

Simple models for public health policy making

Martin Meltzer, Ph.D., MS

**Division of Preparedness and Emerging Infections
Centers for Disease Control and Prevention (CDC)**

qzm4@cdc.gov

The findings and conclusions in this presentation are those of the author and do not necessarily represent the views of the Centers for Disease Control and Prevention



Why use math models for planning public health?

- Model because lack of data

Some reasons to model

- Don't have sufficient epidemiological data
 - E.g., number of cases 20 years in future
- Intervention is not yet applied “in field”
 - E.g., vaccine not yet licensed

Math models

- Wide variety of types
- Wide variation in complexity
- Therefore wide variation in “usefulness”

What do policy makers want?

- **Answers**

- Often to meet/ agree with pre-defined opinions

- **Want “options”**

- Lots and lots of “what if”

- **Scenarios/ answers for “their” situation**

- **To compare/ understand answers to “intuition”**

- See point #1, above

What is NOT needed: A black box



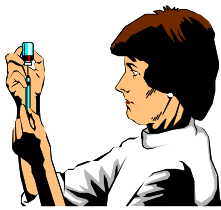
With apologies to Kubrick and Clarke

Remember

Simple \neq Simplistic

**The eye of the beholder is all important
– and you are not the beholder**

The costs and benefits of vaccinating against Lyme disease: A decision analysis



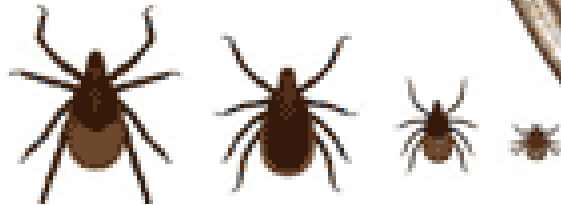
Meltzer ML, Dennis DT, Orlowski KA



Emerg Infect Dis, 1999;5:321-328



Black legged tick

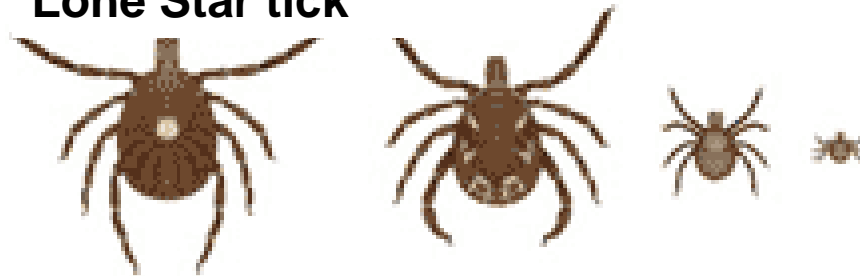


Adult
female

Adult
male

Nymph Larvae

Lone Star tick



Dog Tick





White footed mouse

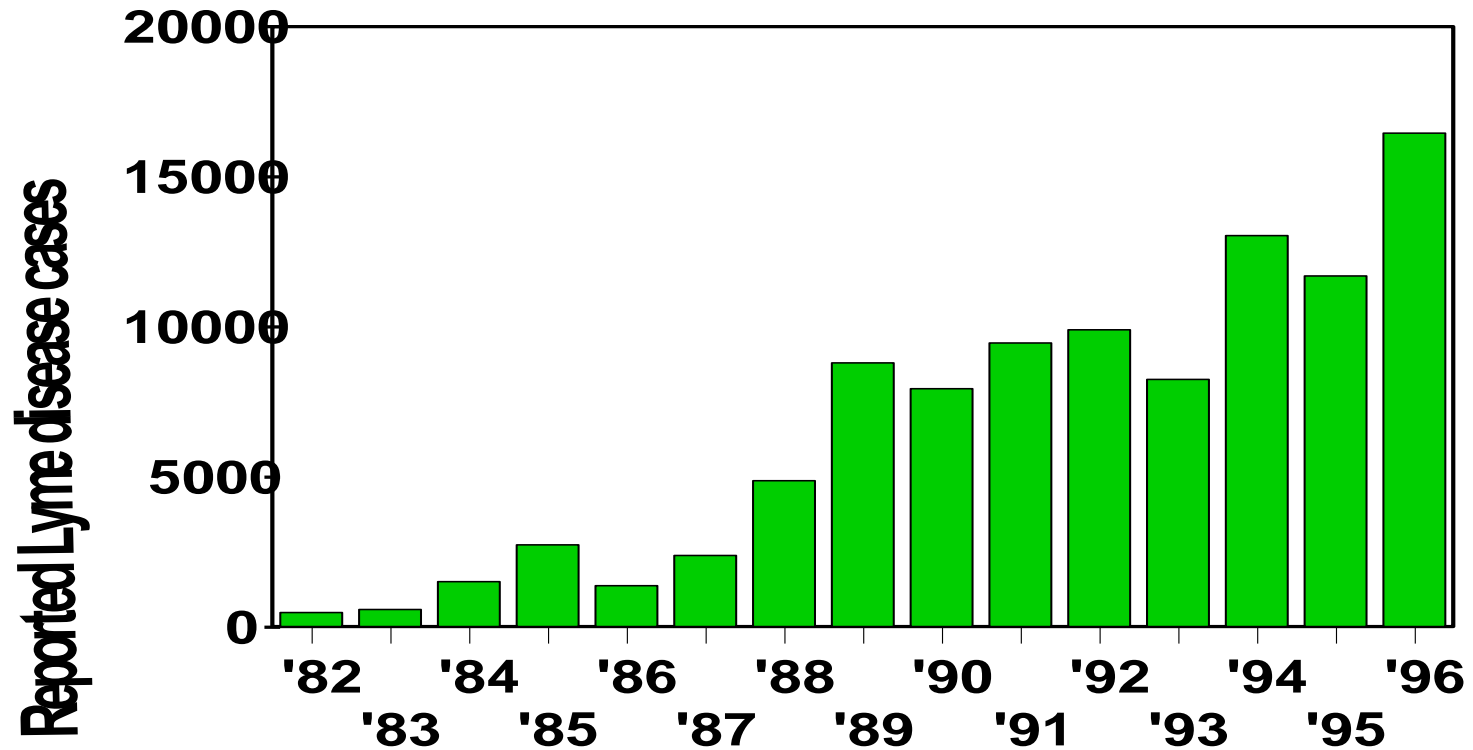


White tailed deer

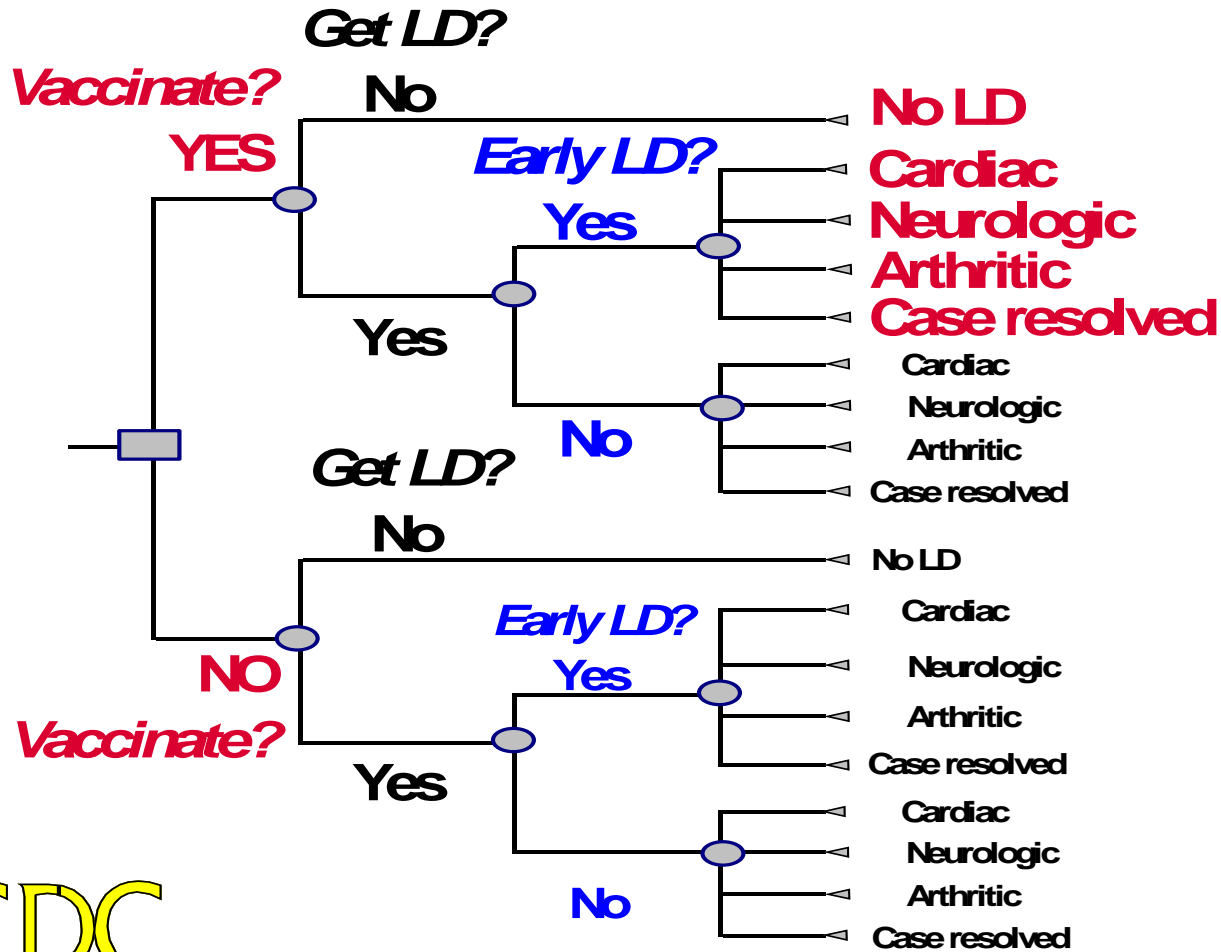
Natural hosts and reservoirs of *B. burgdoferi*



Reported Lyme disease cases: 1982-96



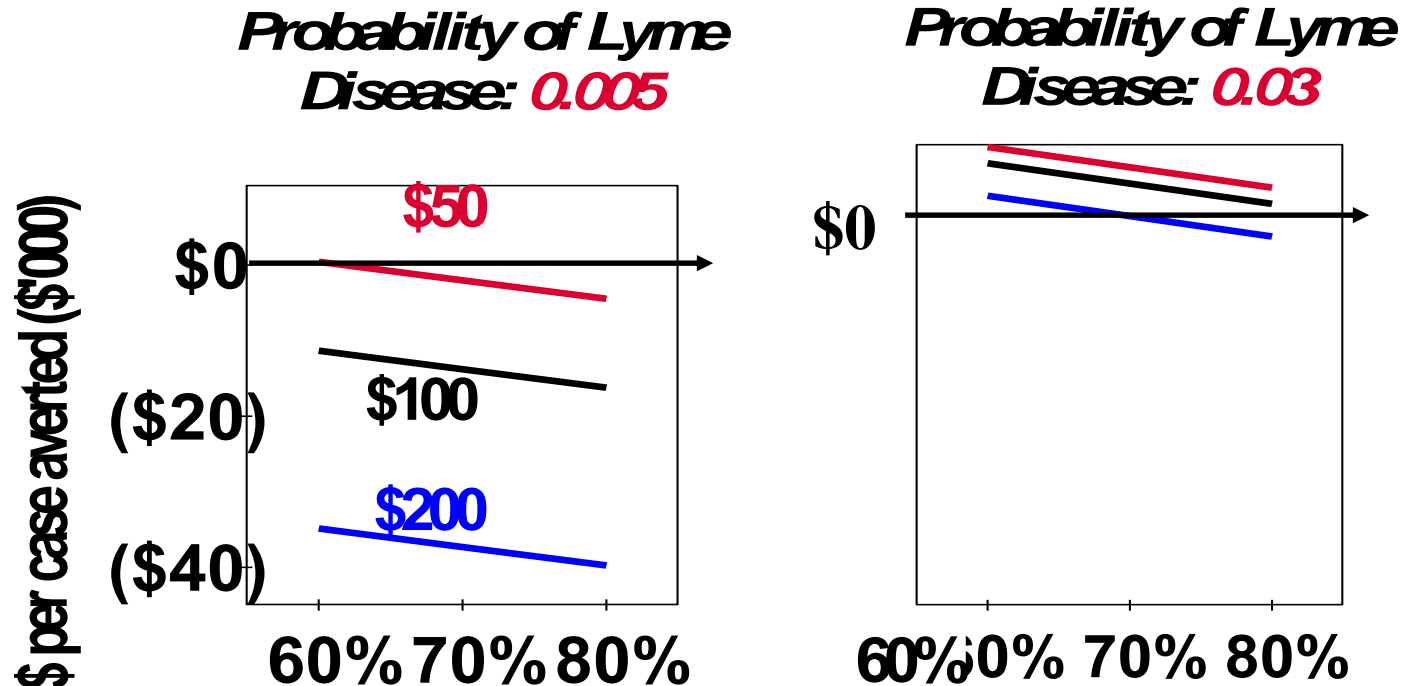
Health outcome



Monte Carlo analysis: Varying probabilities

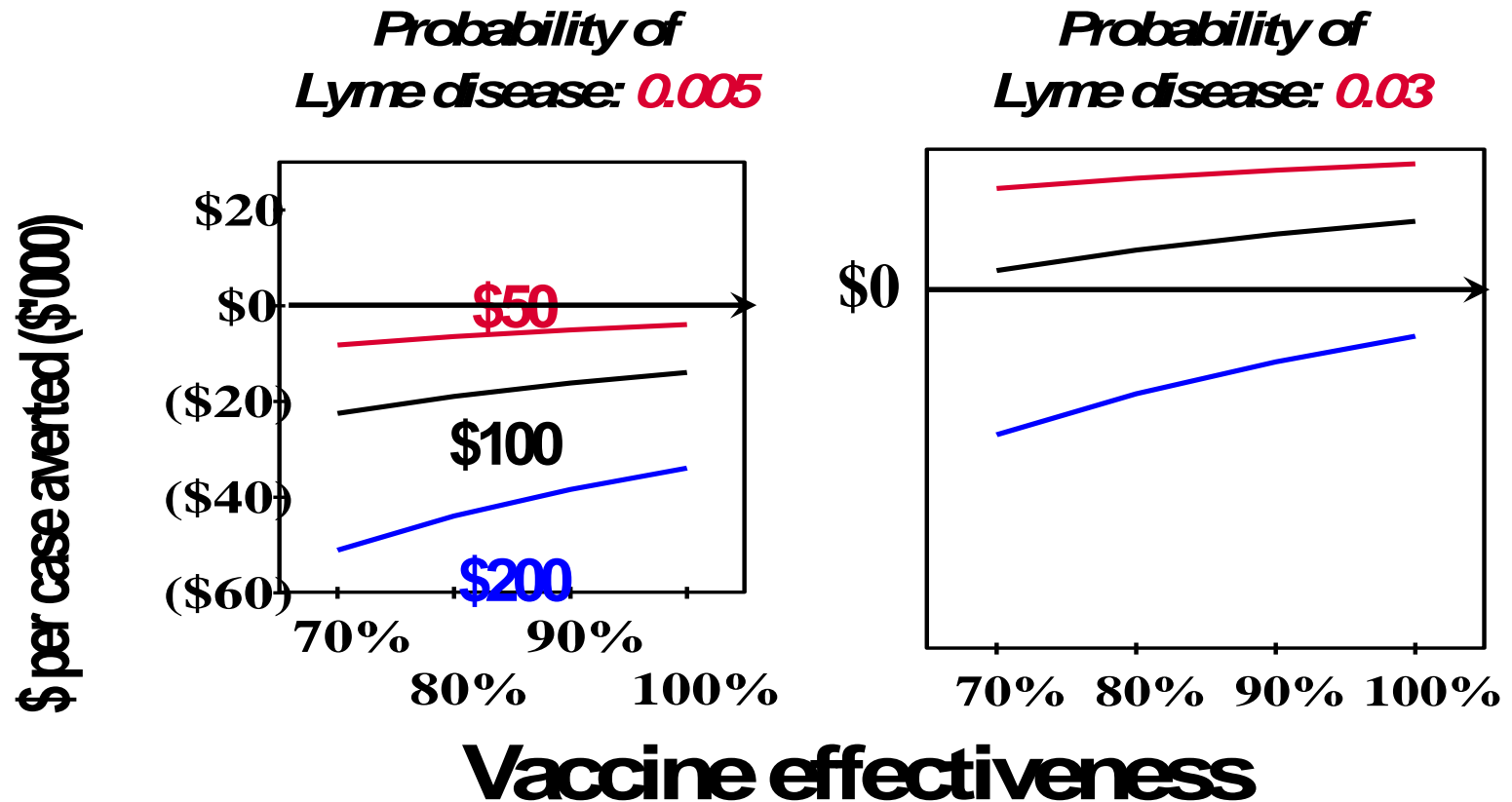
- ▶ **Probability of LD - 0.005, 0.01, 0.03**
- ▶ **Probability of diagnosing early LD - 0.6 - 0.9 (step: 0.1)**
- ▶ **3 cost scenarios**
- ▶ **Vary probability of sequelae**

Results: Cost effectiveness



Probability of early diagnosis and treatment of Lyme disease

Results: Vaccine effectiveness



Conclusions:

- **Public Health Policy Implications**

- ▶ **Value in targeting by risk of LD**

- ▶ **Value in increasing probability of early diagnosis of LD**

Really Simple Models to Assess Novel H1N1 Impact

Martin Meltzer, Ph.D., MS

**Division of Preparedness and Emerging Infections
Centers for Disease Control and Prevention (CDC)**

qzm4@cdc.gov



When will the next 'flu pandemic occur?

Time between start of pandemics

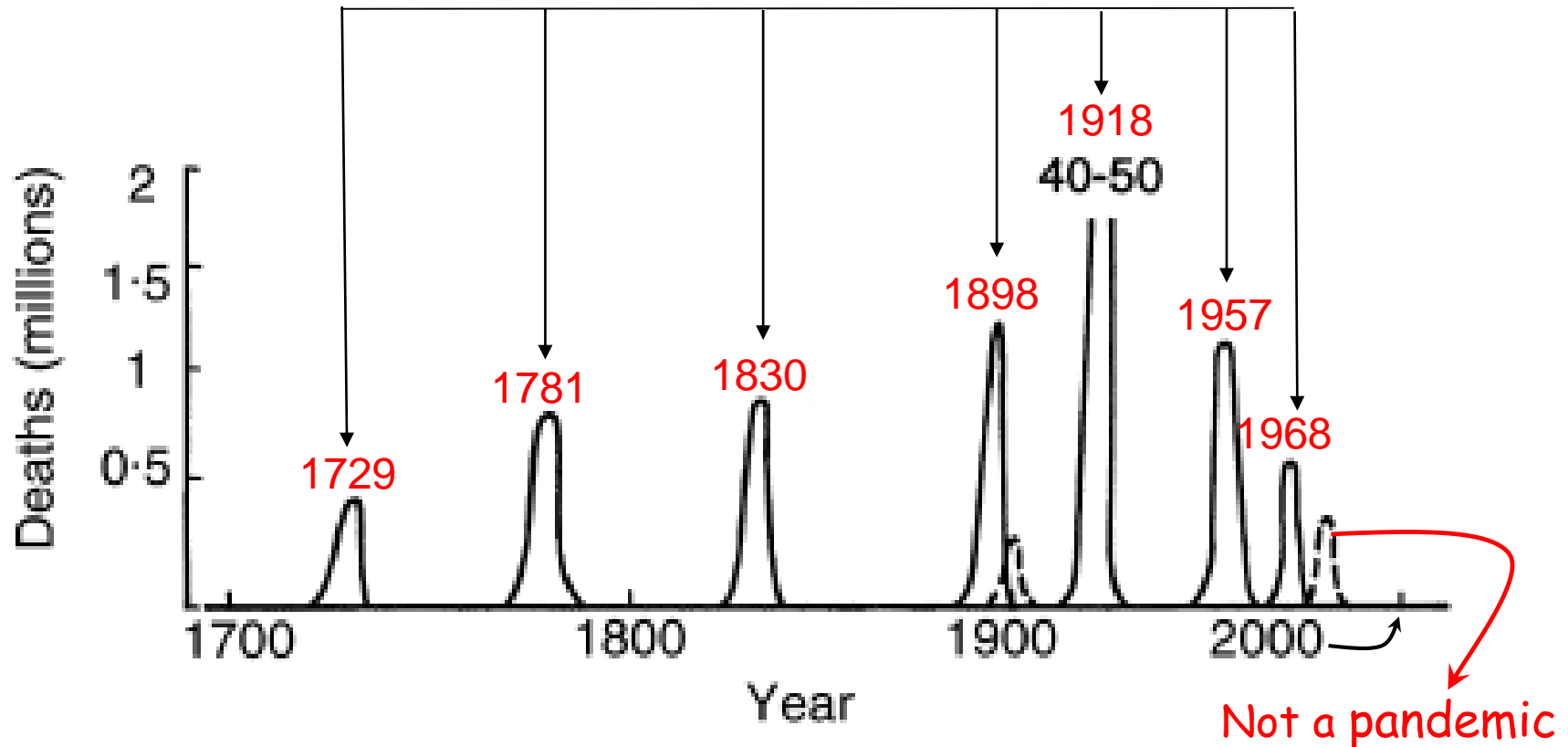


Fig. 2 History of influenza pandemics 1700–2000. Not to exact scale

Source: Potter; J Applied Microbiol. 2001;91:572-579

Pandemic influenza

- When will the next pandemic occur?
- How many deaths, hospitalizations, outpatients, and ill, self care?
- Economic and other impacts
- Implications for policy

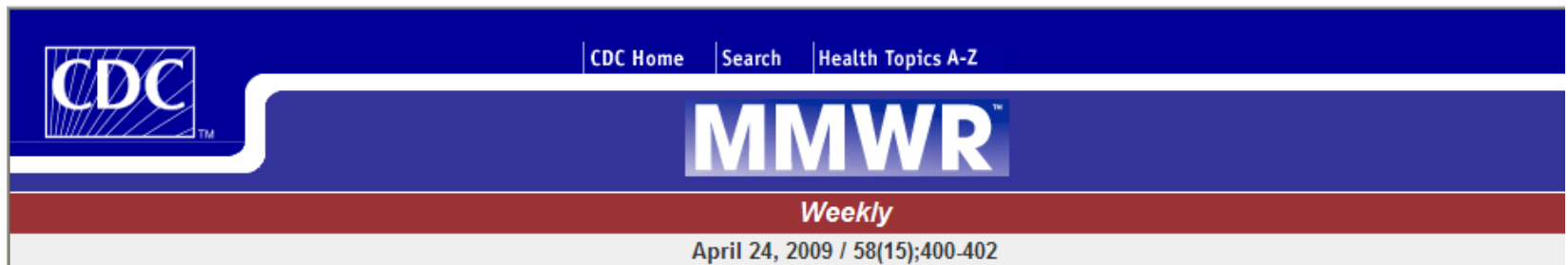
4 resources: free software

<https://www.cdc.gov/flu/pandemic-resources/tools/index.htm>

- **FluAid:** Calculate deaths, hospitalizations, outpatients
- **FluSurge:** demand hospital space
- **Instructions:** Calculate 1968 and 1918-type pandemics
- **FluWorkLoss:** calculate work days lost

Come the Pandemic: April 2009 – April 2010

- How did models help?
- What type of models helped best?



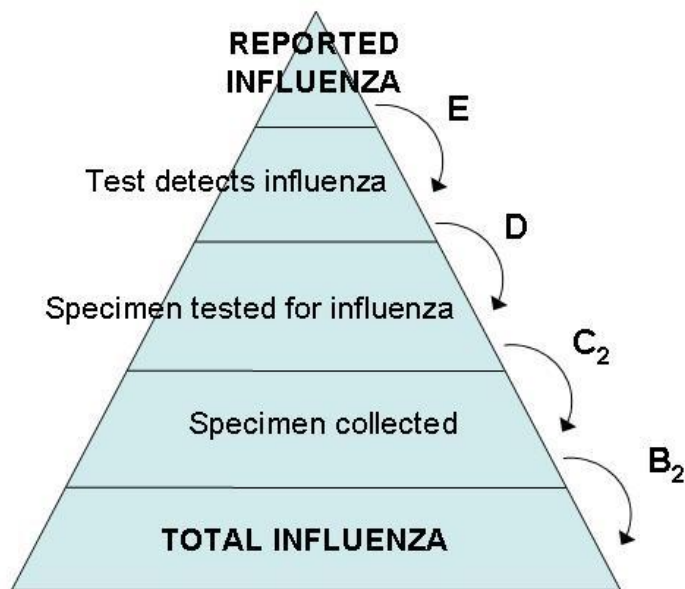
Swine Influenza A (H1N1) Infection in Two Children --- Southern California, March--April 2009

Why is it so difficult to measure impact and severity of 'flu?

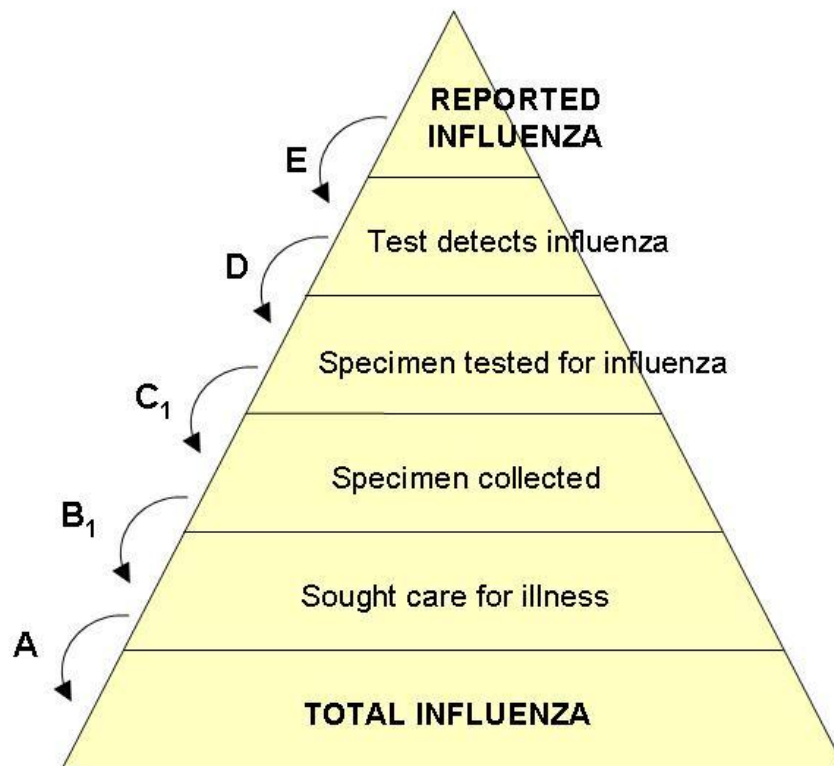
- **Diagnostic tests – slow and/ or inaccurate**
 - **During pandemic: widespread use of RT-PCR**
 - **Still takes time**
 - **Rapid “bedside” diagnostics - Not accurate**
- **Patients often come in after peak of viral load**
- **Doctors can often successfully treat empirically**
 - **No need for lab confirmed basis**
- **‘flu very similar symptoms to other respiratory diseases**
 - **Similar treatments**
- **Many patients stay home and self treat (approx. 50%)**

CDC model: Pyramid model

Hospitalized



Not Hospitalized



Source: Reed et al. Emerg Infect Dis, 2009

Near-real time estimates

ates of 2009 H1N1 Influenza Cases, Hospitalizations and Deaths in - Windows Internet Explorer

gov/h1n1flu/estimates/April_November_14.htm

Tools Help

mics Currency Calculator Free Translation Online T... lyrics - lyrics-songs.com The World Clock - Time Z... Types of Articles CDC EID vassarstats Statistical Com... Web Slice Gallery W Wikipedia

imates of 2009 H1...

CDC Home

 Centers for Disease Control and Prevention
CDC 24/7: Saving Lives. Protecting People.™

A-Z Index A B C D E F G H I J K L M N O P Q R S T U V W X Y Z #

H1N1 Flu

H1N1 Flu

CDC Response: A Year In Review

General Info

► **CDC Estimates of 2009 H1N1 Influenza Cases, Hospitalizations and Deaths in the United States, April – November 14, 2009**

Info for Specific Groups

Guidance

Vaccine

Treatment (Antivirals)

Diagnosis

Infection Control

Situation Update

Press Updates

Reports & Publications

Travel

Emergency Use Authorization

Tools

Audio & Video

Images

Related Links

> [H1N1 Flu](#) > [General Info](#) > [H1N1 Flu](#) > [General Info](#)

 Recommend  Tweet  Share

CDC Estimates of 2009 H1N1 Influenza Cases, Hospitalizations and Deaths in the United States, April – November 14, 2009

This website is archived for historical purposes and is no longer being maintained or updated. For updated information on the current flu season, see the [CDC Seasonal Flu website](#).

December 10, 2009, 1:00 PM ET

[April – October 17 Estimates](#)

Background

Estimating the number of individual flu cases in the United States is very challenging because many people with flu don't seek medical care and only a small number of those that do seek care are tested. More people who are hospitalized or die of flu-related causes are tested and reported, but under-reporting of hospitalizations and deaths occurs as well. For this reason CDC monitors influenza activity levels and trends and virus characteristics through a nationwide surveillance system and uses statistical modeling to estimate the burden of flu illness (including hospitalizations and deaths) in the United States.

When the 2009 H1N1 flu outbreak began in April 2009, CDC began tracking and reporting the number of laboratory-confirmed 2009

On this Page

- [Background](#)
- [The Numbers](#)
- [Table: CDC Cumulative Estimates of 2009 H1N1 Cases and Related Hospitalizations and Deaths from April-November 14, 2009](#)
- [Method to Estimate 2009 H1N1 Cases, Hospitalizations and Deaths](#)
- [Background Emerg...](#)

 Email page link

 Print page

 Subscribe to RSS

 Follow on Twitter

 Podcasts

View page in

[Español](#)

 Get email updates

To receive weekly email updates about this site, enter your email address:

[What's this?](#)

Contact Us:

 Centers for Disease Control and Prevention
1600 Clifton Rd
Atlanta, GA 30333

 800-CDC-INFO
(800-232-4636)
TTY: (888) 232-6348
24 Hours/Every Day

 cdcinfo@cdc.gov



Trusted sites | Protected Mod

Final estimates: pH1N1: U.S. (April 2009–April 2010)

	Total		Rate, per 100
	Median	90% Range	Median
Total deaths	~12,470	8,870 - 18,300	0.004
0-17 yrs	~1,280	910 - 1,880	0.002
18-64 yrs	~9,570	6,800 - 14,040	0.005
65+ yrs	~1,620	1,160 - 2,380	0.004
Total hospitalizations	~274,000	195,000 - 403,000	0.09
0-17 yrs	~87,000	62,000 - 28,000	0.12
18-64 yrs	~160,000	114,000 - 235,000	0.08
65+ yrs	~27,000	19,000 - 40,000	0.07
Total Cases	~61 million	43 - 89 million	19.9
0-17 yrs	~20 million	14 - 28 million	27.0
18-64 yrs	~35 million	25 - 52 million	18.2
65+ yrs	~6 million	4 - 9 million	15.2

Source: Shrestha et al CID; 2011:52 (S1): S75-S82



RESULTS: 2009 H1N1 to seasonal influenza

Age (years)	Numbers per 100,000 (ranges)			
	Deaths		Hospitalizations	
	Median pH1N1	Average 1990 to 1999	Median pH1N1	Average 1979 to 2001
0-17	1.6 (1.2 – 2.4)	0.2 (0.03 – 0.4)	109.2 (77.8 – 160.2)	15.8 (3.6 – 32.3)
18 to 64	4.7 (3.3 – 6.8)	0.4 (0.07 – 1.0)	78 (55.6 – 114.6)	20.8 (4.8 – 42.4)
≥65	3.8 (2.7 – 5.5)	22.1 (3.8 – 54.1)	63.2 (45.1 – 92.8)	282 (64.8 – 575.2)
All	3.8 (2.7 – 5.6)	3.1 (0.5 – 7.6)	83.8 (59.7 – 123.0)	52.4 (12.1 – 107.0)

Source: Shrestha et al CID; 2011:52 (S1): S75-S82

Emergency Preparedness and Response

[Recommend](#) [Tweet](#) [Share](#)

Language: English ▾



[More >](#)

Activations

- Ebola: 2014 West Africa Outbreak
- Polio Eradication

WEST AFRICA Ebola Outbreak

Ebola Virus Disease
Get the CDC's Latest Information

NATURAL DISASTERS

Wildfires, Floods, Hurricanes & more

RECENT INCIDENTS

Ebola, Chikungunya & more



CDC Emergency Operations Center

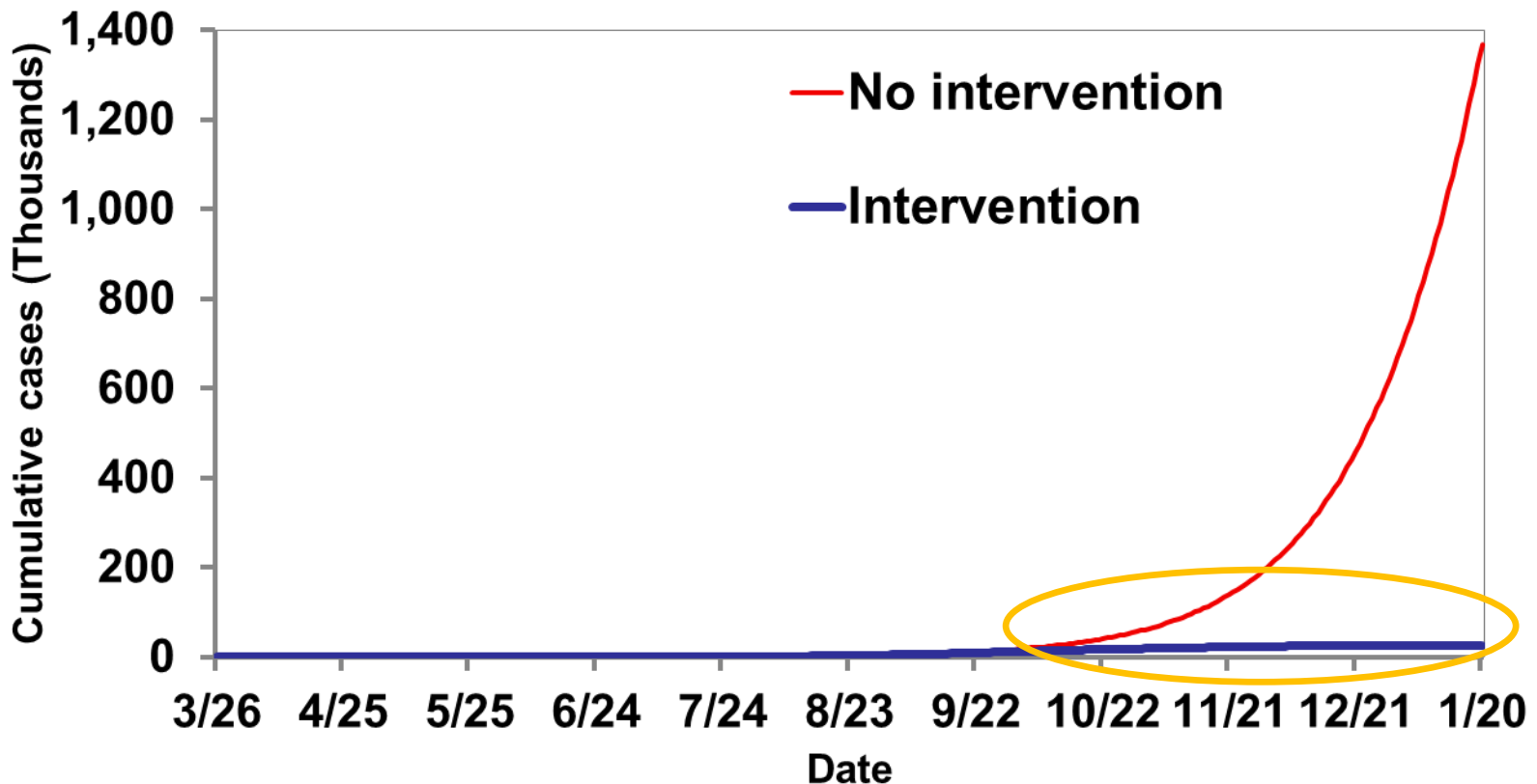
Photo by Spencer Lowell for TIME magazine

Initial Questions from Leadership Modeling Helps Inform

- ❑ **Forecasting: How many cases will there be at any point and in total (with frequent updates)?**
- ❑ **What would be the impact of interventions?**
- ❑ **When will the epidemic end?**
 - With an intervention
 - Without an intervention

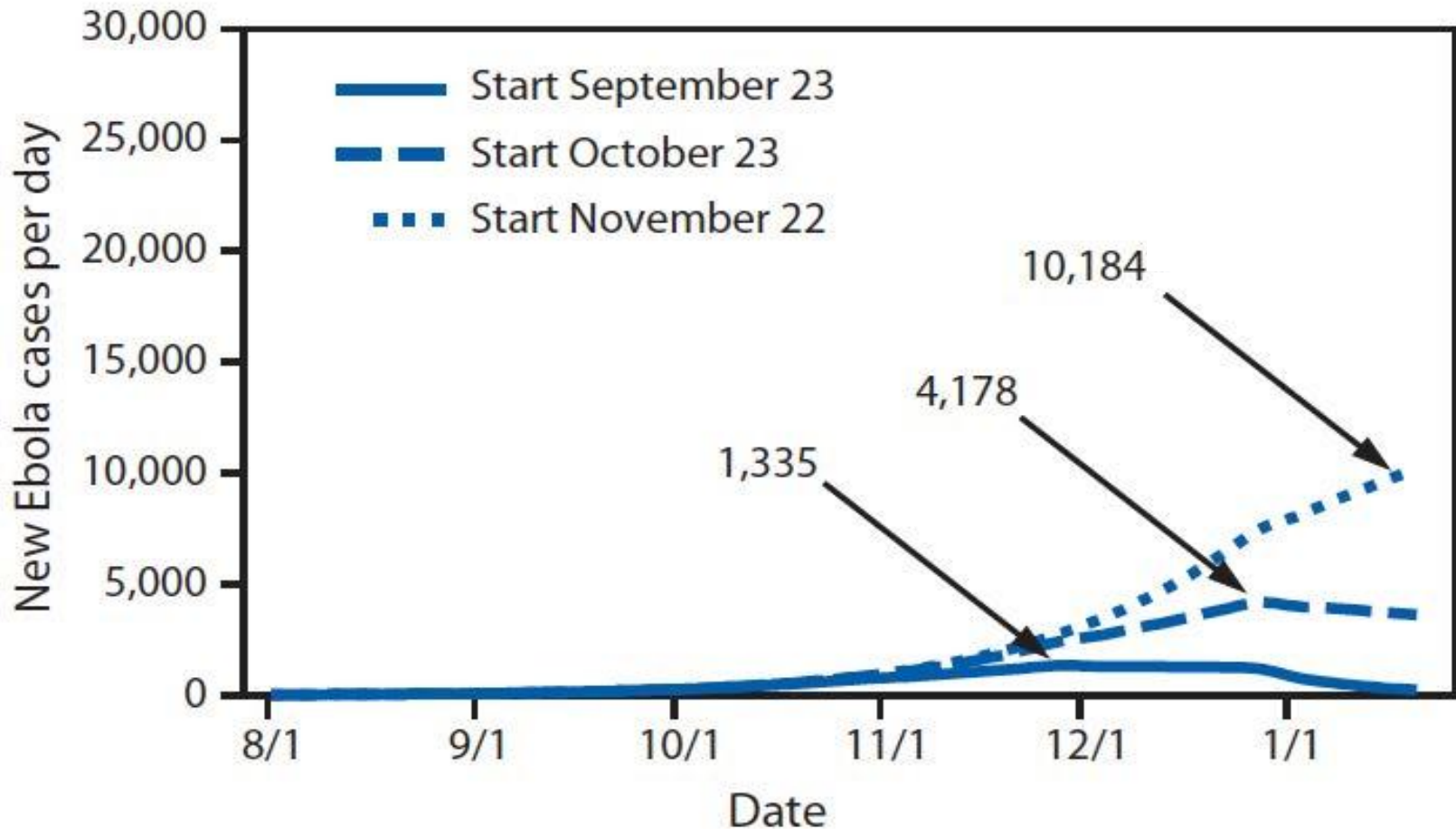
Modeling Projections of Cases With and Without Interventions

Liberia: August 2014 Estimates



MMWR Surveill Summ 2014;63 Suppl 3:1-14. Corrected for potential underreporting by multiplying reported cases by a factor of 2.5.

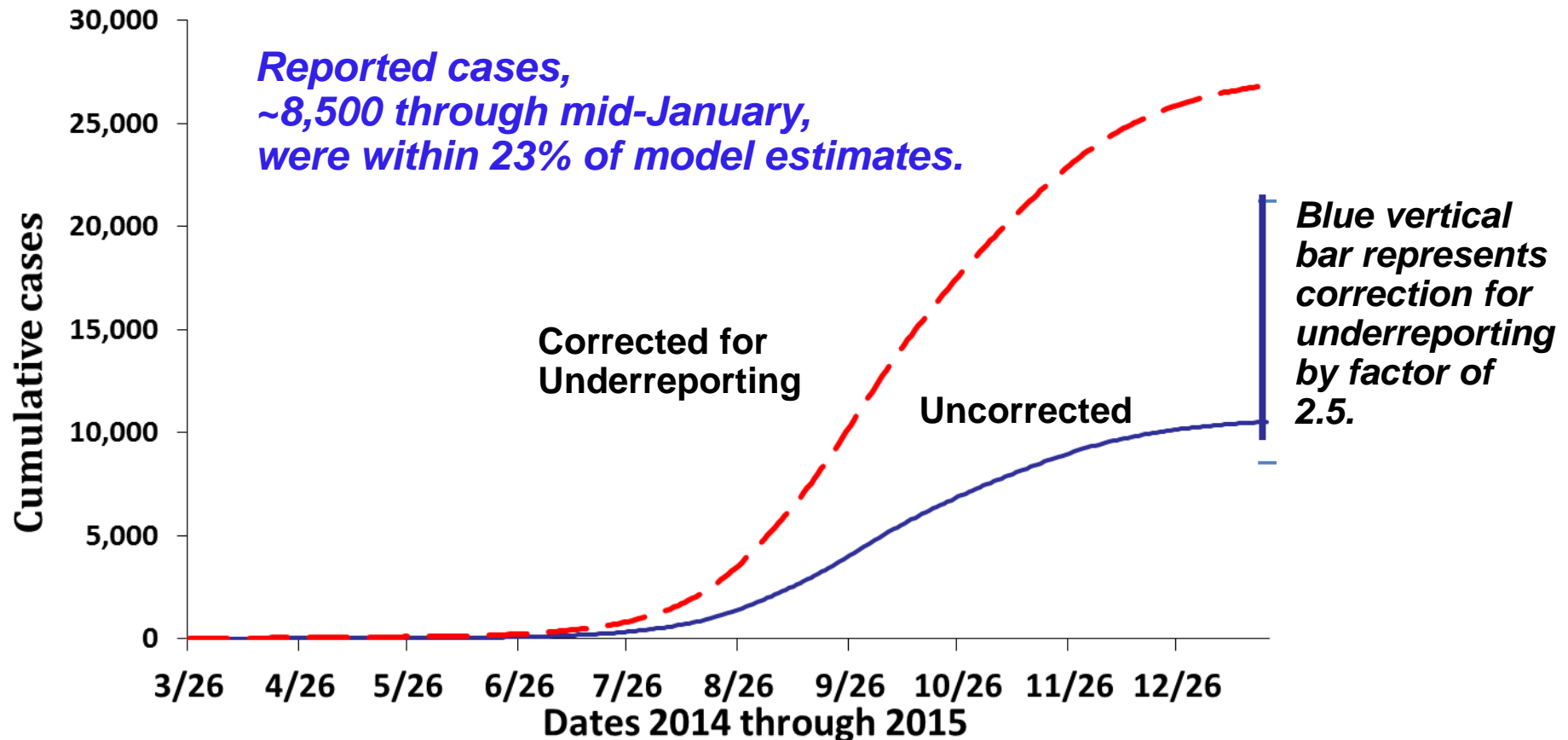
Response Time Matters – Cases Could Triple For Every Month of Inaction



MMWR Surveill Summ 2014;63 Suppl 3:1-14. Not corrected for potential underreporting.

Estimates Compared to Actual Reported Cases With and Without Correction for Underreporting

Liberia Estimates Based on August 2014 Data



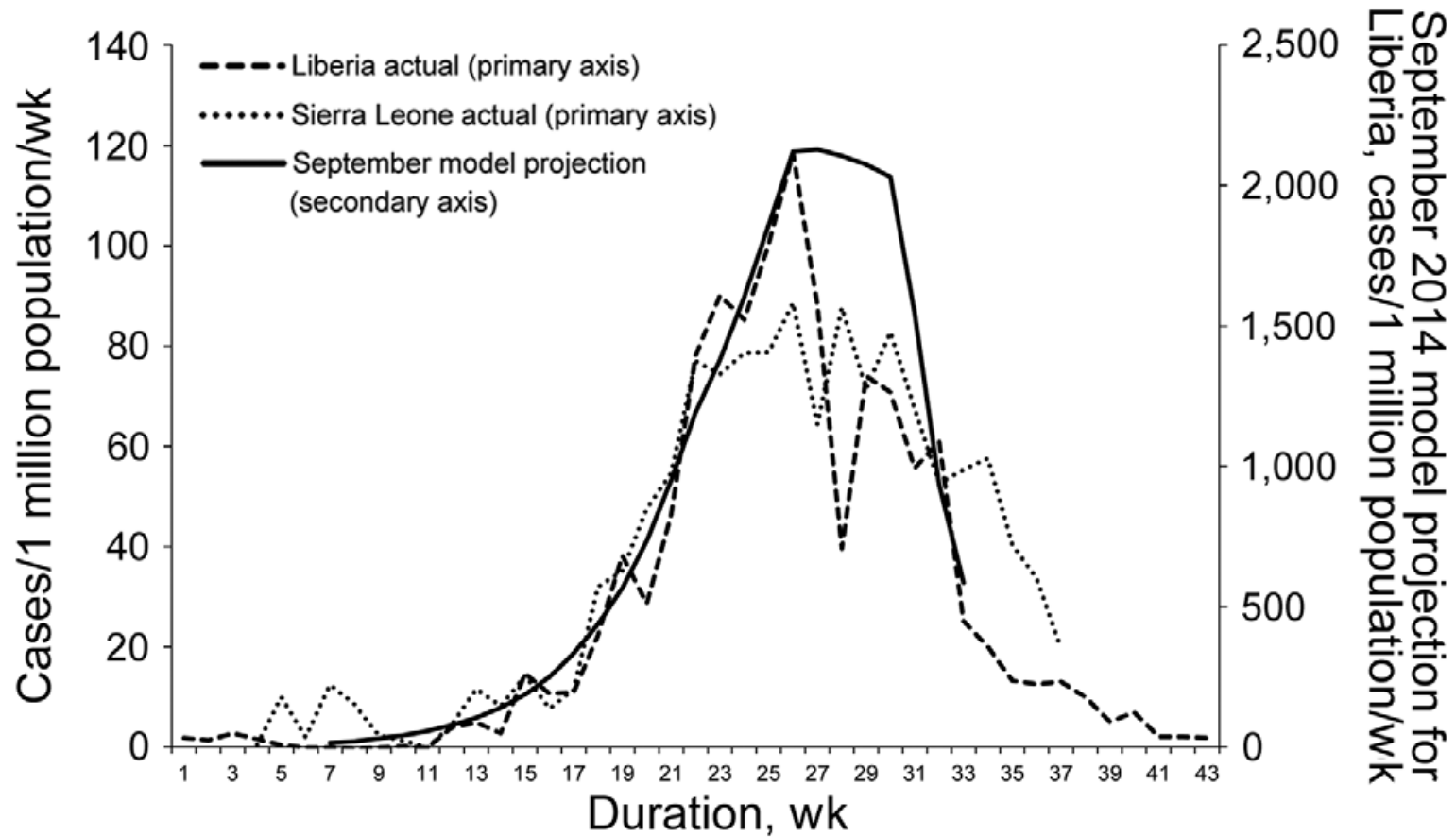
MMWR Surveill Summ 2014;63 Suppl 3:1-14.
WHO Situation Report 21 January 2015.

Single most important number produced by modeling

70%

“The epidemic begins to decrease and eventually end if approximately 70% of persons with Ebola are in medical care facilities or Ebola treatment units (ETUs) or, when these settings are at capacity, in a non-ETU setting such that there is a reduced risk for disease transmission (including safe burial when needed).”

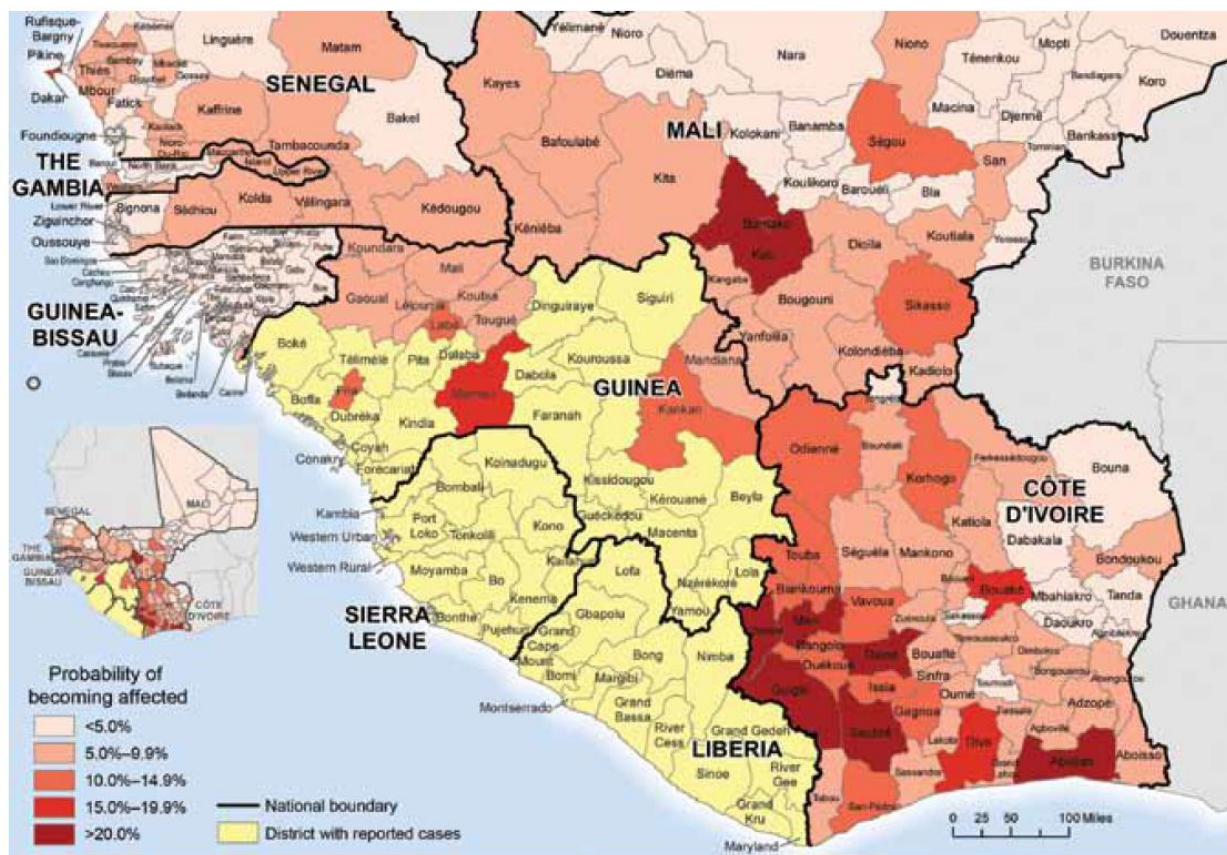
Reliable goal/ target



Frieden & Damon; Emerg Infect Dis 2015; 21:1897-1905

Regional Spread of Ebola Virus, West Africa, 2014

Gabriel Rainisch, Manjunath Shankar,
Michael Wellman, Toby Merlin, Martin I. Meltzer



Impact: Is it working?

Number of Ebola Cases Averted

The cumulative number of estimated cases during March 27–October 31, 2014, based on model assumptions, was 6,218, compared with 6,525 cumulative cases reported in Liberia (6). If no patients had been hospitalized in ETUs starting on September 23, 2014, (scenario 1), there would have been an estimated additional 2,244 cases by October 31, 2014 (Figure, Table 2). If no patients had been placed into CCCs or equivalent community settings with reduced risk for transmission, there would have been an estimated additional 4,487 cases by October 31, 2014. If no patients were placed into either ETUs or CCCs or the equivalent settings with reduced risk for Ebola transmission (scenario 3), there would have been an estimated additional 9,097 cases by October 31, 2014 (Figure).

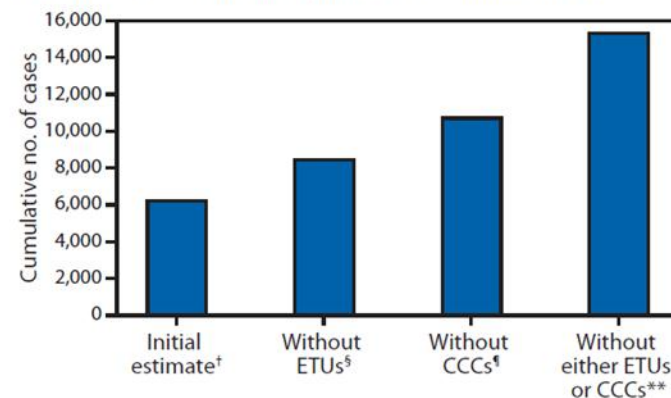
TABLE 1. Percentage of Ebola cases in each category of patient care, by three scenarios used to estimate the impact if there were no Ebola treatment units (ETUs) and community care centers (CCCs)* — Liberia, September 23–October 31, 2014

Patient care category	Initial estimates of % of patients by category [†]	% estimates if no ETUs (scenario 1)	% estimates if no CCCs (scenario 2)	% estimates if no ETUs or CCCs (scenario 3)
ETUs	20	0	20	0
CCCs	35	35	0	0
At home without effective isolation [‡]	45	65	80	100

* CCCs or equivalent community settings with a reduced risk for Ebola

or equivalent settings, an estimated 165 cases would have been averted (Table 2).

FIGURE. Estimates of the cumulative number of Ebola cases with and without Ebola treatment units (ETUs) and community care centers (CCCs)* — Liberia, September 23–October 31, 2014



* CCCs or equivalent community settings with a reduced risk for Ebola transmission (including safe burial and community-based programs to change human behavior to reduce contact with patients).

[†] The initial estimate was calculated by fitting the EbolaResponse model to cumulative cases in Liberia for the period March 27–November 15, 2014. From this fit, 6,218 cumulative cases were estimated to have occurred by October 31, 2014. During September 23–October 31, 2014, it was calculated that 20% of Ebola patients were in ETUs, 35% were in CCCs or equivalent community settings with a reduced risk for Ebola transmission (including safe burial), and, 45% were at home without effective isolation, resulting in an increased risk for Ebola transmission (including unsafe burials).

[‡] The impact if there were no ETUs was calculated by moving the 20% of Ebola

Modeling's Major Contributions During Emergency Response

- ❑ **Estimation of possible size of outbreak before large amounts of data are available**
- ❑ **Assessment of impact of interventions**
- ❑ **Identification of key data needs**
 - Value of what is known
 - Value of what is not known
 - Prioritize data collection efforts

What Is Needed For Modeling To Be Of Use To Leadership In A Response

❑ Accessible to leadership

- Best if modeling/modelers are on site
- Need for lots of “back and forth” to clarify data and the question
- Publication NOT the main goal

❑ Fast and frequent updates

- Available fast enough to help guide policy decisions
- Can be rapidly and easily updated when situation changes or more data are available

❑ Simple models

- Has to be able to be easily conveyed to decision and policy makers
- Spreadsheets or equivalent – post or make widely available

Martin's 10 simple rules for keeping models simple

- Rule 1: Identify primary audience
 - Who exactly needs/ is asking for info?
- Rule 2: Identify the #1 question they want answered
- Rule 3: Build a model that answers the question for the audience
 - Build one model to answer one question

Martin's 10 simple rules for keeping models simple

- Rule 4: Clearly identify biological components in model
 - Epidemiology, clinical, medical technology
- Rule 5: Clearly identify econ and cost components
 - E.g., costs of intervention

Martin's 10 simple rules for keeping models simple

- Rule 6: Do lots of sensitivity analysis
 - Goal: identify 1-3 inputs “driving” result
 - Multivariable sensitivity is a must
- Rule 7: Spend lots of time working on description of results
 - Quality graphics and tables a “must”

Martin's 10 simple rules for keeping models simple

- Rule 8: Always make sure that every input variable is listed and source described
 - Table 1 should be list of inputs: names, values, sources
- Rule 9: Always list and discuss limitations

Martin's 10 simple rules for keeping models simple

- Rule 10: be prepared to explain over and over again
 - Think of innovative ways to have simplified versions of model
 - E.g., spreadsheet versions (FluAid, FluSurge, Maxi-Vac)
- Finally: Good luck – always remain tenacious