

# The History of Vaccines, Lessons Learned and a Look Back in Time

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Jaime Novales, MD	CME Reviewer	No	N/A
Joe Hageman, MD	CME Reviewer	Yes	Roaylties - Owlet

# Speaker



- Assistant Professor of Pediatrics, University of Illinois Chicago
- Chief, Sub-Section of Adolescent Medicine
- Director, Adolescent Medicine Fellowship
- Co- Director, Department of Pediatrics DEI Taskforce
- Society of Adolescent Medicine and Health, Vaccine Committee

# Learning Objectives

By the end of this session, participants will be able to:

Understand the origins of vaccines and key milestones in vaccine history.

Explain how vaccines are developed and approved.

Explore current recommendations and strategies for improving adolescent vaccination rates.



# First Vaccines

From at least the 15th century, people in different parts of the world have attempted to prevent illness by intentionally exposing healthy people to smallpox.

Benjamin Jesty was convinced that milkmaids that contracted cowpox while working, were protected from smallpox.

In 1774 during the smallpox epidemic, he inoculated his wife and sons with cowpox lymph take from a lesion on an infected cow.

In 1796, Dr Edward Jenner expands on this hypothesis by inoculating an 8yo with material cowpox sore. He recovered well, 2months later he was inoculated with human smallpox sore, and remained well

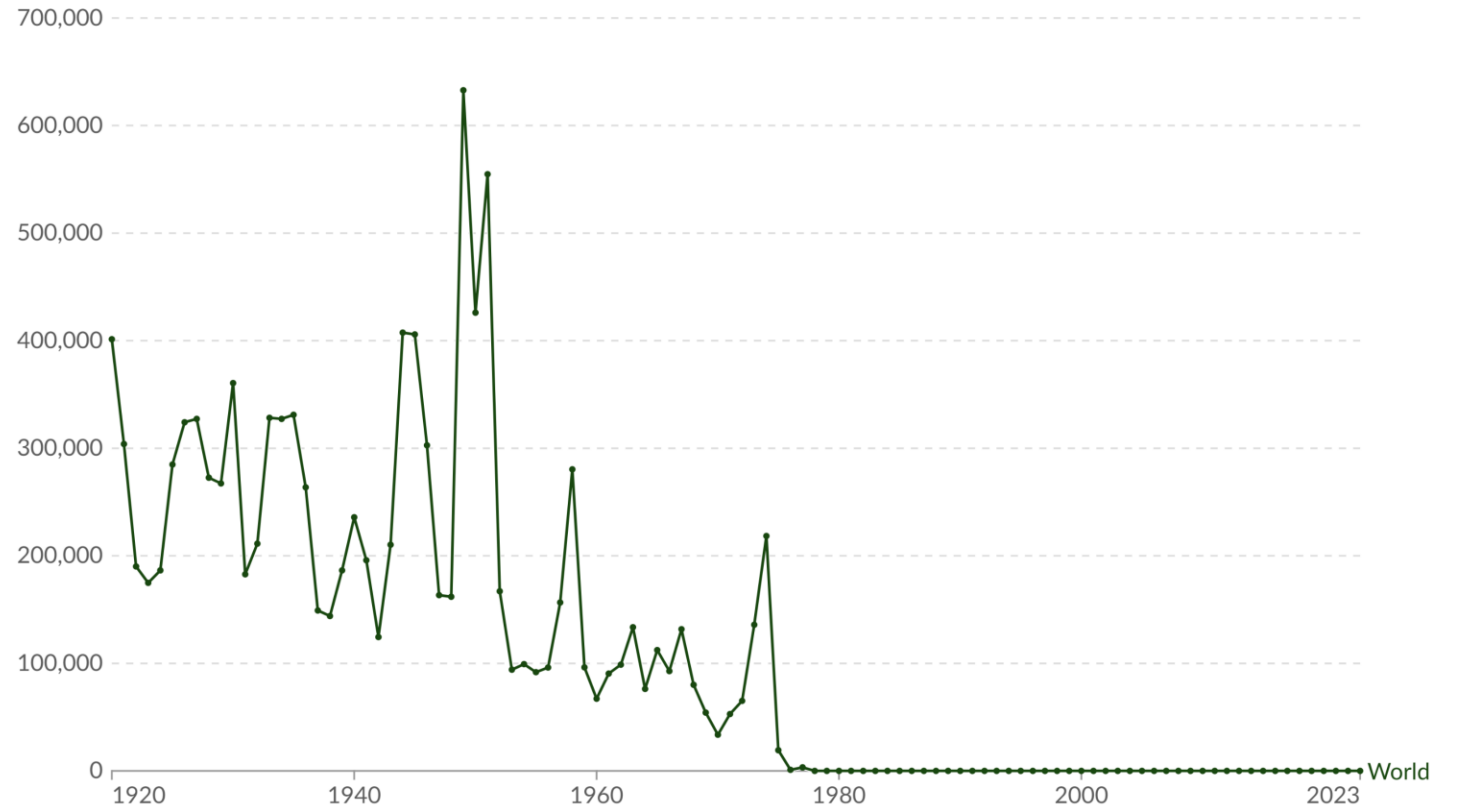
# Success of Smallpox Vaccination

<https://ourworldindata.org/smallpox#all-charts>

## Smallpox cases reported worldwide

Our World in Data

The historical number of smallpox<sup>1</sup> cases reported is lower than the actual number of cases in those years, due to limited testing and reporting.



Data source: WHO (2023)

OurWorldinData.org/smallpox | CC BY

**1. Smallpox:** Smallpox was a severe and contagious disease caused by the variola virus. Patients infected by the virus developed fever, body aches, and a distinctive rash that developed into fluid-filled blisters. The disease was known for its high mortality rate and the permanent scarring it often left on survivors. Historically, it affected people across various continents. Through a global vaccination campaign, smallpox became the first disease to be eradicated by human effort. [Read more on our page on smallpox.](#)



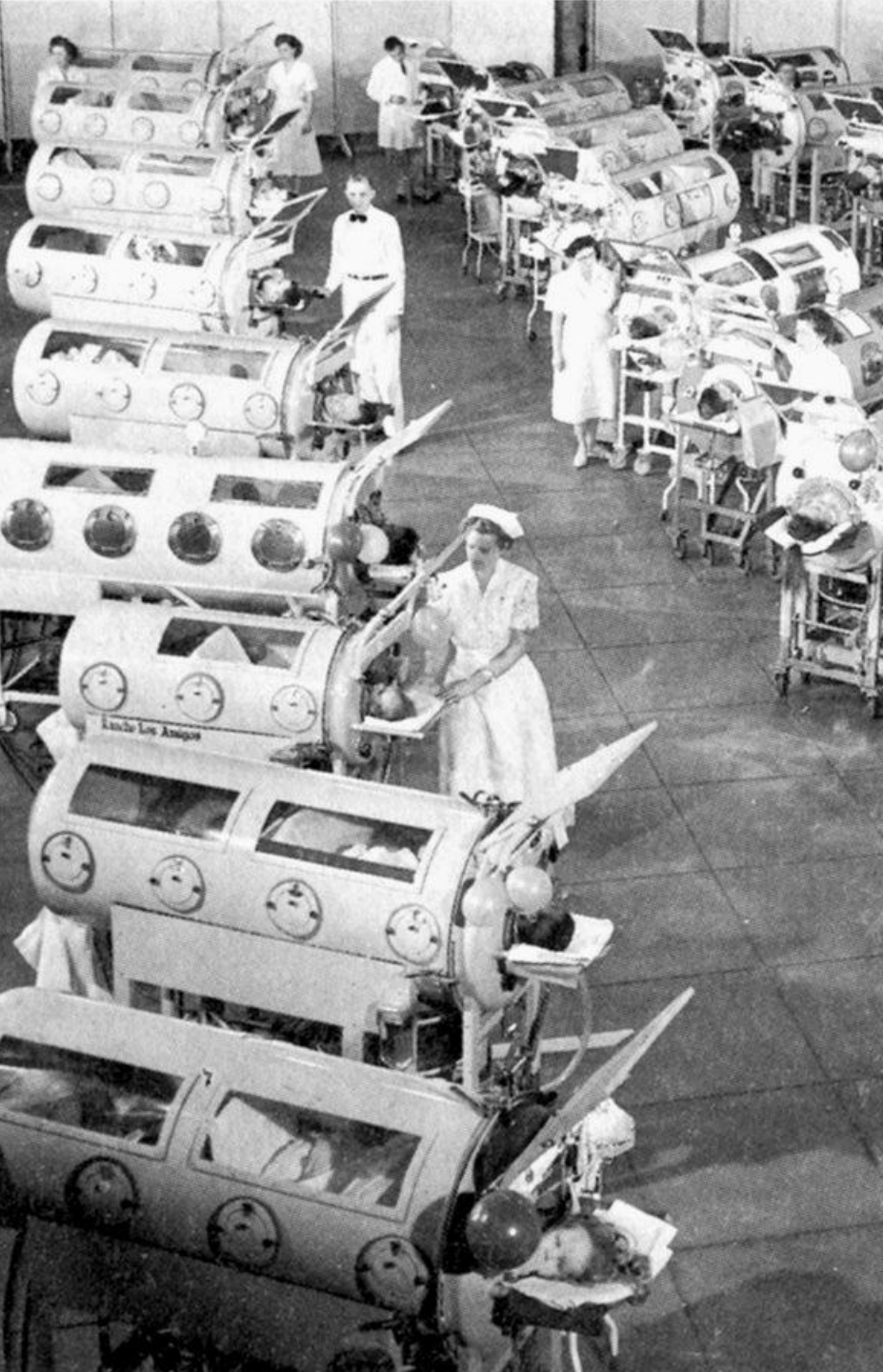
# Early 20<sup>th</sup> Century

- The next routinely recommended vaccines were developed early in the 20th century. These included:
  - Pertussis (1914)
  - Diphtheria (1926)
  - Tetanus (1938)
- These three vaccines were combined in 1948 and given as the DTP vaccine.



Dr. Pearl Kendrick, from Wheaton, Illinois, was one of the key developers of the first Pertussis vaccine.





# Polio Prior to Vaccination

In the 19th and 20th century Polio became the most feared virus worldwide

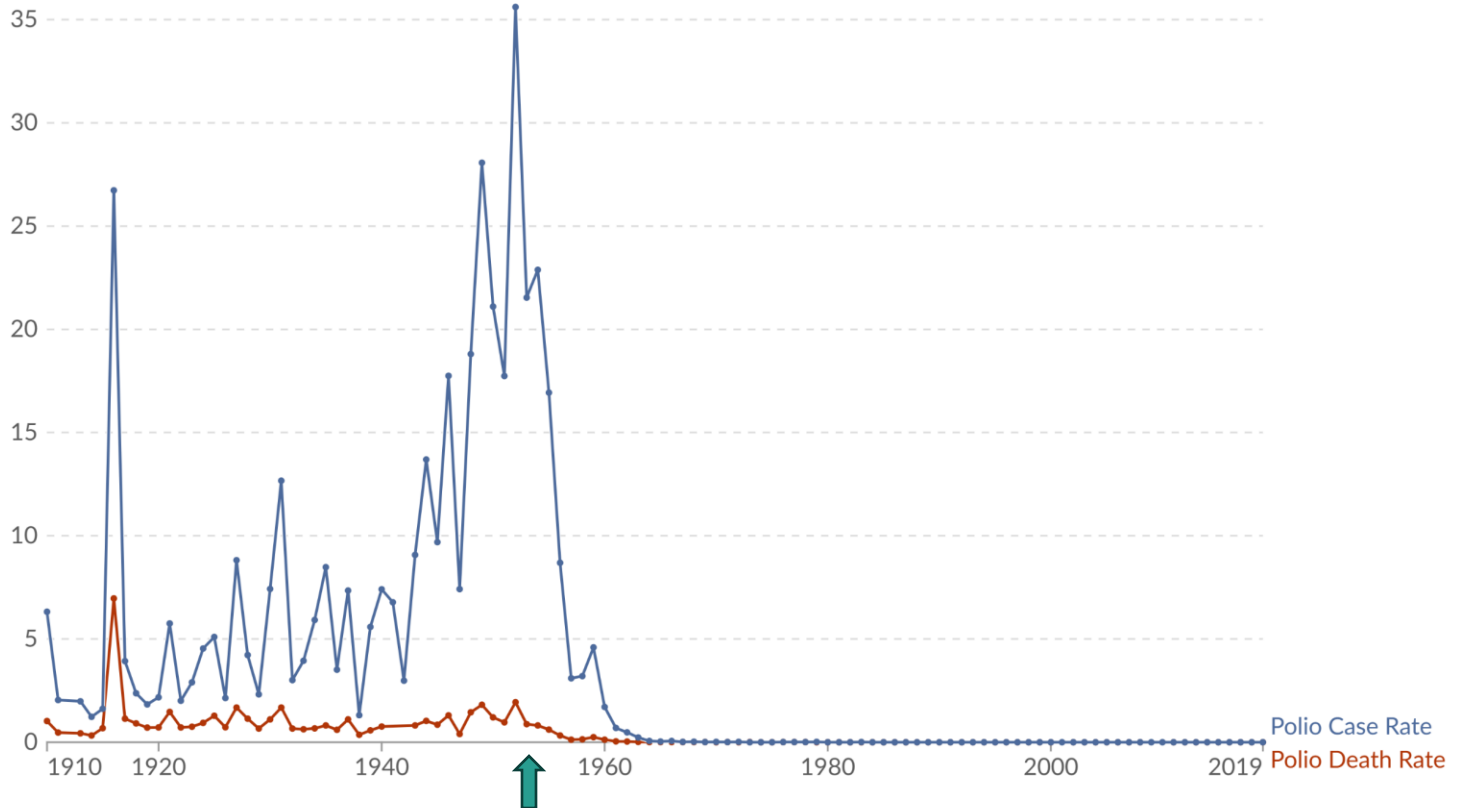
In 1916 an epidemic in NY killed over 2000 people. The worst outbreak occurred in 1952, killing over 3000 people.

- Polio is a highly infectious virus that affects the nerves and spinal cord and/or brain stem. It can lead to breathing difficulty, weakness, and total paralysis in the matter of hours
- 1 in 200 infections lead to irreversible paralysis (usually in the legs)
- In 1952 Polio infections peaked in the United States, with more than 21,000 paralytic cases.
- Led to the use of the iron lung.

Vaccination has decreased the rate of polio significantly with the most recent case in the US occurring in 2022, in an unvaccinated 20yo M

## Polio case and death rates in the United States

The reported rates are per 100,000 US population and include both wild-<sup>1</sup> and vaccine-derived poliovirus<sup>2</sup> infections that occurred indigenously and as imported cases.



Data source: Our World In Data based on US Public Health Service; US Center for Disease Control; and WHO  
OurWorldinData.org/polio | CC BY

**1. Wild poliovirus (WPV):** Wild poliovirus refers to polio viruses that have come from the environment. There are three serotypes of wild poliovirus: wild poliovirus 1, 2 and 3. Two of the three serotypes have already been eradicated worldwide. The last case of wild poliovirus serotype 2 was seen in 1999 in India. It was declared globally eradicated by the WHO in 2015. The last case of wild poliovirus serotype 3 was seen in 2012 in Nigeria and declared eradicated in 2019. [Read more on our page on polio.](#)

**2. Vaccine-derived poliovirus (VDPV):** Vaccine-derived poliovirus refers to polio viruses that have come from Oral Polio Vaccines (OPV) in rare circumstances. There are three serotypes of vaccine-derived poliovirus: vaccine-derived poliovirus 1, 2 and 3. These arise the virus used in the oral poliovirus vaccine can, in very rare circumstances, evolve mutations that allow it to cause disease. If a population has low immunity to polio, because of low rates of vaccination, these vaccine-derived polioviruses can spread more easily and cause an outbreak. Since 2021, the world has a new version of the oral poliovirus vaccine called the "novel Oral Polio Vaccine" (nOPV) that is more genetically stable than the previous vaccine, and can prevent outbreaks of vaccine-derived poliovirus. Vaccine-derived polioviruses contrast with wild poliovirus. [Read more on our page on polio.](#)

Success of  
Polio  
Vaccination

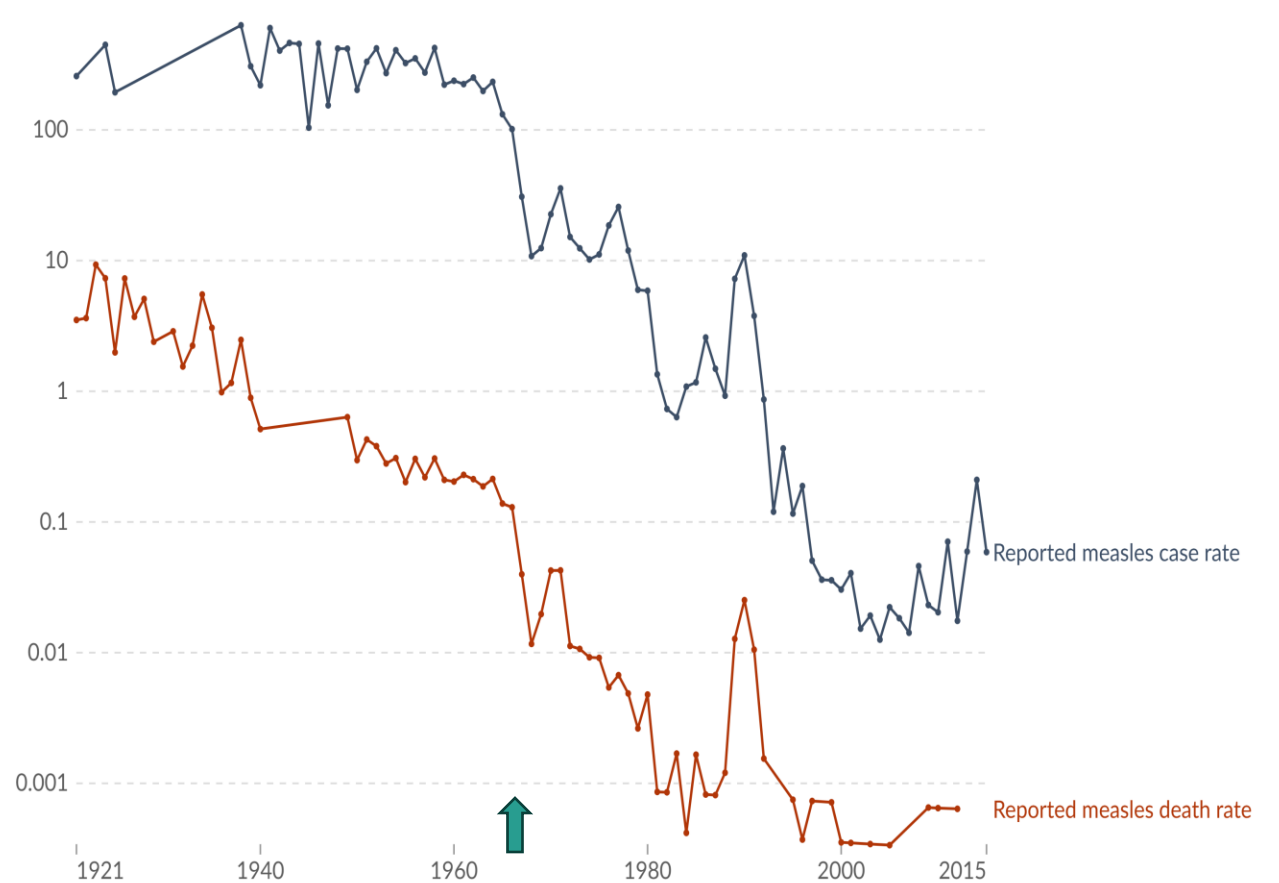


# Measles

- Measles is a highly contagious virus that causes high fever, cough, red eyes and rash
- It can spread via airborne and droplet transmission
- ~90% of people who are not immune can become infected.
- The measles vaccine was developed in 1963, and by the late 1960s, vaccines to protect against mumps (1967) and rubella (1969) were also available.
  - These vaccines were combined into the MMR vaccine in 1971.

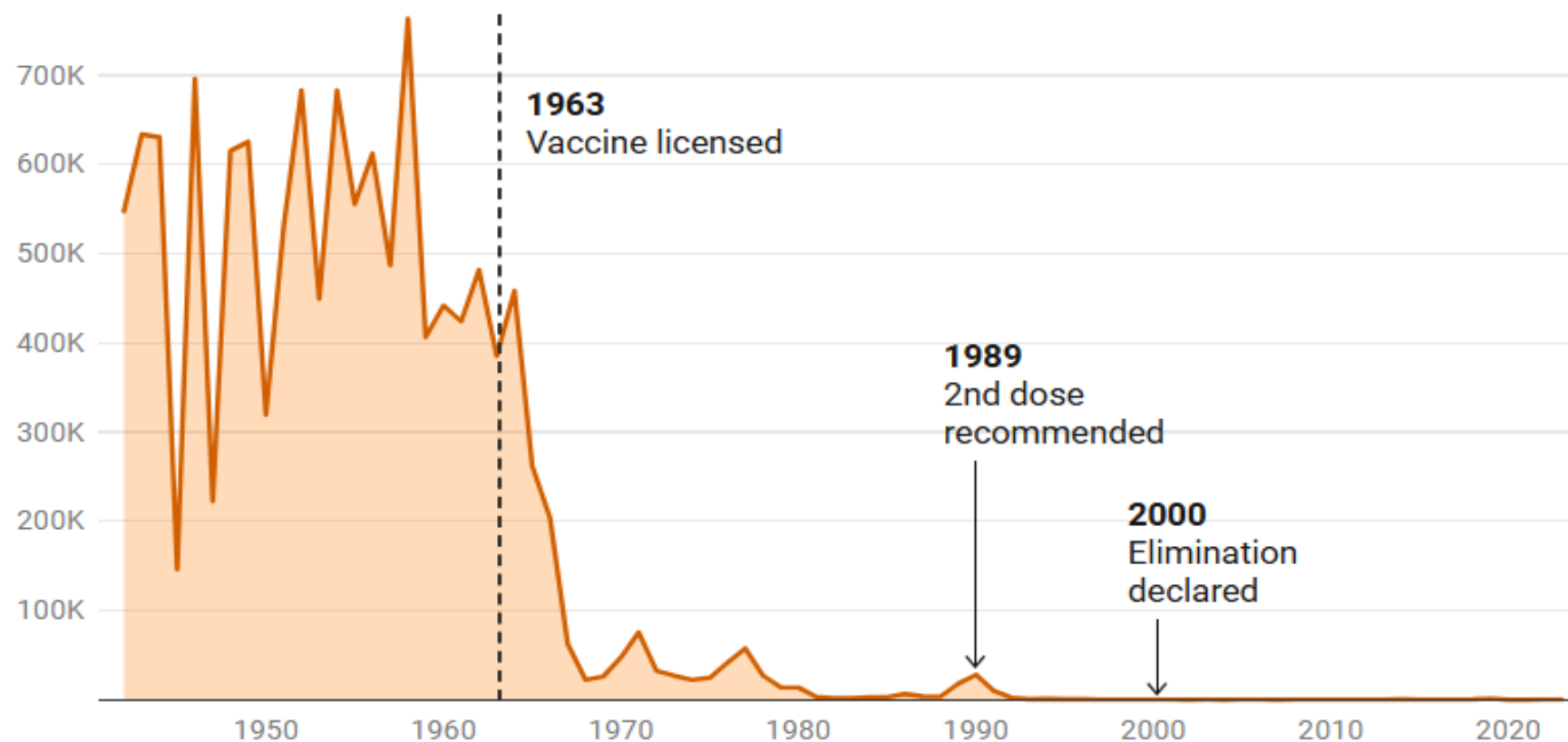
## Rate of cases and deaths from measles in the United States

The reported annual rate of new cases and deaths from measles, per 100,000 people in the population.



# The public health success of the measles vaccine

Reported number of measles cases in the United States, 1942–2023



*Hover or click to see values.*

*Note: Elimination is defined as the absence of endemic measles transmission in a region for at least 12 months.*

Source: Centers for Disease Control and Prevention, "CDC Stacks Collections of Annual Tables of Infectious Diseases and Conditions" (last accessed January 2025).

Chart: Center for American Progress

- Measles was declared eliminated in the US in 2000. This was due to a very high percentage of MMR vaccination rates
- In recent years:
  - Kindergarten MMR vaccination is below the 95% coverage target and much lower in some communities—(and its rate is decreasing)
  - Global measles activity is also increasing, meaning more chances of an unvaccinated person infected with measles abroad returning to the United States.

# Vaccine-preventable diseases in the US

Shown is the reduction of cases and deaths after the introduction of the vaccine



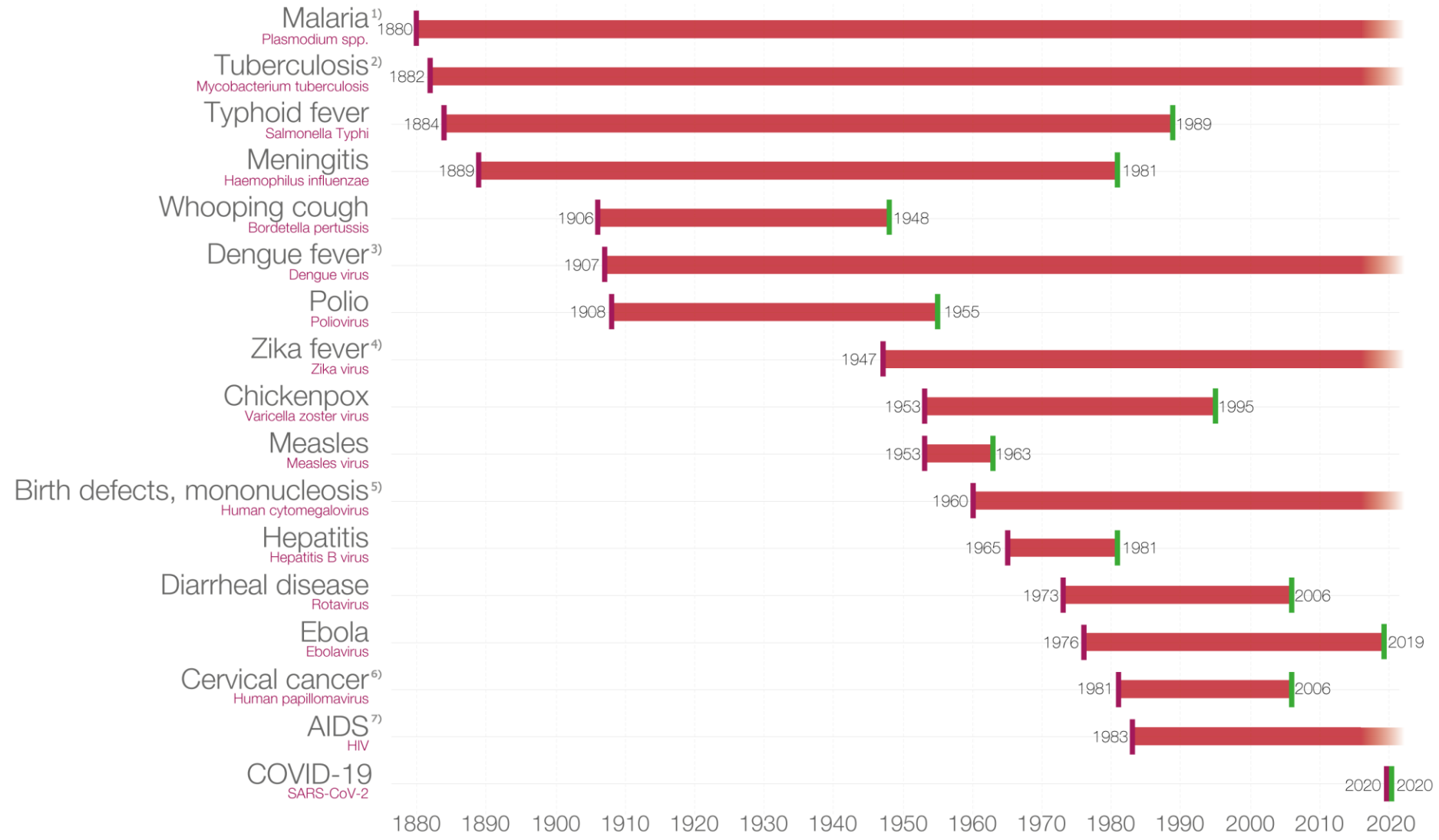
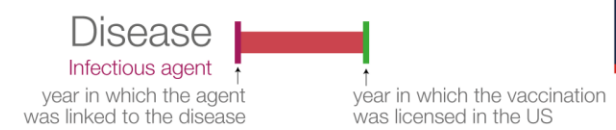
# Vaccine Effectiveness in Reducing Cases and Deaths

Data source: Roush and Murphy (2007) - Historical comparisons of morbidity and mortality for vaccine-preventable diseases in the United States. In The Journal of the American Medical Association, 298, 18, 2155--2163. Licensed under CC-BY by the author Max Roser






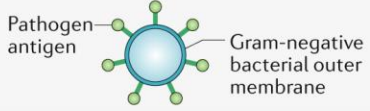
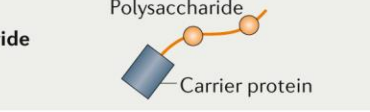
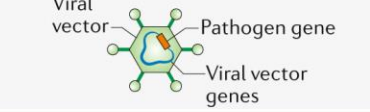

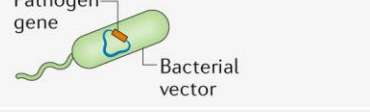
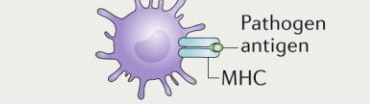
# Vaccine Development



# Vaccination innovation, from 1880 to 2020



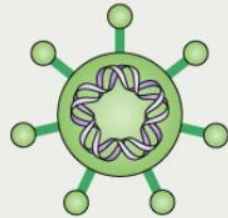
1) – 2016 vaccine RTS,S undergoing pilot trials in select countries after being approved by European regulators in 2015.  
 2) – The only approved vaccine is bacilli Calmette-Guérin (BCG), developed in 1921 but its efficacy in adults is variable. Other tuberculosis vaccines are currently in development.  
 3) – 2016 partially effective vaccine CYD-TDV, sold under the brand name Dengvaxia.  
 4) – Successful first human clinical trials of a vaccine against the virus in 2016. Only in 2016 did the WHO issue statements of concern about the zika virus' links to Guillain-Barré Syndrome (GBS) and microcephaly.  
 5) – A number of vaccine candidates are under investigation.  
 6) – Not all cervical cancers are caused by the HPV virus and the HPV vaccine can protect against other cancers caused by the HPV virus.  
 7) – 2009 efficacy findings for vaccine candidate RV 144 has shown some promise. In stage III human trials.

Type of vaccine		Licensed vaccines using this technology	First introduced
Live attenuated (weakened or inactivated)		Measles, mumps, rubella, yellow fever, influenza, oral polio, typhoid, Japanese encephalitis, rotavirus, BCG, varicella zoster	1798 (smallpox)
Killed whole organism		Whole-cell pertussis, polio, influenza, Japanese encephalitis, hepatitis A, rabies	1896 (typhoid)
Toxoid		Diphtheria, tetanus	1923 (diphtheria)
Subunit (purified protein, recombinant protein, polysaccharide, peptide)		Pertussis, influenza, hepatitis B, meningococcal, pneumococcal, typhoid, hepatitis A	1970 (anthrax)
Virus-like particle		Human papillomavirus	1986 (hepatitis B)
Outer membrane vesicle		Group B meningococcal	1987 (group B meningococcal)
Protein-polysaccharide conjugate		<i>Haemophilus influenzae</i> type B, pneumococcal, meningococcal, typhoid	1987 ( <i>H. influenzae</i> type b)
Viral vectored		Ebola	2019 (Ebola)
Nucleic acid vaccine		SARS-CoV-2	2020 (SARS-CoV-2)
Bacterial vectored		Experimental	–
Antigen-presenting cell		Experimental	–

# Types of Vaccines

# Most Common Types of Vaccines

**Live attenuated  
(weakened or  
inactivated)**



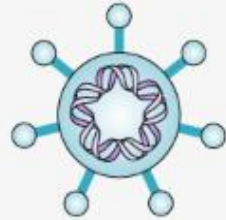
Measles, mumps, rubella,  
yellow fever, influenza, oral  
polio, typhoid, Japanese  
encephalitis, rotavirus, BCG,  
varicella zoster

## ○ Live Attenuated

- Oldest types of vaccines developed; pathogens are made weaker through repeated growth in a lab.
- Contains the whole organism.
- Most widely used live attenuated vaccines in the US are MMR and Varicella (Chickenpox).

# Most Common Types of Vaccines

**Killed whole organism**



Whole-cell pertussis,  
polio, influenza,  
Japanese encephalitis,  
hepatitis A, rabies

1896 (typhoid)

## ○ Killed Whole Organism

- Pathogens are killed or inactivated but contains the whole organism (as the name suggests).
- Most widely used killed whole organism vaccines are Polio and Influenza.

# Most Common Types of Vaccines

Subunit (purified protein, recombinant protein, polysaccharide, peptide)




Pertussis, influenza, hepatitis B, meningococcal, pneumococcal, typhoid, hepatitis A

1970 (anthrax)

## ○ Subunit

- Takes a component or subunit of the virus – typically a protein or polysaccharide – and combines with an adjuvant.
- Most frequently used type of vaccines amongst adult populations.
- Most commonly used vaccines:
  - *Hepatitis A and B*
  - *Pertussis: TDaP*
  - *RSV*

# Most Common Types of Vaccines

Toxoid		Diphtheria, tetanus	1923 (diphtheria)
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## ○ Toxoid

- A subset of subunit vaccines – they target specific bacterial toxins that bacterial diseases are dependent on.
- The toxin is inactivated so it is not harmful to the person being immunized.
- Most commonly used vaccines:
  - *Tetanus: TDaP*
  - *Diphtheria: TDaP*

# Most Common Types of Vaccines

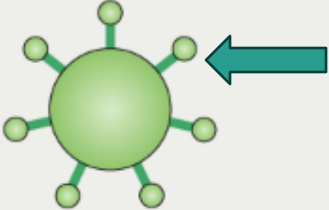
<b>Protein-polysaccharide conjugate</b>	 <p>Polysaccharide</p> <p>Carrier protein</p>	<i>Haemophilus influenzae</i> type B, pneumococcal, meningococcal, typhoid	1987 ( <i>H. influenzae</i> type b)
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## ○ Protein-Polysaccharide Conjugate

- A subset of subunit vaccines – they target specific bacterial toxins that bacterial diseases are dependent on.
- A polysaccharide **subunit** component is linked to a **toxoid** to boost the immune response to the polysaccharide.
- Most commonly used vaccines:
  - *Haemophilus influenzae: Hib (tetanus toxoid)*
  - *Pneumococcus: PCV21 (diphtheria toxoid)*
  - *Meningococcus: Menveo (diphtheria toxoid)*



# Most Common Types of Vaccines

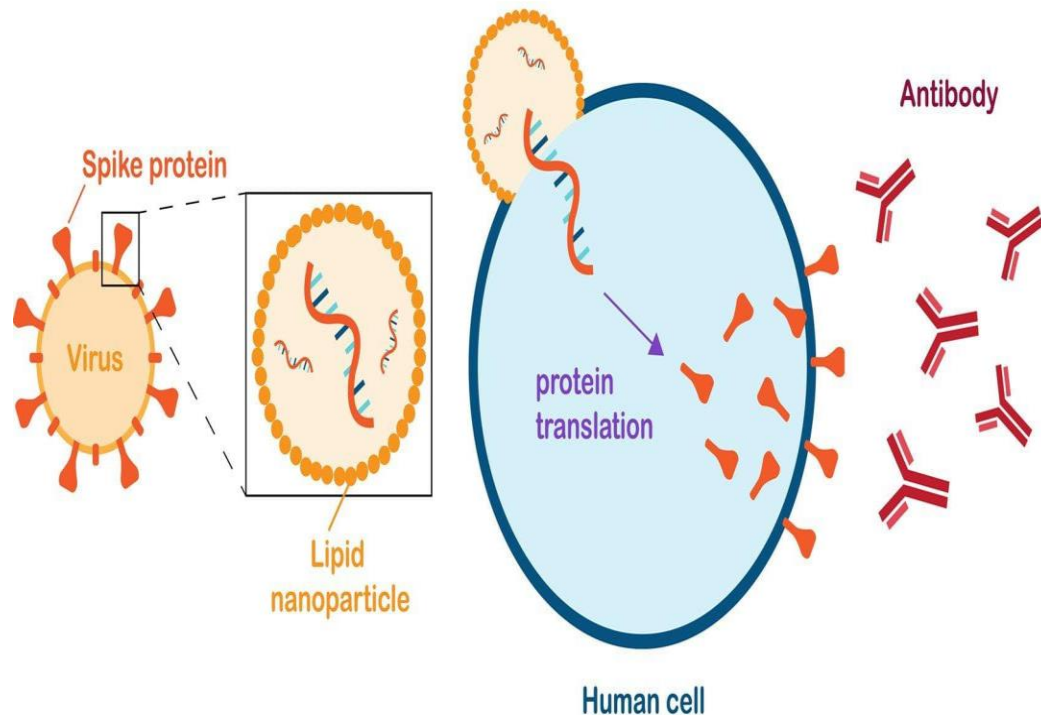
Virus-like particle		Human papillomavirus	1986 (hepatitis B)
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## ○ Virus like-particle

- A relatively new and unique vaccination type. Created due to the historical difficulty of being able to grow certain viruses the laboratory.
  - *One of the reasons it took many years to develop an effective HPV vaccine.*
- Takes developed capsid proteins and alters them into an isolated particle.
- Most commonly used vaccines:
  - *HPV: Gardasil and Cervarix*

# Most Common Types of Vaccines

## Mechanism of mRNA Vaccine



### ○ mRNA

- Takes mRNA from a spike protein on a virus that is packaged into lipid nanoparticles, which functions as an adjuvant, and translated into proteins, which induces an immune response.
- The protein created in the translation process does not and cannot alter DNA and cannot cause a COVID-19 infection.
- Most commonly used vaccines:
  - *COVID-19 vaccines: Comirnaty and Spikevax*

# The Vaccine Life Cycle

safety at every phase

## GUIDE

### ACIP

ADVISORY COMMITTEE ON IMMUNIZATION PRACTICES

### BLA

BIOLOGICS LICENSE APPLICATION

### CDC

CENTERS FOR DISEASE CONTROL AND PREVENTION

### FDA

FOOD AND DRUG ADMINISTRATION

### IND

INVESTIGATIONAL NEW DRUG APPLICATION

## VACCINE DEVELOPMENT

safety is a priority during vaccine development + approval

safety continues with CDC + FDA safety monitoring

BASIC RESEARCH DISCOVERY PRE-CLINICAL STUDIES

IND SUBMITTED

PHASE 1 safety  
PHASE 2 effectiveness  
PHASE 3 safety + effectiveness

CLINICAL STUDIES / TRIALS

BLA SUBMITTED

FDA REVIEW

FDA APPROVAL OF 1 NEW VACCINE

ACIP REVIEW

ACIP RECOMMENDATION

POST-APPROVAL MONITORING + RESEARCH

PHASE 4  
safety monitoring for serious, unexpected adverse events

# The Vaccine Life Cycle - CDC

<https://www.cdc.gov/vaccines/basics/how-developed-approved.html>

# Phase 1: Research and Development

- Vaccine development often takes 10-15 years of laboratory research, usually at a company in private industry, but often involves collaboration with researchers at a university.
- Before a vaccine can be tested in people, researchers study its ability to cause an immune response in lab-grown cells or small animals, like mice.
  - This is called a pre-clinical trial.

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PHASE 1  
*safety*

PHASE 2  
*effectiveness*

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FDA REVIEW

PHASE 4

*safety monitoring for serious, unexpected adverse events*

POST-APPROVAL MONITORING + RESEARCH

safety continues with CDC + FDA safety monitoring

# The Vaccine Life Cycle - CDC

<https://www.cdc.gov/vaccines/basics/how-developed-approved.html>



# Phase 2: Clinical Trials

- Researchers submit an Investigational New Drug (IND) application to FDA to get approval for clinical trials in humans.
- Clinical trials are split into three phases:
  - Phase 1: Testing in a group of 20 – 80 adults.
  - Phase 2: Randomized controlled trials with several hundreds of people.
  - Phase 3: Randomized trials with thousands to tens of thousands.
- Goal of clinical trials: evaluate strength of the immune response and identify any rare side effects.

# Clinical Trials cont.

- After a successful phase 3 clinical trial, a company submits a Biological License Application (BLA) that contains prescribing information to FDA.
- FDA reviews the BLA and clinical trial data to see if the vaccine is safe and effective.
- FDA also evaluates the company's proposed manufacturing process and ensures everything is appropriate for large-scale manufacturing.
- FDA requires manufacturers to submit data from these tests to support a successful manufacturing process, even after approval.



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safety at every phase

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# The Vaccine Life Cycle - CDC

<https://www.cdc.gov/vaccines/basics/how-developed-approved.html>

# Phase 3: Review

- Vaccines and Related Biological Products Advisory Committee (VRBPAC) is a committee of the FDA.
  - Made up of independent scientific and public health experts.
  - Review and evaluate data on safety and effectiveness of vaccines.
- The FDA will consider, but is not bound by, the input received from the VRBPAC when determining whether to approve a vaccine.
- Once FDA approval is given, the vaccine can be distributed.

# ACIP

- After FDA approval, the vaccine can go to the Advisory Committee on Immunization Practices (ACIP) to develop recommendations for use of a vaccine in the United States.
  - Committee of the CDC
  - ACIP considers:
    - How efficacious the vaccine is and for what ages.
    - How serious the vaccine-preventable disease is.
    - How many would get the disease if there was no vaccine.

# Review cont.

- After ACIP recommends a vaccine, the CDC Director will decide whether to approve the recommendation.
- Once the CDC Director approves the recommendation, it becomes the official CDC public health guidance for safe vaccine use in the US and added to the immunization schedule.

# The Vaccine Life Cycle

safety at every phase

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safety

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# The Vaccine Life Cycle - CDC

<https://www.cdc.gov/vaccines/basics/how-developed-approved.html>

# Phase 4: Safety Monitoring

- The US has very robust and highly sensitive vaccine safety monitoring systems.
- **Vaccine Adverse Event Reporting System (VAERS)**
  - Anyone can [report suspected vaccine reactions](#)
    - Sometimes lead to being misused to sow misinformation.
  - VAERS will follow-up for more information or guidance.
- **Vaccine Safety Datalink (VSD)**
  - Uses electronic health record data from member sites to assess vaccine safety and detect adverse events in near-real time.

# Vaccine Monitoring Systems cont.

- **Clinical Immunization Safety Assessment (CISA)**
  - Provides consultations for providers with complex vaccine safety questions about individual patients residing in the United States.
  - Conducts vaccine safety research and contributes to emergency response activities.
- **V-Safe**
  - Patient-focused vaccine safety monitoring system where patients enroll voluntarily. V-SAFE first launched in December 2020.
  - Currently monitors:
    - COVID-19 (Pfizer-BioNTech, Moderna, Novavax)
    - RSV (ABRYSCO by Pfizer, mRESVIA by Moderna, AREXVY by GSK)

# Adolescent Immunization Action Week

April 7 – 11





# Vaccines for Adolescents

Vaccines for adolescents and young adults:

- **Meningococcal (MenACWY):** First dose at age 11, second dose at age 16
- **Meningococcal (MenB):** First dose age 16-17, second dose 6 months later
- **TDaP:** Booster dose at age 10 or 11. ( Booster at age 21)
- **HPV:** 9-14 year olds: 2 doses, 6 months apart
  - 15 and older: 3 doses, 0, 1-2, and 6 month schedule
- **COVID-19:** One dose every year
- **Flu:** One dose every year
- *Countless catch-up vaccines (IPV, PCV23, Hep A, etc.)*



# Encouraging Autonomy

- During appointments, take time to encourage adolescents and young adults to ask questions and be confident about vaccination
  - Acknowledge fears regarding vaccination, pain, soreness, previous negative experiences
  - Ask where they get health information from and how they can find trusted sources
  - Don't be afraid to combat misinformation on social media ( TikTok, You tube, Instagram, etc.)
  - Rewards work for teens! (stickers, lollipops, advocate that family treats them to a snack)

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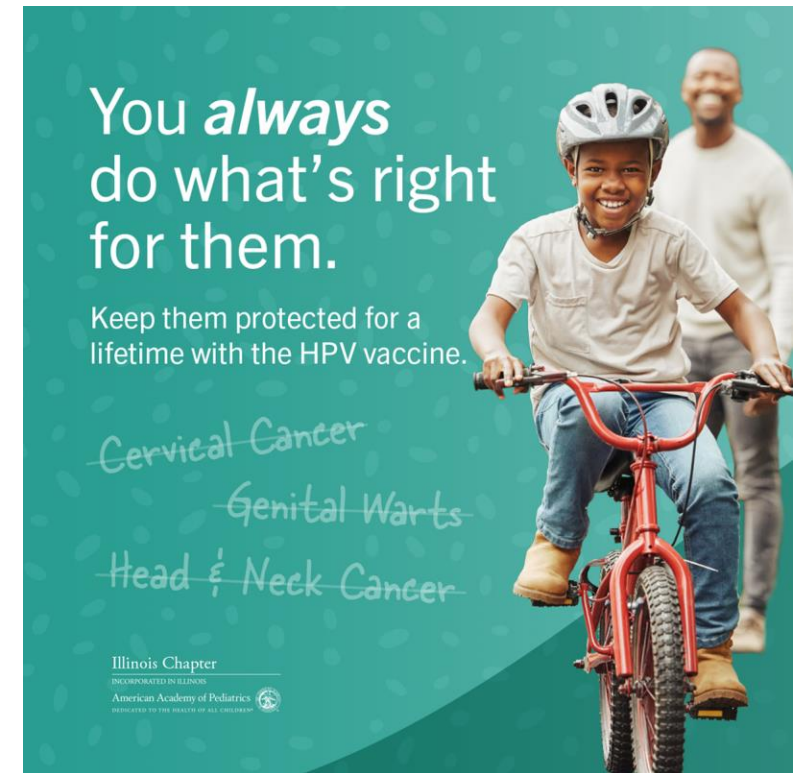
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# Questions?



# Teen-Specific Vaccination Resources

- [Tips & Tricks to Get Through the Needlestick \*English\* and \*Spanish\*](#)
- [ICAAP HPV Toolkit](#)
- [Tips for Talking with Your Parents/Guardians about Vaccines \*English\* and \*Spanish\*](#)
- [Child and Adolescent Immunization Schedule](#)
- [Tips for Teens - Talking with Your Parents or Guardians about Vaccines](#)
- [Anti-Vax to Pro-Vax Stories](#)
- [Conversation Simulator](#)
- [Answers to Questions about COVID-19 and Other Vaccines](#)
- [Illinois Minor Consent Laws](#)



# Check Out Our Social Media Toolkits!

ICAAP has several immunization social media toolkits that allow you to download images, copy and paste pre-written captions, and share on your social media pages.

Find the toolkits on our [respiratory virus, VFC](#), and [school resources](#) webpages.

We recommend you check out the [Vaccine Safety Toolkit](#) now!

Share quick and helpful information about the benefits of the flu vaccine, co-administration, signs and symptoms of RSV, ways to limit the spread of germs, tips for taking care of sick children, Nirsevimumab, and more! Simply post the graphic or personalize it by writing your own caption.





# Upcoming ICAAP Immunization Events

- **CDPH & IDPH In-Person VFC Trainings** – *limited seating!*
  - March - September
- **Immunizations Webinar: A Roadmap for Vaccine Advocacy and Policy**
  - Wednesday, April 16 from 12-1PM
- **Summer Travel Immunizations**
  - Wednesday, May 21 from 12-1pm



[illinoisAAP.org/events](https://illinoisAAP.org/events)



5.5 hours of CME

**Register Now!**

# Join Us for Our In-Person Pediatric Mental Health Conference

**Ideal for:**

Pediatricians - Family Physicians - Nurses - Allied Health Professionals  
and Professionals Providing Pediatric Mental Health Care

**May 15, 2025**

**Champaign, IL**

LEARN MORE & REGISTER HERE



The Illinois Chapter, American Academy of Pediatrics is accredited by the Illinois State Medical Society (ISMS) to provide continuing medical education for physicians. The Illinois Chapter, American Academy of Pediatrics designates this live conference for a maximum of 5.5 AMA PRA Category 1 Credit(s). Physicians should claim only the credit commensurate with the extent of their participation in the activity. Nurses, Nurse Practitioners, and Medical Assistants can submit Certificates of Attendance to their accrediting board to claim credit for participation in the live conference.