Why do vaccine-preventable disease outbreaks (still) occur in the US?

USA TODAY

Texas measles outbreak linked to church

Liz Szabo, USA TODAY 6:32 p.m. EDT August 25, 2013

CNN Health

10 infants dead in California whooping cough outbreak

From Miriam Falco, CNN
October 20, 2010 10:10 p.m. EDT

NBC NEWS HEALTH

CDC: Whooping cough epidemic worst in 50 years

Maggie Fox, Senior Writer, NBC News

July 19, 2012 at 1:32 PM ET

Los Angeles Times

In 2011, U.S. logged the most measles cases it's had in 15 years

Two Main Epidemiological Concepts

- ***Reproduction number*** - R_0 ("R naught")
- ***Community immunity***
  - = "herd" immunity
  - = population immunity

Reproduction number

- The (average) number of secondary cases resulting from an infected person in a completely susceptible population.
- Influenced by
  - Transmissibility of the pathogen
  - Probability of infection resulting from a contact
  - Duration of infectious period
- Other factors in disease spread
  - Proportion of susceptibles
  - Duration of immunity
  - Population dynamics
  - Pattern(s) of mixing of individuals

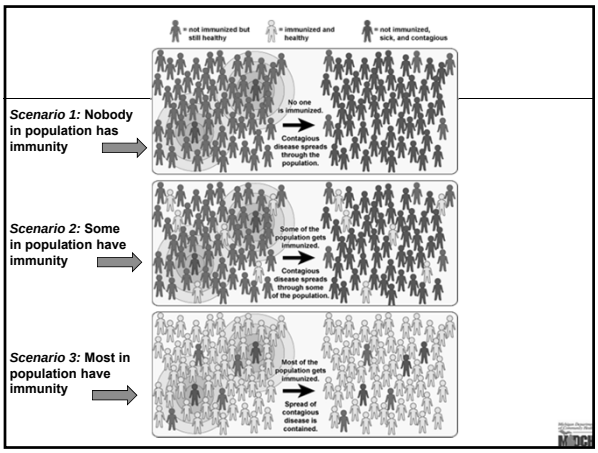
Values of R_0 of well-known infectious diseases

Disease	Transmission	R_0
Measles	Airborne	12–18
Pertussis	Airborne droplet	12–17
Diphtheria	Saliva	6–7
Smallpox	Social contact	5–7
Polio	Fecal-oral route	5–7
Rubella	Airborne droplet	5–7
Mumps	Airborne droplet	4–7
HIV/AIDS	Sexual contact	2–5
SARS	Airborne droplet	2–5
Influenza (1918 pandemic strain)	Airborne droplet	2–3

Herd immunity

- Protection provided to non-immune individuals when a significant % of the population have immunity
- "Herd" immunity implies
  - Disease risk reduced for susceptible persons by the presence & proximity of immune individuals *("indirect protection")*
  - Achieving threshold proportion of immunity should lead to decline in disease

These slides were presented at the MDCH Fall Regional Immunization Conference on Nov. 22, 2013, in Troy, Michigan . This information is valid as of 11/22/13.



Recent examples of herd immunity

Los Angeles Times | SCIENCE

SCIENCE NOW DISPATCHES FROM FRONT LINES OF SCIENCE, MEDICINE, HEALTH AND THE ENVIRONMENT

Rotavirus vaccine for infants protects others too, CDC study says By Karen Kaplan August 27, 2013 | 4:07 p.m.

UPI.com OVER 100 YEARS OF JOURNALISTIC EXCELLENCE

Health News

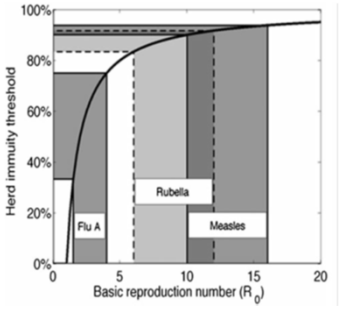
Pneumonia vaccine for children also protects older adults

Published: Aug. 27, 2013 at 1:56

NASHVILLE, Aug. 27 (UPI) -

Relationship between R_0 and threshold concept of herd immunity

Threshold = $(R_0 - 1)/R_0$



After Fine et al. CID 2011:52 (7):911-916

Measles

Challenges:

- Highly communicable (airborne transmission)
- Contagious period > 1 week
- R_0 = 12 – 18
- Requires high threshold (high vx coverage)

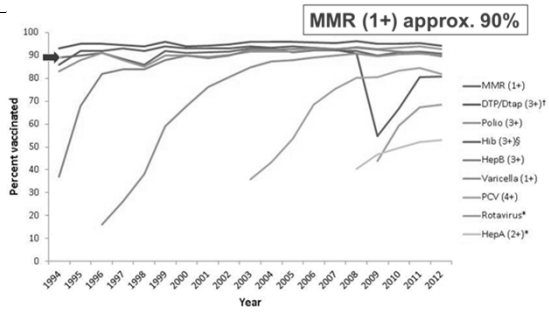
In our favor:

- Lifelong immunity following disease or immunization
- Measles vaccine highly efficacious
- Humans are sole reservoir

Pertussis

- Droplet/airborne transmission
- High R_0 : 12 -17
- Long contagious period (3 weeks)
- **Additional challenges:**
  - ✓Waning immunity
  - ✓Acellular vx (DTaP, Tdap) duration of immunity shorter than previous whole cell vaccine
  - ✓Vaccine effectiveness lower than desired (~ 80–85%)
  - ✓Endemic disease
  - ✓Broader clinical spectrum, many cases undiagnosed

Vaccine-specific coverage* among children 19-35 months, National Immunization Survey, 1994-2012



These slides were presented at the MDCH Fall Regional Immunization Conference on Nov. 22, 2013, in Troy, Michigan . This information is valid as of 11/22/13.

Kindergarten immunization coverage

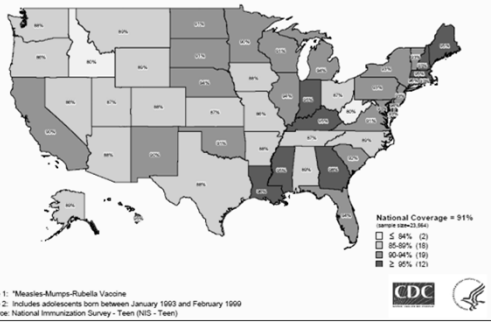
For the 2012–13 school year, national median vaccination coverage for **kindergarteners**:

- 94.5% for MMR vx
- 95.1% for DTaP vx
- 93.8% for Varicella vx

Source: *MMWR*, **August 2, 2013 / 62(30);607-612**

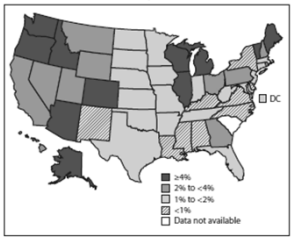
Coverage of 2 or More Doses of MMR*
Adolescents Aged 13-17 Years Old, 2011

National =91% 20 states < 90%



Waivers

FIGURE. Estimated percentage of children enrolled in kindergarten who have been exempted from receiving one or more vaccines* — United States, 2012–13 school year



* Exemptions might not reflect a child's vaccination status. Children with an exemption who did not receive any vaccines are indistinguishable from those who have an exemption but are up-to-date for one or more vaccines.

MMWR, **August 2, 2013 / 62(30);607-612**)

USA TODAY

Vaccine refusal linked to California pertussis outbreak

Michelle Healy, USA TODAY 6:45 a.m. EDT September 30, 2013

New evidence suggests that clusters of people who refused the whooping vaccine may have been one of the factors that contributed to California's 2010 whooping cough outbreak.

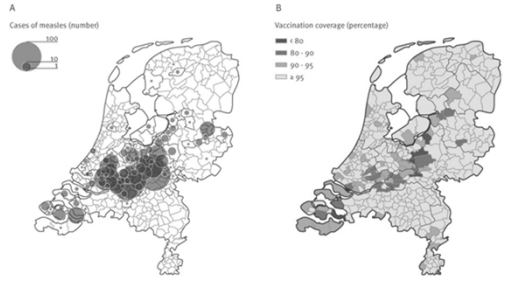
Nonmedical Vaccine Exemptions and Pertussis in California, 2010, Atwell et al, Pediatrics 2013;132:624–630

Measles outbreak, Netherlands, 2013 (May- present)

Most cases occurred in municipalities with MMR vaccination coverage below 90%

FIGURE 3

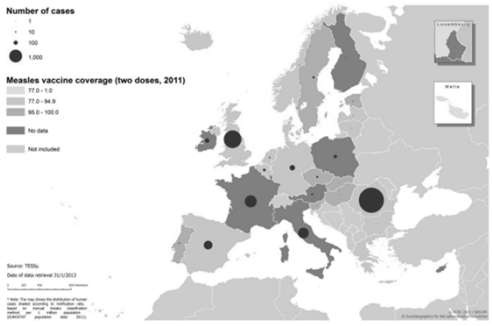
Reported measles cases by municipality, 1 May–28 August 2013 (panel A, n=1,226) and vaccination coverage of first MMR vaccine dose by municipality* for birth cohort 2010 at the age of two years (panel B, n=184,230), the Netherlands



Euro Surveill. 2013;18(36):pii=20580

Reported measles, Europe 2012

Figure 4. Number of measles cases by country, January – December 2012, EU/EEA countries (n=8 230), and two-dose measles vaccine coverage* (2011 CISID), EU/EEA countries



source: European Centre for Disease Prevention and Control/TESSy

These slides were presented at the MDCH Fall Regional Immunization Conference on Nov. 22, 2013, in Troy, Michigan . This information is valid as of 11/22/13.

Measles, US, 2013, as of August 24

(CDC, *MMWR Vol. 62 / No. 36*, September 13, 2013)

FIGURE 2. Number of measles cases (N = 159), by state — United States, 2013*

* As of August 24, 2013.
† Includes New York City.

Imperfect immunity issues

- No vaccine (no medication) is 100% effective
- % vx coverage ≠ % immune
  - Vaccines can fail
  - Problems in storage, handling, administration
  - Some immune systems fail
- Emphasizes need for highest possible coverage
- "Even vaccinated people might not be protected if vaccination rates aren't high enough"
  - Paul Offit MD, ***Deadly Choices – How the Anti-Vaccine Movement Threatens Us All***, p. xvii

Mumps example

- Mumps vaccine effectiveness (2 dose) ~ 88%
- Threshold for herd immunity ~ 85%
- If population has 90% vaccination coverage:
  - actual immunity level is 79.2% (.88 X .90 = .792)
  - below threshold
  - outbreaks possible

Summary

- Despite great progress, VPDs can occur
- 2 important concepts in understanding why:
  - Pathogen Reproduction Number (R_0)
  - Community/Herd Immunity
- Leveraging Herd Immunity can help overcome limits of biologic immunity to protect a community from outbreaks
- Individual vaccination decisions may fail to factor community benefit

References, further reading

- ***Why Do VPD Outbreaks Occur in the US*** (JD Cherry, KH Harriman) - Infectious Disease Special Edition 2012

  http://www.idse.net/download/VPD_IDSE12_WM.pdf

- ***"Herd Immunity": A Rough Guide*** (P. Fine, K Eamse, D.L. Heymann) – VACCINES, Clinical Infectious Diseases 2011;52(7):911–916

  http://cid.oxfordjournals.org/content/52/7/911.full.pdf

- ***Deadly Choices – How the Anti-Vaccine Movement Threatens Us All*** Paul Offit, MD Basic Books, 2010

These slides were presented at the MDCH Fall Regional Immunization Conference on Nov. 22, 2013, in Troy, Michigan . This information is valid as of 11/22/13.