

Coronavirus: Science and Policy Update November 24, 2021

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Goals for today's talk

- Convey as much information as I can in 30 minutes
 - Then open for questions
 - Can ask me privately too, I know lots that isn't on these slides
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- Caveat: I try hard to keep up with the COVID literature
 - But inevitably miss some things.
 - I will sometimes have strong opinions
 - You are welcome to ask: What's the basis for that?

My COVID-related writing

- Jesse Pines, Mark Zocchi, Bernard Black, Jestin Carlson, Pablo Celodon, Ali Moghtaderi, and Arvind Venkat, *Characterizing Pediatric Emergency Department Visits During the COVID-19 Pandemic*, xx **American Journal of Emergency Medicine** yyy-zzz
- Pines, Zocchi, Black, Celedon, Carlson, Moghtaderi, and Venkat, The Effect of the COVID-19 Pandemic on Emergency Department Visits for Serious Cardiovascular Conditions, 47 **American Journal of Emergency Medicine** xxx-yyy (2021)
- Pines, Zocchi, Black, Carlson, Celedon, Ali Moghtaderi, and Arvind Venkat, *How Emergency Department Visits for Substance Use Disorders Have Evolved During the Early COVID-19 Pandemic*, xx **Journal of Substance Abuse Treatment** yyy-zzz (2021).
- Bernard Black and Martin Skladalny, Time for the FDA to Get Out of the Way of Vaccinating Children, **Los Angeles Times** (op-ed) (August 23, 2021).
- Black and Skladalny, No, Poor Countries Don't Need Your Booster. They Need Help Getting Shots in Arms, **San Francisco Chronicle** (op-ed) (Sept, 24, 2021)
- Bernard Black and David Thaw, On Covid-19 Booster Shots, the FDA Has Overstepped Its Role, **Stat News** (op-ed) (October 18, 2021), at <https://www.statnews.com/2021/10/18/booster-shots-fda-overstepped-role/>
- Sadiya S. Khan, Alona Furmanchuk, Laura E. Seegmiller, Faraz S. Ahmad, Bernard S. Black, and Kevin J. O'Leary, Divergent Trends in Hospital Presentations Amidst the Novel Coronavirus Disease 2019 Pandemic in Chicago, Illinois, xx **Journal of Cardiac Failure** yyy-zzz (forthcoming 2021)
- Paula Natalia Barreto Parra, Vladimir Atanasov, John Meurer, Jeff Whittle, Eric Luo, Ruohao Zhang, and Bernard Black, The COVID-19 Pandemic, Years of Life Lost, and Life Expectancy: Decomposition Using Individual-Level Mortality Data (working paper 2021), at <http://ssrn.com/abstract=3795801>.
- Barreto Parra, Atanasov, Meurer, Whittle, Luo, Zhang, and Black, Data and Methodology Documentation for A COVID-19 Risk Calculator: Mortality Rates and Loss of Life Expectancy (working paper 2021) (<http://ssrn.com/abstract=3795802>)
- Black, Bernard, and David Thaw, COVID-19 Vaccine Efficacy, the Delta Variant, and the Evidence on Boosters (working paper Nov. 2021)

News: Terrible, Sad, Okay, Good, and Great

- Terrible: Delta wave in US and Europe; Cases rising, deaths still very high
 - Delta is **way** more infectious than earlier variants. Would've had herd immunity w 2020 variant by now
 - Israel looks much better today (but will this last?)
- Sad: Vaccine resistance/refusal
 - Israel is ahead of many countries but not all, especially Arab population (not sure about Haredim)
 - US is a laggard among developed countries in adult percentage vaccinated
 - Mortality rate (vaccine + booster versus unvax): Could be **25x** lower: US: 50 people/day versus 1250 (or more)
- Okay: Treatment if infected
 - **Once hospitalized**, with low oxygen: dexamethasone (steroid) [but little new since mid-2020]
 - If on ventilator or ECMO, already in deep trouble
 - **Early infection**: monoclonal antibodies help a lot; Merck and Pfizer pills are coming, but supply is very limited
- Good: High percentage of adults vaccinated, infected, or both
 - US estimate > 90% among age 65+ [highest risk]; 85% for all adults. Israel is higher, not sure by how much
 - Boosters needed, but COVID is running out of naïve targets
 - Vaccine mandates work [most people comply]
 - Tav Yarov surely helps, but how much
- Great: mRNA vaccines (Pfizer-BioNTech; Moderna)
 - Safety profile is **excellent** [myocarditis/pericarditis for young men, but mostly mild]
 - But efficacy wanes [by 5-6m for Pfizer, maybe 8m for Moderna]. J&J was never as good.
 - Advice **for all**: get an mRNA booster. In US: ignore FDA/CDC mixed signals.

The Current (Delta Variant) Wave

Delta variant has outcompeted all prior variants:

Way more infectious.

Estimate $R_0 = 9$ or so

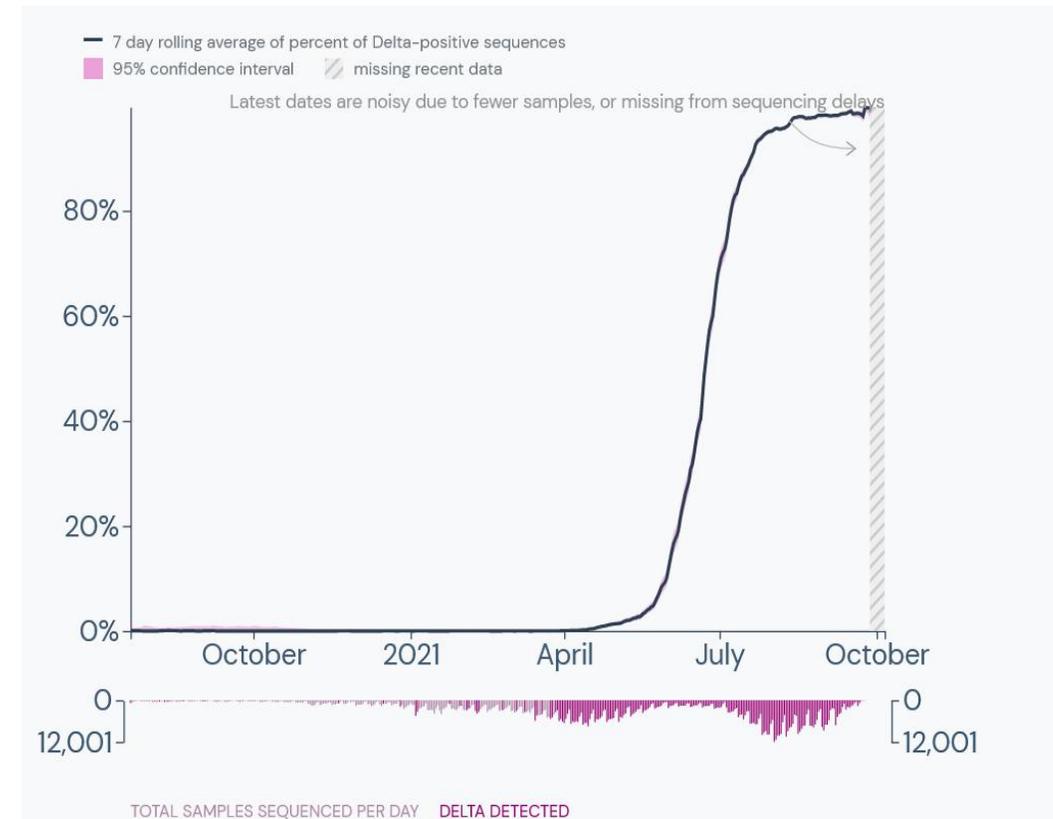
More severe also? Next slide

Are there other, still worse variants coming?

Many infections even if vaccinated

If vaccinated, less serious, on **average**

Which may not help you



Is Delta More Severe (as well as more contagious)?

- Risk of being hospitalized if (confirmed) infected = unknown
- I've seen one UK study of risk if vaccinated
 - not limited to Delta period
 - not specific to vaccine type
 - no control for time since vaccination.
- Why is this unknown?

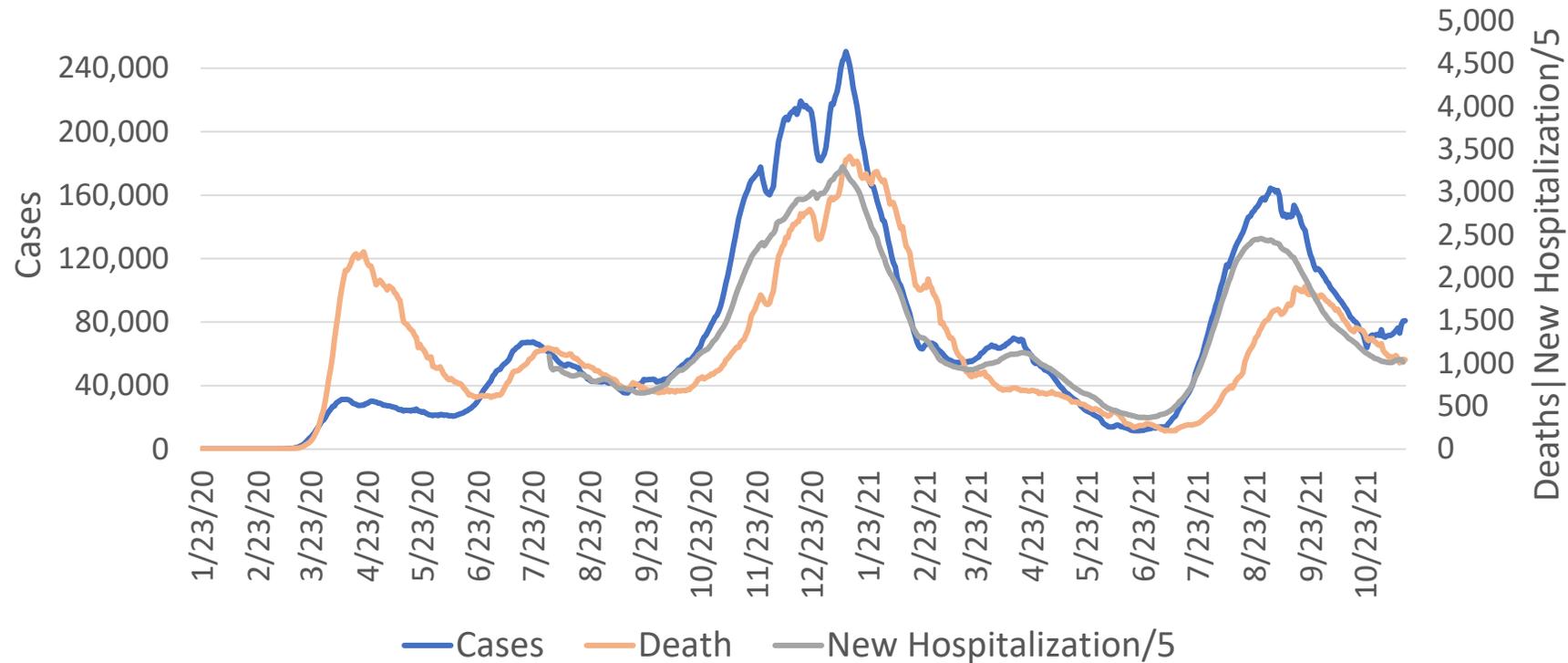
Is Delta More Severe (as well as more contagious)?

- US study of risk of death **if hospitalized**
 - Reported as no significant difference (by CDC people running the study)
 - Rather than: Delta likely worse for elderly; underpowered study

Period	2021 pre-Δ	Delta	2021 pre-Δ	Delta	2021 pre-Δ	Delta
	All		Unvaccinated		Fully Vaccinated	
18–49	3.4 (2.2–5.0)	2.0 (0.7–4.3)	3.2 (2.0–4.9)	2.1 (0.7–4.7)	5.0 (0.6–16.7)	2.0 (0.0–12.8)
50–64	7.5 (5.9–9.3)	9.5 (6.4–13.5)	7.6 (5.8–9.6)	10.5 (6.8–15.2)	4.2 (1.0–11.3)	7.3 (1.4–20.7)
≥65	12.3 (10.2–14.8)	18.5 (13.8–23.9)	12.0 (9.6–14.7)	18.6 (12.6–25.9)	8.2 (4.5–13.5)	17.4 (10.5–26.3)
All adults	8.6 (7.5–9.9)	9.9 (7.9–12.2)	8.2 (7.0–9.5)	8.7 (6.6–11.1)	7.2 (4.3–11.1)	13.9 (8.7–20.7)

US: Confirmed Cases; Hospitalization, Deaths (thru Nov. 14, 2021)

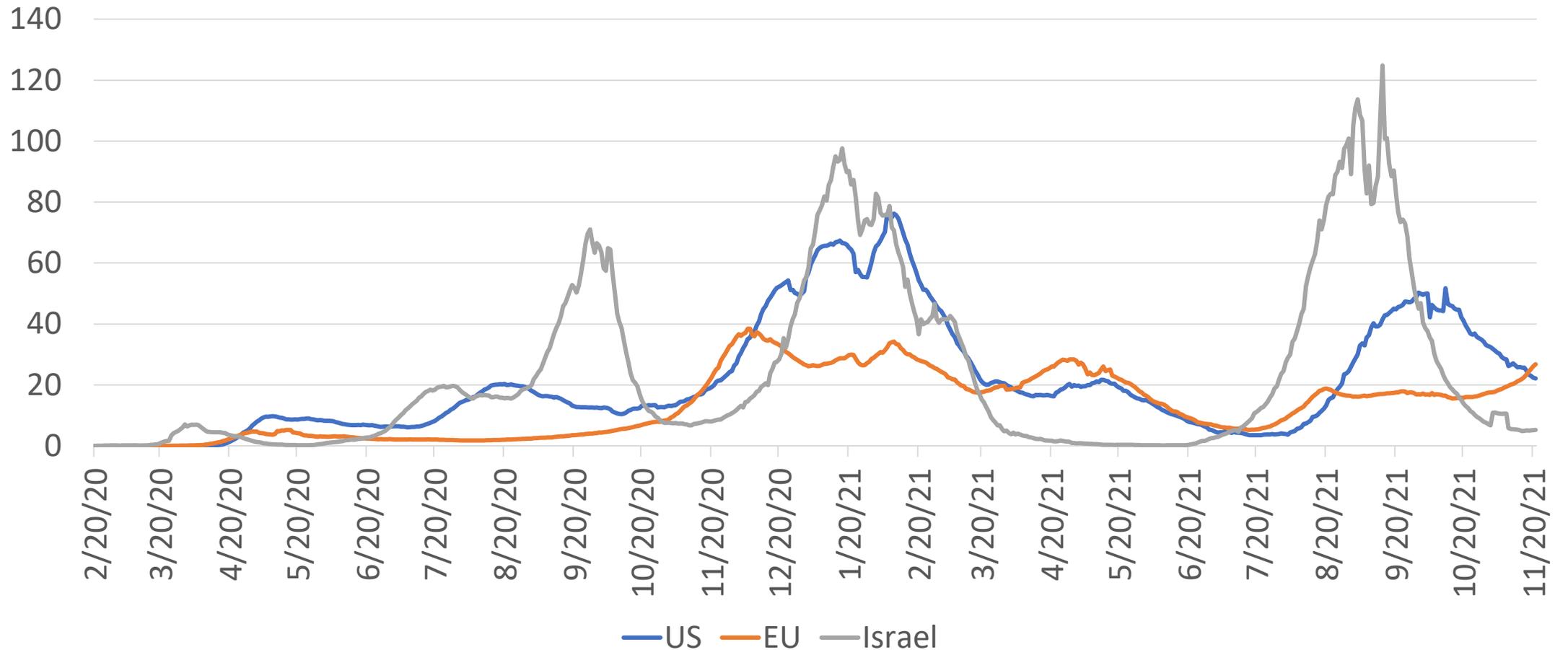
US 7-Day Running Average of Cases, Deaths and Hospitalization
(thru 11/14/21)



Will US (and Europe) see a winter surge?
Already happening in northern (cold) states . . .

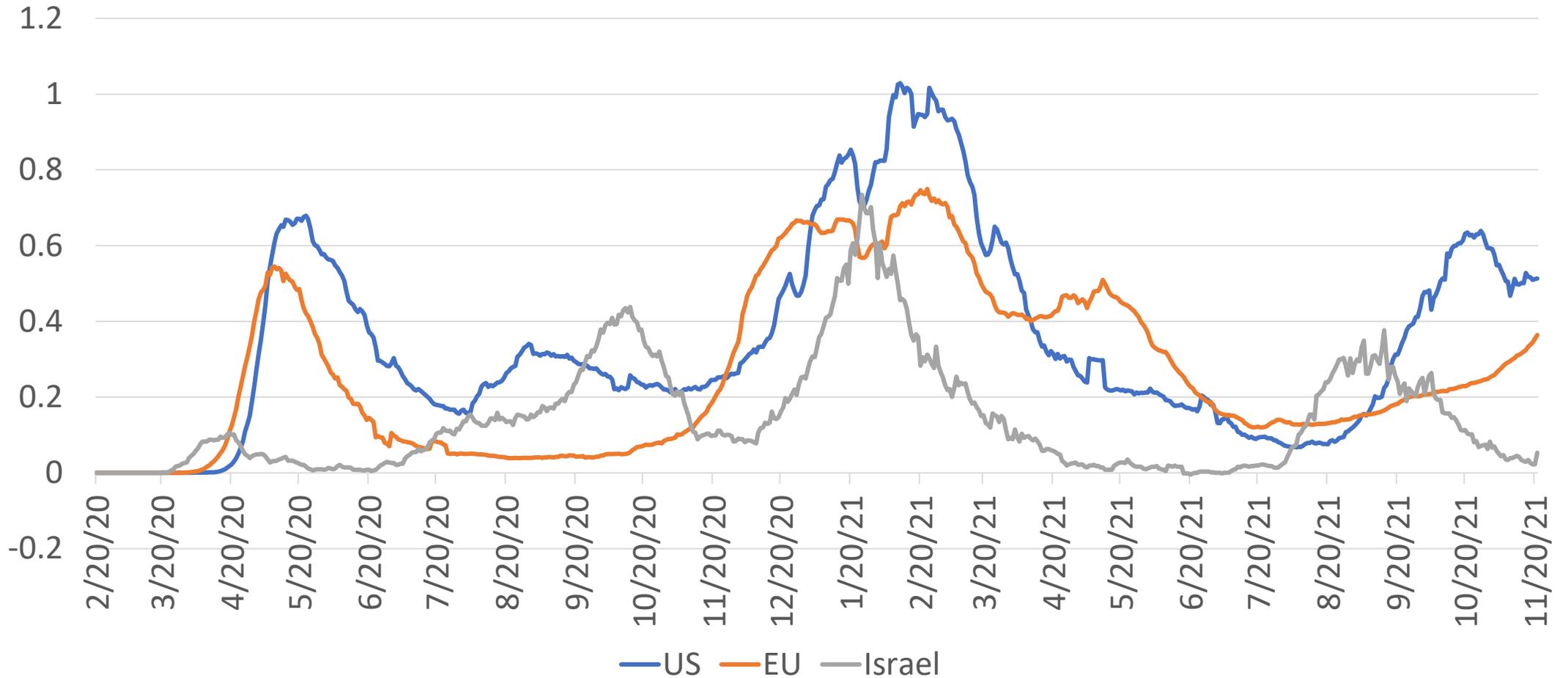
US v Europe v. Israel over Time: Cases

Daily New COVID Cases per 100K, 7-day Moving Average



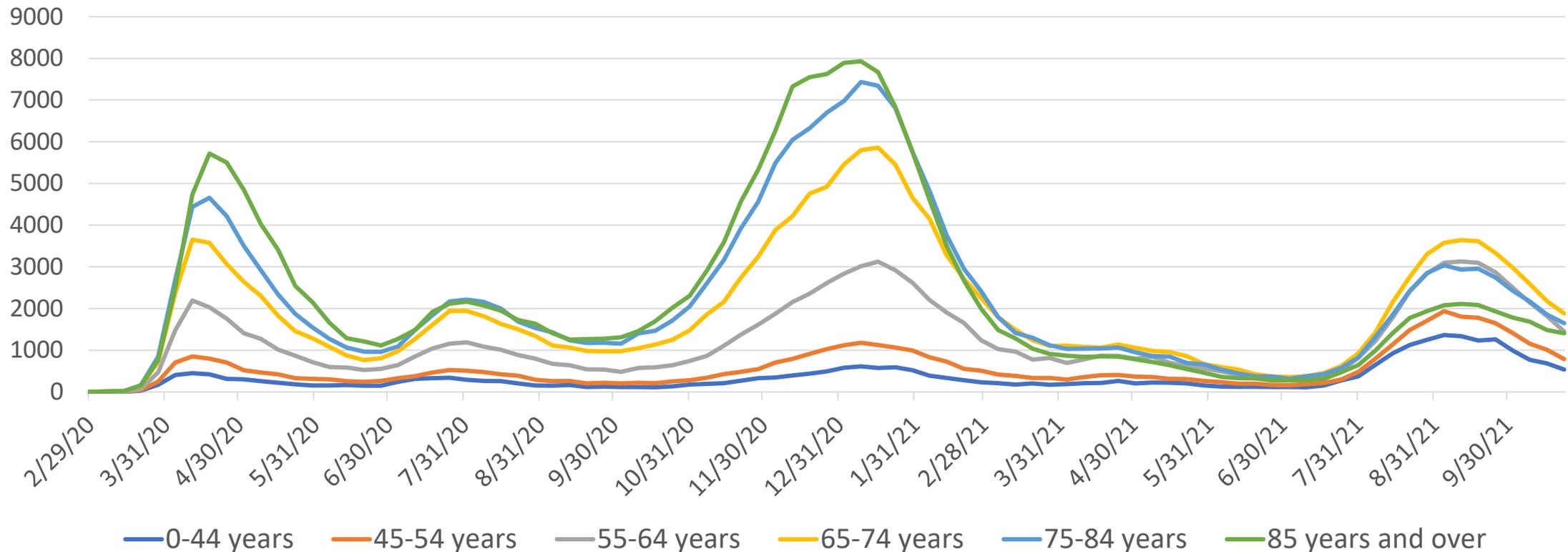
US v Europe v. Israel over Time: Deaths

Daily New COVID Deaths per 100K, 7-day Moving Average



US deaths by age over time: all ages

COVID-19 Weekly Deaths (thru 2021-10-23)



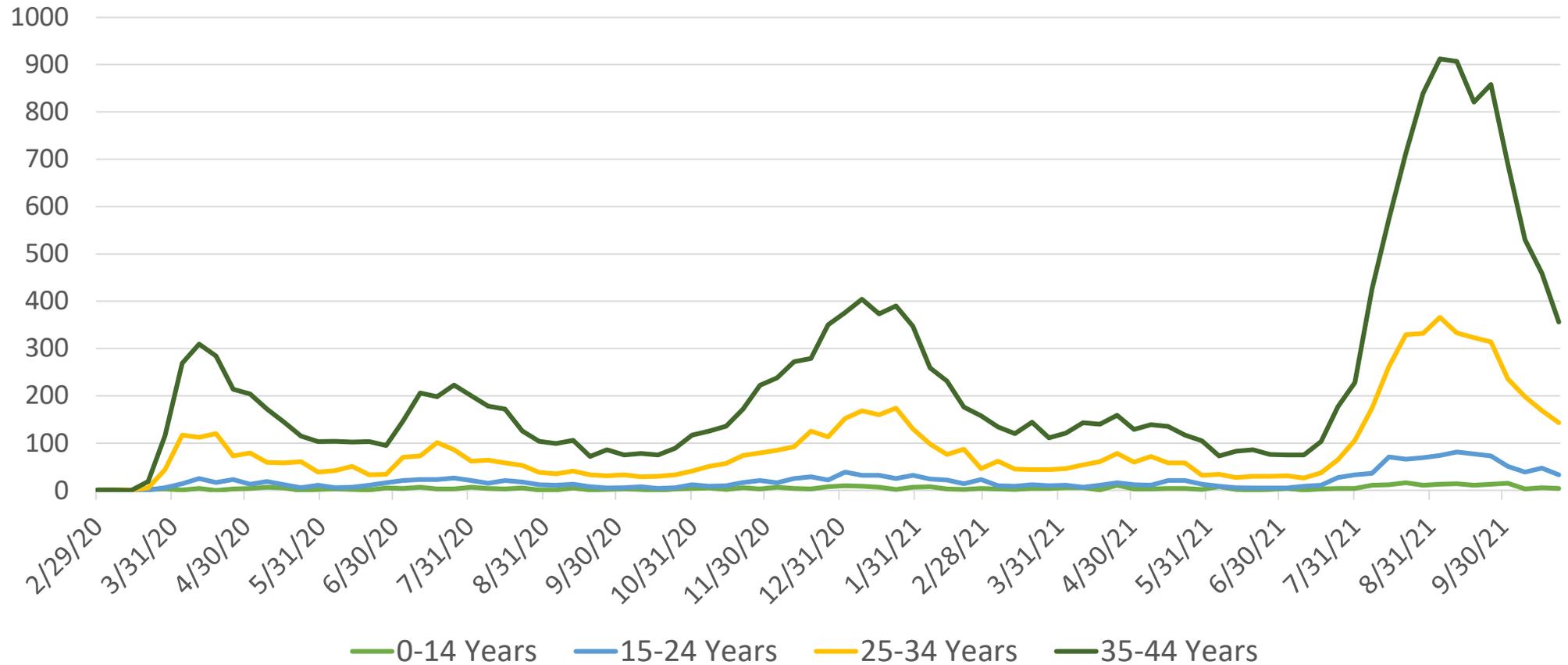
Earlier end date, more recent data not yet reliable

Recent deaths are at younger ages (driven by lower vaccination rates)

If you know of similar Israeli data, please tell me where to find it!

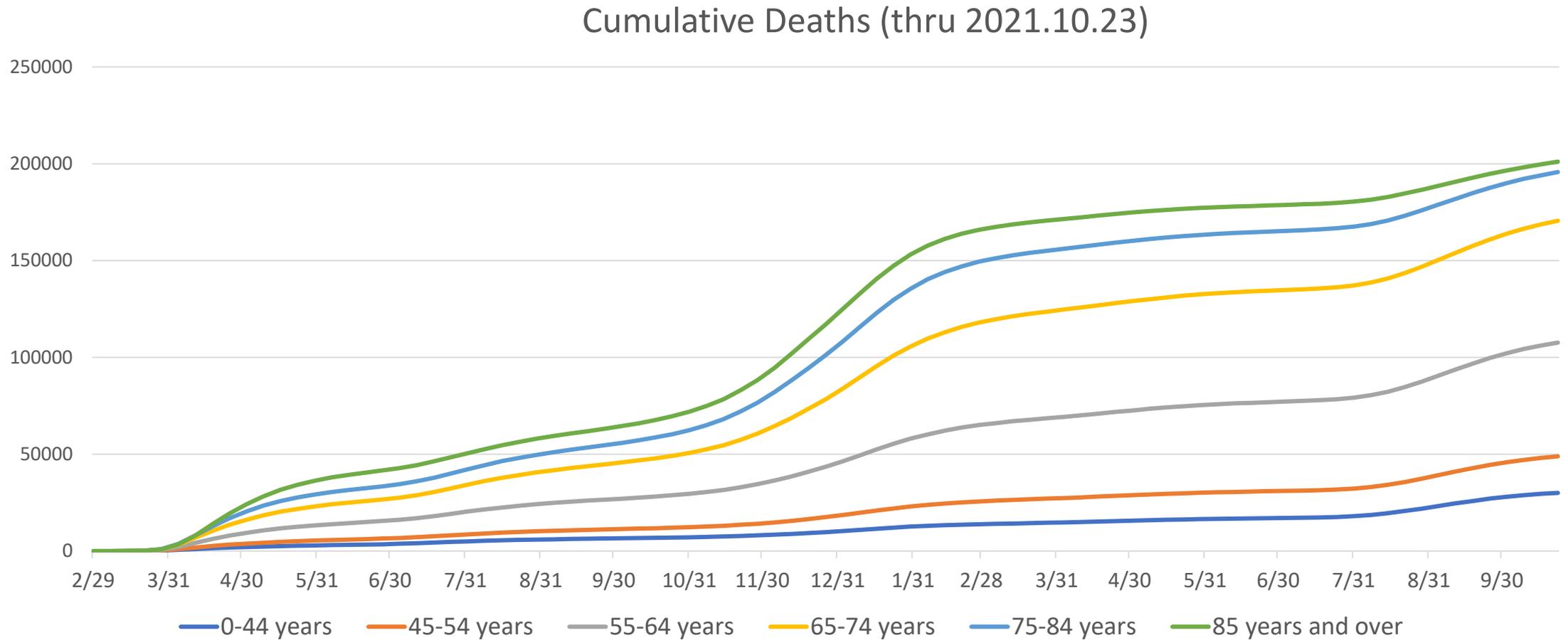
US deaths by age over time: age 0-44 (expanded scale)

COVID-19 Weekly Deaths, Ages 0-44, (thru 2021-10-23)



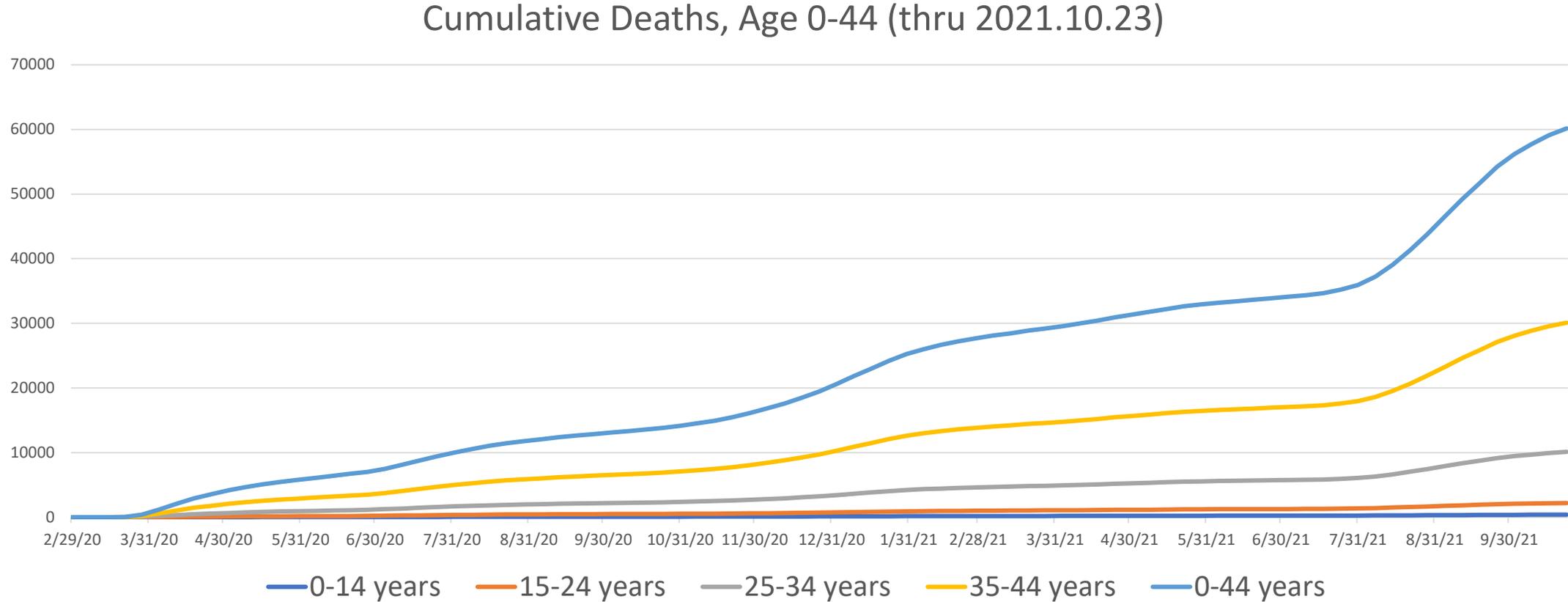
For ages up to 54, Delta wave is worst yet.

Cumulative US Deaths by Age



Age remains a huge factor in mortality risk.

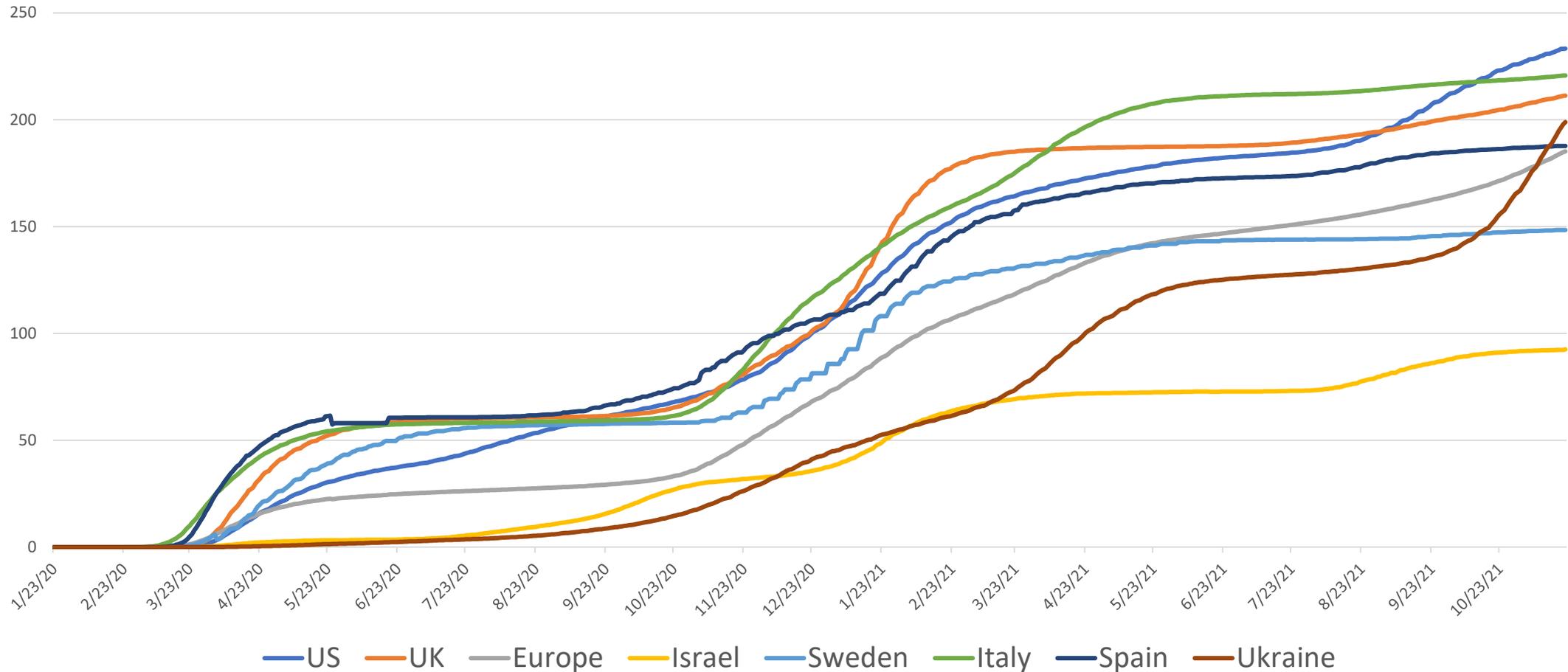
Cumulative US Deaths (Age 0-44), Expanded Scale



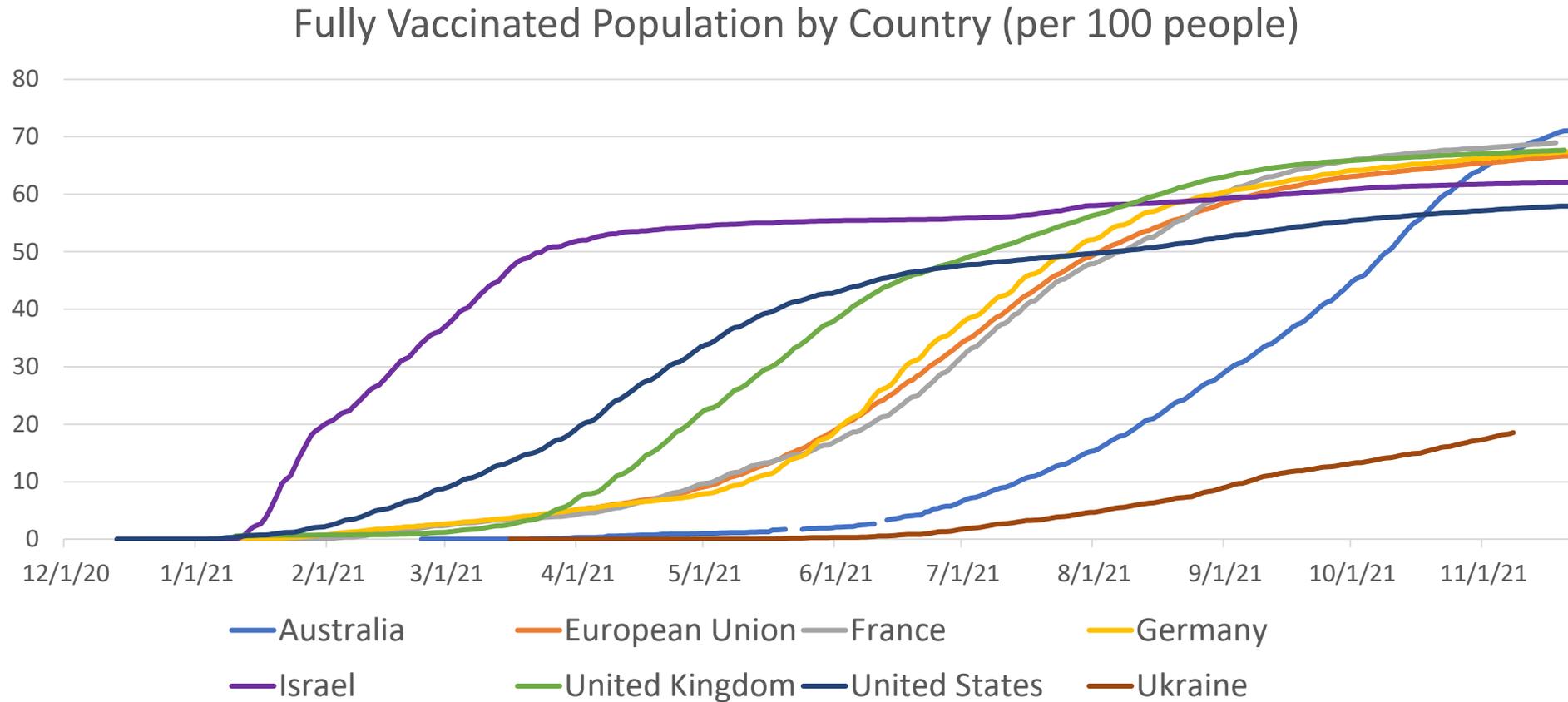
Sharp rise for younger people (less vaccinated) in current (Delta) wave

Mortality Across Countries

Cumulative COVID-19 Deaths per 100K Population



World Vaccination Rates (thru Nov. 21)



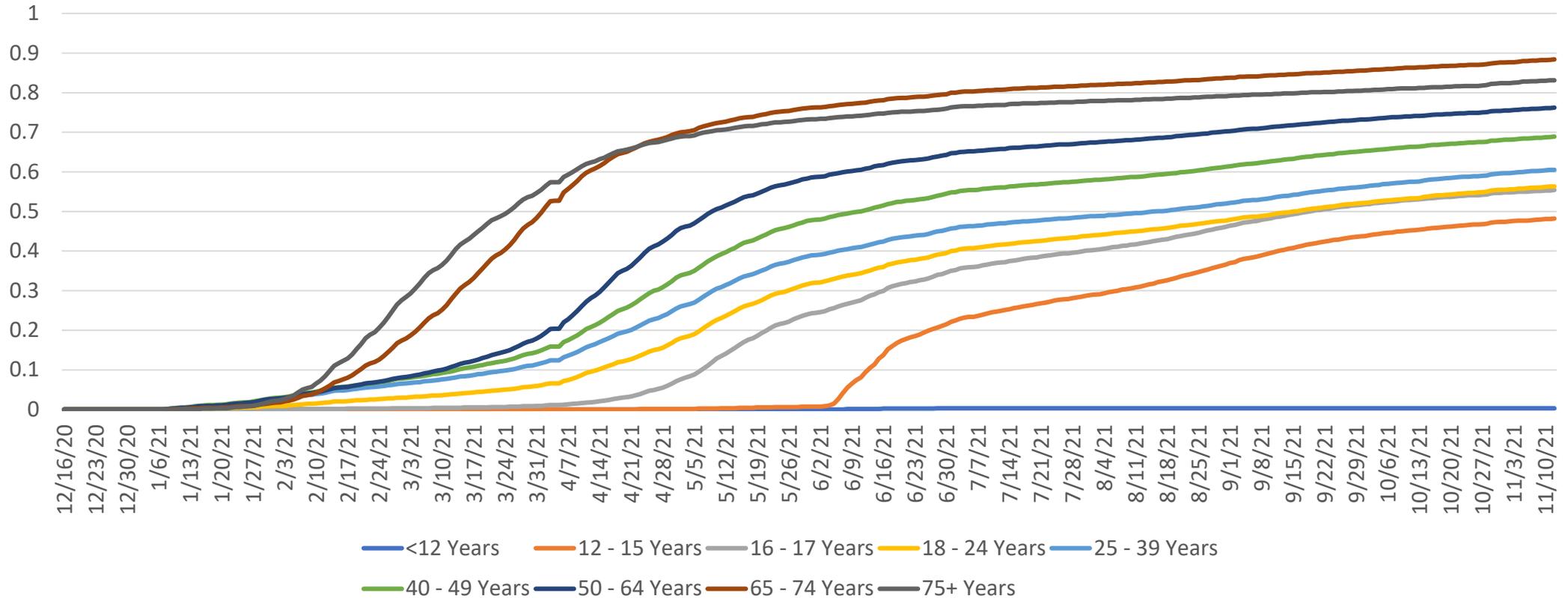
Israel was great early, less great now.

US levels rising, but still a large outlier among advanced economies

If you know of data by Jewish (incl "other"), Arab, Haredi, please let me know

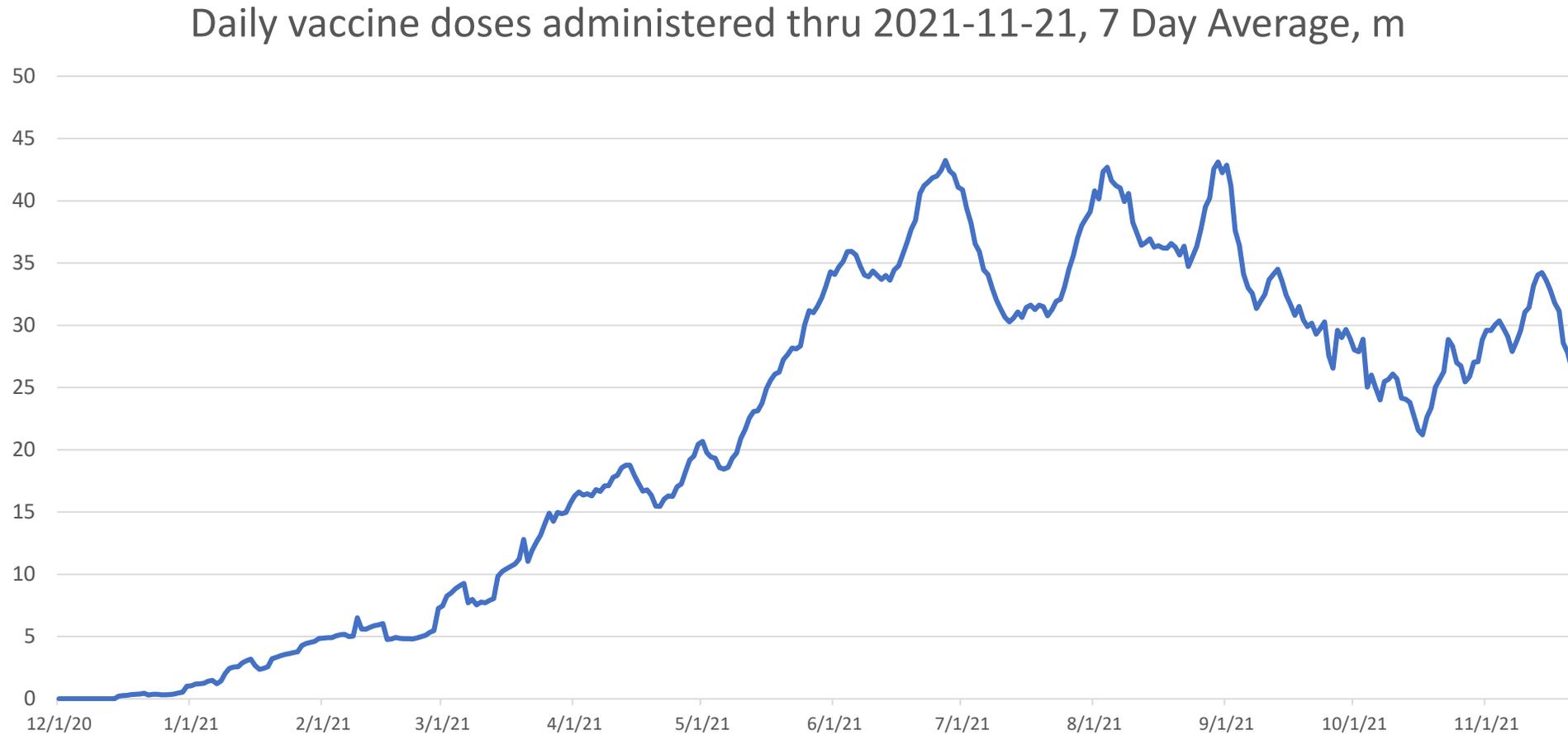
U.S. full vaccination rates by age

Vaccination rates by age group (through Nov. 12, 2021)



If you know Israeli data by age (must exist), let me know.

Worldwide: Who Else Isn't Getting Vaccinated



Europe: New lockdowns

- Hospitals at or near capacity in several countries
- Austria: Lockdown only for the unvaccinated (unless prior infection)
 - Enforced using digital vaccination record
 - Berlin: Same

Vaccines and Boosters

- US: Pfizer, Moderna, J&J
- Others: Astra Zeneca (mostly UK), Novavax, Chinese, Russian vaccines
- Main vaccine types (most to least effective):
 - mRNA: Pfizer, Moderna
 - Spike protein: Novavax
 - Viral vector: Astra Zeneca, J&J, Sputnik
 - Killed virus: Chinese vaccines
- All are two-dose except J&J (which should be two dose)

Pfizer-BioNTech vaccine trial in one slide

Solid squares/circles are for “severe” cases

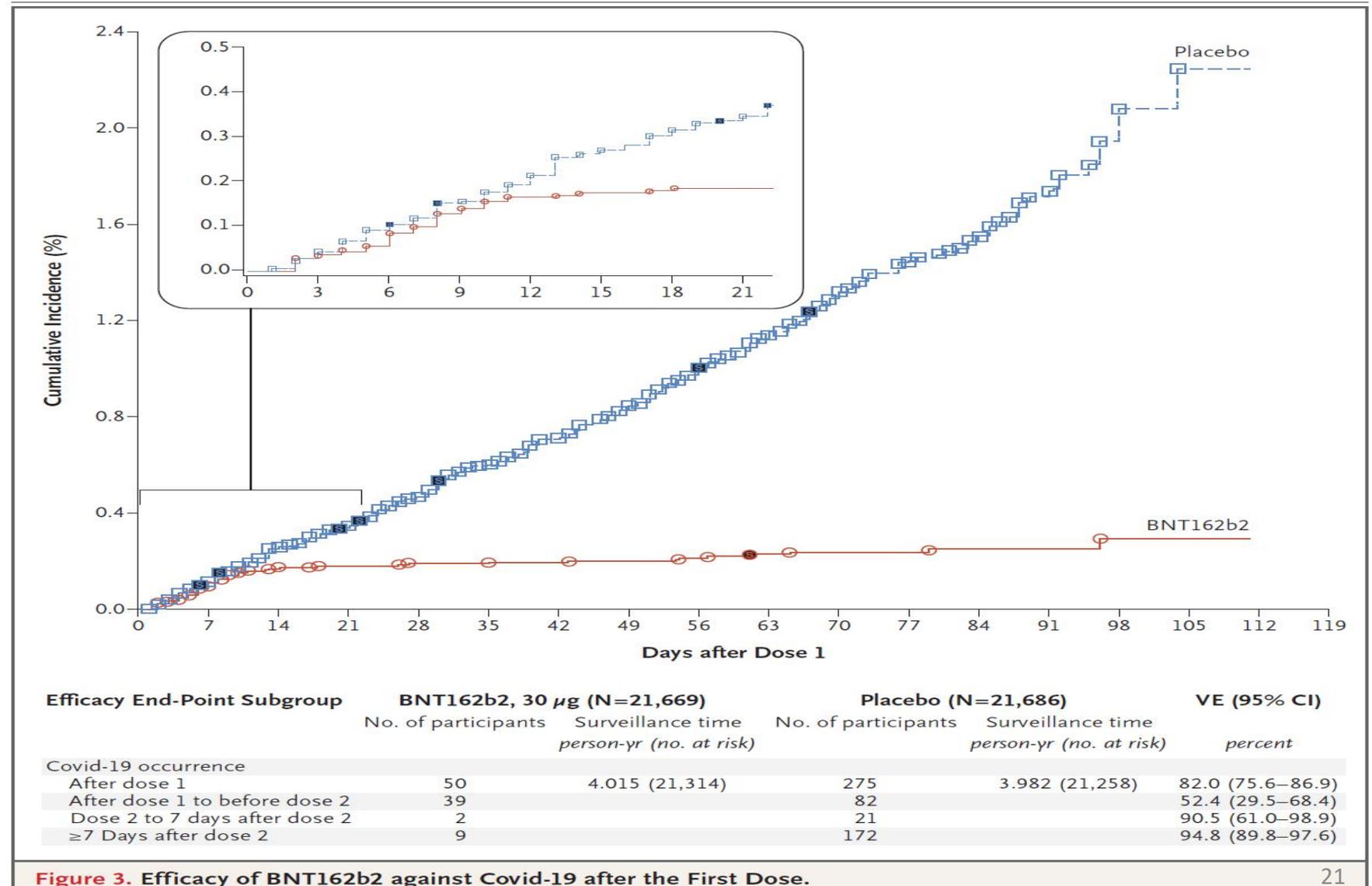


Figure 3. Efficacy of BNT162b2 against Covid-19 after the First Dose.

If only that were still true today

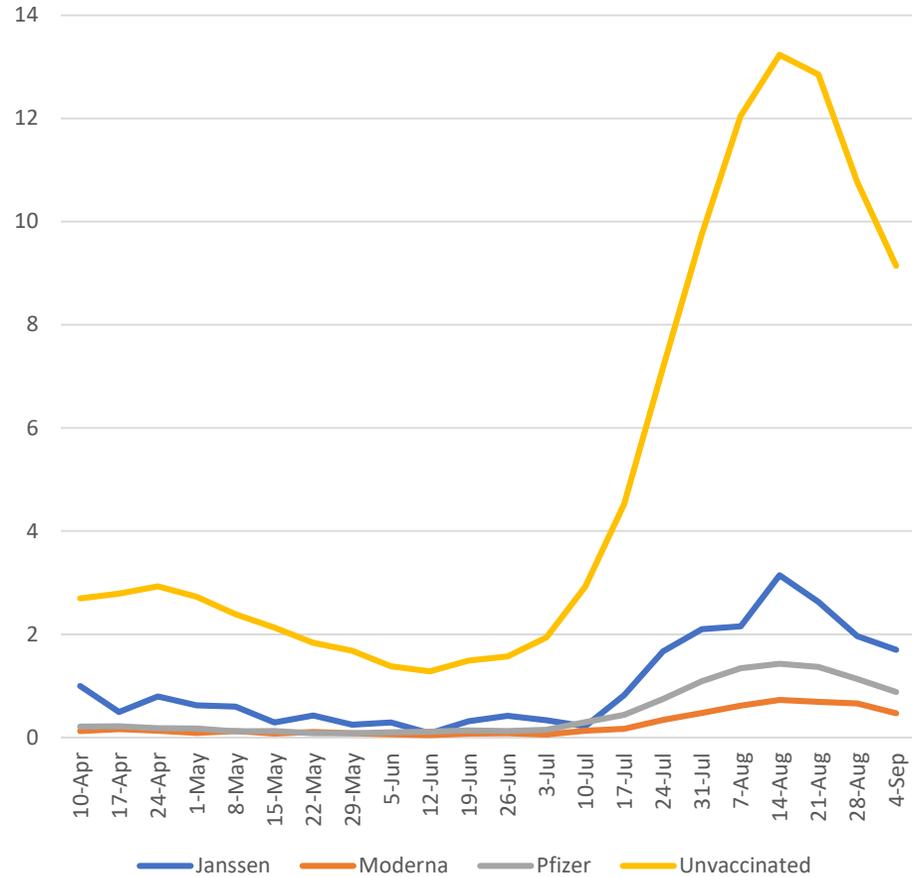
- Early on, for the mRNA vaccines (Pfizer, Moderna)
 - 95% protection against symptomatic infection
 - Even better (98-99%) protection against hospitalization and death
 - Almost no transmission by the vaccinated
- But 6 months after Pfizer vaccine, for Delta
 - little protection against **infection**, maybe 1/3 against **transmission**
 - 75-85% protection against hospitalization
 - Still Low 90s for Moderna
 - Substantial transmission by the vaccinated
- NPIs (non pharmaceutical interventions) therefore needed
 - Masks
 - Avoid travel, restaurants, gyms
 - Avoid indoor spaces, especially crowded ones
 - Ventilation is super-important, not focused on

Infected and Vaccinated in Israel: July 2021 (Pre-Booster)

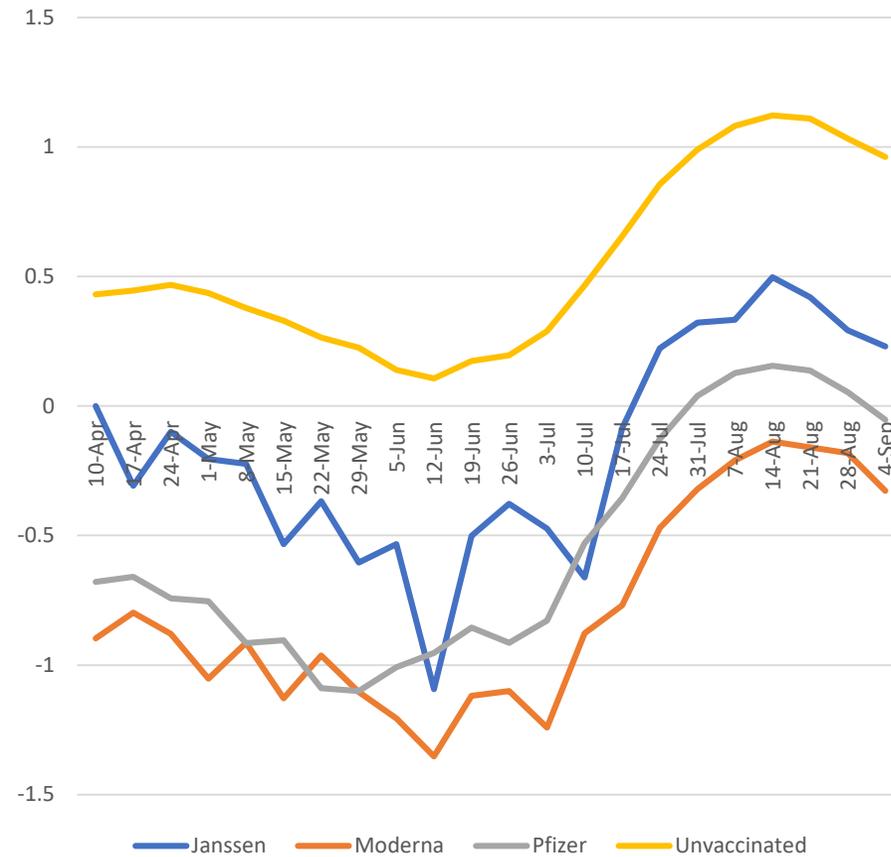
Israel Confirmed Cases, July 25th - July 31st				
Age Group	Cases Fully Vaccinated	Cases Unvaccinated	Percent of Cases Fully Vaccinated	Percentage of Population Fully Vaccinated
20-29	1272	418	75.3%	72.2%
30-39	1549	425	78.5%	77.7%
40-49	1476	297	83.2%	81.1%
50-59	1021	175	85.4%	84.6%
60-69	1026	92	91.8%	87.1%
70-79	656	55	92.3%	93.0%
80-89	284	33	89.6%	91.4%
90+	86	7	92.5%	90.1%
Total	Total	Total	Average	Average
20-90+	7370	1502	86.1%	84.7%

Vaccine Protection Against Mortality

COVID-19 Death Rates by Vaccine Type



Same, using Log Scale



An aside on Israeli data

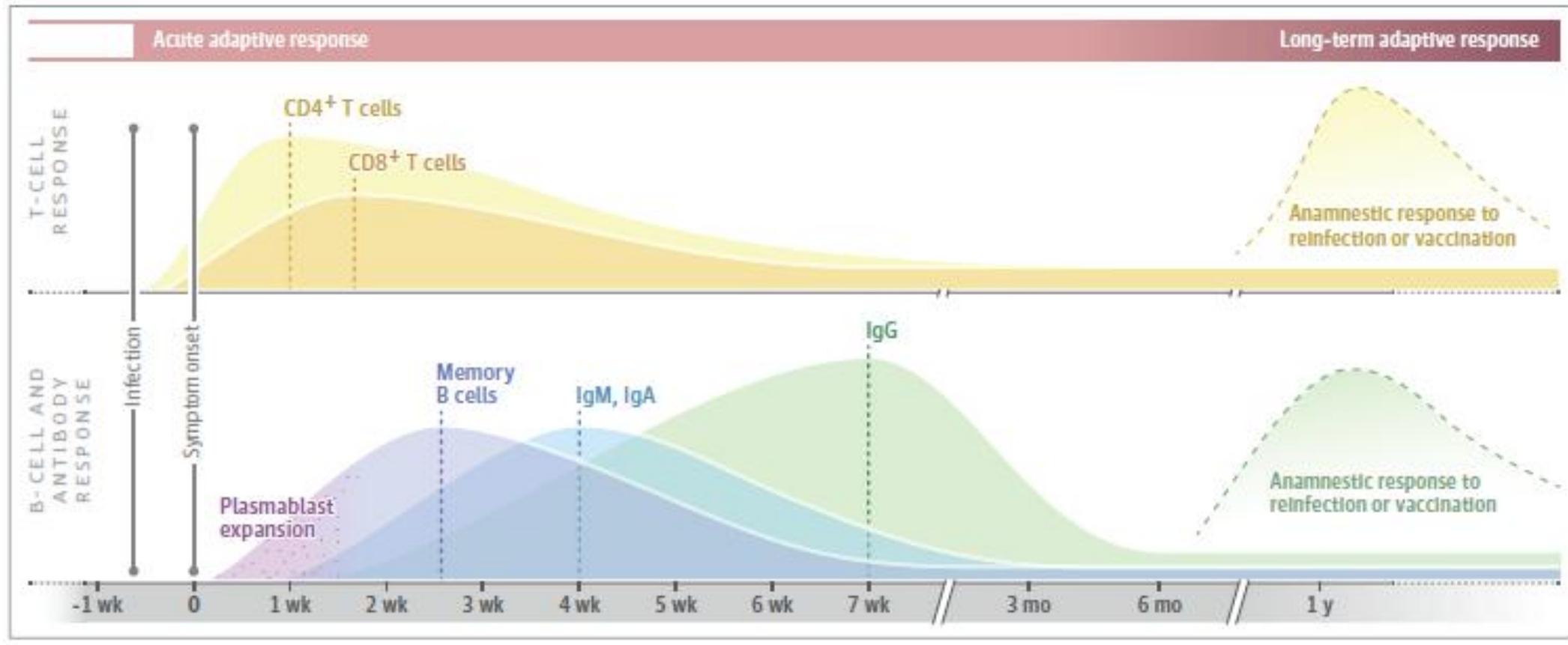
- Much of the best research on vaccine efficacy comes from Israel
 - Good data, good researchers
 - Israel Health Ministry, Clalit, Maccabi groups, others
- UK has some good studies
 - But can't figure out how to report by vaccine type
- US has huge problems aggregating data

Many Other Vaccines Need Boosters

- We hoped COVID protection would be more durable
 - But many other vaccines require multiple doses, spaced in time
- Booster efficacy (Pfizer, Moderna is likely similar)
 - Early evidence: Can recover early vaccine efficacy
 - 90-95% versus symptomatic infection
 - 98% against hospitalization, death
 - Most deaths among very old, immune-compromised, severely comorbid
- How long will booster protection last? [We don't know yet]
 - But reason to hope: will be years, not months
- Hybrid immunity: Infected, then vaccinated, or vice versa
 - One vaccine dose is sufficient (US has not figured this out)
 - Does the order matter?

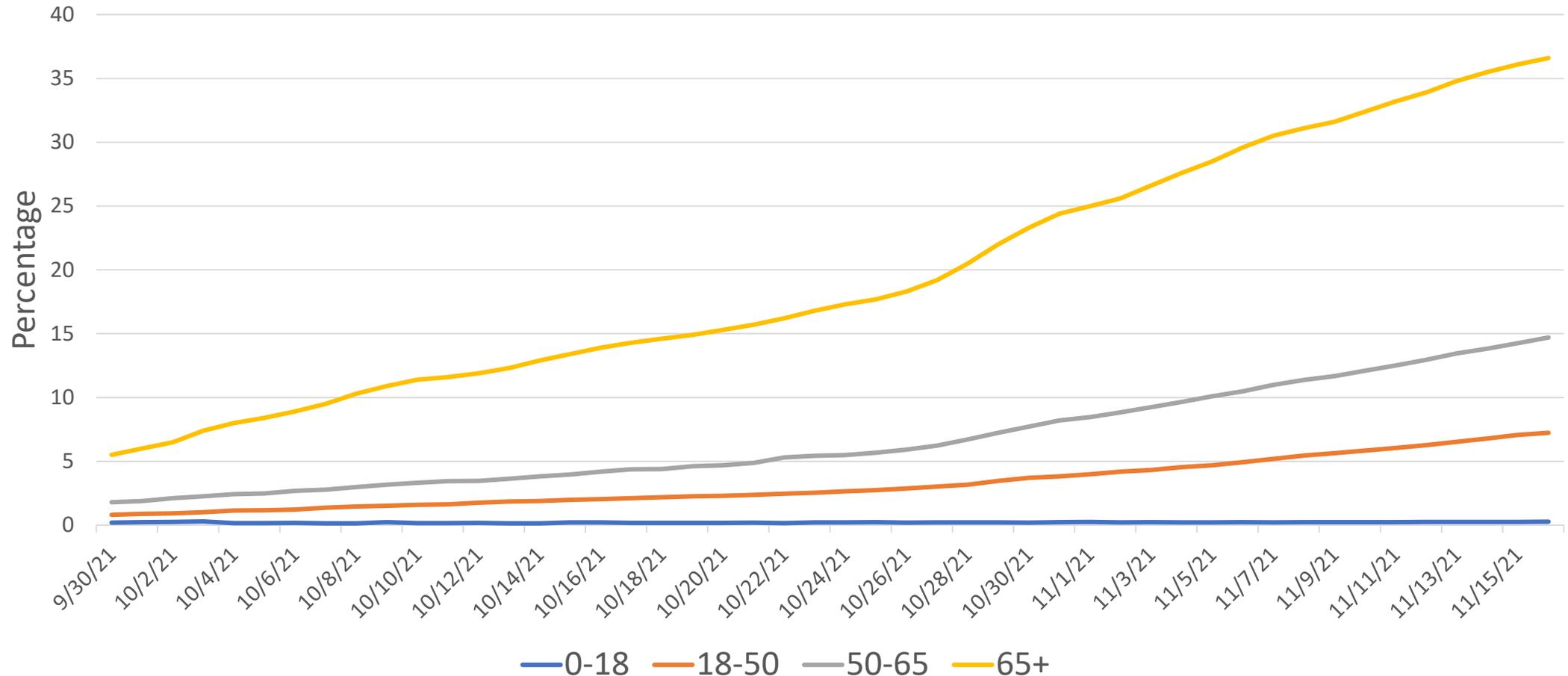
Illustrative Chart (from fall 2020)

Figure. Adaptive Immunity to Coronavirus Disease 2019



US Data on Booster Takeup Rates

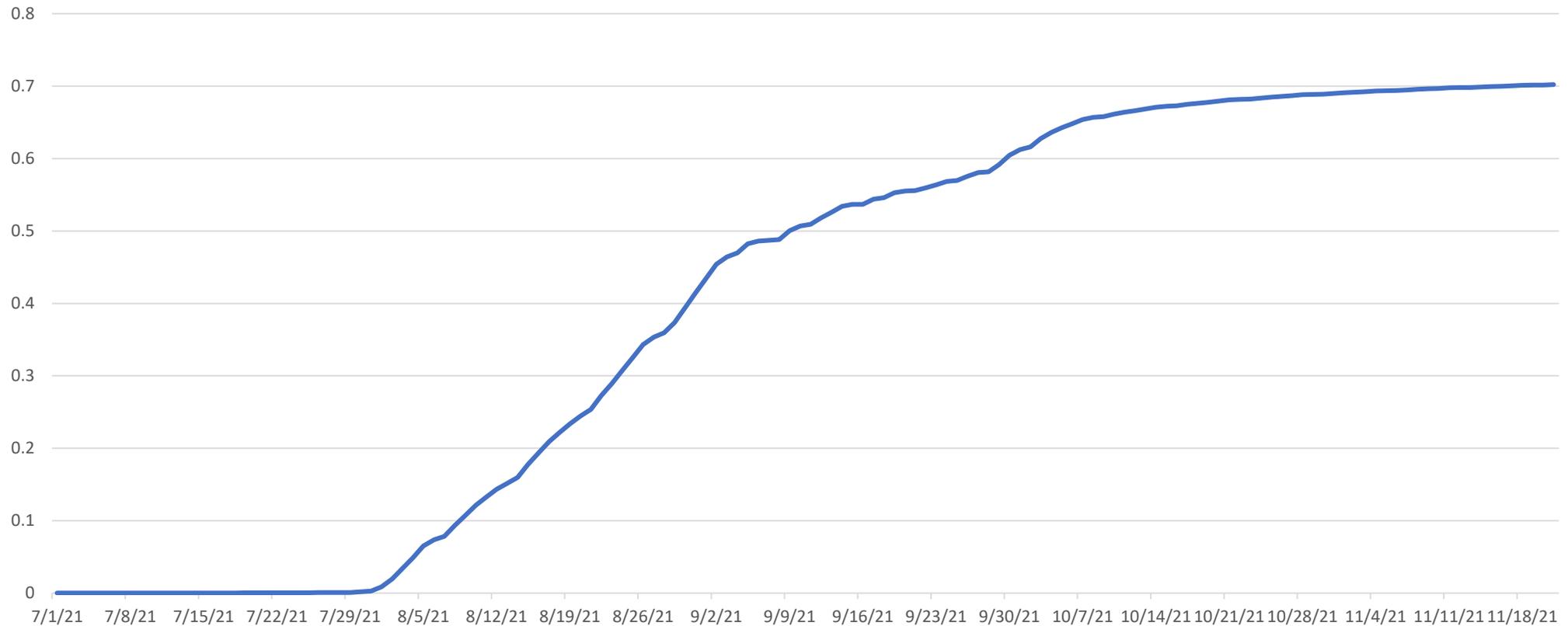
Percentage of Fully Vaccinated People Received Booster in US, by Ages



Is there Israeli data?

Israel aggregate data

Percent of Fully Vaccinated People with Booster in Israel, thru 11/21/2021



70% (of the already vaccinated is not great
I have not seen breakdown by age

Booster efficacy

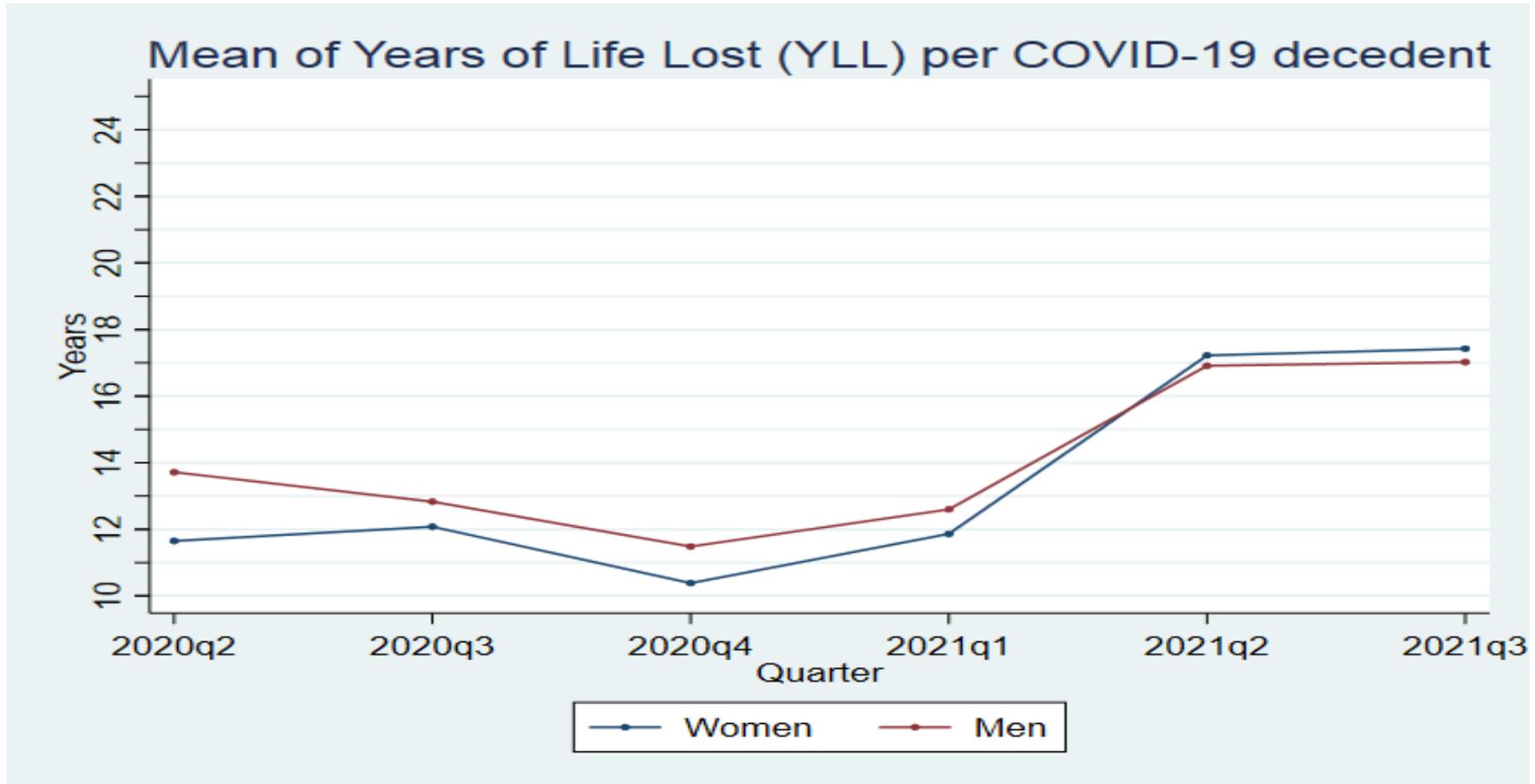
- Recent Israel data:
- Vaccinated: 23 hospitalized out of 4M (.00057%)
 - Not all of those had boostre
- Unvaccinated: 160 out of 700,000 (.023%)
- $.00057 / .023 = .024$ (97.6% efficacy)
 - Caveats: No controls for age, which would likely drive efficacy up since older are more vaccinated, and more prone to hospitalization
 - Does not distinguish between (vax + booster) and only vax
 - This is people in the hospital at given time, not number hospitalized

US: Median age at death by gender

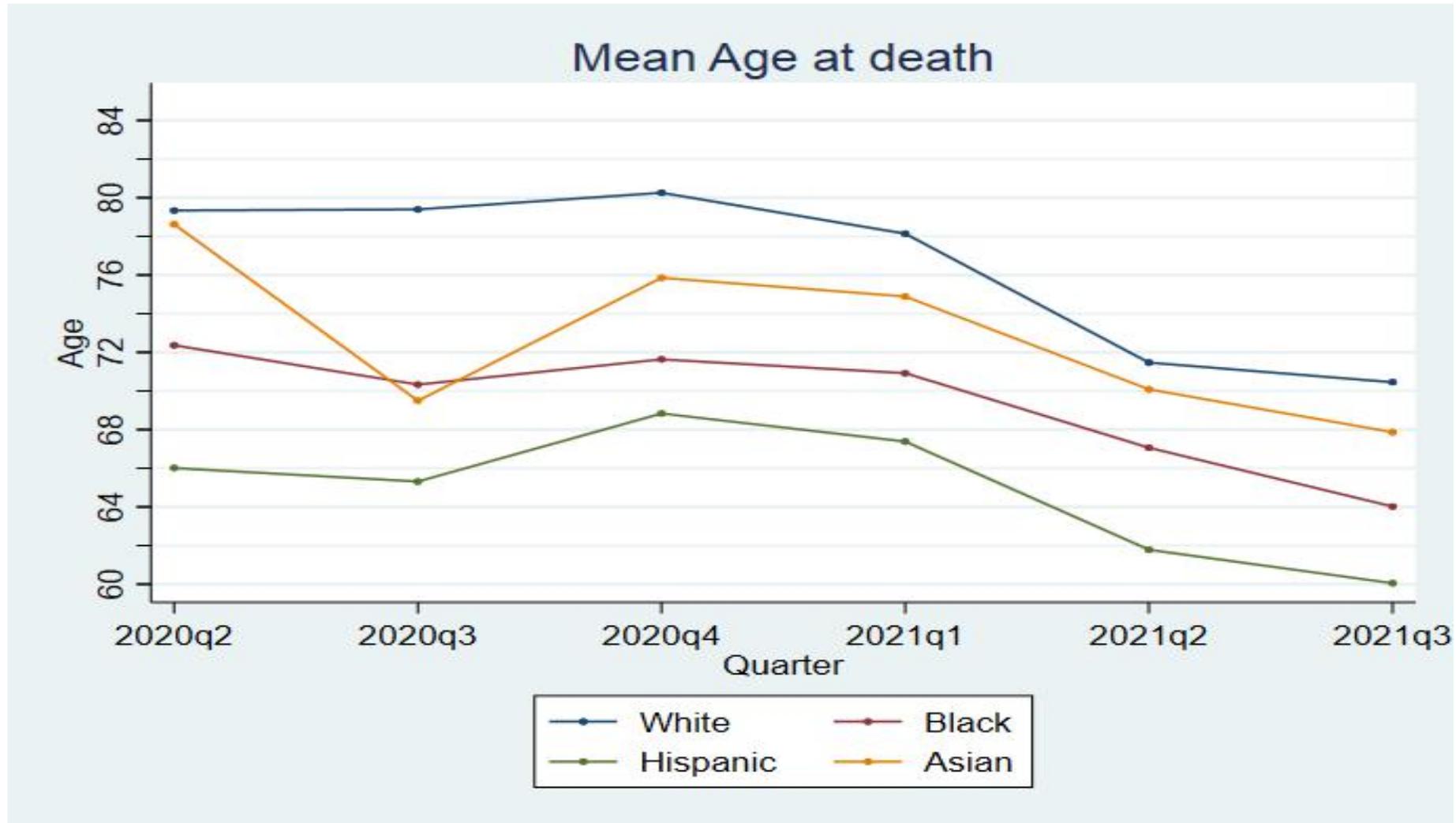


Median age is dropping in 2021, because young are less likely to be vaccinated

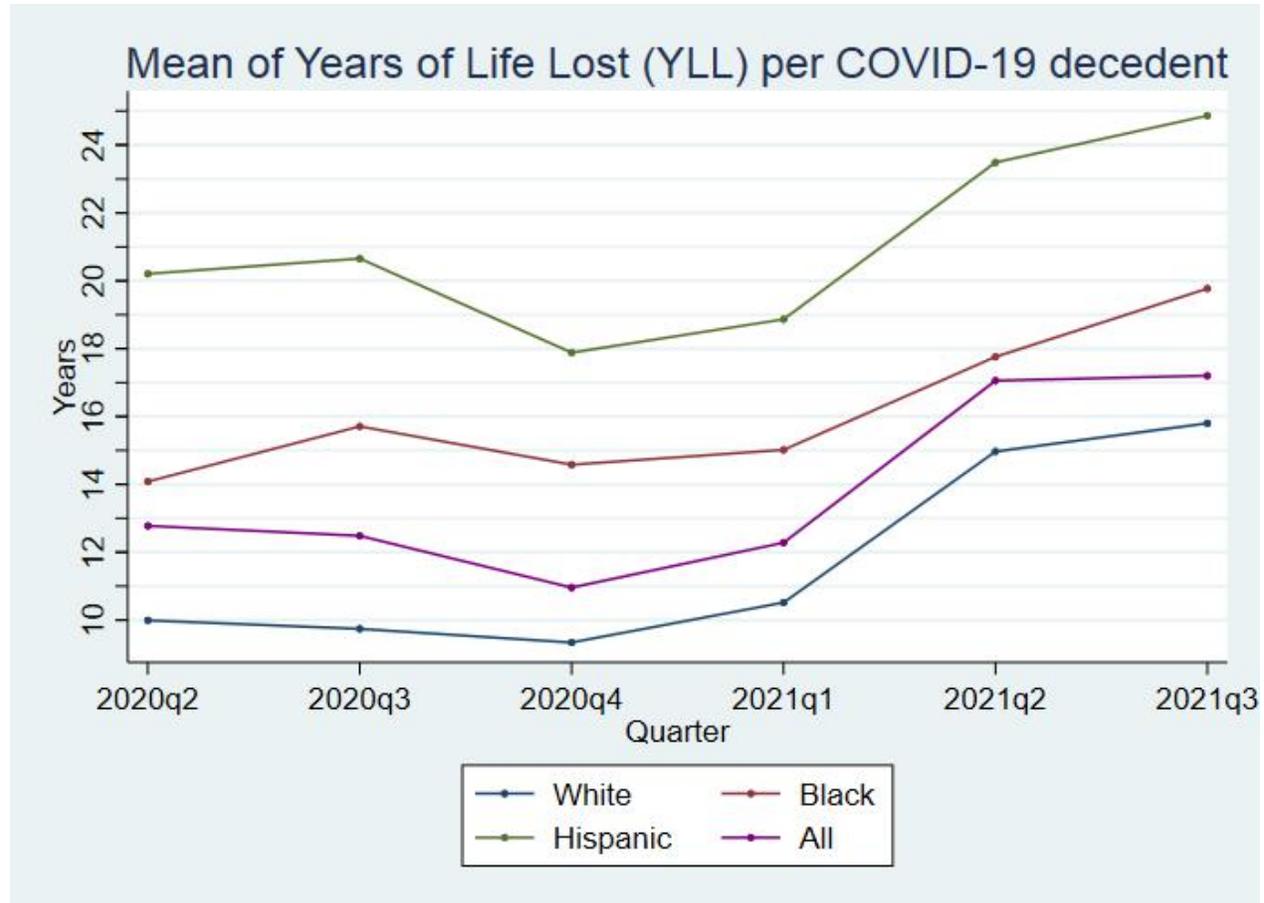
US: Mean Years of Life Lost: By Gender



Median age at death by race/ethnicity



Mean Years of Life Lost: By Race/Ethnicity



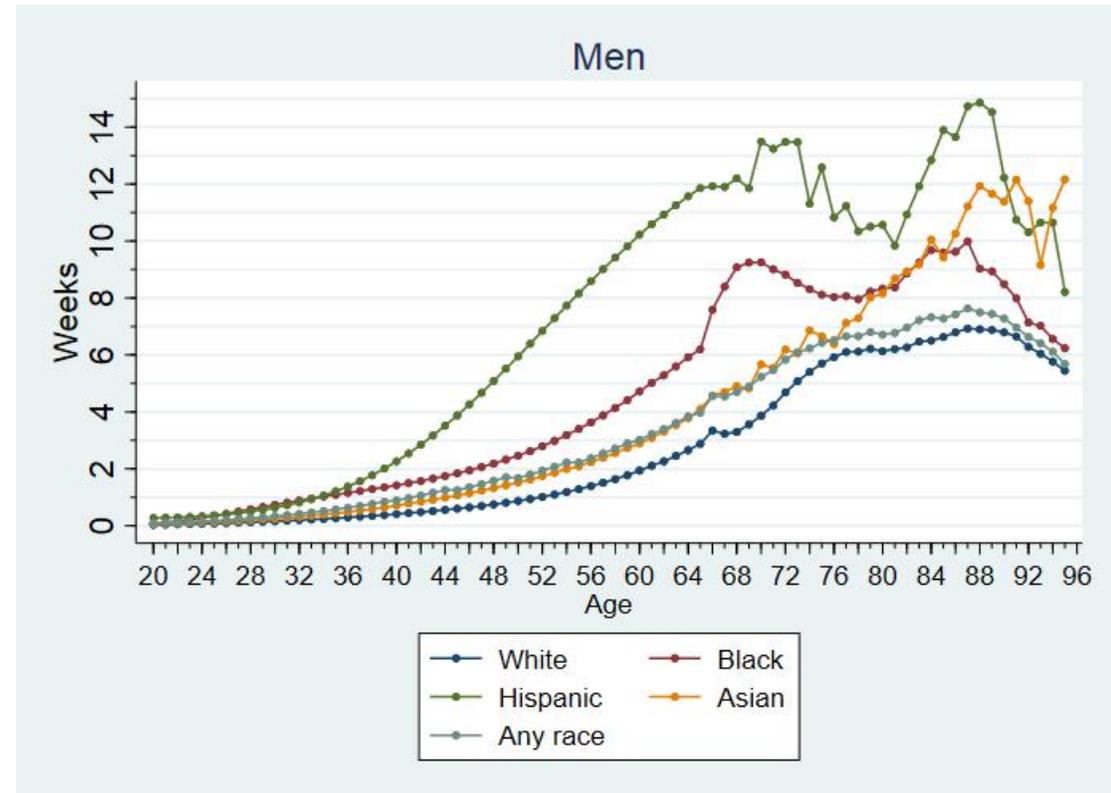
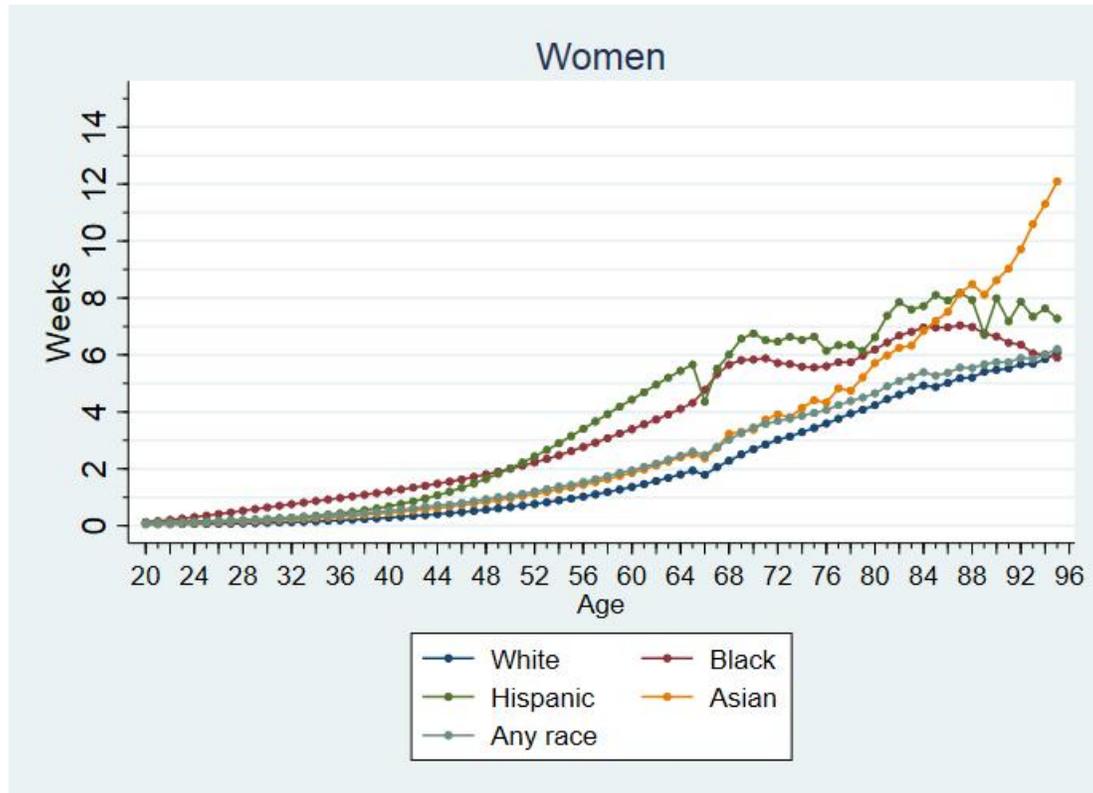
Enter the FDA (and CDC)

- Whatever you think of Israeli Health Ministry
 - US agencies (FDA, CDC) are a disaster
- Approved J&J booster for everyone
 - Since initial vaccine wasn't very good
- But until last week Pfizer, Moderna boosters only for:
 - Over 65, Health compromised
 - High risk (public facing job)
 - Now allowed for all adults, but recommended only for 50+
- Otherwise, 5x protection against death = good enough?
 - Even though 25-50x is achievable with booster

Micro-behavior matters

- Northwestern Law School versus Kellogg School of Management
- Law students behave like adults.
 - Law School confirmed COVID cases last four weeks, counting backwards in time: 1-0-1-1-0-0-2-1-1-1
- Business school students, not so much
 - Kellogg: 10-10-9-30-54-24-26-19-7
 - Students 99% vaccinated, staff 95%, but that ain't enough

Population Life Expectancy Loss (LEL, in weeks)



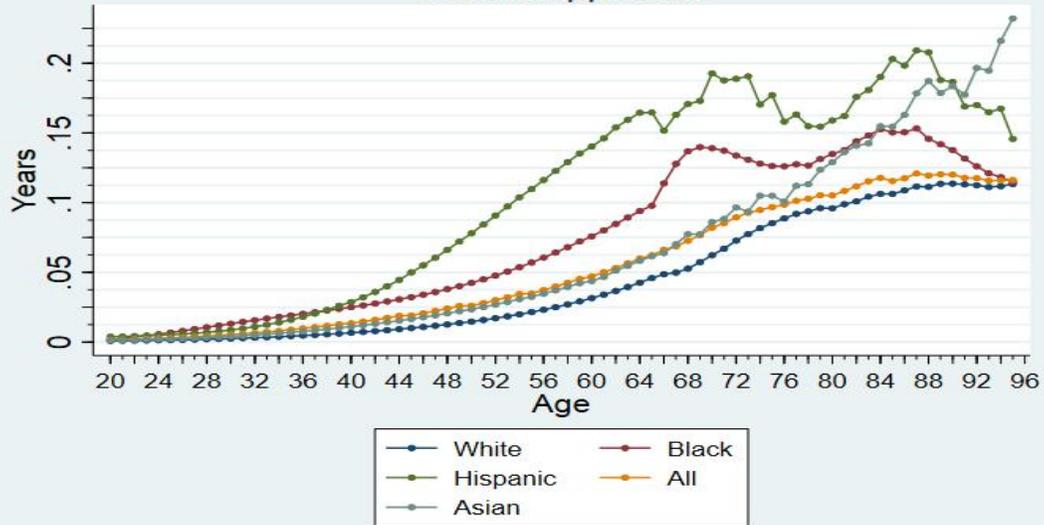
My research: IL, IN, WI (where we have individual level data)

Weeks, not years.

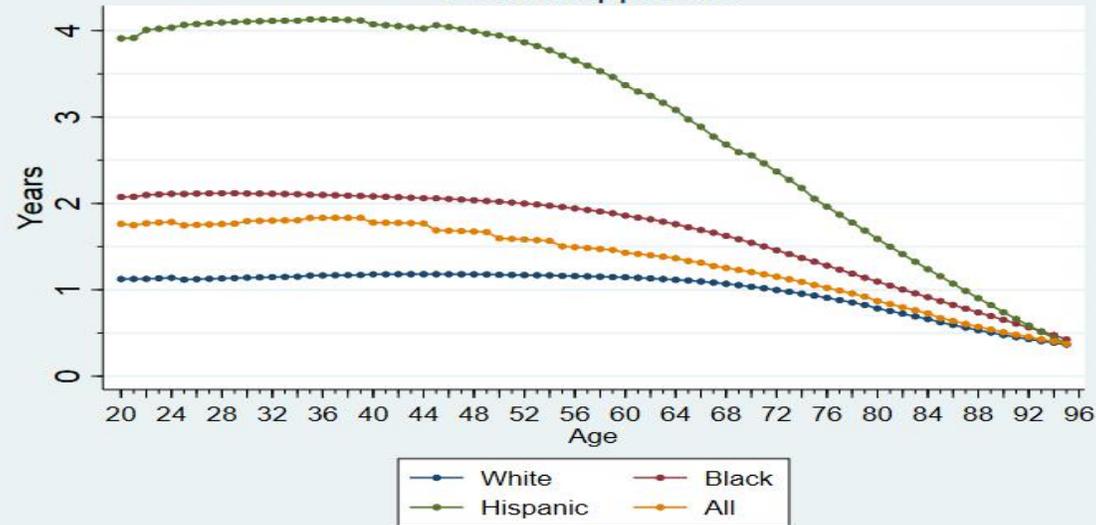
National estimates similar, slightly higher (due to Delta in low-Vax states)

Cohort vs. Period Estimates of LEL

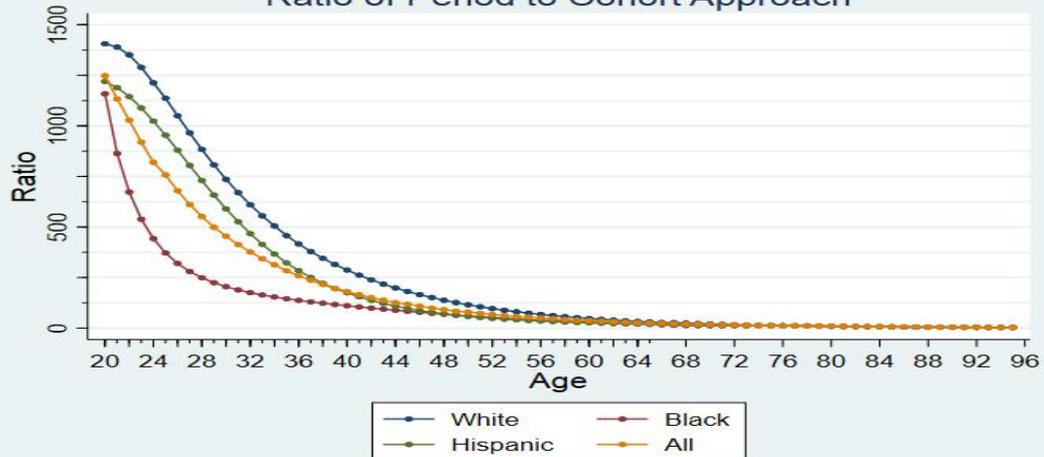
Cohort Approach



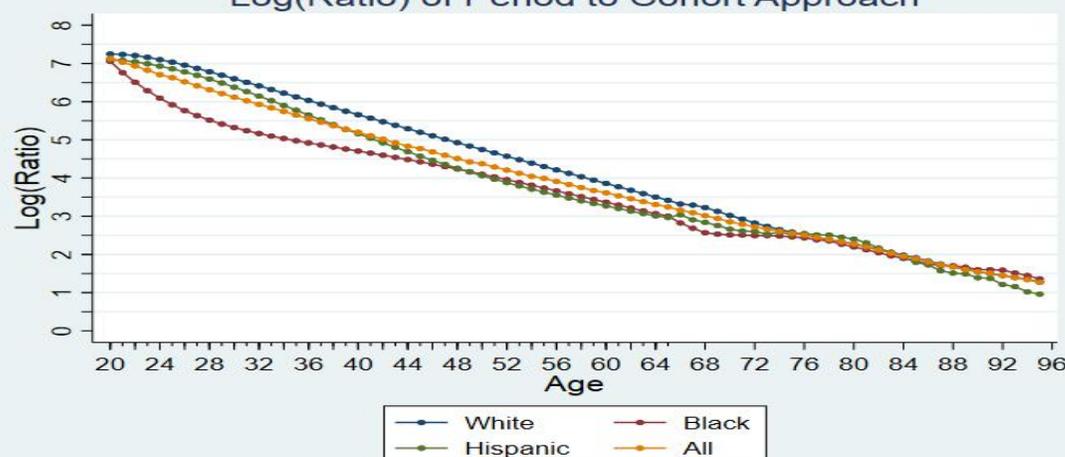
Period Approach



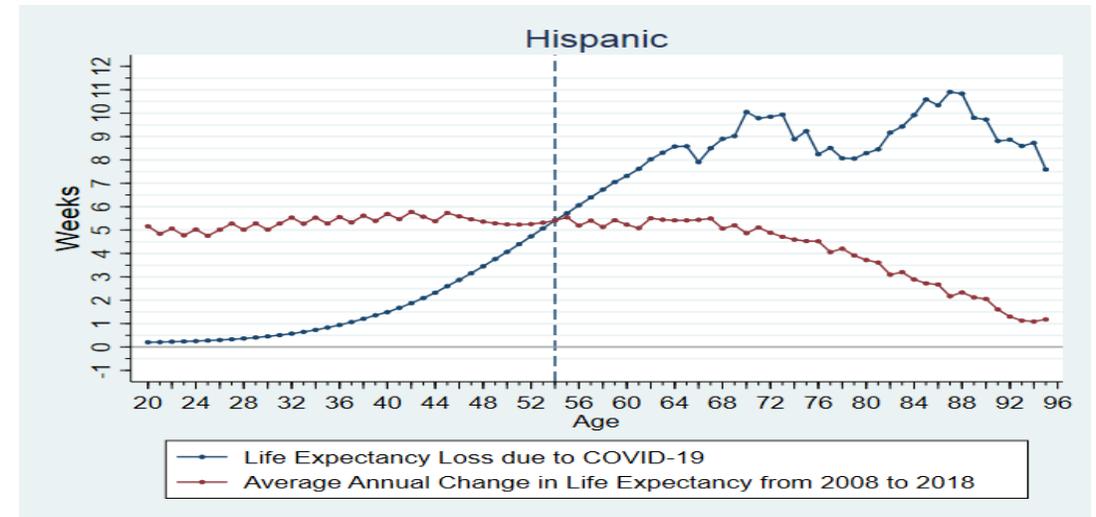
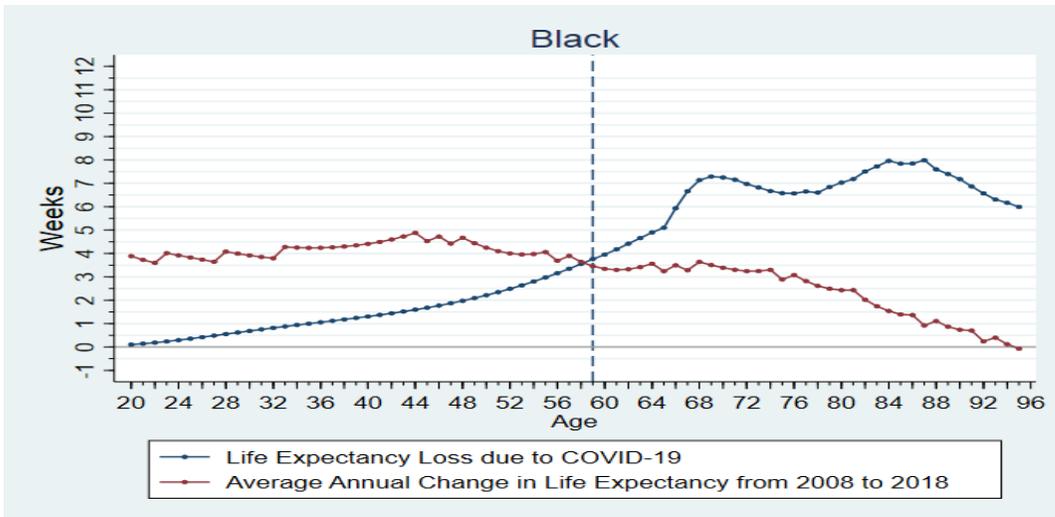
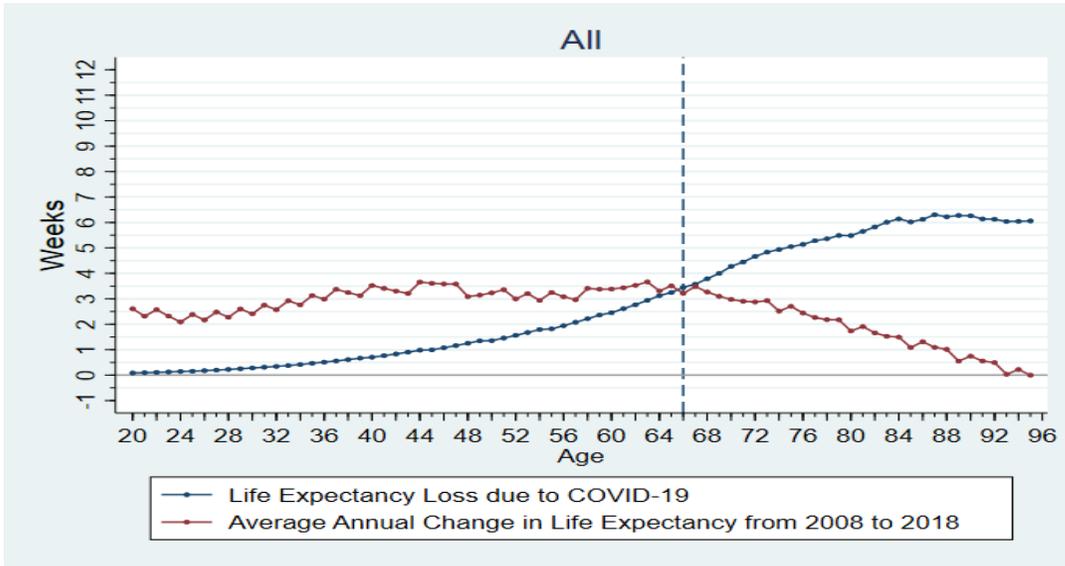
Ratio of Period to Cohort Approach



Log(Ratio) of Period to Cohort Approach



COVID LEL vs. Annual Pre-Pandemic Gains



National PFR, LEL thru end of September

	COVID Decedents	COVID PFR (%)	Decedent life expectancy	Life Expectancy Loss (Years)
All ages	687,172	0.21	13.68	0.029
Men	378,267	0.23	14.04	0.033
Women	308,905	0.19	13.24	0.025
White	432,199	0.21	11.56	0.024
Black	105,691	0.26	15.73	0.041
Hispanic	124,925	0.23	19.58	0.045
Asian	24,737	0.15	16.26	0.024
Other	13,755	0.13	17.39	0.023

0.029 years = 10.6 days

Maybe we'll get up to 2 weeks

Does not include excess mortality.

SES matters too (can measure only for age 66+)

	Population Fatality Rate for Age 66+			
Location	Cook County	Indiana	Milwaukee	Three Areas
Male	0.0067*** (0.00026)	0.0053*** (0.00023)	0.0042*** (0.00057)	0.0057*** (0.00017)
Black	0.0035*** (0.00035)	0.0053*** (0.00057)	0.0095*** (0.00130)	0.0049*** (0.00031)
Hispanic	0.0081*** (0.00051)	0.0062*** (0.00107)	0.0170*** (0.00269)	0.0097*** (0.00052)
Asian	0.0007 (0.00051)	0.0049*** (0.00173)	0.0249*** (0.00543)	0.0021*** (0.00058)
Other Race	0.0362*** (0.00283)	-0.0080*** (0.00086)		0.0122*** (0.00139)
SES Status				
SDI Quintile = 2	0.0030*** (0.00042)	0.0026*** (0.00040)	0.0061*** (0.00099)	0.0030*** (0.00027)
SDI Quintile = 3	0.0047*** (0.00035)	0.0038*** (0.00039)	0.0058*** (0.00086)	0.0044*** (0.00025)
SDI Quintile = 4	0.0036*** (0.00036)	0.0033*** (0.00036)	0.0057*** (0.00069)	0.0037*** (0.00024)
SDI Quintile = 5	0.0064*** (0.00037)	0.0047*** (0.00040)	0.0052*** (0.00061)	0.0056*** (0.00026)
Population	719,290	1,006,224	119,895	1,846,289
Decedents	7,234	12,232	794	20,260

Masks Help: How Much and Where?

- Protection **for others**, against you: Large effect.
 - Missouri hair stylists anecdote [Peeples]
 - 2-layer cotton masks. Family members infected, but not clients
 - Hamster study, adjacent cages: 67% infected; drops to 25% w. surgical mask barrier
- Protection **for you**, against others: Some, but not clear how much
- Indoors vs. Outdoors
 - Crowds aside, minimal outdoor risk (walking, exercising). Masks not needed.
 - Qian et al. Wuhan study: “Among our 7,324 identified cases in China, only one outdoor outbreak A 27-year-old man had a conversation outdoors with an individual who had returned from Wuhan on 25 January and had the onset of symptoms on 1 February.
 - 1 out of 7,000!

Droplets vs. Aerosols

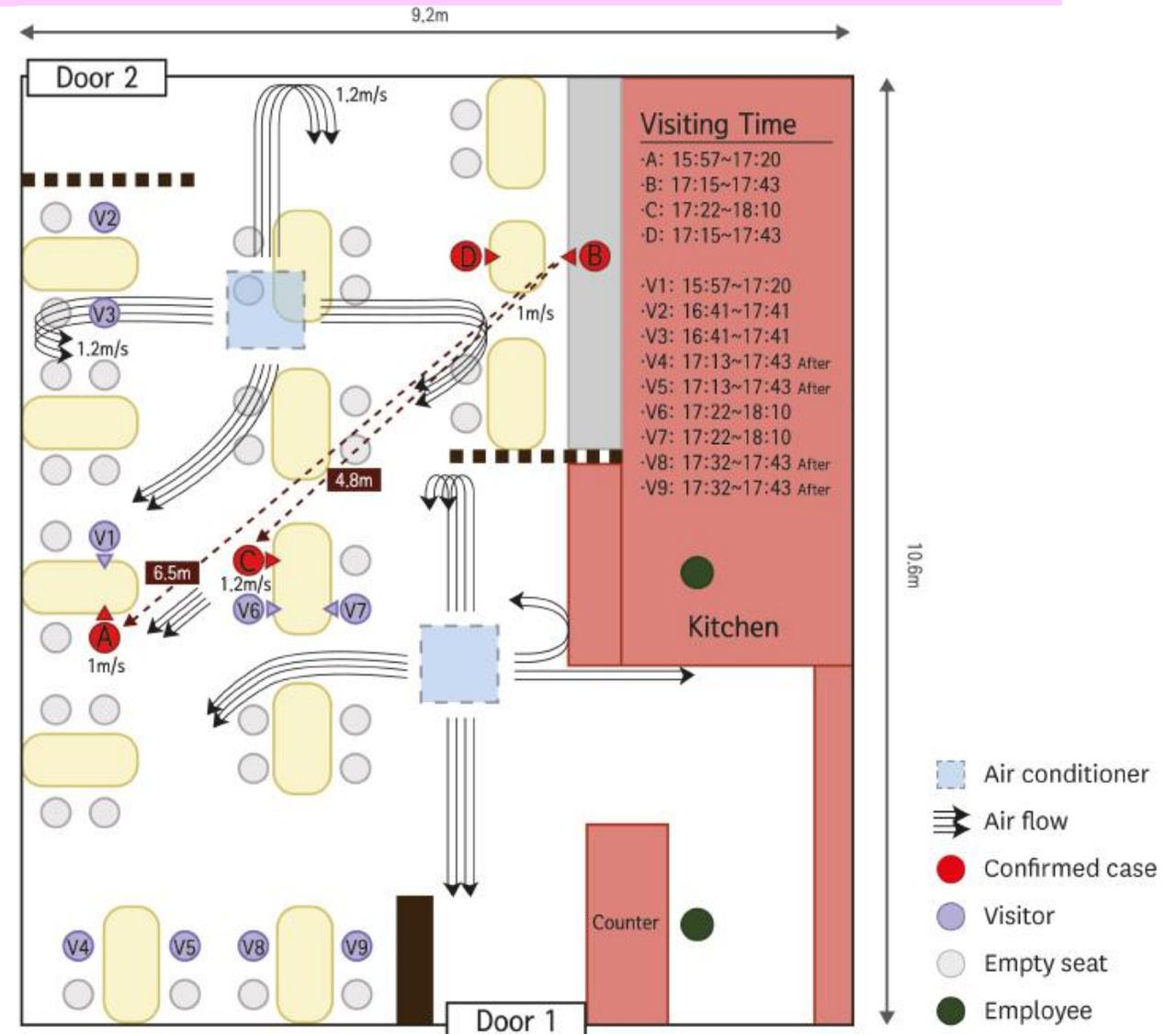
- Coronavirus hitchhikes a ride on water droplets
 - Continuum of sizes
 - Bigger ones (“droplets”) don’t travel far, fall to the ground
 - Smaller ones (“aerosols”) can linger in the air for hours
- Social distancing advice: 2 meters
 - Helps for larger “droplets”
 - Especially if infected person is wearing a mask
 - Helps, but not enough, for aerosols [on either side]
 - Aerosol concentration can rise over time in closed, poorly ventilated spaces
- Early bad WHO, CDC advice: Transmission only through droplets
 - We knew better, but WHO, CDC didn’t want to believe . . .
 - Because aerosols are **much harder** to combat

A Scary Korean Restaurant Study with Good Contact Tracing

- A infected
- Traced to B [**source**]
- B then traced to C, D
 - No other source
- Gene sequence: same variant
- Effect of airflow
- B → A: 5 minutes overlap, 6.5 meters!
- B → C: 21 minutes, at 5 meters

Stay out of closed spaces!

Especially small ones, long time



Masks → Less Severe Infection?

- Theory: Lower initial dose → more time for body to respond
 - Higher % of mild, asymptomatic infections
- Evidence:
 - Hamster study
 - Low IFR in several Asian countries with universal masking
 - Higher % asymptomatic with masking:
 - Early cruise ship (Diamond Princess) **18%** asymptomatic
 - Later, smaller ship (Shackleton): isolation; N95 masks for crew; surgical masks for passengers after first infection; **81%** asymptomatic
 - Current estimates w. partial masking (many sources, incl. CDC): 40-45% asymptomatic

Which Mask?

- Respirator (with good seal) versus non-respirator
- My ranking
 - Korean KF-94
 - Similar protection to US N-95, but more wearable; I can't wear N-95
 - Just don't tell the FDA you're using them for COVID protection . . .
 - Chinese KN-95: Depends on the manufacturer
 - Surgical masks are decent
 - Way too loose on the sides
 - Cloth masks variable, but least effective
 - Double mask: Not recommended (or needed) with respirator mask
- Why do we have no good data, or CDC advice?

Ventilation

- Good ventilation is **critical** to indoor safety vs. aerosols
 - What's the ventilation in this room? In the classrooms?
 - Why don't we know?
 - Why isn't the law school (or anyone else) telling us?
- Why no CDC guidance; why no rules?

Treatments

- Need to separate:
 - Tested positive, not (yet) symptomatic
 - Symptomatic, not yet in hospital
 - In hospital, not yet in ICU
 - seriously ill, in ICU
- Need different treatments at different stages

Infected but asymptomatic

- Infection caught through testing
- I'm not sure what treatment protocols are
- Probably: same as if symptomatic
 - NIH recommendation for monoclonals specifies only positive viral test
 - Goal: Help body get ahead of virus
 - Regeneron: reports 80% lower infection risk (through 8 months)
 - Useful prophylactic for the immune compromised?

Symptomatic, but pre-hospitalization

- Best available treatment: monoclonal antibodies
 - 70-80% lower hospitalization risk
 - But IV only, expensive
- Merck and Pfizer pills
 - Under FDA review
 - Merck trial results: 50% reduction in hospitalization
 - Pfizer: 90% reduction for high-risk persons (no deaths)
- Fluvoxamine (antidepressant)
 - Recent clinical trial: 32% lower risk of hospitalization for high-hospitalization-risk patients
 - More benefit for “per protocol” [too > 80% of doses]
- But these are results for unvaccinated; without monoclonals
 - Benefit if vaccinated [which also gives body a head start]?
 - Incremental benefit over monoclonals?

Drugs for seriously ill

- Harm from body overreaction to virus
 - Response: corticosteroids for patients on oxygen supplementation
 - Dexamethasone, others
 - Suppress immune response
- Many other anti-inflammatories tried, limited success
 - Mild evidence for tocilizumab (interferon) [rheum. arthritis drug]: 10% lower in-hospital mortality
- COVID is thrombolytic [causes blood clots]
 - But anticoagulants don't appear to help much
- Remdesivir (approved but . . .)
 - Some evidence for shorter hospital stays
 - No evidence of lower mortality

Treatment for serious cases: avoid ventilator

- Early in pandemic: If O₂ saturation levels drop, transfer to ICU, put on ventilator
- We now know: Ventilator is harmful
 - Early NYC results: 88% mortality if on ventilator
- Current approach: supplemental oxygen
 - “Happy hypoxics”: lower O₂, but no other distress
 - O₂ supplementation
 - Ventilator as last resort
 - Avoid as long as you can
 - Limit positive pressure [which causes lung damage]
- Prone positioning [on stomach]
 - Improves O₂ levels; less pressure on lungs
 - Especially if obese, as many seriously ill patients are

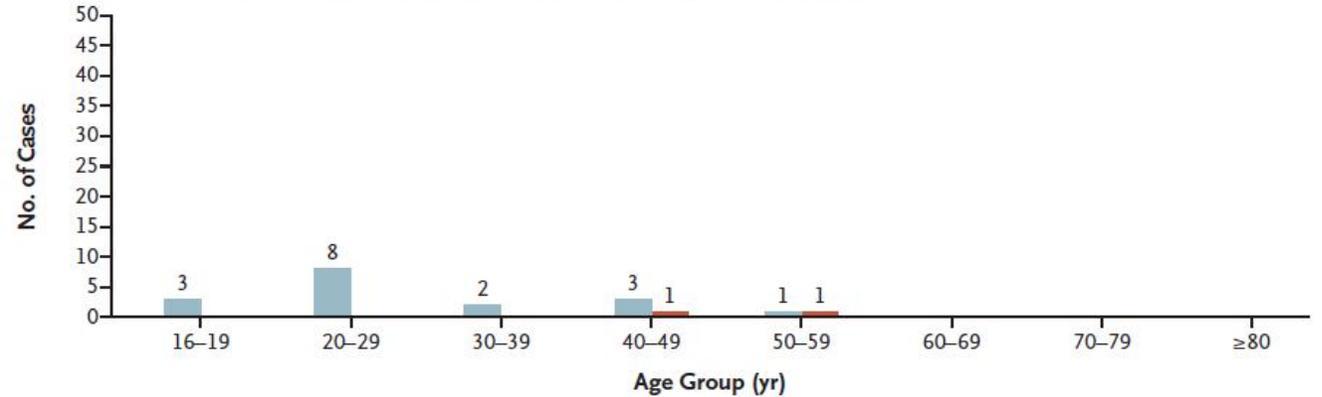
mRNA safety

- Will not discuss J&J; no one should be taking it; few are
 - Even if CDC won't say so
- Simple vaccine: RNA for spike protein
 - Spike protein is used by coronavirus to attach to and invade cells
 - Synthetic process (No live virus culture [unlike, say, flu vaccine, grown in eggs])
- mRNA degrades rapidly, in or out of body
 - Hence need for “cold chain” before use
 - Encased in fat nanoparticles to preserve in body for long enough to reach cells
- Common “side effects”
 - Mild fever
 - Short-term fatigue, can be severe
 - These are signs that the body is reacting to the mRNA trigger!

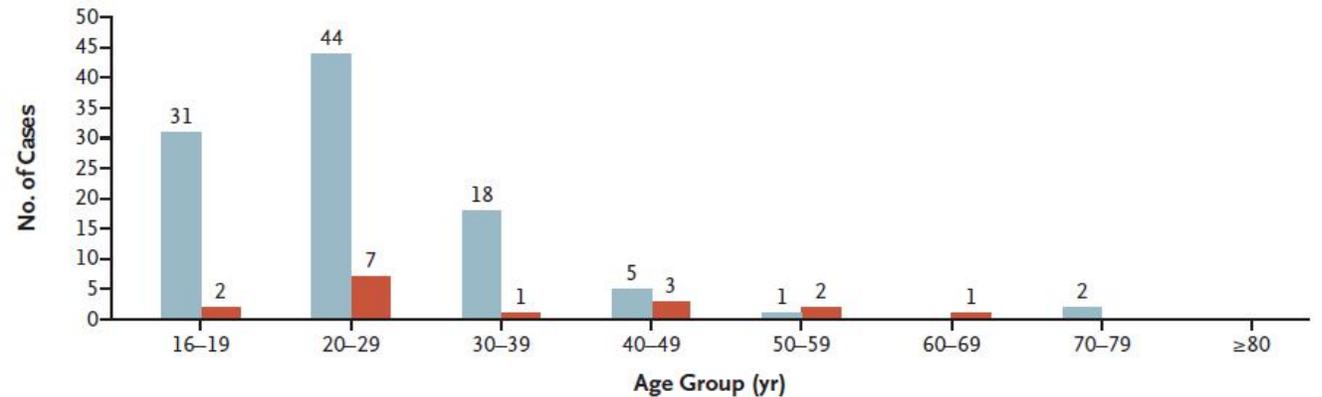
Myocarditis/pericarditis

- Principal risk identified on actual use
- Mostly young men, second dose
- Mostly mild, resolves quickly
 - I know of one death in Israel, none in US

C Distribution of 19 Cases of Myocarditis after First Vaccine Dose, According to Age and Sex



D Distribution of 117 Cases of Myocarditis after Second Vaccine Dose, According to Age and Sex



Vaccine Efficacy Overview

- Black, Bernard, and David Thaw, COVID-19 Vaccine Efficacy, the Delta Variant, and the Evidence on Boosters (working paper Nov. 2021)
- We collect evidence on:
 - .Initial efficacy in clinical trials
 - Early efficacy in observational studies
 - Recent efficacy against Delta variant
- Conclude: Strong case for boosters

Phase III Trial Results

	Efficacy vs.			
	Any Infection	Symptomatic Infection	Hospitalization	Death
Vaccine				
BNT-162b2 (Pfizer)	NR	95%	100%	100%
mRNA-1273 (Moderna)	NR	94.5%	100%	100%
Ad26.COV2.S (J&J)	59.7%	66.5%	83.5%	100%
ChAdOx1-S (AstraZeneca)	27.3%	70.4%	100%	100%

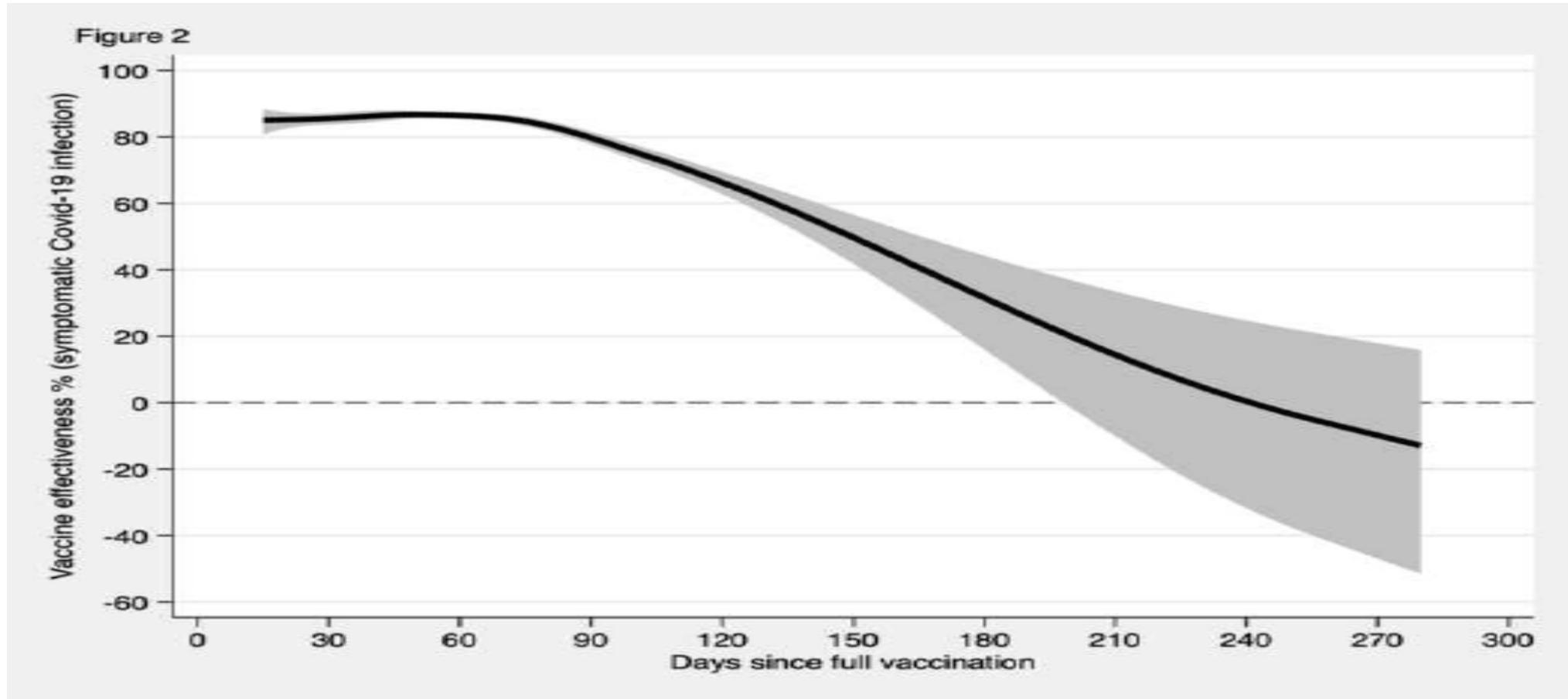
Early Evidence (< 120 days since full vaccination)

	Efficacy vs.			
	Any Infection	Symptomatic Infection	Hospitalization	Death
Pfizer	75.0% - 93.8%	88.0% - 97.7%	87.0% - 100.0%	95.2% - 100.0%
Moderna	NR	94.5% - 96.3%	93.0% - 100.0%	NR
J&J	NR	NR	71.0%	NR
AstraZeneca	NR	66.7% - 74.5%	95.2%	94.1%

Later Evidence on Waning (120+ days since full vaccination)

	Efficacy vs.			
	Any Infection	Symptomatic Infection	Hospitalization	Death
Pfizer	0% - 47%	16.0% - 70.1%	64.0% - 90.7%	88.4% - 90.4%
Moderna	NR	81.9%	85.0% - 92.3%	93.7%
J&J	NR	37.5% - 64.3%	65.0% - 80%	80%
AstraZeneca	NR	47.3%	77.0%	78.7%

Swedish study (thru 9 months; Pfizer, Moderna, Astra-Zeneca)



And against hospitalization (across all vaccines)

