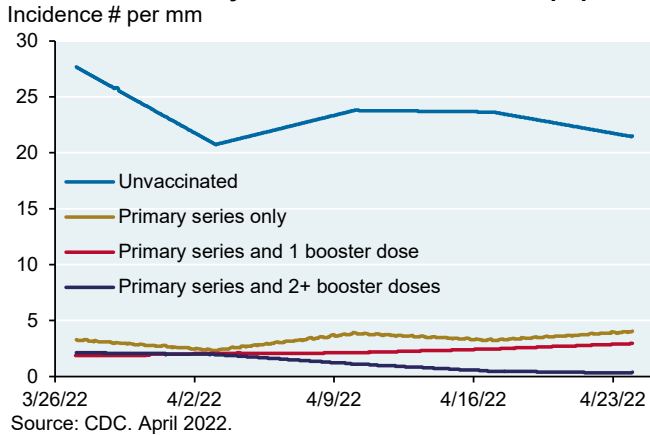


Source: “Neutralization escape by SARS-CoV-2 Omicron sub-variants”, Hachmann (Beth Israel Deaconess Medical Center) et al, June 2022



**Vaccine efficacy vs Omicron:** despite Omicron mutations, mRNA vaccinations combined with multiple boosters still reduced Omicron risks substantially. The chart shows that the lowest COVID death rates observed in April 2022 were for people with a primary mRNA series and 2+ booster doses. Even with only one booster dose, efficacy vs mortality was still around 85%-90%. These measurements took place when BA.2 was the dominant variant circulating in the US. Vaccine efficacy vs hospitalization with Omicron is also still very high, although only with 3 shots; estimates differ markedly for efficacy vs hospitalization with only two shots.

**COVID-19 deaths by vaccination status in 50+ population**



Source: CDC. April 2022.

**The latest on vaccine efficacy vs hospitalization due to Omicron**

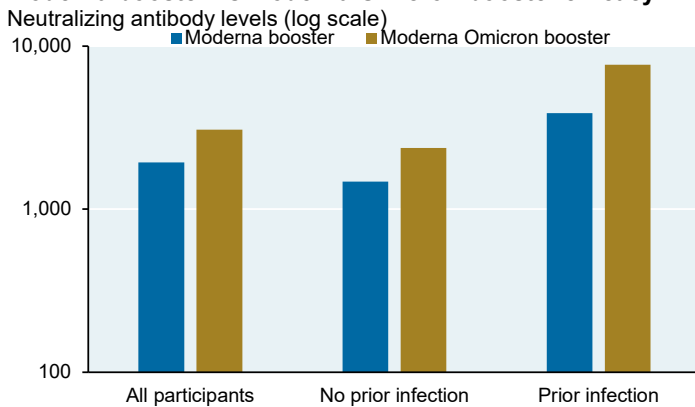
- According to Kaiser Permanent, vaccine efficacy vs Omicron is still 99% vs hospitalization with 3 doses, and 85%-99% for 2 doses
- The UK health security agency cites lower figures of 80% for 3 shots, and 30%-50% for 2 shots
- Part of the difference may be explained by large populations of previously infected/unvaccinated people with some immunity that exaggerate the vaccine efficacy decline

**Omicron-specific vaccines.** The next chart below shows results from Moderna’s Omicron-specific booster tests. The booster that Moderna tested was derived based on BA.1/2 variants, and tested when these variants were dominant. As per the chart, Moderna’s Omicron booster increased antibody results relative to the existing booster formulation. The chart is shown in log scale, so small relative increases can translate into large antibody increases in absolute terms.

However, we have no data from Moderna on how its BA.1/2 booster would perform vs BA.4/5 variants. We do have clues from Pfizer, which tested two different boosters in mice (one was Omicron specific, and the other was a combination of the original booster with the Omicron booster). Results:

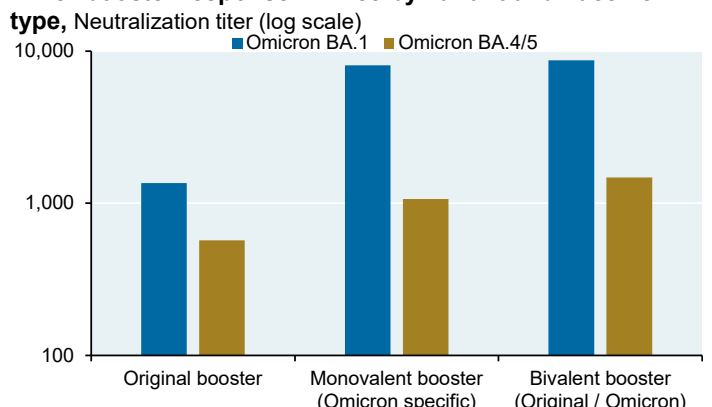
- both of Pfizer’s new boosters delivered higher antibody responses in mice than the original booster
- however, Pfizer’s Omicron boosters generated substantially lower antibody responses vs BA.4/5 than vs BA.1
- bottom line: BA.1/2 booster effectiveness vs BA.4/5 may be lower, but is still expected to be higher than using the existing booster which was designed based on the original variant’s spike protein

**Moderna booster vs Moderna Omicron booster efficacy**



Source: Moderna. June 25, 2022.

**Pfizer booster response in mice by variant and vaccine type, Neutralization titer (log scale)**



Source: Pfizer. June 2022.



**Vaccine types and locations**

The table outlines the approaches that vaccine companies are taking to provoke an antibody response. Vaccines train the immune system to recognize the disease-causing part of a virus so that when people are infected, their bodies are prepared to fight the virus with a combination of antibody and T-cell responses. Historically, most vaccines contained either weakened viruses or the signature proteins of the virus (Types 1, 2 and 3), but the first approved vaccines for COVID were genetic (Types 4 and 5).

Type	Method of provoking antibody response to SARS-CoV-2	Drug companies (bold = approved)	Existing licensed vaccines
1 Attenuated	A live but weakened coronavirus that will infect cells and cause them to make viral proteins	Codagenix	Measles, yellow fever, mumps, smallpox, polio
2 Attenuated	A "killed" coronavirus that will get recognized as foreign matter by the immune system	<b>Sinovac<sup>1</sup>, Sinopharm<sup>2</sup>, Covaxin<sup>3</sup></b>	Polio (dev countries)
3 Recombinant	Recombinant coronavirus proteins, produced industrially in outside cell cultures, which are recognized as foreign matter by the immune system	GlaxoSmithKline/Sanofi, Novavax <sup>4</sup>	Tetanus, pertussis, flu, shingles
4 Genetic (vector vaccines)	A different virus (human or ape adenovirus, measles, etc) that is engineered to include genetic components coding for the SARS-CoV-2 spike proteins, which causes the body to produce them	<b>CanSino<sup>5</sup>, Oxford/AstraZeneca<sup>6</sup>, J&amp;J<sup>7</sup>, Gamaleya<sup>8</sup></b>	Ebola
5 Genetic	DNA or RNA that will be taken up by cells and will cause them to make coronavirus proteins	<b>Moderna, Inovio, BioNTech/Pfizer</b>	

1: Sinovac has been approved for use in China, Hong Kong, Indonesia, Philippines, Brazil, Chile, Mexico, Turkey and several other countries

2: Sinopharm has been approved in China, UAE, Bahrain, Egypt, Hungary and Jordan and several other countries

3: Covaxin has been approved for emergency use in India, Iran, Philippines, Paraguay, Guatemala and several other countries

4: Protein vaccines are not new, but the Novavax vaccine is combined with a proprietary adjuvant which has not been approved for use before

5: CanSino has been approved for use in China, Mexico, Pakistan, Argentina, Chile, Indonesia, and several other countries

6: Oxford/AstraZeneca's vaccine has been approved for use in the UK, Europe, South Africa, Brazil, Chile, and several other countries

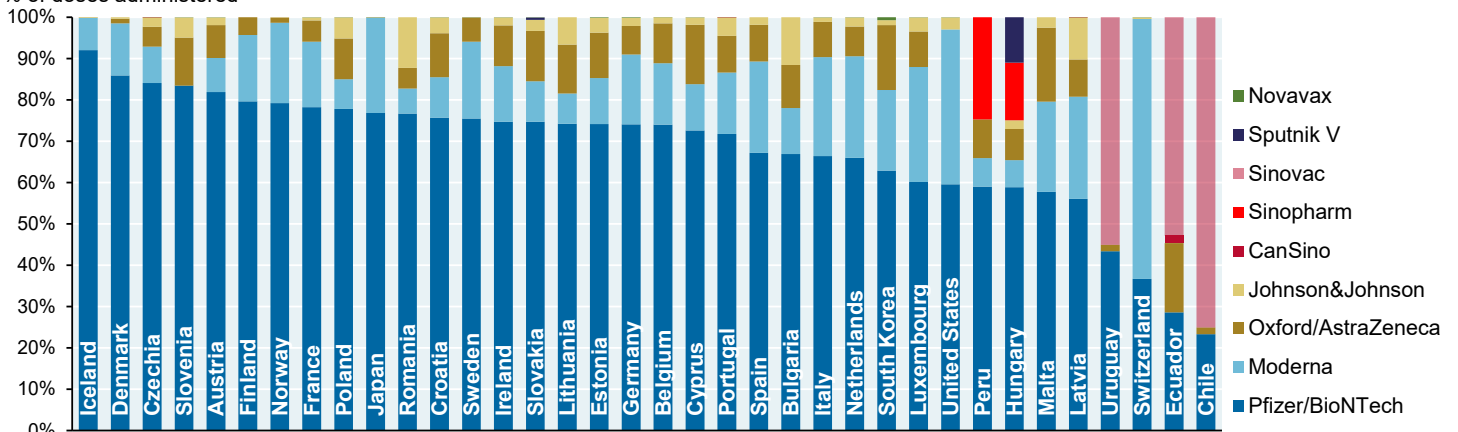
7: J&J's vaccine has been approved for use in the US, UK and more than 60 other countries.

8: Gamaleya's vaccine has been approved in Russia, Argentina, Venezuela, Mexico, Hungary, Iran, UAE, and several other countries

Source: J.P. Morgan Asset Management. 2021.

**Vaccine type usage by country**

% of doses administered



Source: OWID, JPMAM. December 7, 2022.



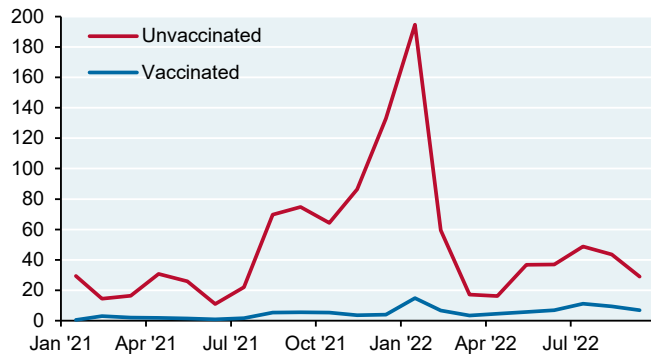
**“A pandemic (mostly) of the unvaccinated”: adverse outcomes in unvaccinated vs vaccinated people**

*Age and population adjusted data on vaccinated and unvaccinated people*

The first two charts show COVID hospitalization and mortality outcomes from multiple states as reported by COVID-NET (250 acute care hospitals) and by select state health departments reporting directly to the CDC. The subsequent charts show the same gaps for states that publish high-frequency downloadable information to the public. Other states like Michigan, Georgia, Pennsylvania, Texas, Alaska and Arizona also publish this data, but in PDF form that also tends to be more dated; the trends are similar.

**Age adjusted hospitalizations: 250 acute-care hospitals**

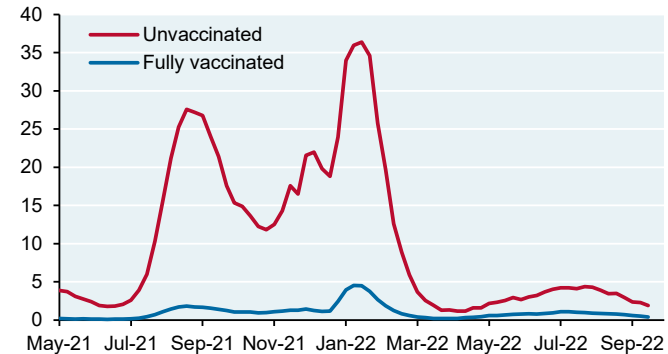
Daily hospital admissions, # per mm



Source: CDC, JPMAM. September 1, 2022. Universe: CA, CO, CT, MD, MI, MN, NM, NY, OH, OR, TN, UT.

**Age adjusted mortality: 20 US states**

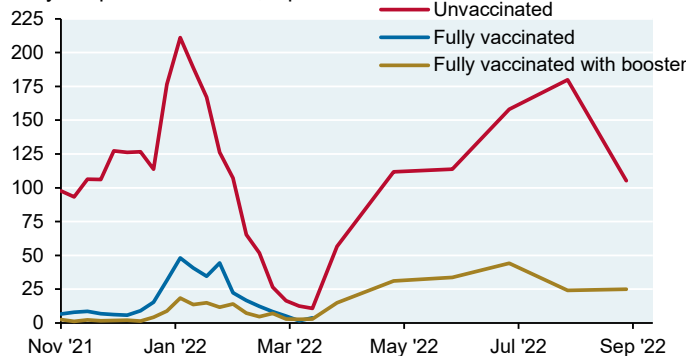
Daily deaths, # per mm



Source: CDC. October 1, 2022. Universe: AL, AZ, AR, CO, CT, FL, GA, ID, IN, LA, MD, MA, MI, NE, NM, NY, PA, RI, TN, UT.

**250 acute-care hospitals: 50-64 year old hospitalizations**

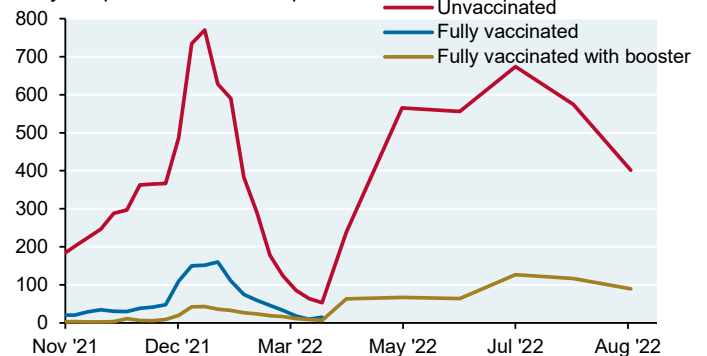
Daily hospital admissions, # per mm



Source: CDC, JPMAM. September 1, 2022. Universe: CA, CO, CT, MD, MI, MN, NM, NY, OH, OR, TN, UT.

**250 acute-care hospitals: 65 and older hospitalizations**

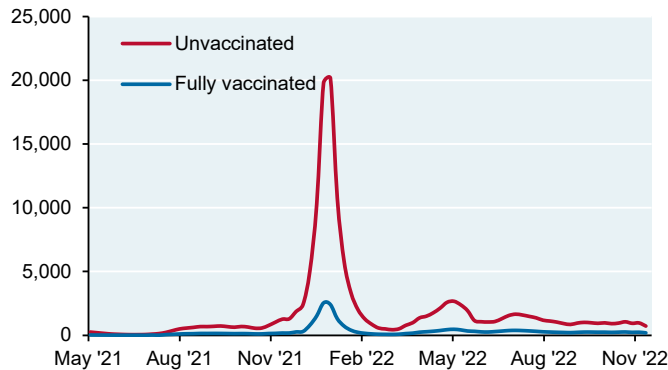
Daily hospital admissions, # per mm



Source: CDC, JPMAM. September 1, 2022. Universe: CA, CO, CT, MD, MI, MN, NM, NY, OH, OR, TN, UT.

**New York: infections**

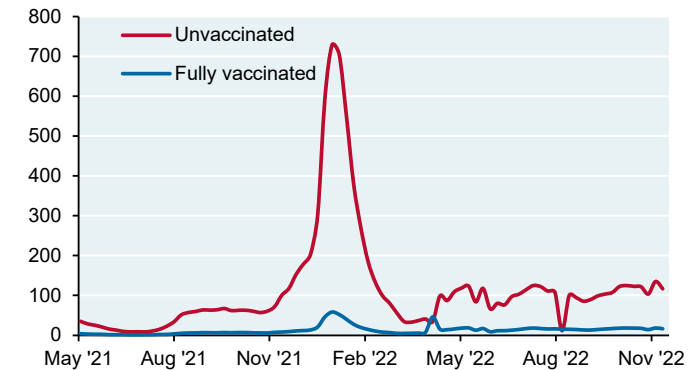
Daily infections, # per million



Source: NY Department of Health, JPMAM. November 27, 2022.

**New York: hospitalizations**

Daily hospital admissions, # per million

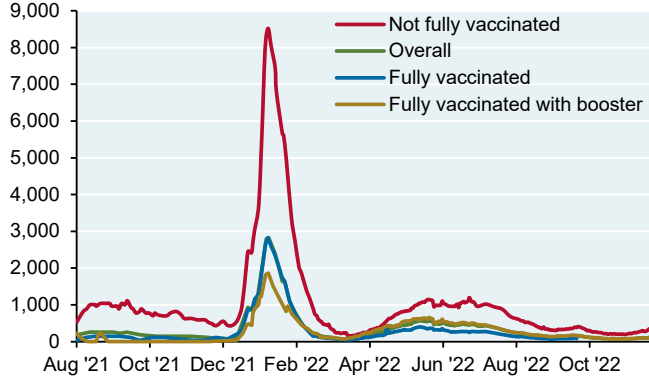


Source: NY Department of Health, JPMAM. November 27, 2022.



**Seattle: age adjusted infections**

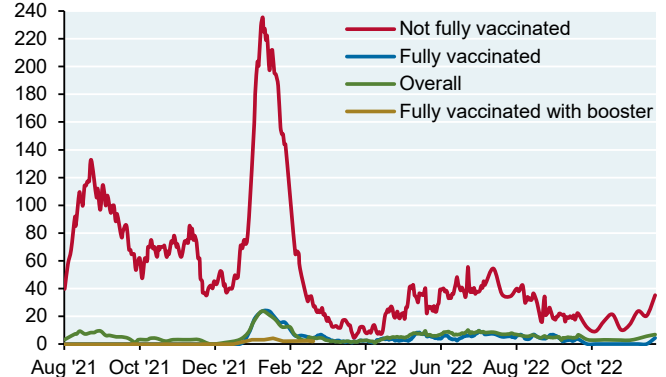
Daily infections, # per mm, smoothing = 7 days



Source: Washington Department of Health. November 30, 2022.

**Seattle: age adjusted hospitalizations**

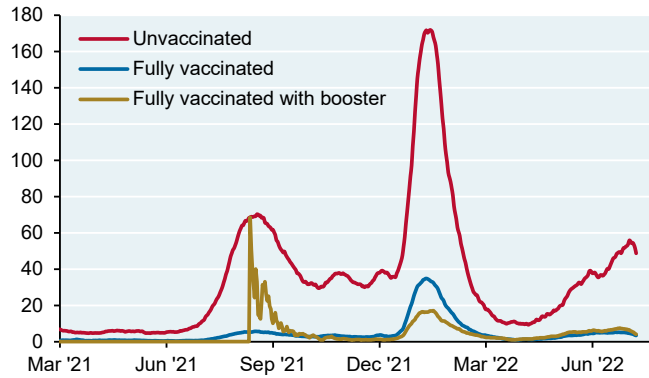
Current hospitalizations, # per mm, smoothing = 7 days



Source: Washington Department of Health. November 30, 2022.

**California: hospitalizations**

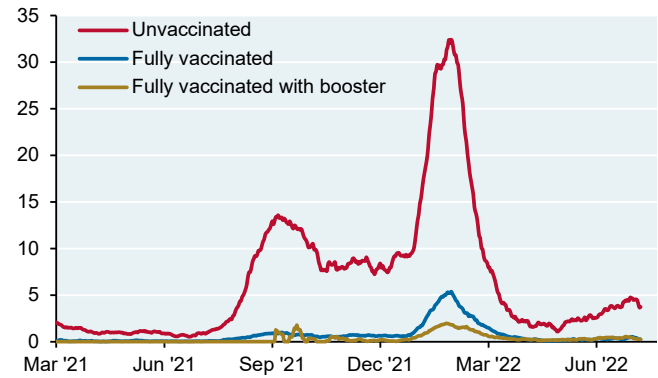
Daily hospital admissions, # per mm



Source: California Department of Health. October 31, 2022.

**California: mortality**

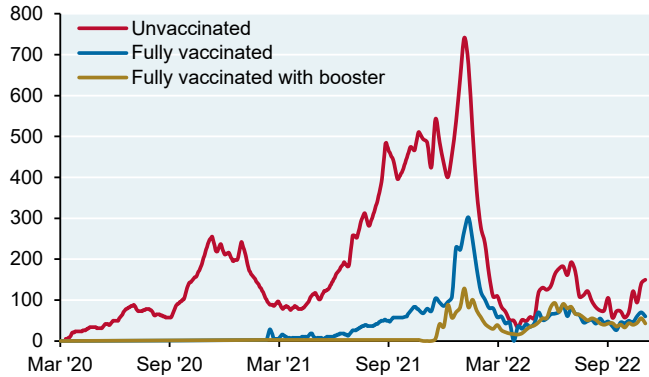
Daily deaths, # per mm



Source: California Department of Health. October 31, 2022.

**Utah: age adjusted hospitalizations**

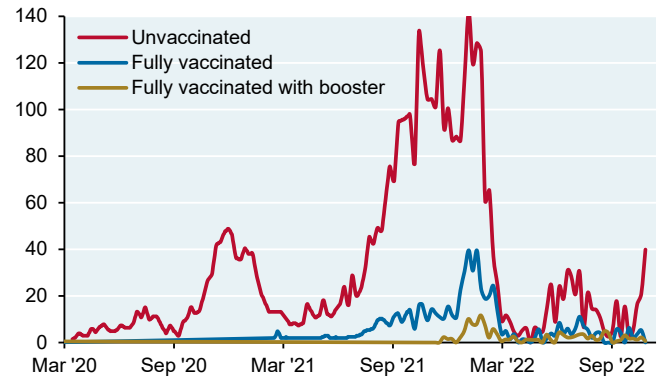
Weekly hospital admissions, # per mm



Source: Utah Department of Health. November 20, 2022.

**Utah: age adjusted mortality**

Weekly deaths, # per mm

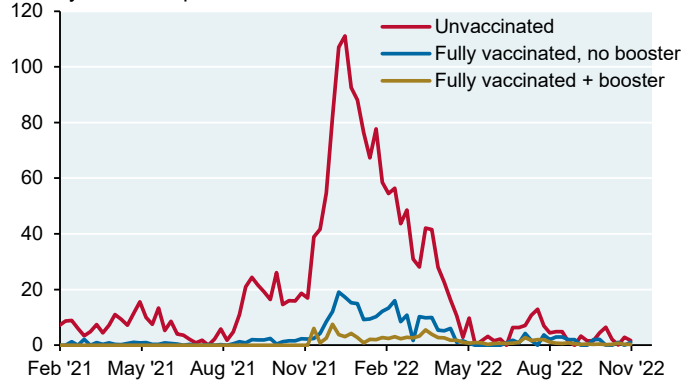


Source: Utah Department of Health. November 13, 2022.



**Switzerland: mortality**

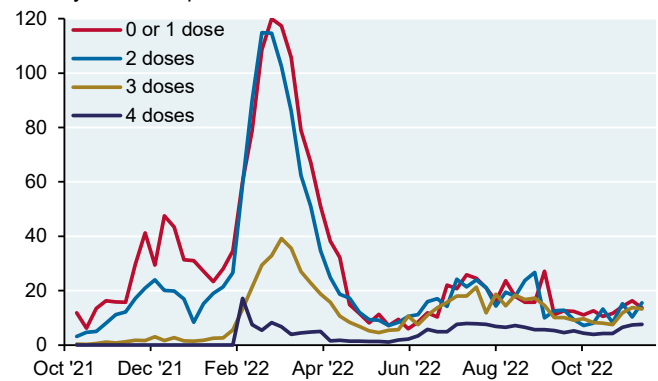
Weekly deaths, # per mm



Source: OWID, JPMAM. November 6, 2022.

**Chile: mortality**

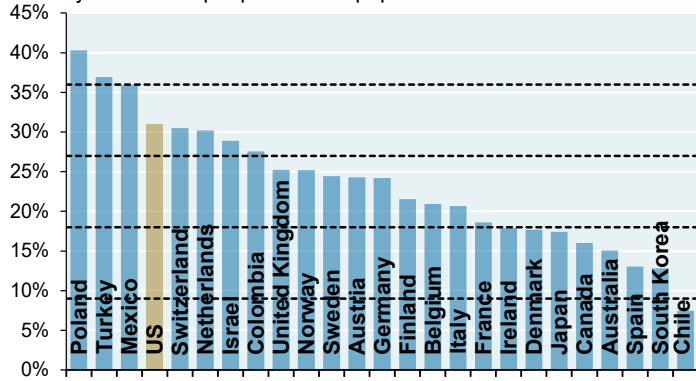
Weekly deaths, # per mm



Source: OWID, JPMAM. November 20, 2022.

**OECD countries by highest share of unvaccinated people**

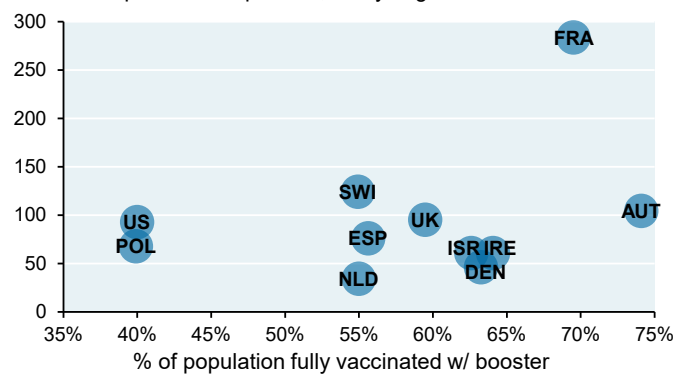
Not fully vaccinated people as % of population



Source: OWID, JPMAM. Dec 6, 2022. Largest 25 OECD countries by GDP

**Current hospitalizations vs boosted population**

Current hospitalizations per mm, 7 day avg



Source: OWID, JPMAM. Dec 6, 2022. Largest 25 OECD countries by GDP

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