Centers for Disease Control and Prevention
National Center for Immunization and Respiratory Diseases

Updates to COVID-19 vaccine effectiveness (VE) in the U.S

September 12, 2023

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

Organization of presentation

- Included today:
  - VE against emergency department/urgent care encounters in young children
  - VE against emergency department/urgent care encounters in older children, adolescents, and adults
  - VE against hospitalization and critical illness in adults

- Note: updates in this presentation are meant to complement results of the GRADE presentation

Context for interpreting VE across age groups

- High rates of infection-induced immunity by July–August 2022.*
- VE findings should be interpreted as the incremental benefit provided by COVID-19 vaccination in a population with a high prevalence of infection-induced immunity.

Age group	% with infection-induced immunity
6-11 month	66%
12-23 months	74%
2-4 years	83%
5-11 years	88%
12-17 years	86%
16-29 years	83%
30-49 years	78%
50-64 years	68%
≥65 years	48%

* https://www.cdc.gov/vaccines/acip/meetings/downloads/slides-2023-06-21-23/03-COVID-Jones-508.pdf; data on children aged 6 months – 17 years is from cross-sectional blood specimens collected by commercial laboratories. Data on persons aged ≥16 years is from a longitudinal, national cohort of >70,000 blood donors.

Vaccine effectiveness in young children

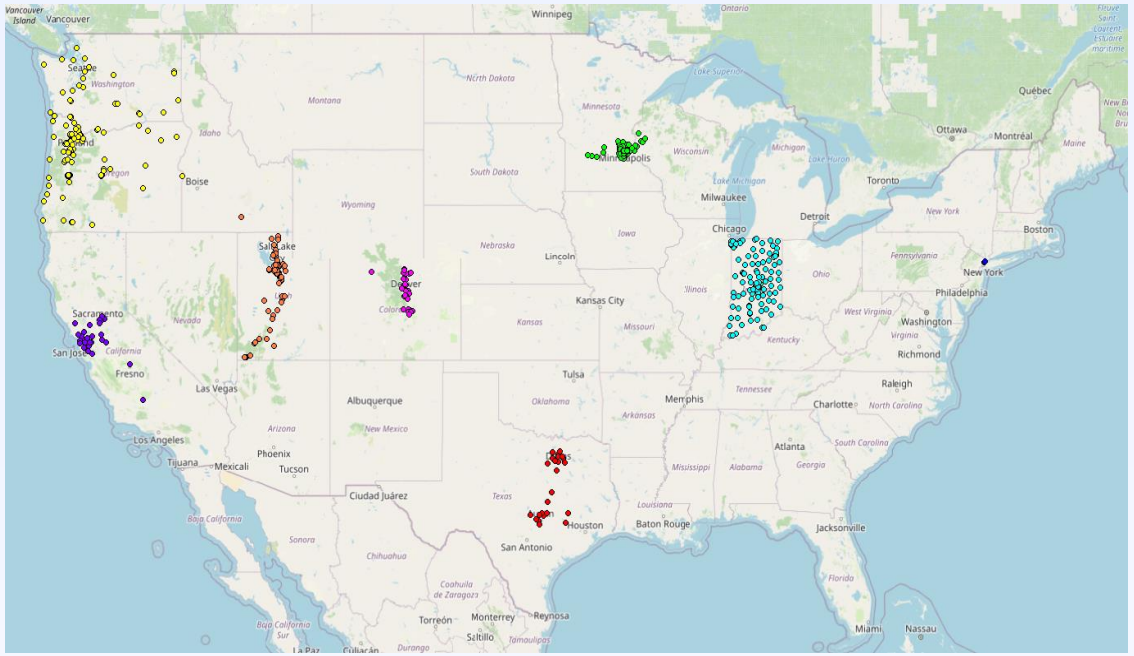
VISION Network (emergency department/urgent care encounters)

Updates based on analyses in recent MMWR:

- Link-Gelles R, Ciesla AA, Rowley EA, et al. Effectiveness of Monovalent and Bivalent mRNA Vaccines in Preventing COVID-19–Associated Emergency Department and Urgent Care Encounters Among Children Aged 6 Months–5 Years — VISION Network, United States, July 2022–June 2023. MMWR Morb Mortal Wkly Rep 2023;72:886–892. DOI: http://dx.doi.org/10.15585/mmwr.mm7233a2

VISION Multi-Site Network of Electronic Health Records

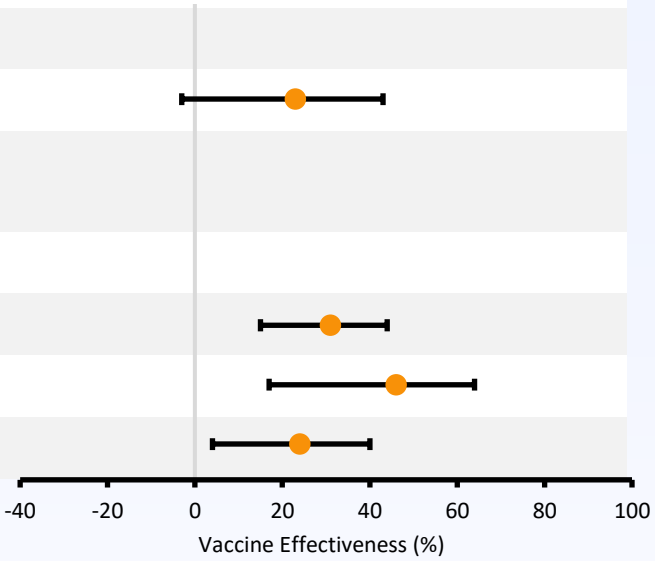
- **Design:** Test-negative case-control
- **Population:** Immunocompetent children aged 6 months – 4 or 5 years visiting a participating emergency department or urgent care (ED/UC) with COVID-19-like illness (CLI) with a SARS-CoV-2 NAAT test result within 14 days before or 72 hours after encounter
  - **Cases**: CLI with *positive* NAAT for SARS-CoV-2
  - **Controls**: CLI with *negative* NAAT for SARS-CoV-2



- **Vaccination data:** Documented by electronic health records and state and city registries
- **Dates of analysis:** July 2022 – August 2023

VISION: Estimates of VE for *original monovalent* Moderna primary series vaccine (children aged 6 months–5 years) against *ED/UC encounters*, July 4, 2022 – August 9, 2023*

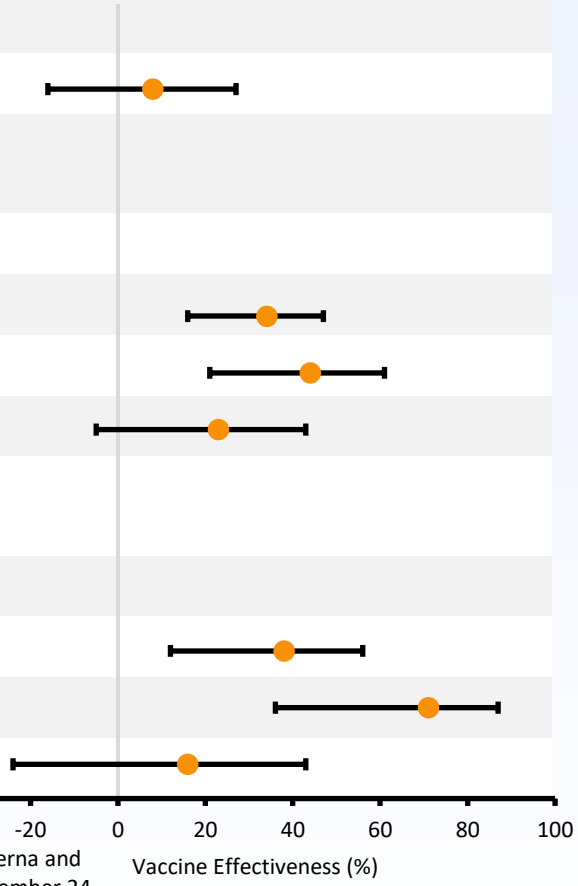
Vaccination status (months since last dose)	Total tests	SARS-CoV-2 positive, N (%)	Median interval since last dose, days (IQR)	Adjusted VE (95% CI)
Moderna, 1 dose (partial series; ages 6mo–5 years) *July 4, 2022–June 17, 2023*				
Unvaccinated	90,737	4,966 (5.5)	NA	Ref
1 (original) monovalent dose (≥14 days)	1,053	47 (4.5)	66 (30–127)	**23 (–3 to 43)**
Moderna, 2 doses (complete series; ages 6mo–5 years) *August 1, 2022–June 17, 2023*				
Unvaccinated	85,746	4,061 (4.7)	NA	**Ref**
2 (original) monovalent doses (≥14 days)	3,736	98 (2.6)	105 (64–169)	**31 (15 to 44)**
2 (original) monovalent doses (14-59 days)	811	23 (2.8)	38 (26–49)	**46 (17 to 64)**
2 (original) monovalent doses (≥60 days)	2,925	75 (2.6)	124 (91–193)	**24 (4 to 40)**



* Different analysis periods were used for each product and dose number because vaccinated children became eligible to be included 14 days after the dose at different times: 1 dose of Moderna and Pfizer-BioNTech on July 4, 2022; 2 doses of Pfizer-BioNTech on July 25, 2022; 2 doses of Moderna on August 1, 2022; 3 doses of Pfizer-BioNTech on September 19, 2022; bivalent doses on December 24, 2022.

VISION: Estimates of VE for *original monovalent* Pfizer-BioNTech primary series vaccine (children aged 6 months–4 years) against *ED/UC encounters*, July 4, 2022 – June 17, 2023

Vaccination status (months since last dose)	Total tests	SARS-CoV-2 positive, N (%)	Median interval since last dose, days (IQR)	Adjusted VE (95% CI)
Pfizer, 1 dose (partial series; ages 6mo–4 years) *July 4, 2022–June 17, 2023*				
Unvaccinated	79,480	4,632 (5.8)	NA	**Ref**
1 (original) monovalent dose (≥14 days)	1,640	78 (4.8)	60 (29–112)	**8 (–16 to 27)**
Pfizer, 2 doses (partial series; ages 6mo–4 years) *July 25, 2022–June 17, 2023*				
Unvaccinated	75,965	3,990 (5.2)	NA	**Ref**
2 (original) monovalent doses (≥14 days)	2,682	78 (2.9)	70 (41–121)	**34 (16 to 47)**
2 (original) monovalent doses (14-59 days)	1,138	34 (3.0)	37 (25–47)	**44 (21 to 61)**
2 (original) monovalent doses (≥60 days)	1,544	44 (2.9)	111 (82–164)	**23 (–5 to 43)**
Pfizer, 3 doses (complete series; ages 6mo–4 years) *September 19, 2022–June 17, 2023*				
Unvaccinated	66,847	2,992 (4.5)	NA	**Ref**
3 (original) monovalent doses (≥14 days)	1,542	33 (2.1)	82 (43–153)	**38 (12 to 56)**
3 (original) monovalent doses (14-59 days)	573	6 (1.1)	35 (26–46)	**71 (36 to 87)****
3 (original) monovalent doses (≥60 days)	969	27 (2.8)	132 (89–187)	**16 (–24 to 43)****

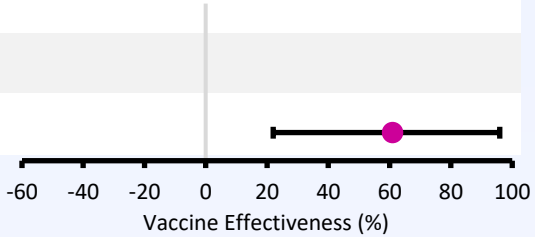


* Different analysis periods were used for each product and dose number because vaccinated children became eligible to be included 14 days after the dose at different times: 1 dose of Moderna and Pfizer-BioNTech on July 4, 2022; 2 doses of Pfizer-BioNTech on July 25, 2022; 2 doses of Moderna on August 1, 2022; 3 doses of Pfizer-BioNTech on September 19, 2022; bivalent doses on December 24, 2022.

** This estimate is imprecise, which might be due to there being a relatively small number of persons in each level of vaccination or case status. This imprecision indicates that the actual VE could be substantially different from the point estimate shown, and estimates should therefore be interpreted with caution. Additional data accrual could increase precision and allow more precise interpretation.

VISION: Estimates of VE for *≥1 bivalent* vaccine (children aged 6 months–4 or 5 years) against *ED/UC encounters*, December 24, 2022 – June 17, 2023

Vaccination status (months since last dose)	Total tests	SARS-CoV-2 positive, N (%)	Median interval since last dose, days (IQR)	Adjusted VE (95% CI)
Regardless of manufacturer, ≥1 bivalent dose (ages 6mo–5 years)				
Unvaccinated	34,582	1,505 (4.3)	NA	**Ref**
≥1 **bivalent** dose (≥14 days)	458	8 (1.8)	66 (39–103)	**61 (22 to 83)****



*This estimate was calculated using unadjusted exact methods due to the small number of vaccinated case-patients. Five vaccinated case-patients received bivalent Pfizer-BioNTech doses and three received Moderna doses; vaccinated control-patients included those who received both bivalent Moderna (126) and Pfizer-BioNTech (324) doses.
This estimate is imprecise, which might be due to there being a relatively small number of persons in each level of vaccination or case status. This imprecision indicates that the actual VE could be substantially different from the point estimate shown, and estimates should therefore be interpreted with caution. Additional data accrual could increase precision and allow more precise interpretation.
Children included in the bivalent analysis were either unvaccinated (received 0 COVID-19 vaccine doses) or had received ≥1 bivalent vaccine dose from either manufacturer. Among those who received a bivalent vaccine dose, any combination of original monovalent and bivalent doses was included, but at minimum children had to have received 2 Moderna doses or 3 Pfizer-BioNTech doses (i.e., a complete primary series).

Conclusions: Vaccine effectiveness in young children

- 1 dose of original monovalent Moderna or Pfizer-BioNTech vaccines did not provide significant protection
- 2 doses of either product (and 3 doses of Pfizer-BioNTech) provided protection against ED/UC and hospitalization, though waning was evident (similar to older children and adults)
- A bivalent dose provided protection, though sample size was limited.
- Median interval since receipt of the most recent dose among children who had not completed their primary series was longer than expected based on the recommended dosing intervals → some children not completing primary series

Updates to bivalent vaccine effectiveness

VISION Network

Updates based on analyses in recent MMWRs:

Link-Gelles, et al. Estimates of Bivalent mRNA Vaccine Durability in Preventing COVID-19–Associated Hospitalization and Critical Illness Among Adults with and Without Immunocompromising Conditions — VISION Network, September 2022–April 2023. https://www.cdc.gov/mmwr/volumes/72/wr/mm7221a3.htm

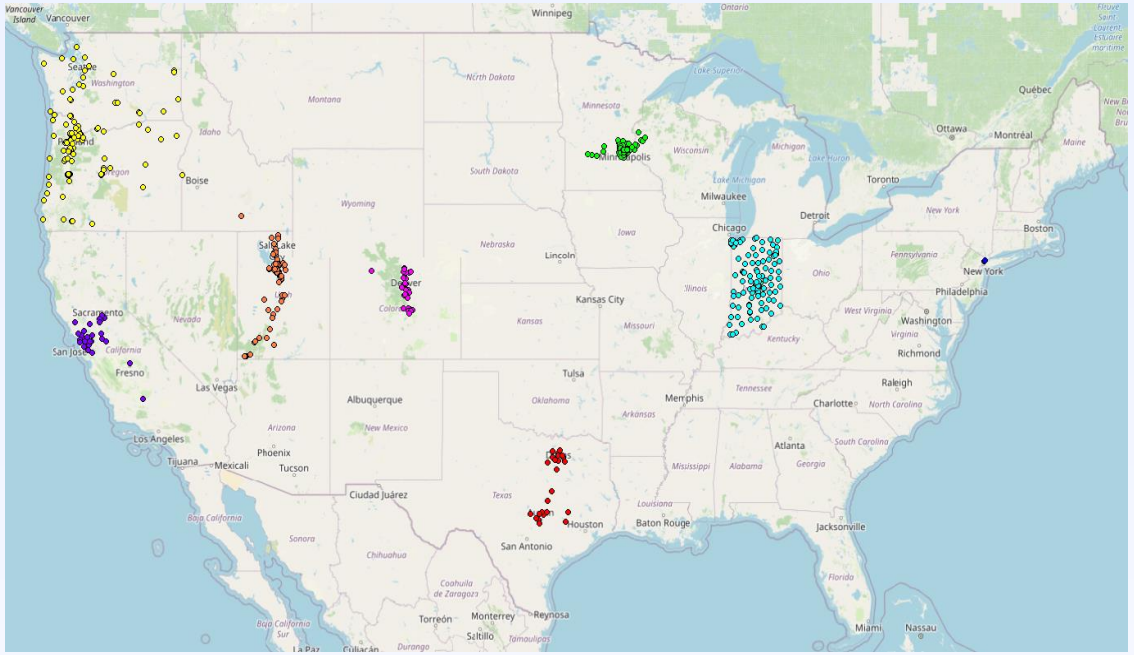
IVY Network

Updates based on analyses in recent MMWR:

- DeCuir, Surie, et al. MMWR. Effectiveness of Monovalent mRNA COVID-19 Vaccination in Preventing COVID-19–Associated Invasive Mechanical Ventilation and Death Among Immunocompetent Adults During the Omicron Variant Period — IVY Network, 19 U.S. States, February 1, 2022–January 31, 2023. https://www.cdc.gov/mmwr/volumes/72/wr/mm7217a3.htm

VISION Multi-State Network of Electronic Health Records

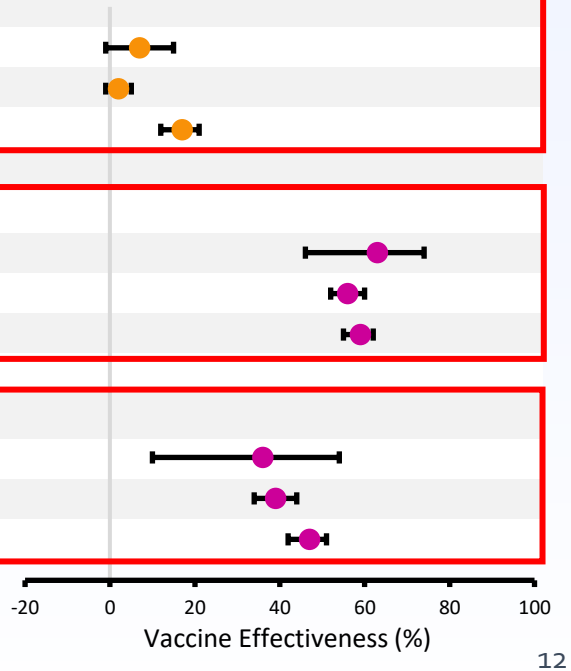
- **Design:** Test-negative case-control
- **Population:** Persons admitted to a participating emergency department, urgent care, or hospital with COVID-19-like illness (CLI) with a SARS-CoV-2 NAAT test result within 14 days before or 72 hours after encounter or admission
  - **Cases**: CLI with *positive* NAAT for SARS-CoV-2
  - **Controls**: CLI with *negative* NAAT for SARS-CoV-2



- **Vaccination data:** Documented by electronic health records and state and city registries
- **Dates of analysis:** September 2022 – August 2023

VISION: *Absolute* VE of *original monovalent* and *bivalent* booster doses against *ED/UC encounters* among immuno*competent* persons, by age group – September 2022 – August 2023

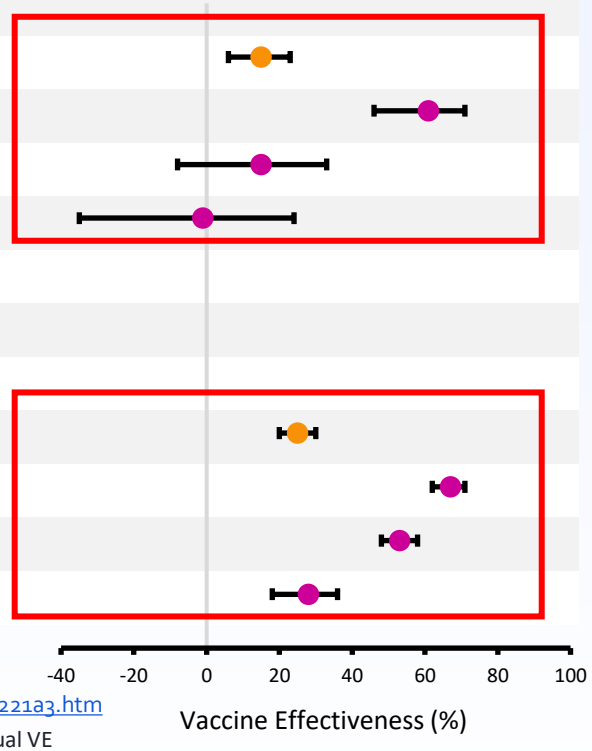
mRNA Dosage Pattern	Total tests	SARS-CoV-2-test-positive, N (%)	Median interval since last dose, days (IQR)	Adjusted VE (95% CI)
Unvaccinated				
5-17 years	41,910	1,446 (4)	--	**Ref**
18-64 years	90,349	8,201 (9)	--	**Ref**
≥65 years	17,108	2,453 (14)	--	**Ref**
Original monovalent doses only				
5-17 years	28,369	1,092 (4)	334 (253-439)	**7 (-1 to 15)**
18-64 years	14,9267	14,270 (10)	441 (334-564)	**2 (-1 to 5)**
≥65 years	69,989	8,538 (12)	383 (266-531)	**17 (12 to 21)**
Bivalent booster, 7-59 days earlier				
5-17 years	1,858	30 (2)	30 (18-44)	**63 (46 to 74)**
18-64 years	9,763	549 (6)	33 (21-46)	**56 (52 to 60)**
≥65 years	1,1826	970 (8)	35 (21-48)	**59 (55 to 62)**
Bivalent booster, 60-119 days earlier				
5-17 years	1,268	37 (3)	89 (74-105)	**36 (10 to 54)**
18-64 years	9,558	682 (7)	86 (72-102)	**39 (34 to 44)**
≥65 years	12,753	1,255 (9)	87 (73-102)	**47(42 to 51)**



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

VISION: *Absolute* VE of *original monovalent* and *bivalent* booster doses against *hospitalization* among immuno*competent* adults, by age group – September 2022 – August 2023

mRNA Dosage Pattern	Total tests	SARS-CoV-2-test-positive, N (%)	Median interval since last dose, days (IQR)	Adjusted VE (95% CI)
18-64 years				
Unvaccinated (ref)	13,089	803 (6)	--	**Ref**
Original monovalent doses only	19,799	1,129 (6)	455 (333-575)	**15 (6 to 23)**
Bivalent booster, 7-59 days earlier	1,208	45 (4)	33 (21-45)	**61 (46 to 71)**
Bivalent booster, 60-119 days earlier	1,248	87 (7)	87 (73-102)	**15 (-8 to 33)**
Bivalent booster, 120-179 days earlier	1,075	59 (6)	147 (134-163)	**-1 (-35 to 24)***
≥65 years				
Unvaccinated (ref)	12,015	1,688 (14)	--	**Ref**
Original monovalent doses only	37,001	4,216 (11)	402 (288-555)	**25 (20-30)**
Bivalent booster, 7-59 days earlier	4,607	328 (7)	35 (21-48)	**67 (62-71)**
Bivalent booster, 60-119 days earlier	5,252	490 (9)	88 (73-104)	**53 (48-58)**
Bivalent booster, 120-179 days earlier	4,482	415 (9)	149 (134-164)	**28 (18-36)**

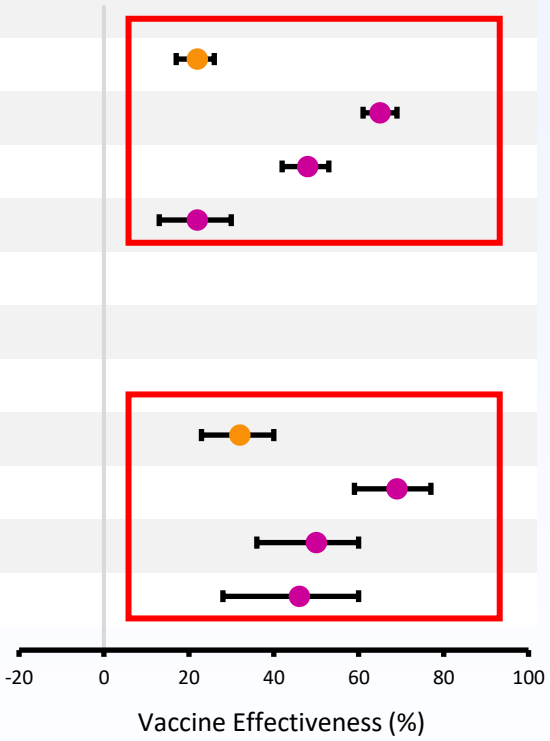


VE estimates adjusted for age, sex, race and ethnicity, geographic region, and calendar time. Updated from: Link-Gelles et al., MMWR, https://www.cdc.gov/mmwr/volumes/72/wr/mm7221a3.htm

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

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

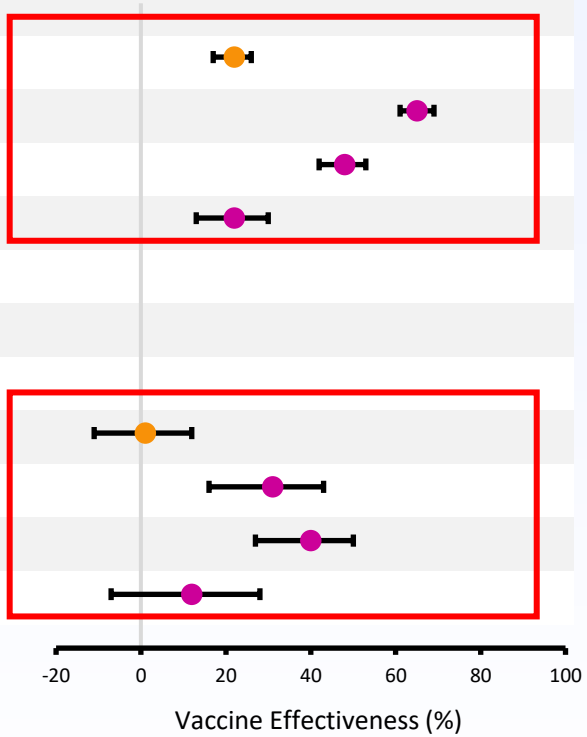
mRNA Dosage Pattern	Total tests	SARS-CoV-2-test-positive, N (%)	Median interval since last dose, days (IQR)	Adjusted VE (95% CI)
Hospitalization				
Unvaccinated (ref)	25,104	2,491 (10)	--	**Ref**
Original monovalent doses only	56,800	5,345 (9)	420 (306-563)	**22 (17-26)**
Bivalent booster, 7-59 days earlier	5,815	373 (6)	34 (21-47)	**65 (61-69)**
Bivalent booster, 60-119 days earlier	6,500	577 (9)	87 (73-103)	**48 (42-53)**
Bivalent booster, 120-179 days earlier	5,557	474 (9)	149 (134-164)	**22 (13-30)**
Critical illness				
Unvaccinated (ref)	23,140	527 (2)	--	**Ref**
Original monovalent doses only	52,352	897 (2)	422 (306-564)	**32 (23-40)**
Bivalent booster, 7-59 days earlier	5,504	62 (1)	34 (21-47)	**69 (59-77)**
Bivalent booster, 60-119 days earlier	6,023	100 (2)	87 (73-103)	**50 (36-60)**
Bivalent booster, 120-179 days earlier	5,144	61 (1)	149 (134-164)	**46 (28-60)**



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 *original monovalent* and *bivalent* booster doses against *hospitalization* among adults ≥18 years, by immunocompromise status – September 2022 – August 2023

mRNA Dosage Pattern	Total tests	SARS-CoV-2-test-positive, N (%)	Median interval since last dose, days (IQR)	Adjusted VE (95% CI)
Without immunocompromising conditions				
Unvaccinated (ref)	25,104	2,491 (10)	--	**Ref**
Original monovalent doses only	56,800	5,345 (9)	420 (306-563)	**22 (17-26)**
Bivalent booster, 7-59 days earlier	5,815	373 (6)	34 (21-47)	**65 (61-69)**
Bivalent booster, 60-119 days earlier	6,500	577 (9)	87 (73-103)	**48 (42-53)**
Bivalent booster, 120-179 days earlier	5,557	474 (9)	149 (134-164)	**22 (13-30)**
With immunocompromising conditions				
Unvaccinated (ref)	5,044	440 (9)	--	**Ref**
Original monovalent doses only	16,937	1,575 (9)	397 (276-539)	**1 (-11-12)**
Bivalent booster, 7-59 days earlier	1,970	168 (9)	34 (20-47)	**31 (16-43)**
Bivalent booster, 60-119 days earlier	2,336	172 (7)	88 (74-104)	**40 (27-50)**
Bivalent booster, 120-179 days earlier	2,188	166 (8)	149 (134-164)	**12 (-7-28)**



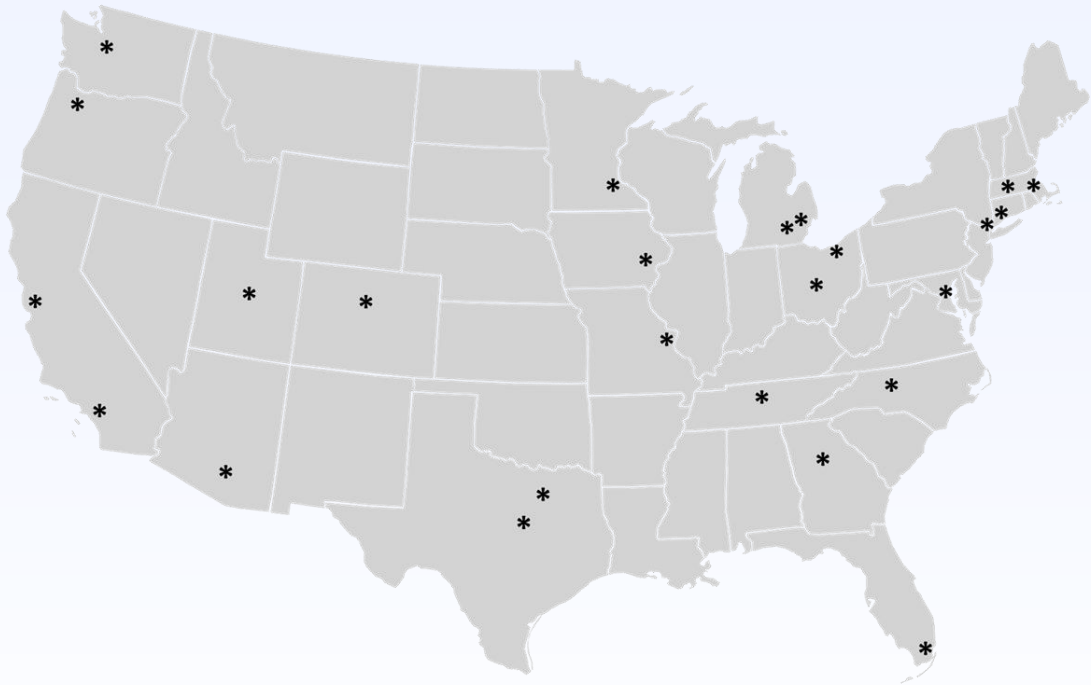
VE estimates adjusted for age, sex, race and ethnicity, geographic region, and calendar time. Updated from: Link-Gelles et al., MMWR, https://www.cdc.gov/mmwr/volumes/72/wr/mm7221a3.htm

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
- **Dates of analysis:** September 2022 – May 2023

IVY

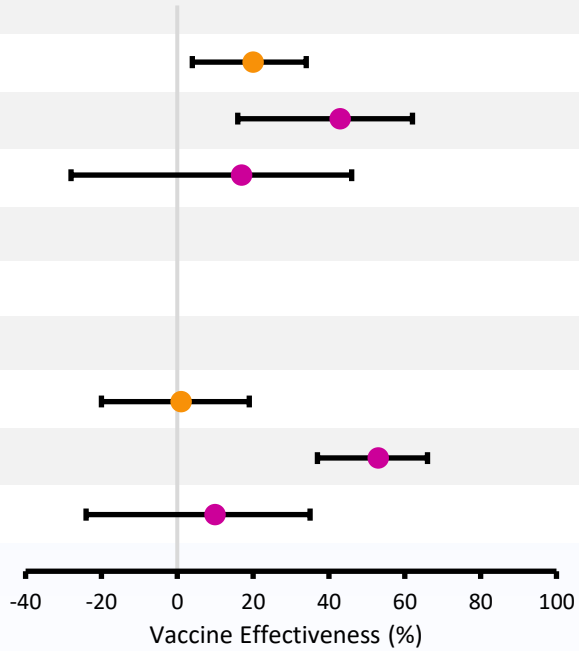
INVESTIGATING RESPIRATORY VIRUSES IN THE ACUTELY ILL



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

IVY: *Absolute* VE against COVID-19 *hospitalization* among immuno*competent* adults aged ≥*18 years* — September 8, 2022 – May 31, 2023

	Case vaccination status, no. (%)	Control vaccination status, no. (%)	Median time since last dose, days (IQR)	Adjusted VE*, % (95% CI)
18–64 years	**N=927**	**N=1,680**		
Unvaccinated	307 (33)	483 (29)	--	**Ref**
Original monovalent doses only	514 (55)	979 (58)	412 (297–533)	**20 (4–34)**
Bivalent booster dose, 7–89 days earlier	48 (5)	123 (7)	54 (33–71)	**43 (16–62)**
Bivalent booster dose, 90–179 days earlier	58 (6)	95 (6)	130 (110–151)	**17 (-28 to 46)****
≥65 years	**N=1,556**	**N=1,971**		
Unvaccinated	238 (15)	274 (14)	--	**Ref**
Original monovalent doses only	992 (64)	1108 (56)	385 (278–510)	**1 (-20 to 19)**
Bivalent booster dose, 7–89 days earlier	131 (8)	329 (17)	52 (29–68)	**53 (37–66)**
Bivalent booster dose, 90–179 days earlier	195 (13)	260 (13)	130 (109–151)	**10 (-24 to 35)****

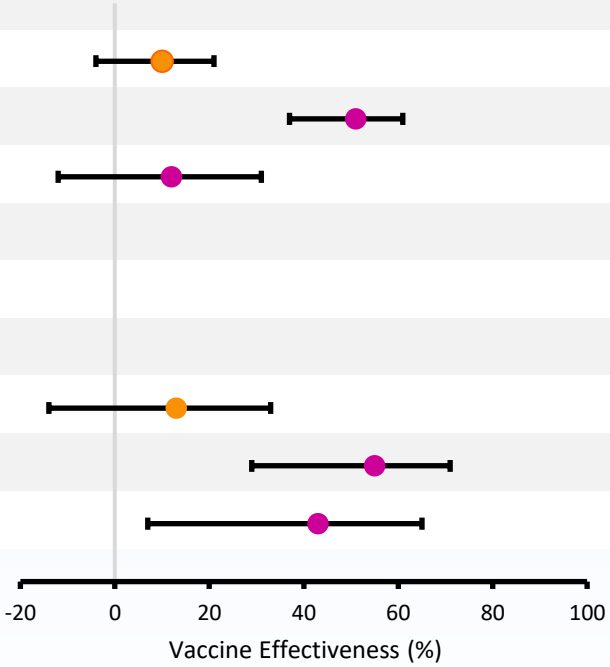


*VE adjustments: Age, sex, race/ethnicity, admission date (biweekly), and HHS region

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

IVY: *Absolute* VE against COVID-19 *hospitalization* among adults aged ≥*18 years*, by immunocompromise status — September 8, 2022 – May 31, 2023

	Case vaccination status, no. (%)	Control vaccination status, no. (%)	Median time since last dose, days (IQR)	Adjusted VE*, % (95% CI)
Immunocompetent	**n=2,483**	**n=3,651**		
Unvaccinated	545 (22)	757 (21)	--	**Ref**
Original monovalent doses only	1506 (61)	2087 (57)	395 (286–521)	**10 (-4 to 21)**
Bivalent booster dose, 7–89 days earlier	179 (7)	452 (12)	53 (30–69)	**51 (37–61)**
Bivalent booster dose, 90–179 days earlier	253 (10)	355 (10)	130 (109–151)	**12 (-12 to 31)**
Immunocompromised	**n=809**	**n=1,257**		
Unvaccinated	132 (16)	182 (14)	--	**Ref**
Original monovalent doses only	543 (67)	767 (61)	374 (256–504)	**13 (-14 to 33)**
Bivalent booster dose, 7–89 days earlier	59 (7)	160 (13)	46 (26–72)	**55 (29–71)**
Bivalent booster dose, 90–179 days earlier	75 (9)	148 (12)	126 (107–152)	**43 (7–65)****



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

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

Conclusions: Updates to waning of bivalent vaccine effectiveness

- VE waning against hospitalization and ED/UC; more sustained protection against critical illness
  - Difficult to separate impact of time since vaccination from emergence of new variants
- Patterns are similar across age groups, though low uptake of bivalent doses in younger age groups prevented assessment of waning beyond 4 months from the bivalent dose.
- Persons with immunocompromise may have reduced protection after COVID-19 vaccination, compared with persons without immunocompromise. Historically, COVID-19 VE has been lower and waned more quickly for adults with immunocompromise compared to adults without immunocompromise. Trends in bivalent VE are less clear and additional data are needed.
- VE findings should be interpreted as the incremental benefit provided by COVID-19 vaccination in a population with a high prevalence of infection-induced immunity.

Acknowledgements

CDC COVID-19 Vaccine Effectiveness and Policy Team

- Amadea Britton
- Allison Ciesla
- Monica Godfrey
- Eric Griggs
- Katherine Fleming-Dutra
- Dani Moulia
- Morgan Najdowski
- Erica Okwuazi
- Josephine Mak
- Amanda Payne
- Lauren Roper
- Laura Steinhardt
- Megan Wallace
- Ryan Wiegand

VE platforms teams, including:

- Sarah Ball
- Angela Campbell
- Jennifer DeCuir
- Monica Dickerson
- Margaret Dunne
- Kiara Everett
- Shikha Garg
- Victoria Lazariu
- Patrick Mitchell
- Palak Patel
- Heidi Moline
- Caitlin Ray
- Sarah Reese
- Elizabeth Rowley
- Regina Simeone
- Zach Smith
- Diya Surie
- Mark Tenforde
- Zack Weber
- Laura Zambrano

And many more!!!

Questions?

For more information, contact CDC
1-800-CDC-INFO (232-4636)
TTY: 1-888-232-6348 www.cdc.gov

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Back-up

New Vaccine Surveillance Network (NVSN)

Design: active, prospective, population-based ARI surveillance network for pediatric viral infections at 7 medical centers.

Study population: Children <18 years with ARI are enrolled year-round in the outpatient, ED, and hospital settings. Healthy controls are enrolled in the outpatient setting (well child visits).

- 5794 children 6mos-4yrs with acute respiratory illness during July 1, 2022 —June 30, 2023

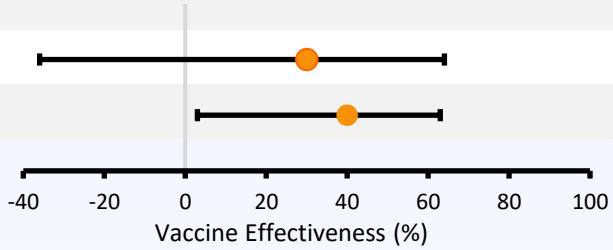
Data collection: Demographic and clinical data are collected through parent/guardian interviews and medical chart reviews, and laboratory testing. Vaccine status verified through state immunization registries and primary care record review.

NVSN COVID-19 Vaccine Effectiveness Methodology

- Test-negative design. All enrolled children are tested for 8 respiratory viruses.
  - Cases = SARS-CoV-2 positive, controls = SARS-CoV-2 negative.
- Regression models adjusted for study site, sex, race, and calendar time (week of enrollment).
- Vaccine status was defined as 1) *unvaccinated* = received zero COVID-19 vaccine doses of any product, 2) *one dose only* = received one COVID-19 vaccine dose of any product, or 3) *two or more doses* = received two or more COVID-19 vaccine doses of any product. Children within two weeks of vaccine receipt were excluded.

New Vaccine Surveillance Network (NVSN): VE of any product against emergency department visits and hospitalization, children 6 months – 4 years, July 2022-June, 2023

	Case vaccination status (n=291)	Control vaccination status (n=5,503)	Median time since last dose, days (IQR)	Adjusted VE*, % (95% CI)
Unvaccinated	260 (89)	4,691 (85)	NA	
Vaccinated with ≥1 dose*	31 (11)	812 (15)	Not calculated	Not calculated
One dose	10 (3)	228 (4)	61 (31-105)	**30 (-36-64)****
Two doses	21 (7)	584 (11)	74 (42-131)	**40 (3-63)****

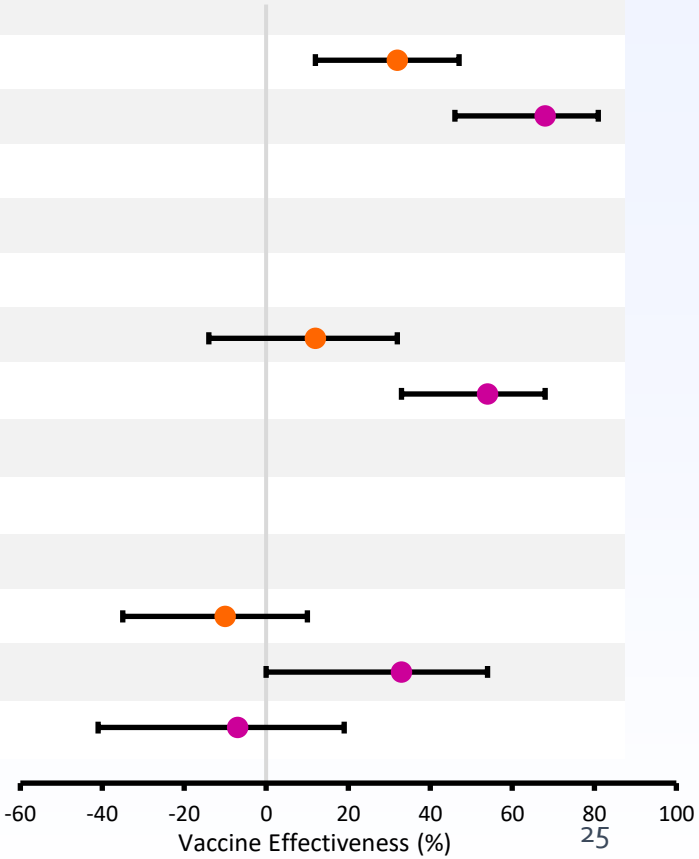


* Vaccine status was defined as 1) unvaccinated = received zero COVID-19 vaccine doses of any product, 2) one dose only = received one COVID-19 vaccine dose of any product, or 3) two or more doses = received two or more COVID-19 vaccine doses of any product. Children within two weeks of vaccine receipt were excluded.

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

IVY: Absolute VE against COVID-19 *hospitalization* among immunocompetent adults aged ≥18 years by SARS-CoV-2 subvariant predominance— September 8, 2022 – May 31, 2023

	Case vaccination status, no. (%)	Control vaccination status, no. (%)	Median time since last dose, days (IQR)	Adjusted VE*, % (95% CI)
BA.4/5 (September 8 – November 26, 2022)	**n=688**	**n=989**		
Unvaccinated	169 (25)	199 (20)		
Original monovalent doses only	479 (70)	692 (70)	311 (195–403)	**32 (12–47)**
Bivalent booster dose, 7–89 days earlier	40 (6)	98 (10)	29 (16-45)	**68 (46–81)**
BQ.1 (November 27, 2022 – January 17, 2023)	**n=622**	**n=1,080**		
Unvaccinated	145 (23)	223 (21)		
Original monovalent doses only	399 (64)	617 (57)	388 (306–517)	**12 (-14 to 32)**
Bivalent booster dose, 7–89 days earlier	78 (13)	240 (22)	55 (37-69)	**54 (33–68)**
XBB.1.5 (January 18 – May 31, 2023)	**n=1,148**	**n=1,529**		
Unvaccinated	231 (20)	335 (22)		
Original monovalent doses only	628 (55)	778 (51)	464 (374–593)	**-10 (-35 to 10)**
Bivalent booster dose, 7–89 days earlier	61 (5)	114 (7)	65 (46–80)	**33 (0–54)****
Bivalent booster dose, 90–179 days earlier	228 (20)	302 (20)	136 (116–154)	**-7 (-41 to 19)****

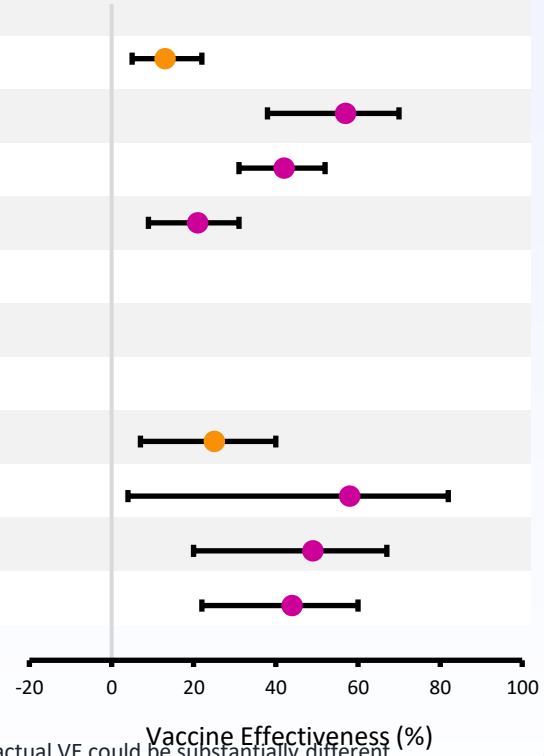


*VE adjustments: Age, sex, race/ethnicity, admission date (biweekly), and HHS region

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

VISION: *Absolute* VE of *original monovalent* and *bivalent* booster doses against *hospitalization* and *critical illness* among immuno*competent* adults aged ≥18 years, during *XBB* predominance – January – July 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)	10,443	700 (7)	--	**Ref**
Original monovalent doses only	23,140	1,662 (7)	511 (411-639)	**13 (5-22)**
Bivalent booster, 7-59 days earlier	701	33 (5)	38 (23-49)	**57 (38-70)**
Bivalent booster, 60-119 days earlier	2,350	165 (7)	98 (83-110)	**42 (31-52)**
Bivalent booster, 120-179 days earlier	5,067	434 (9)	150 (136-165)	**21 (9-31)**
Critical illness				
Unvaccinated (ref)	9,890	147 (2)	--	**Ref**
Original monovalent doses only	21,751	273 (1)	512 (412-640)	**25 (7-40)**
Bivalent booster, 7-59 days earlier	674	6 (1)	38 (23-49)	**58 (4-82)***
Bivalent booster, 60-119 days earlier	2,211	26 (1)	98 (83-110)	**49 (20-67)**
Bivalent booster, 120-179 days earlier	4,690	57 (1)	150 (136-165)	**44 (22-60)**



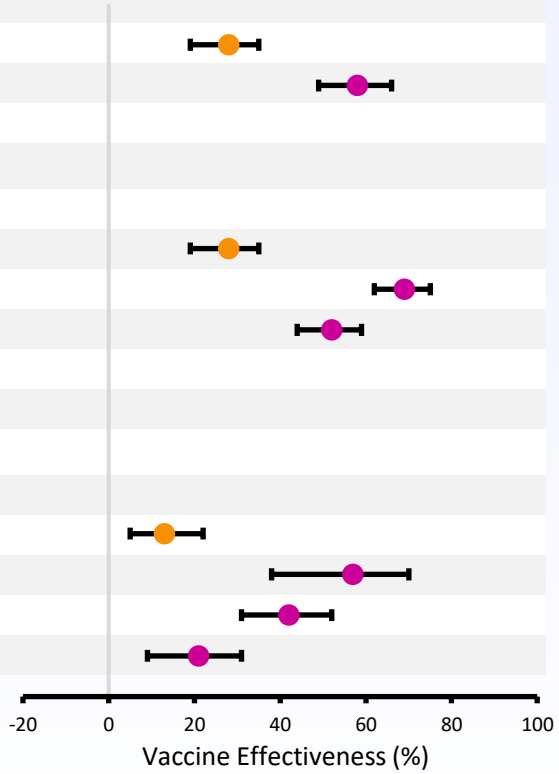
CDC unpublished data. VE estimates adjusted for age, sex, race and ethnicity, geographic region, and calendar time.

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

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

VISION: *Absolute* VE of *original monovalent* and *bivalent* booster doses against *hospitalization* among immuno*competent* adults aged ≥18 years, by SARS-CoV-2 subvariant predominance – September 2022 – August 2023

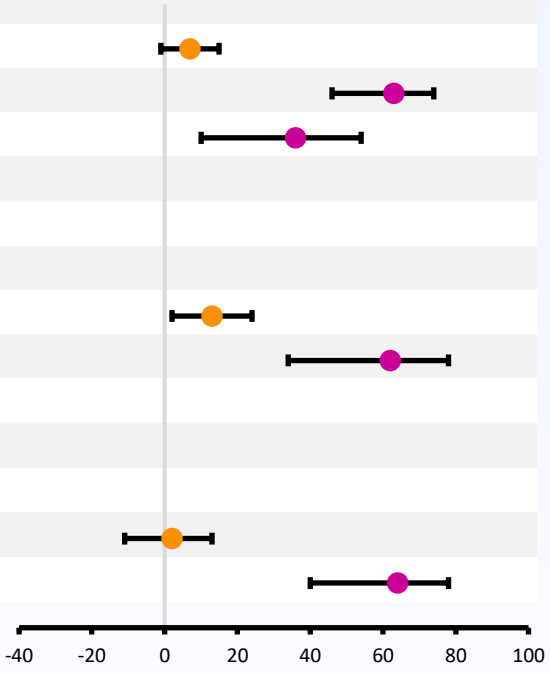
mRNA Dosage Pattern	Total tests	SARS-CoV-2-test-positive, N (%)	Median interval since last dose, days (IQR)	Adjusted VE (95% CI)
BA.4/BA.5 predominance (September 2022 – November 2022)				
Unvaccinated (ref)	5427	606 (11)	--	**Ref**
Original monovalent doses only	14521	1377 (10)	312 (183-397)	**28 (19-35)**
Bivalent booster, 7-59 days earlier	1856	129 (7)	25 (15-37)	**58 (49-66)**
BQ.1 predominance (December 2022 – January 2023)				
Unvaccinated (ref)	4,193	619 (15)	--	**Ref**
Original monovalent doses only	9,787	1,300 (13)	390 (296-495)	**28 (19-35)**
Bivalent booster, 7-59 days earlier	1,870	133 (7)	41 (28-51)	**69 (62-75)**
Bivalent booster, 60-119 days earlier	2,780	288 (10)	82 (71-94)	**52 (44-59)**
XBB predominance (February 2023 – August 2023)				
Unvaccinated (ref)	10,443	700 (7)	--	**Ref**
Original monovalent doses only	23,140	1,662 (7)	511 (411-639)	**13 (5-22)**
Bivalent booster, 7-59 days earlier	701	33 (5)	38 (23-49)	**57 (38-70)**
Bivalent booster, 60-119 days earlier	2,350	165 (7)	98 (83-110)	**42 (31-52)**
Bivalent booster, 120-179 days earlier	5,067	434 (9)	150 (136-165)	**21 (9-31)**



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 *original monovalent* and *bivalent* booster doses against *ED/UC encounters* among immuno*competent* children and adolescents, by age group – September 2022 – August 2023

mRNA Dosage Pattern	Total tests	SARS-CoV-2-test-positive, N (%)	Median interval since last dose, days (IQR)	Adjusted VE (95% CI)
5-17 years				
Unvaccinated (ref)	41,910	1,446 (4)	--	**Ref**
Original monovalent doses only	28,369	1,092 (4)	334 (253-439)	**7 (-1 to 15)**
Bivalent booster, 7-59 days earlier	1,858	30 (2)	30 (18-44)	**63 (46 to 74)**
Bivalent booster, 60-119 days earlier	1,268	37 (3)	89 (74-105)	**36 (10 to 54)**
5-11 years				
Unvaccinated (ref)	31,608	905 (3)	--	**Ref**
Original monovalent doses only	14,956	396 (3)	309 (193-368)	**13 (2 to 24)**
Bivalent booster, 7-59 days earlier	1,004	13 (1)	29 (17-42)	**62 (34 to 78)**
12-17 years				
Unvaccinated (ref)	10302	541 (5)	--	**Ref**
Original monovalent doses only	13413	696 (5)	394 (291-496)	**2 (-11 to 13)**
Bivalent booster, 7-59 days earlier	854	17 (2)	32 (19-47)	**64 (40 to 78)**



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

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

Updated estimates of bivalent VE against symptomatic infection among children and adolescents aged 5–17 and adults aged ≥18 years

Interpreting absolute and relative vaccine effectiveness

- **Absolute VE:** comparing the frequency of health outcomes in vaccinated and unvaccinated people
  - E.g., comparing outcomes in people vaccinated with an updated bivalent booster versus no vaccine at all
- **Relative VE:** comparing the frequency of health outcomes in people who received one type of vaccine to people who received a different vaccine or by comparing people who received more vaccine doses to those who received fewer doses
  - E.g., comparing outcomes in people vaccinated with an updated bivalent booster versus monovalent vaccine only
- In the analyses presented today, relative vaccine effectiveness can be interpreted as the ***additional protection provided by an updated bivalent booster*** among people who already received monovalent COVID-19 vaccines

ICATT: *Relative* VE of bivalent booster against *symptomatic infection* in children and adolescents aged 5–17 years and adults aged ≥18 years

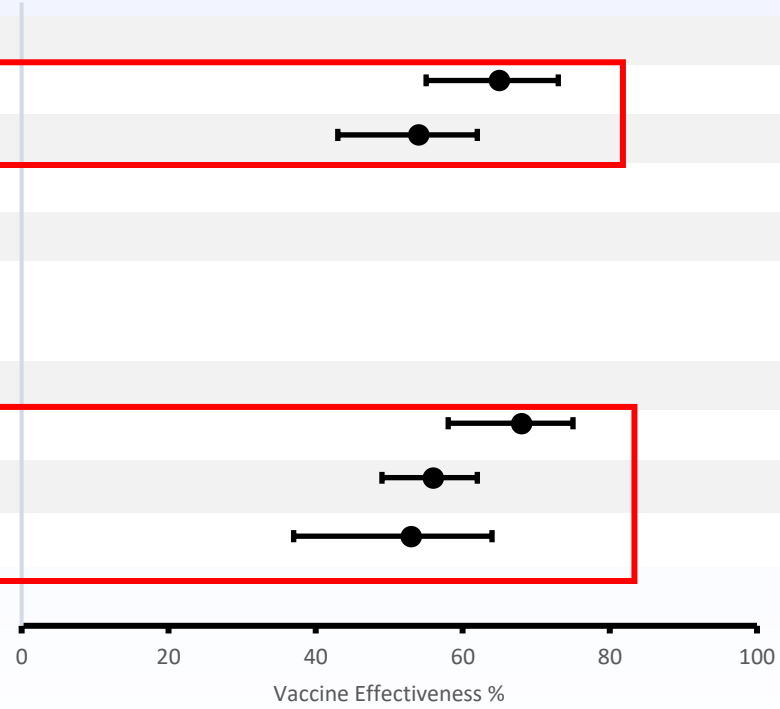
- Nationwide community-based drive-through SARS-CoV-2 testing via pharmacies
- Self-reported vaccine history at time of registration for COVID-19 testing
- **Design**: Test-negative, case-control analysis*
- **Population**: Children and adolescents aged 5–17 years and adults aged ≥18 years with ≥1 COVID-like symptom and nucleic acid amplification testing (NAAT)
- **Exclusion criteria:** Excluded individuals <4 months from last monovalent dose and individuals with immunocompromising conditions
- **Periods for analysis:**
  - Tested: December 1, 2022 – February 13, 2023**
  - Includes periods of both BA.5-related sublineage and XBB/XBB.1.5 sublineage predominance

*Models adjusted for: age, gender, race, ethnicity, social vulnerability index and HHS region of the testing location, underlying conditions (presence versus absence), local incidence (cases per 100,000 by individual county and state in the 7 days before test date), and date of testing

**Analysis is an update of data published in Link-Gelles R, Ciesla AA, Roper LE, et al. Early estimates of bivalent mRNA booster dose vaccine effectiveness in preventing symptomatic SARS-CoV-2 infection attributable to SARS-CoV-2 Omicron BA.5-related and XBB/XBB.1.5-related sublineages among immunocompetent adults—Increasing Community Access to Testing Program, United States, December 2022–January 2023. MMWR Morb Mortal Wkly Rep 2023;72. https://www.cdc.gov/mmwr/volumes/72/wr/mm7205e2.htm

ICATT: *Relative* VE of bivalent booster against *symptomatic infection* in children and adolescents aged 5–17 years, December 1, 2022 – February 13, 2023*

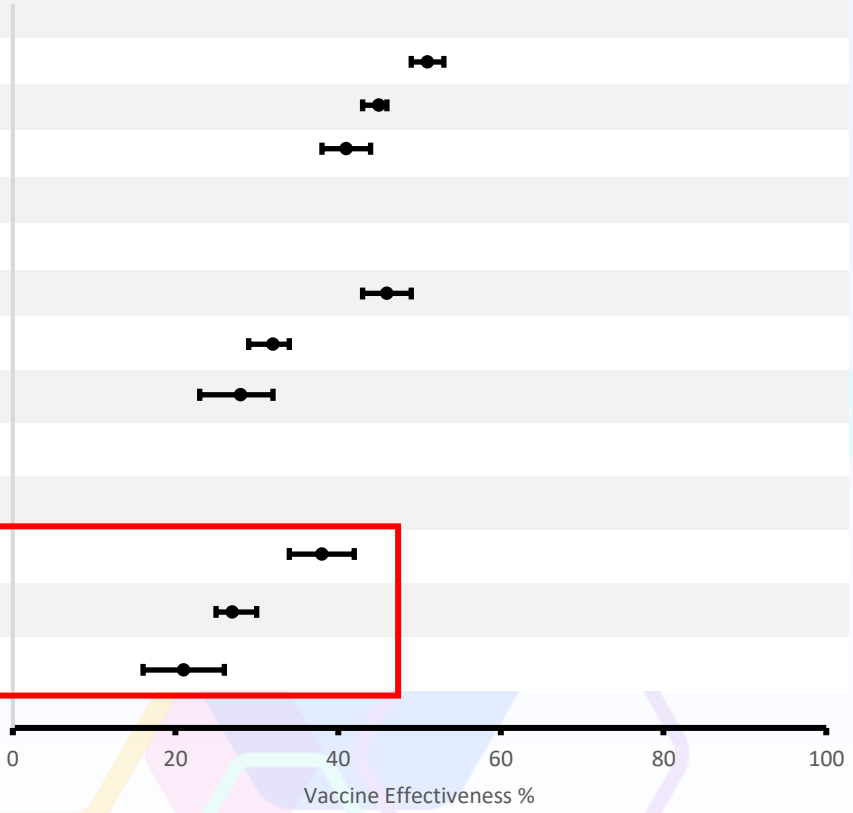
Age group, years/mRNA Dosage Pattern	Total tests	SARS-CoV-2 positive tests, N (row %)	Adjusted VE (95% CI)
5-11 years (*authorized for bivalent booster on October 12, 2022*)			
Received 2-3 monovalent doses only (Ref)	4,855	1,433 (30)	Ref
2 weeks-1 month since bivalent booster	600	73 (12)	65 (55 to 73)
2-3 months since bivalent booster	881	139 (16)	54 (43 to 62)
4-5 months since bivalent booster	58	10 (17)	----
12-17 years (*authorized for bivalent booster on September 1, 2022*)			
Received 2-3 monovalent doses only (Ref)	8,243	3,194 (39)	Ref
2 weeks-1 month since bivalent booster	443	73 (16)	68 (58 to 75)
2-3 months since bivalent booster	1,122	230 (20)	56 (49 to 62)
4-5 months since bivalent booster	283	68 (24)	53 (37 to 64)



*Unpublished CDC data.

ICATT: *Relative* VE of bivalent booster against *symptomatic infection* in adults aged ≥18 years, December 1, 2022 – February 13, 2023*

Age group, years/mRNA Dosage Pattern	Total tests	SARS-CoV-2 positive tests, N (row %)	Adjusted VE (95% CI)
18-49 years			
Received 2-3 monovalent doses only (Ref)	182,741	82,043 (45)	**Ref**
2 weeks-1 month since bivalent booster	10,758	3,127 (29)	**51 (49 to 53)**
2-3 months since bivalent booster	32,577	10,206 (31)	**45 (43 to 46)**
4-5 months since bivalent booster	9,197	2,882 (31)	**41 (38 to 44)**
50-64 years			
Received 2-4 monovalent doses only (Ref)	60,822	31,878 (52)	**Ref**
2 weeks-1 month since bivalent booster	6,223	2,331 (37)	**46 (43 to 49)**
2-3 months since bivalent booster	18,399	7,898 (43)	**32 (29 to 34)**
4-5 months since bivalent booster	4,837	2,030 (42)	**28 (23 to 32)**
≥65 years			
Received 2-4 monovalent doses only (Ref)	28,307	14,246 (50)	**Ref**
2 weeks-1 month since bivalent booster	4,579	1,788 (39)	**38 (34 to 42)**
2-3 months since bivalent booster	19,071	8,080 (42)	**27 (25 to 30)**
4-5 months since bivalent booster	5,796	2,431 (42)	**21 (16 to 26)**



*Unpublished CDC data.