Ebola and Influenza — Perception & reality

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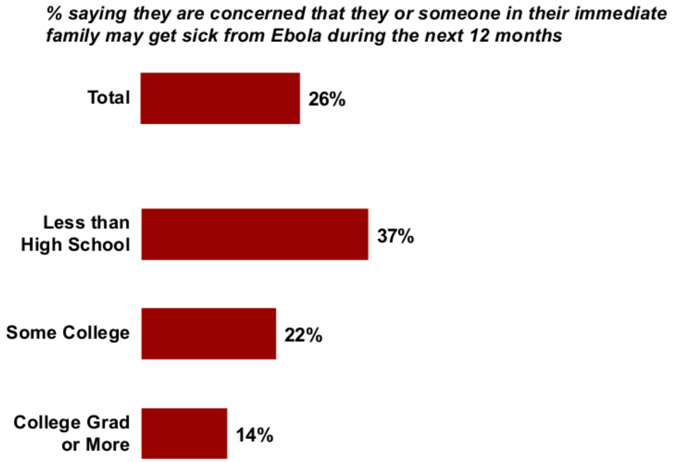
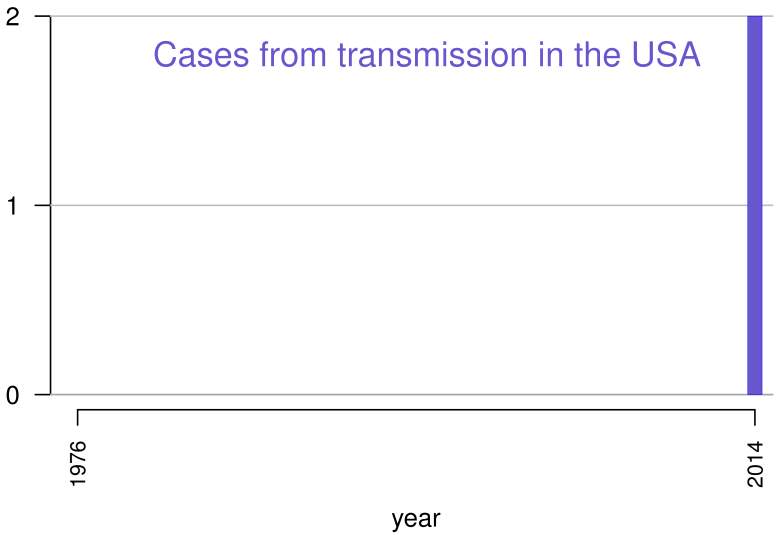
Public Concern About Getting Sick from Ebola by Level of Education

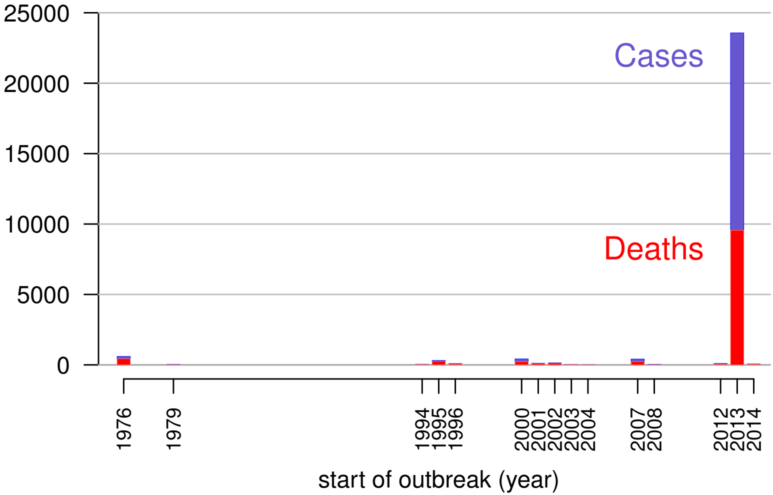


Harvard School of Public Health/SSRS, Ebola poll, August 13-17, 2014

Ebola cases the United States

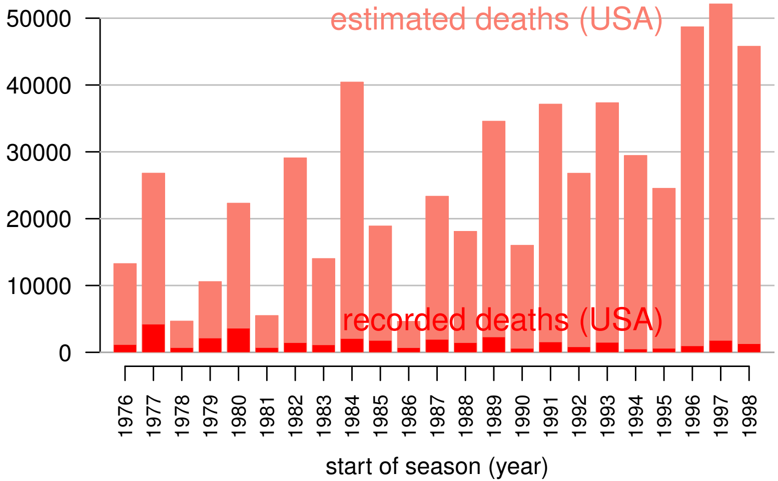


Ebola outbreaks since 1976



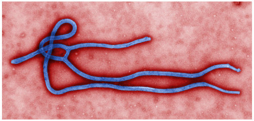
data from http://en.wikipedia.org/wiki/List_of_Ebola_outbreaks, downloaded Feb 24, 2015

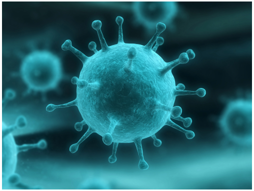
Influenza deaths in the United States



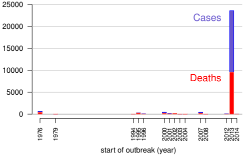
Data from: Doshi. Trends in Recorded Influenza Mortality: United States, 1900–2004. Am J Public Health. 2008 May;98(5):939-45

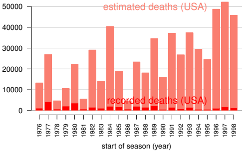
Ebola vs influenza





	Ebola	**Influenza**
transmission route	blood, feces, vomit	airborne
transmissibility	high (in some settings)	moderate
case fatality	50–70%	0.001–2%
annual cases	hundreds	hundreds of millions?





annual deaths	tens	hundreds of thousands?

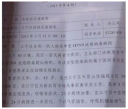
How do we count cases?

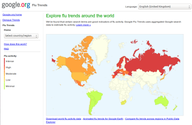
Active

Door-to-door or telephone surveys, contact tracing

(Can be) accurate, expensive

Passive



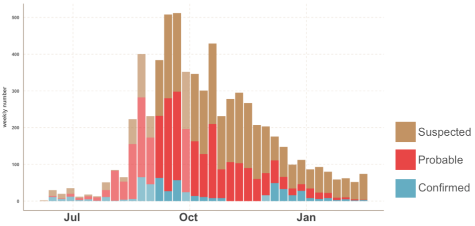


Hospital and death records, internet search, medical-related purchase histories

Can miss mild cases, hard to extrapolate

Surveillance systems combine active and passive approaches to measure populations.

How do we count *ebola* cases?



Ebola cases in Liberia. London School of Hygiene & Tropical Medicine. http://ntncmch.github.io/ebola/liberia_sitrep.html

- Hospitals and clinics (should) report how many seek care for ebola.
- But not everyone seeks care at medical facilities.
- Underreporting may be as high as 50% in the current ebola epidemic.
  - Estimating the number of cases may require comparing different data sources (hospitalization vs death reports), active surveillance in remote communities, and/or mathematical modeling.

Since ebola symptoms are severe, it is easier to count cases.

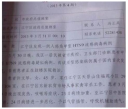
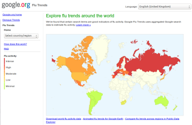
How do we count *influenza* cases?

Active


Door-to-door or telephone surveys, contact tracing

(Can be) accurate, expensive

Passive

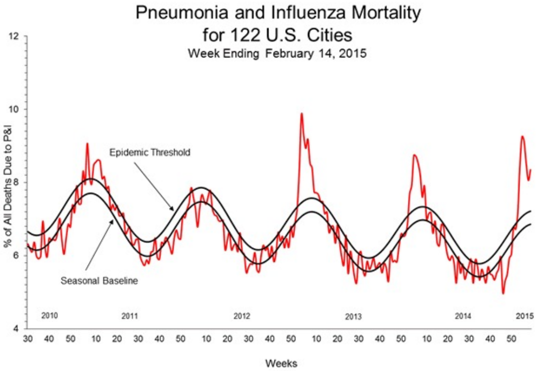



Hospital and death records, internet search, medical-related purchase histories

Can miss mild cases, hard to extrapolate

How good is this for influenza?

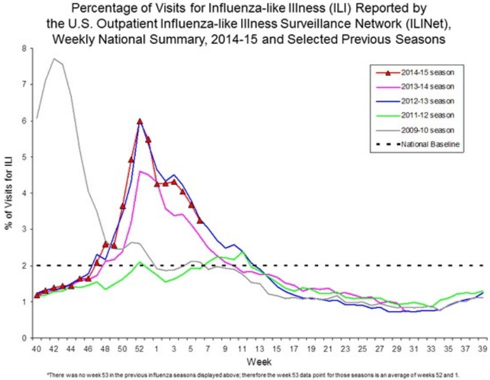
Influenza-related deaths



http://www.cdc.gov/flu/weekly

Monitor "excess" pneumonia and influenza deaths in a sample of hospitals. Elderly influenza cases have higher mortality than younger cases.

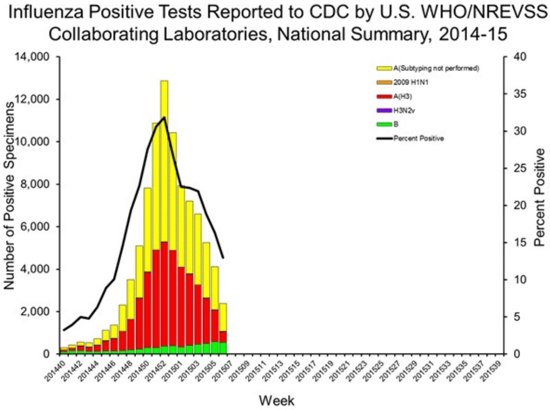
Influenza-like illness



http://www.cdc.gov/flu/weekly

ILI is defined as fever (temperature of 100°F [37.8°C] or greater) and a cough and/or a sore throat without a KNOWN cause other than influenza.

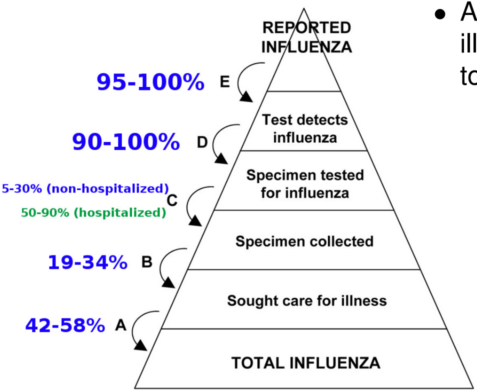
Confirmed influenza infections



http://www.cdc.gov/flu/weekly

Some influenza patient samples are tested in the lab.

How do we count *influenza* cases?

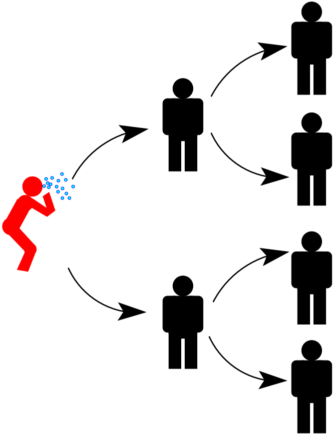


Reed, Angulo, Swerdlow, Lipsitch, Meltzer, Jernigan, Finelli. Estimates of the prevalence of pandemic (H1N1) 2009, United States, April–July 2009. Emerg Infect Dis. 2009 Dec;15(12):2004–7.

- As many as 140 influenza illnesses for every laboratory confirmed case.

Each level in the pyramid can introduce error and uncertainty.

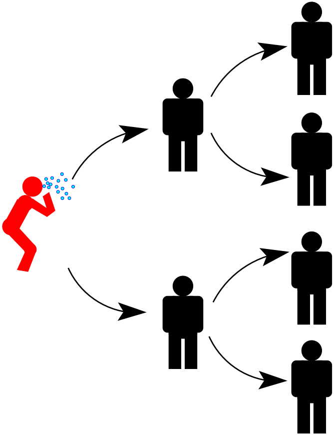
How transmissible are pathogens?



$R_0 = 2.0$

- R_0 is popular measure of transmissibility.
- R_0 is the number of people that a typical infected person infects in a fully susceptible population.

How transmissible are pathogens?

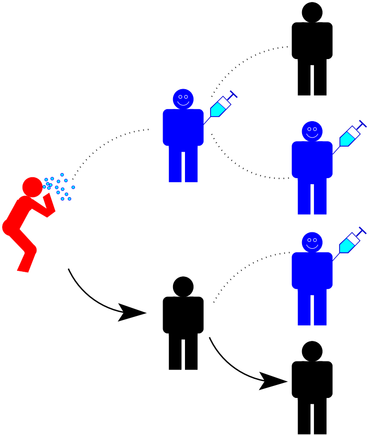


pathogen	R_0
Influenza	1.1–2.0
Ebola	1.7–2.0
SARS	2.7
Smallpox	3
Rubella	6–7
Measles	7–12

$R_0 = 2.0$

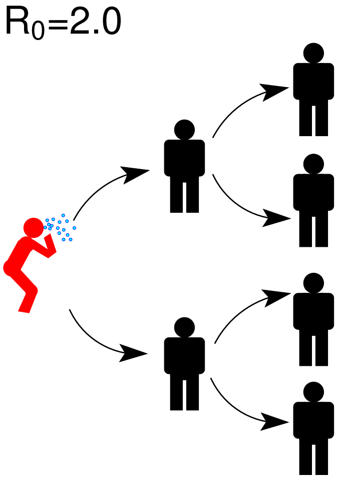
Disease can spread *exponentially*.

How does vaccination reduce transmission?



- **Individual-level benefit:** **Vaccination** reduces the chances of infection.
- **Population-level benefit:** **Vaccination** reduces the number of people a person can infect.
- If infected people infect less than **1** other on average (R_0<1), outbreaks will not occur.

How many people do we need to vaccinate?



pathogen	*R or R_0*
Influenza	1.1–2.0
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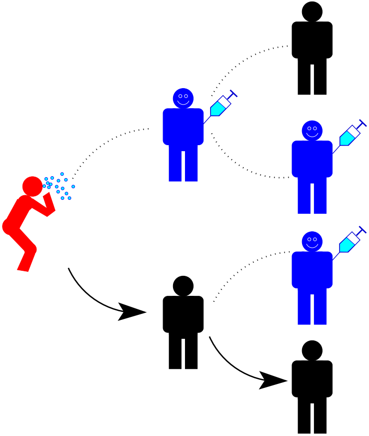
Measles	7–12

How many people do we need to vaccinate?

50% for R_0=2.0



(assuming a perfect vaccine)

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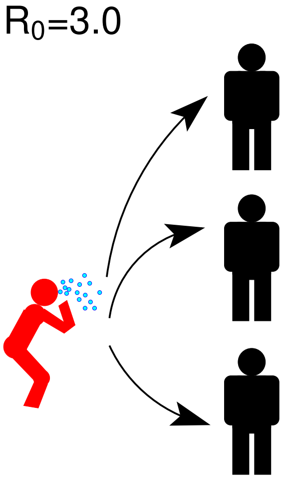

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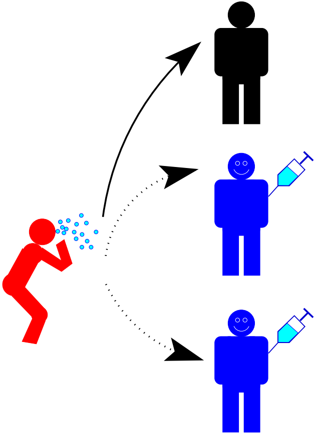
How many people do we need to vaccinate?

67% for R_0=3.0



(assuming a perfect vaccine)

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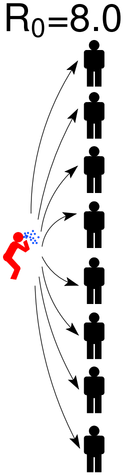
How many people do we need to vaccinate?



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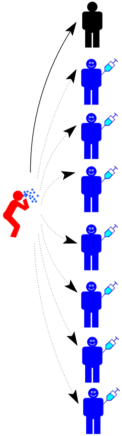
How many people do we need to vaccinate?

87.5% for R_0=8.0



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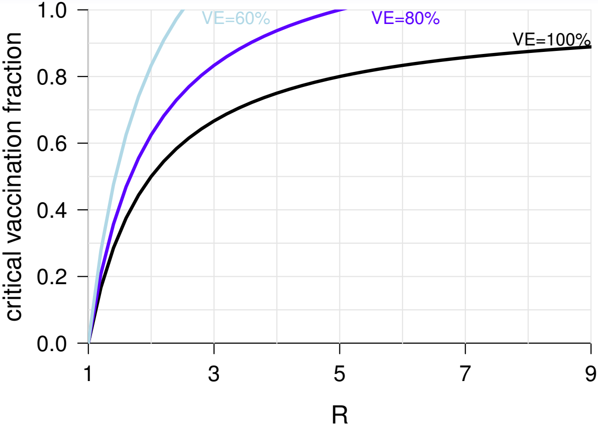
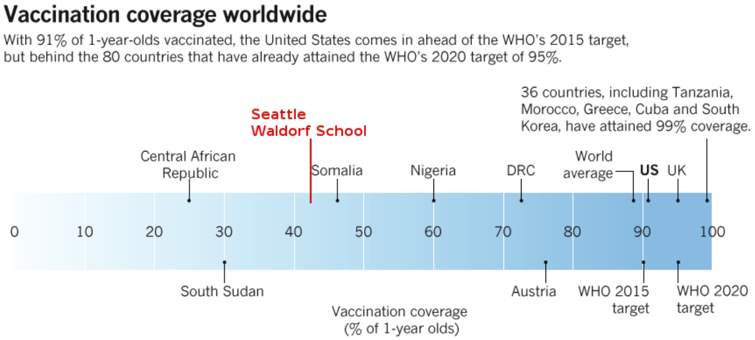
(assuming a perfect vaccine)

Critical vaccination fraction



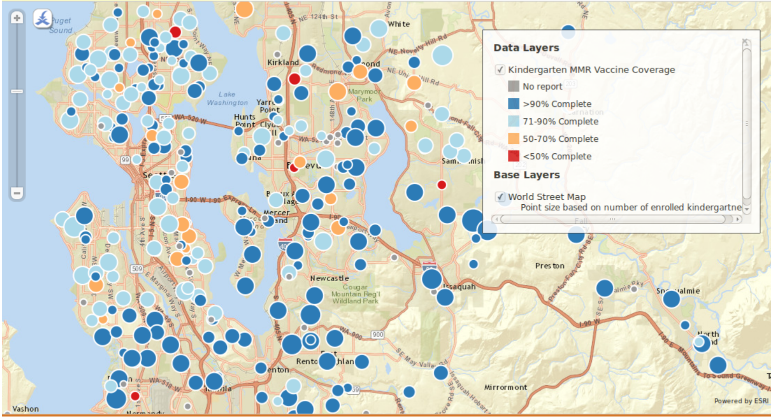
- The *critical vaccination fraction* is the proportion of the population that needs to be vaccinated to prevent outbreaks.
- Basically, vaccinate enough to drive R_0 below 1.
- The critical vaccination fraction depends on R_0 and the vaccine efficacy, VE: $\dfrac{1-1/R_0}{\mathrm{VE}}$

Measles vaccination coverage around the world



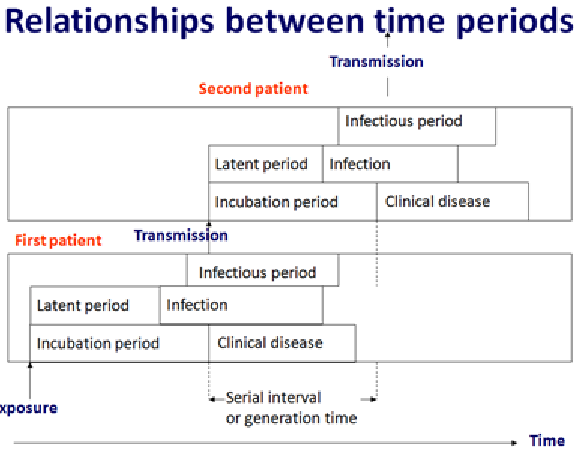
Measles by the numbers: A race to eradication. Nature 518:148–149. 2015. Annotation added by Dennis.

Local MMR vaccination coverage



https://data.kingcounty.gov/dataset/Kindergarten-MMR-Vaccine-Coverage/kbfa-mvcb

How long does it take to infect someone else?



Field Epidemiology Manual. https://wiki.ecdc.europa.eu/fem

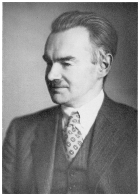
Transmissibility + speed can be used to model outbreaks

$$\boxed{S} \xrightarrow{\beta I} \boxed{I} \xrightarrow{\gamma} \boxed{R}$$

$$\frac{dS}{dt} = -\beta SI$$

$$\frac{dI}{dt} = \beta SI - \gamma I$$

$$\frac{dR}{dt} = \gamma I$$

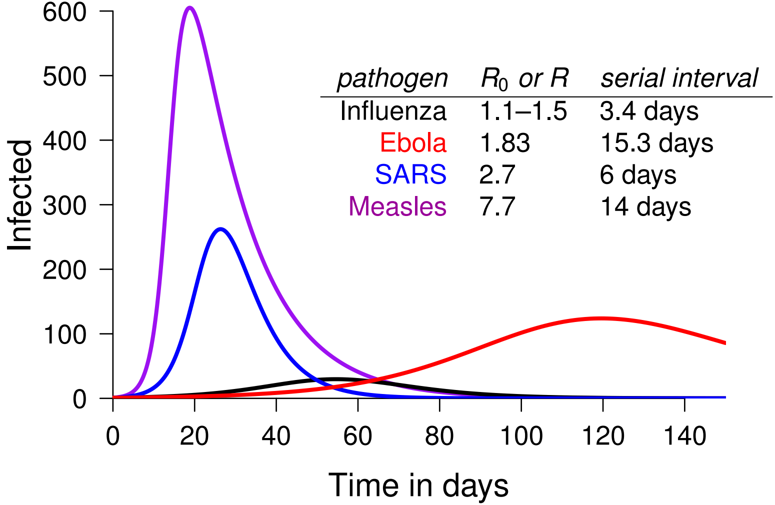


William Kermack
1898–1970

Anderson McKendrick
1876–1943

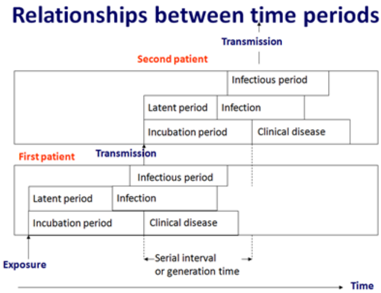
Calculus is often used to model epidemic dynamics.

Simple epidemic dynamics



Epidemic dynamics of a simple mathematical model.

What outbreaks are containable?



Field Epidemiology Manual. https://wiki.ecdc.europa.eu/fem

Influenza: Many asymptomatic but infectious cases. Short generation time.
Ebola: Cases are not very infectious until late. Longer generation time. Clinical disease is debilitating.
SARS: Most cases are symptomatic. Little transmission before symptoms appear.
Measles: Highly transmissible. Vaccination is very effective.
HIV: Highly infectious before symptoms appear.

Projecting the ebola epidemic with models


The New York Times

HEALTH

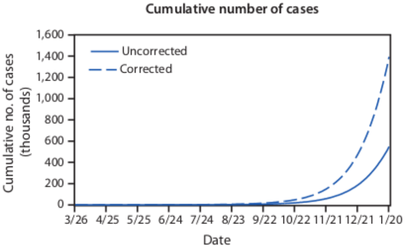
246 COMMENTS

Ebola Cases Could Reach 1.4 Million Within Four Months, C.D.C. Estimates

By DENISE GRADY SEPT. 23, 2014

A Red Cross team removed the body of a woman believed to have died of Ebola in Monrovia, Liberia, last week. Officials urge caution in handling victims' bodies. Daniel Berehulak for The New York Times

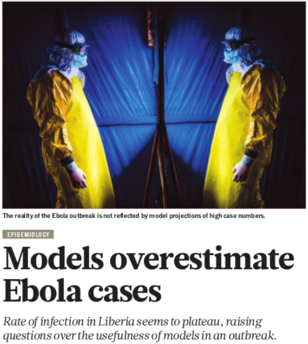
Ebola Cases Could Reach 1.4 Million Within Four Months, C.D.C. Estimates. New York Times. September 2014.



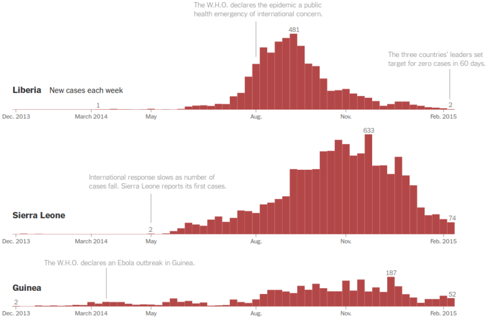
Meltzer, Atkins, Santibanez, Knust, Petersen, Ervin, Nichol, Damon, Washington. Estimating the Future Number of Cases in the Ebola Epidemic — Liberia and Sierra Leone, 2014–2015. *MMWR Surveill Summ* 63:1–14. 2014.

With initial R_0 and generation time estimates, one can forecast epidemic spread.

(Over-) estimating Ebola



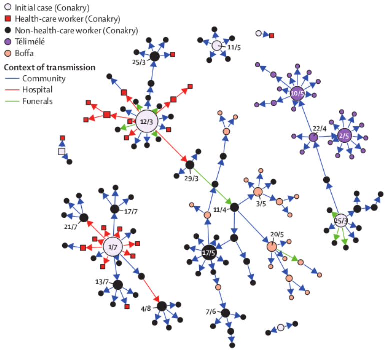
Models overestimate Ebola cases. November 2014.



Ending the Ebola Outbreak. New York Times. February 2015.

Projections may assume that the epidemic will maintain its initial course.

Ebola transmission in hospitals and funerals



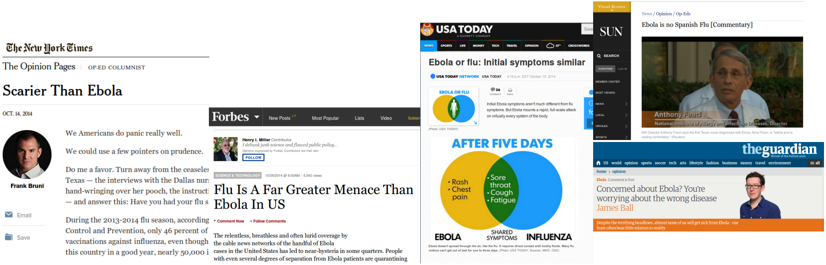
Faye, Boëlle, Heleze, Faye, Loucoubar, Magassouba, Soropogui, Keita, Gakou, Bah, Koivogui, Sall, Cauchemez. Chains of transmission and control of Ebola virus disease in Conakry, Guinea, in 2014: an observational study. Lancet Infect Dis. In press.

- "Ebola virus disease who were not health-care workers infected a mean of 2·3 people (95% CI 1.6–3.2): 1.4 (0.9–2.2) in the community, 0.4 (0.1–0.9) in hospitals, and 0.5 (0.2-1.0) at funerals."
- "After the implementation of infection control in April, the reproduction number in hospitals and at funerals reduced to lower than 0.1."
- "In the community, the reproduction number dropped by 50% for patients that were admitted to hospital, but remained unchanged for those that were not."

Behaviors change and authorities take action during large outbreaks.

Summary and conclusions

- Epidemiologists design surveillance systems to detect and quantify infectious disease transmission.
- Mathematical modelers use these data for projections and to estimate the impact of interventions.
- Early projections may be inaccurate, but can be useful. One should not extrapolate trends too far into the future.
- It is hard to predict behavioral responses to epidemics. Fear (or lack of fear) can have a large effect.
- Someone else needs to communicate infectious disease risk to policymakers and the general public.



The New York Times
The Opinion Pages | OP-ED COLUMNIST
Scarier Than Ebola
OCT. 14, 2014
Frank Bruni
We Americans do panic really well.
We could use a few pointers on prudence.
Do me a favor. Turn away from the ceaseles Texas — the interviews with the Dallas nur hand-wringing over her pooch, the instructi — and answer this: Have you had your flu s
During the 2013-2014 flu season, according Control and Prevention, only 46 percent of vaccinations against influenza, even though this country in a good year, nearly 50,000 i

Forbes
Henry I. Miller Contributor
Flu Is A Far Greater Menace Than Ebola In US
The relentless, breathless and often lurid coverage by the cable news networks of the handful of Ebola cases in the United States has led to near-hysteria in some quarters. People with even several degrees of separation from Ebola patients are quarantining

USA TODAY
Ebola or flu: Initial symptoms similar
Initial Ebola symptoms aren't much different from flu symptoms. But Ebola mounts a rapid, full-scale attack on virtually every system of the body.
AFTER FIVE DAYS
• Rash
• Chest pain
• Sore throat
• Cough
• Fatigue
EBOLA
SHARED SYMPTOMS
INFLUENZA

SUN
Ebola is no Spanish Flu [Commentary]
Anthony Fauci
National Institute of Allergy and Infectious Diseases, Director

theguardian
Concerned about Ebola? You're worrying about the wrong disease
James Ball
Despite the terrifying headlines, almost none of us will get sick from Ebola - our fears often bear little relation to reality

Thank you!

Boukan Kare, Haiti.
Photo by D. Chao

dchao@fredhutch.org

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