COVID-19 vaccine effectiveness updates

15 June 2023

Ruth Link-Gelles, PhD, MPH
LCDR, US Public Health Service
COVID-19 Vaccine Effectiveness Program Lead
Centers for Disease Control and Prevention

U.S. COVID-19 Vaccination Coverage (%) of Total Population by Age Group — May 10, 2023

Coverage / Age (years)	<2	2-4	5-11	12-17	18-24	24-49	50-64	≥65
At least one dose†	8.9	10.9	40.0	72.2	82.3	85.5	95.0	95.0
At least one bivalent dose	0.6	0.6	4.8	7.8	7.4	12.1	21.7	43.3
Unvaccinated	91.1	89.1	60.0	27.8	17.7	14.5	—†	—†

†Note: Coverage is capped at 95%

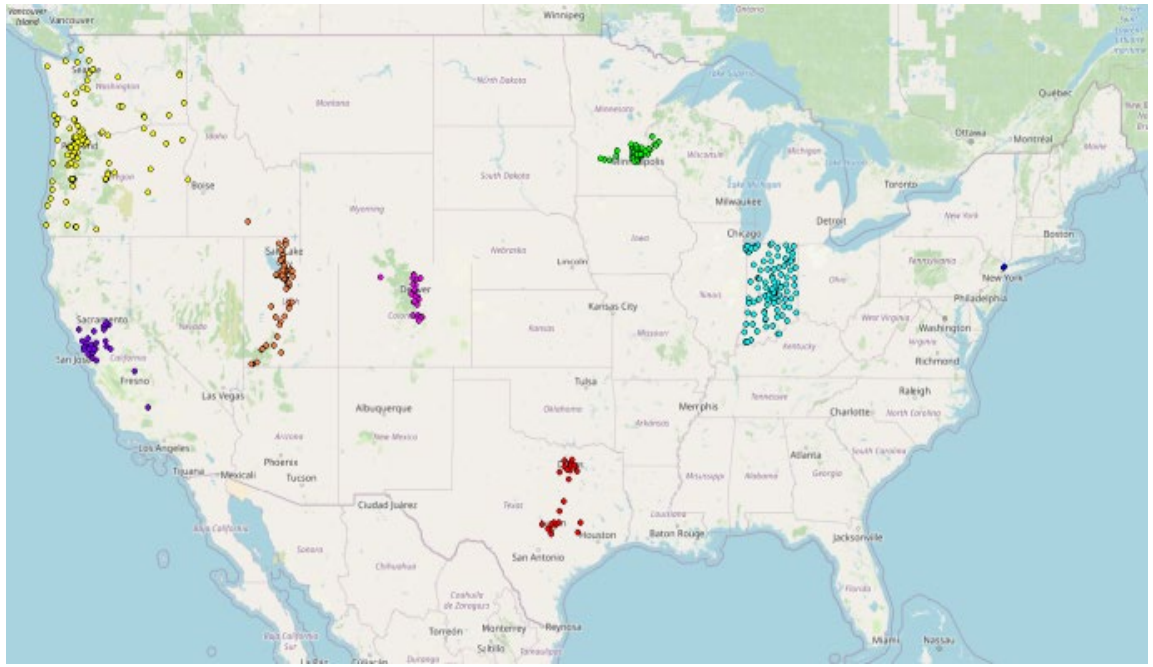
Source: https://covid.cdc.gov/covid-data-tracker/#vaccination-demographics-trends Updated June 1, 2023

Organization of vaccine effectiveness (VE) data

- *Bivalent* VE, by outcome and Omicron subvariant in adults
- VE in special populations:
  - *Monovalent* and *bivalent* VE in pregnant people
  - *Bivalent* people with immunocompromising conditions

Monovalent and *bivalent* VE, against *hospitalization* and *critical illness* by Omicron subvariant in adults ≥18 years, VISION Network

VISION Multi-State Network of Electronic Health Records

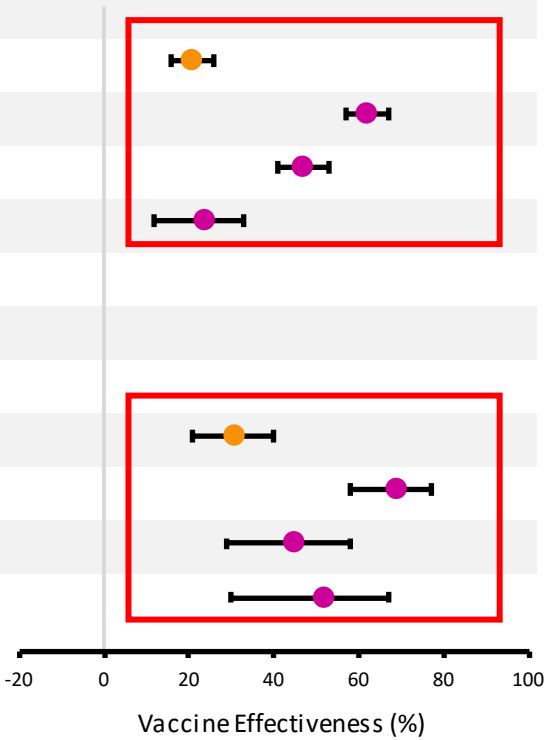


- **Cases**: COVID-like illness (CLI) with positive PCR for SARS-CoV-2 within 14 days before or 72 hours after the admission or encounter
- **Controls**: CLI with negative PCR for SARS-CoV-2

- Variant periods designated for analysis based on time when novel sublineage became predominant (>50%) at study site
- VE adjusted for age, sex, race and ethnicity, geographic region, and calendar time
- Vaccination documented by electronic health records and state and city registries

VISION: *Absolute* VE of *monovalent* and *bivalent* booster doses against *hospitalization* and *critical illness* among immuno*competent* adults aged ≥18 years – September 2022 – May 2023

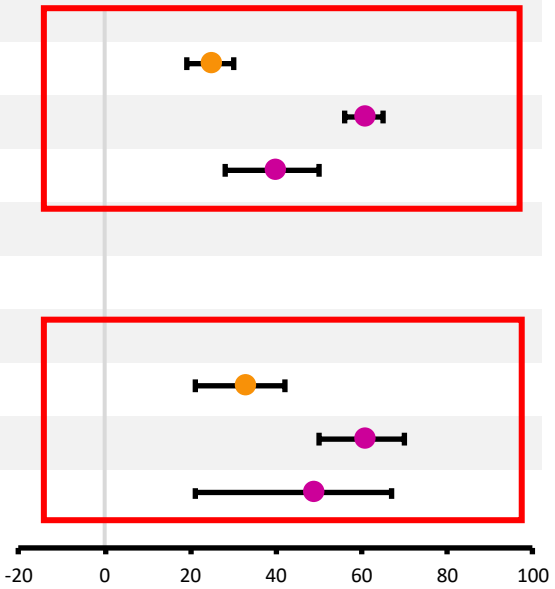
mRNA Dosage Pattern	Total tests	SARS-CoV-2-test-positive, N (%)	Median interval since last dose, days (IQR)	Adjusted VE (95% CI)
Hospitalization				
Unvaccinated (ref)	16,219	1,835 (11)	--	**Ref**
Monovalent doses only	38,843	4,086 (11)	381 (275-513)	**21 (16-26)**
Bivalent booster, 7-59 days earlier	4,894	329 (7)	35 (21-47)	**62 (57-67)**
Bivalent booster, 60-119 days earlier	5,283	491 (9)	87 (73-103)	**47 (41-53)**
Bivalent booster, 120-179 days earlier	3,756	346 (9)	146 (132-161)	**24 (12-33)**
Critical illness				
Unvaccinated (ref)	14,762	378 (3)	--	**Ref**
Monovalent doses only	35,415	658 (2)	380 (275-514)	**31 (21-40)**
Bivalent booster, 7-59 days earlier	4,614	49 (1)	34 (21-47)	**69 (58-77)**
Bivalent booster, 60-119 days earlier	4,880	88 (2)	87 (73-103)	**45 (29-58)**
Bivalent booster, 120-179 days earlier	3,445	35 (1)	146 (132-161)	**52 (30-67)**



Critical illness defined as admission to intensive care unit or death; case-patients were persons admitted to ICU or who experienced death associated with COVID-19, and control patients were persons hospitalized without COVID-19. VE estimates adjusted for age, sex, race and ethnicity, geographic region, and calendar time. Updated from: Link-Gelles et al., MMWR, https://www.cdc.gov/mmwr/volumes/72/wr/mm7221a3.htm

VISION: *Absolute* VE of *monovalent* and *bivalent* booster doses against *hospitalization* and *critical illness* among immuno*competent* adults aged ≥18 years, during BA.4/5 predominance – September 2022 – January 2023

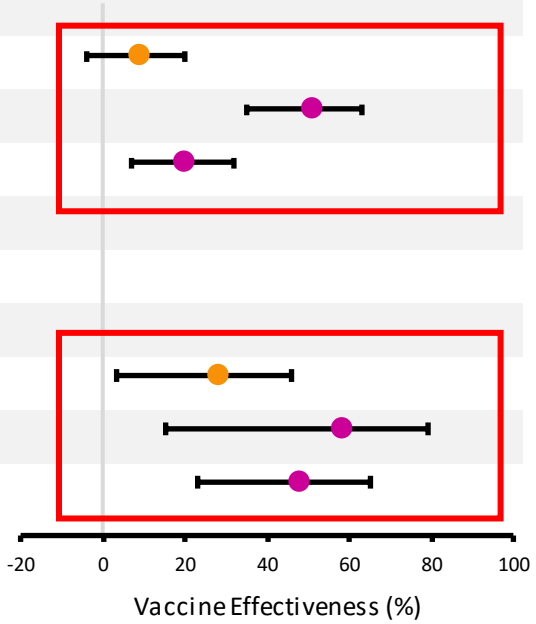
mRNA Dosage Pattern	Total tests	SARS-CoV-2-test-positive, N (%)	Median interval since last dose, days (IQR)	Adjusted VE (95% CI)
Hospitalization				
Unvaccinated (ref)	11,240	1,426 (13)	--	Ref
Monovalent doses only	27,564	3,106 (11)	349 (238-460)	**25 (19-30)**
Bivalent booster, 7-89 days earlier	6,723	524 (8)	47 (28-67)	**61 (56-65)**
Bivalent booster, ≥90 days earlier	1,511	163 (11)	105 (96-115)	**40 (28-50)**
Critical illness				
Unvaccinated (ref)	10,110	296 (3)	--	Ref
Monovalent doses only	24,976	518 (2)	347 (236-460)	**33 (21-42)**
Bivalent booster, 7-89 days earlier	6,199	91 (1)	47 (28-66)	**61 (50-70)**
Bivalent booster, ≥90 days earlier	1,348	25 (2)	105 (96-115)	**49 (21-67)**



CDC unpublished data. VE estimates adjusted for age, sex, race and ethnicity, geographic region, and calendar time.
Variant predominance based on regional circulation: https://covid.cdc.gov/covid-data-tracker/#variant-proportions

VISION: *Absolute* VE of *monovalent* and *bivalent* booster doses against *hospitalization* and *critical illness* among immuno*competent* adults aged ≥18 years, during *XBB* predominance – January – May 2023

mRNA Dosage Pattern	Total tests	SARS-CoV-2-test-positive, N (%)	Median interval since last dose, days (IQR)	Adjusted VE (95% CI)
Hospitalization				
Unvaccinated (ref)	4,979	409 (8)	--	Ref
Monovalent doses only	11,279	980 (9)	469 (375-605)	9 (-4 to 20)
Bivalent booster, 7-89 days earlier	1,045	60 (6)	65 (43-79)	**51 (35 to 63)**
Bivalent booster, 90-179 days earlier	4,654	419 (9)	139 (119-157)	**20 (7 to 32)**
Critical illness				
Unvaccinated (ref)	4,652	82 (2)	--	Ref
Monovalent doses only	10,439	140 (1)	469 (375-602)	**28 (3 to 46)**
Bivalent booster, 7-89 days earlier	994	9 (1)	65 (43-78)	**58 (15 to 79)***
Bivalent booster, 90-179 days earlier	4282	47 (1)	139 (119-157)	**48 (23 to 65)**



CDC unpublished data. VE estimates adjusted for age, sex, race and ethnicity, geographic region, and calendar time.

* These interim estimates are imprecise, which might be because of a relatively small number of persons in each level of vaccination or case status. This imprecision indicates the actual VE may be substantially different from the point estimate shown, and estimates should therefore be interpreted with caution. Additional data accrual should increase precision and allow appropriate interpretation.

Variant predominance based on regional circulation: https://covid.cdc.gov/covid-data-tracker/#variant-proportions

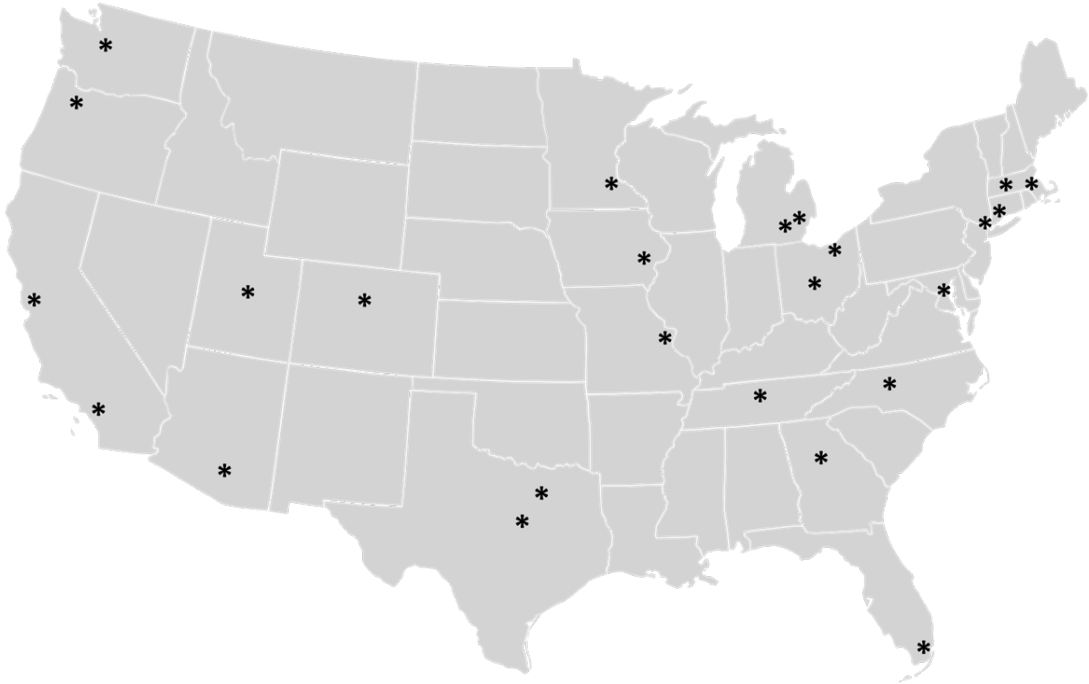
Monovalent and *bivalent* VE against *hospitalization* among adults aged *≥18 years*, IVY Network

IVY Network — 25 hospitals, 20 U.S. States

- **Design**: Prospective, case-control
- **Population**: Adults aged ≥18 years hospitalized with Acute respiratory illness (ARI)*
  - **Cases:** ARI and test positive for SARS-CoV-2 by NAAT or antigen test within 10 days of illness
  - **Controls:** ARI and test negative for SARS-CoV-2 and influenza by NAAT within 10 days of illness
- **Vaccination data:** Electronic medical records (EMR), state and city registries, and self-report
- **Specimens:** Upper respiratory specimens obtained for central RT-qPCR testing and sequencing

IVY

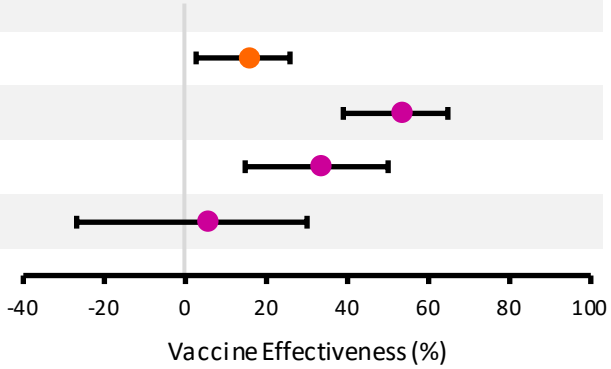
INVESTIGATING RESPIRATORY VIRUSES IN THE ACUTELY ILL



*ARI is defined as presence of any one of the following: fever, cough, shortness of breath, chest imaging consistent with pneumonia, hypoxemia

IVY Network: *Absolute* VE against COVID-19 *hospitalization* among immuno*competent* adults *aged ≥18 years* —September 8, 2022 – May 29, 2023

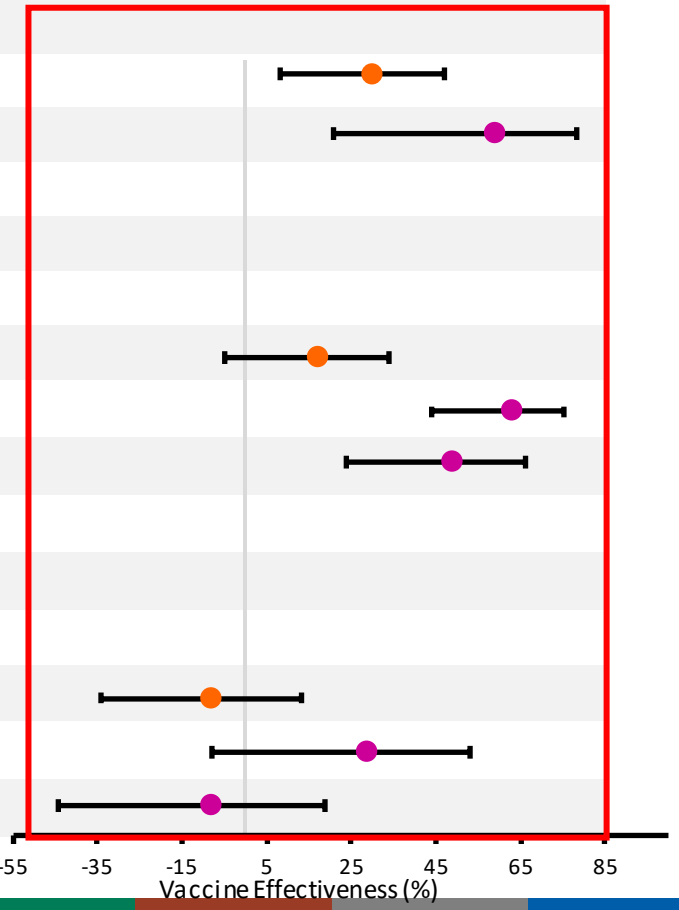
	Total Cases and Controls	Cases (%)	Median time since last dose, days (IQR)	Adjusted VE*, % (95% CI)
Absolute VE				
Unvaccinated (Ref)	1286	537 (42)	--	**Ref**
Monovalent doses only	3511	1460 (42)	393 (282–517)	**16 (3 to 26)**
Bivalent booster dose, 7–59 days earlier	374	100 (27)	36 (21–49)	**54 (39 to 65)**
Bivalent booster dose, 60–119 days earlier	443	160 (36)	89 (73–103)	**34 (15 to 50)**
Bivalent booster dose, 120–179 days earlier	366	157 (43)	145 (133–159)	**6 (-27 to 30)**



*VE adjustments: Age, sex, race, ethnicity, admission date (biweekly), and HHS region

IVY Network: *Absolute* VE against COVID-19 *hospitalization* among immuno*competent* adults aged *≥18 years* by lineage period — September 8, 2022 – May 24, 2023

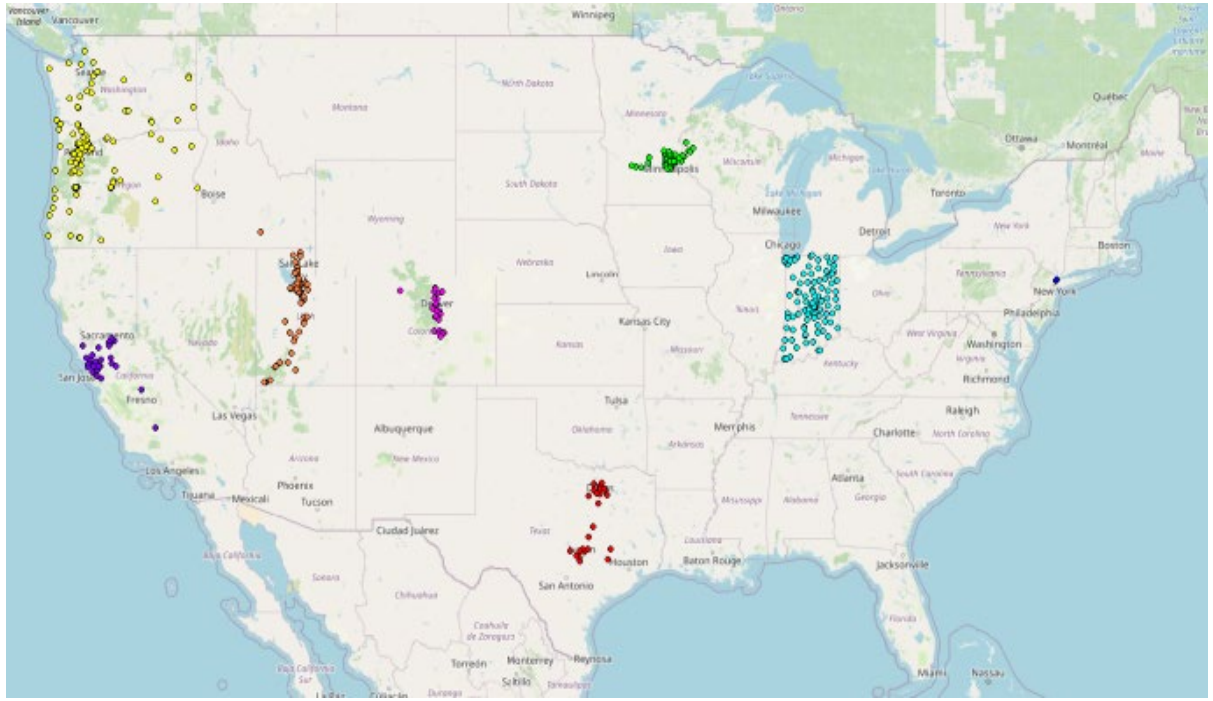
	Total Cases and Controls	Cases (%)	Median time since last dose, days (IQR)	Adjusted VE*, % (95% CI)
BA.4/5 (September 8 – November 13, 2022)				
Unvaccinated (Ref)	313	138 (44)	--	**Ref**
Monovalent doses only	1003	398 (40)	304 (188–386)	**30 (8– 47)**
Bivalent booster dose, 7–59 days earlier	83	26 (31)	25 (13–40)	**59 (21–78)**
BQ.1 (November 14, 2022 – January 22, 2023)				
Unvaccinated (Ref)	458	190 (41)	--	**Ref**
Monovalent doses only	1262	504 (40)	386 (297–518)	**17 (-5 to 34)**
Bivalent booster dose, 7–59 days earlier	226	52 (23)	40 (25–52)	**63 (44–75)**
Bivalent booster dose, 60–119 days earlier	225	68 (30)	83 (69–95)	**49 (24–66)**
XBB (January 23 – May 24, 2023)				
Unvaccinated (Ref)	514	209 (41)	--	**Ref**
Monovalent doses only	1246	558 (45)	464 (378–590)	**-8 (-34 to 13)**
Bivalent booster dose, 7–89 days earlier	155	56 (36)	64 (46–78)	**29 (-8 to 53)**
Bivalent booster dose, 90–179 days earlier	478	208 (44)	137 (118–154)	**-8 (-44 to 19)**



*VE adjustments: Age, sex, race, ethnicity, admission date (biweekly), and HHS region

VE in special populations: pregnant people

VISION Multi-State Network of Electronic Health Records

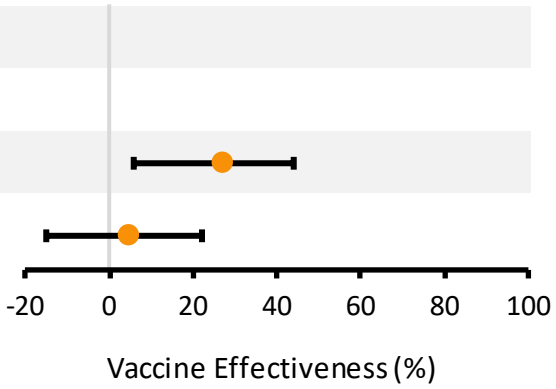


- **Cases**: COVID-like illness (CLI) with positive PCR for SARS-CoV-2 within 14 days before or 72 hours after the encounter
- **Controls**: CLI with negative PCR for SARS-CoV-2

- Among pregnant people 18-45 years at time of emergency department/urgent care encounter
- VE adjusted for age, ethnicity, race, underlying medical conditions, gestational age at encounter, site, Medicaid status, day of encounter, site facility urbanicity
- Vaccination documented by electronic health records and state and city registries
- Separate results for COVID-19 vaccine monovalent doses received prior to pregnancy and bivalent doses received during pregnancy due to timing of bivalent authorization/analysis

VISION: *Absolute* VE of COVID-19 *monovalent* doses received *prior to* pregnancy against *ED/UC encounters* among immuno*competent* pregnant persons aged 18-45 years – June 2022 – May 2023*

Vaccine Dosage Pattern	Total tests	SARS-CoV-2-test-positive, N (%)	Median interval since last dose, days (IQR)	Adjusted VE (95% CI)
Absolute VE				
Unvaccinated (ref)	2238	317 (14)	--	*Ref*
Monovalent received:				
<6 months before pregnancy	833	108 (13)	270 (216, 326)	**27 (6, 44)**
≥6 *months before pregnancy*	1986	264 (13)	454 (375, 544)	**5 (-15, 22)**

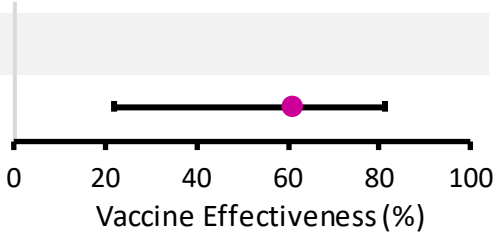


Adjusted for: Age, ethnicity, race, underlying medical conditions, gestational age at encounter, site, Medicaid status, day of encounter, site facility urbanicity

*Unpublished CDC data.

VISION: *Absolute* VE of COVID-19 *bivalent* doses received *during* pregnancy against *ED/UC encounters* among immuno*competent* pregnant persons aged 18-45 years – September 2022 – May 2023*

Vaccine Dosage Pattern	Total tests	SARS-CoV-2-test-positive, N (%)	Median interval since last dose, days (IQR)	Adjusted VE (95% CI)
Absolute VE				
Unvaccinated (ref)	1701	196 (12)	--	*Ref*
Bivalent dose**	191	10 (5)	56 (29, 97)	**61 (22, 81)*** **



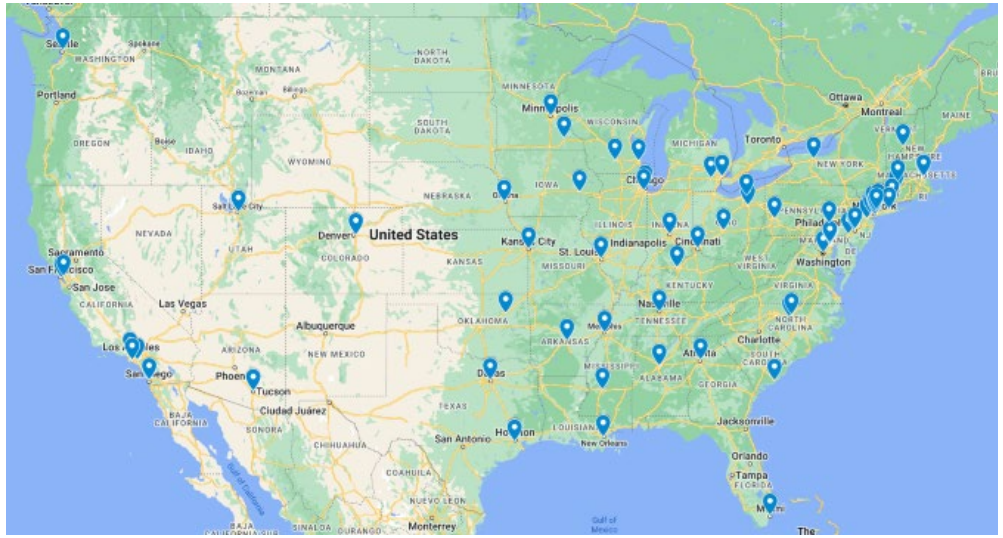
Adjusted for: Age, ethnicity, race, underlying medical conditions, gestational age at encounter, site, Medicaid status, day of encounter, site facility urbanicity

*Unpublished CDC data

Doses received **during pregnancy for bivalent group

***These interim estimates are imprecise, which might be because of a relatively small number of persons in each level of vaccination or case status. This imprecision indicates the actual VE may be substantially different from the point estimate shown, and estimates should therefore be interpreted with caution. Additional data accrual should increase precision and allow appropriate interpretation.

Overcoming COVID-19 network



- **Cases infants**: hospitalized with COVID-19 as the primary reason for admission and with a positive SARS-CoV-2 RT-PCR or antigen test result

- **Control infants**: hospitalized with or without COVID-19 symptoms and negative SARS-CoV-2 RT-PCR or antigen test result
  - Matched to case-infants by site; hospitalized within 4 weeks of case-infant admission

- Case-control study to assess effectiveness of maternal vaccination for COVID-19 in infants < 6 months of age

- 25 pediatric hospitals across 19 states

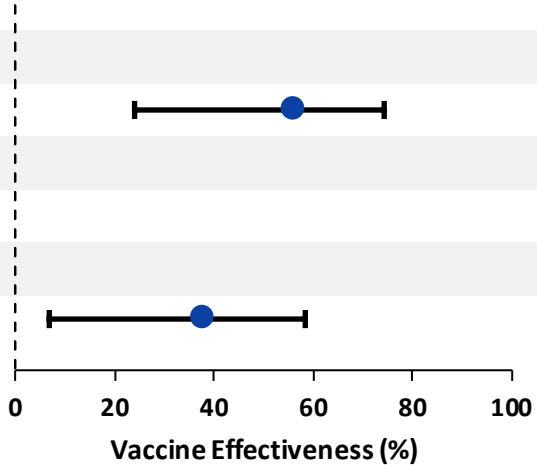
- Infants admitted between March 9, 2022, and May 9, 2023

- Baseline demographic and clinical characteristics obtained via parent interview

- Maternal vaccination status verified using state vaccination registries, electronic medical records, or other sources

Overcoming COVID-19: Effectiveness of maternal vaccination in prevention of hospitalization among infants – March 9, 2022 – May 9, 2023

Vaccination during pregnancy*	Total	Case infants, N (%)	Median interval since last maternal dose, days (IQR)	Infant median age at hospitalization, days (IQR)	Adjusted VE (95% CI)	Effectiveness of Maternal Vaccination against Infant Covid-19 Hospitalization % (95% CI)†
Infants <3 months of age at hospitalization						
Unvaccinated (ref)	310	174 (56)	NA	44 (27 to 63)	Ref	
Vaccinated	101	43 (43)	222 (152 to 271)	41 (23 to 66)	56 (24 to 75)*	
Infants < 6 months of age at hospitalization						
Unvaccinated (ref)	498	281 (56)	NA	68 (37 to 125)	Ref	
Vaccinated	163	78 (48)	236 (190 to 302)	74 (33 to 132)	38 (7 to 59)*	



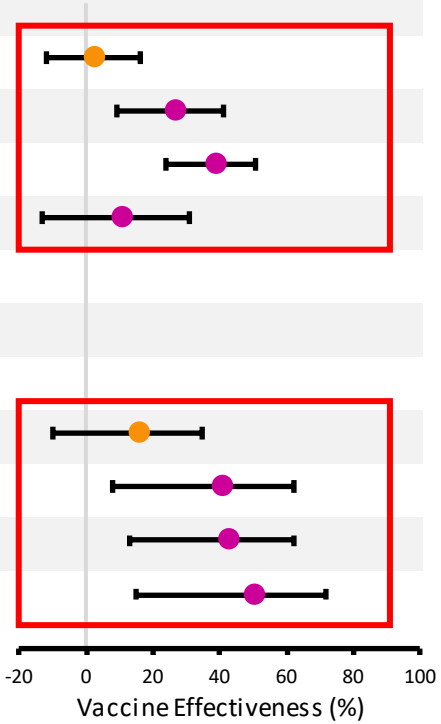
*Last mRNA or viral vector vaccine dose received between the beginning of pregnancy and 14 days before delivery. 14 people received a bivalent mRNA vaccine.
†These estimates are imprecise, which might be because of a relatively small number of persons in each level of vaccination or case status. This imprecision indicates the actual VE may be substantially different from the point estimate shown, and estimates should therefore be interpreted with caution. Additional data accrual should increase precision and allow appropriate interpretation.

CDC unpublished data. VE estimates adjusted for infant age, sex, race and ethnicity, census region, and month and year of hospitalization.

Bivalent VE in special populations: people with immunocompromising conditions

VISION: *Absolute* VE of *monovalent* and *bivalent* booster doses against *hospitalization* and *critical outcomes* among immuno*compromised* adults aged ≥18 years – September 2022 – May 2023

mRNA Dosage Pattern	Total tests	SARS-CoV-2-test-positive, N (%)	Median interval since last dose, days (IQR)	Adjusted VE (95% CI)
Hospitalization				
Unvaccinated (ref)	3,240	322 (10)	--	Ref
Monovalent doses only	11,623	1,169 (10)	359 (242-481)	**3 (-12-16)**
Bivalent booster, 7-59 days earlier	1,627	144 (9)	33 (19-46)	**27 (9-41)**
Bivalent booster, 60-119 days earlier	1,862	144 (8)	88 (74-104)	**39 (24-51)**
Bivalent booster, 120-179 days earlier	1,448	118 (8)	146 (133-161)	**11 (-13-31)**
Critical illness				
Unvaccinated (ref)	3,006	88 (3)	--	Ref
Monovalent doses only	10,725	271 (3)	358 (241-481)	**16 (-10-35)**
Bivalent booster, 7-59 days earlier	1,515	32 (2)	33 (19-46)	**41 (8-62)***
Bivalent booster, 60-119 days earlier	1,755	37 (2)	88 (74-104)	**43 (13-62)**
Bivalent booster, 120-179 days earlier	1,348	18 (1)	146 (133-162)	**51 (15-72)***



* These interim estimates are imprecise, which might be because of a relatively small number of persons in each level of vaccination or case status. This imprecision indicates the actual VE may be substantially different from the point estimate shown, and estimates should therefore be interpreted with caution. Additional data accrual should increase precision and allow appropriate interpretation.

Critical illness defined as admission to intensive care unit or death; case-patients were persons admitted to an ICU or who experienced death associated with COVID-19, and control patients were persons hospitalized without COVID-19. VE estimates adjusted for age, sex, race and ethnicity, geographic region, and calendar time. Updated from: Link-Gelles et al., MMWR, https://www.cdc.gov/mmwr/volumes/72/wr/mm7221a3.htm

Summary and conclusions

Limitations of VE against severe disease

- For estimates of ***absolute*** vaccine effectiveness, if unvaccinated are meaningfully different from vaccinated individuals (e.g., by COVID-19 risk factors), estimates may be biased.
- For estimates of ***relative*** vaccine effectiveness, residual protection from prior doses is an important consideration for interpretation.
- Information on prior infection is limited, although we know rates of prior infection in the U.S. population are high and vary by age.
- VE against COVID-19-associated hospitalization may underestimate protection against more severe COVID-19 disease.

Conclusions: updates to VE of *bivalent* COVID-19 boosters

- *Bivalent* boosters are helping provide additional protection against hospitalization, though evidence of waning
- For most people who received *monovalent* doses and are eligible for a *bivalent* booster, more than a year has elapsed since their last monovalent dose. Because of waning, they may have limited remaining protection against hospitalization.
- Effectiveness against the most critical illness (ICU admission and death) more sustained compared to less severe illness
- VE during XBB predominance may wane more quickly against hospitalization compared to early variant predominant periods
- Vaccination during pregnancy provides protection against hospitalization for infants <6 months; protection may be highest in the first 3 months
- CDC will continue ongoing monitoring of VE, including for all outcomes of interest and for all authorized COVID-19 vaccines in the U.S. with a focus on assessing new policy recommendations and VE in populations at higher risk of severe COVID-19

Acknowledgements

CDC COVID-19 Vaccine Effectiveness and Policy Team

- Amadea Britton
- Allison Ciesla
- Monica Godfrey
- Eric Griggs
- Katherine Fleming-Dutra
- Morgan Najdowski
- Sara Oliver
- Amanda Payne
- Lauren Roper
- Laura Steinhardt
- Evelyn Twentyman
- Megan Wallace
- Ryan Wiegand

VE platforms teams, including:

- Sarah Ball
- Angela Campbell
- Jennifer DeCuir
- Monica Dickerson
- Margaret Dunne
- Matthew Levy
- Patrick Mitchell
- Palak Patel
- Caitlin Ray
- Sarah Reese
- Regina Simeone
- Zach Smith
- Diya Surie
- Mark Tenforde
- Zack Weber
- Laura Zambrano

And many more!!!