

# **Non-pharmaceutical Strategies to Limit Spread of Pandemic Influenza**

**Martin Cetron, MD  
Director, Division of Global Migration and Quarantine  
Centers for Disease Control and Prevention**

# Definitions

- Isolation

- Separation of ill persons with contagious diseases
- For ill people
- Usually in hospital, but can be at home or in a dedicated isolation facility

- Quarantine

- Separation or restriction of movement select person(s)
- For people exposed but not ill
- Home, institutional, or other forms (“work quarantine”)
- Voluntary vs. compulsory

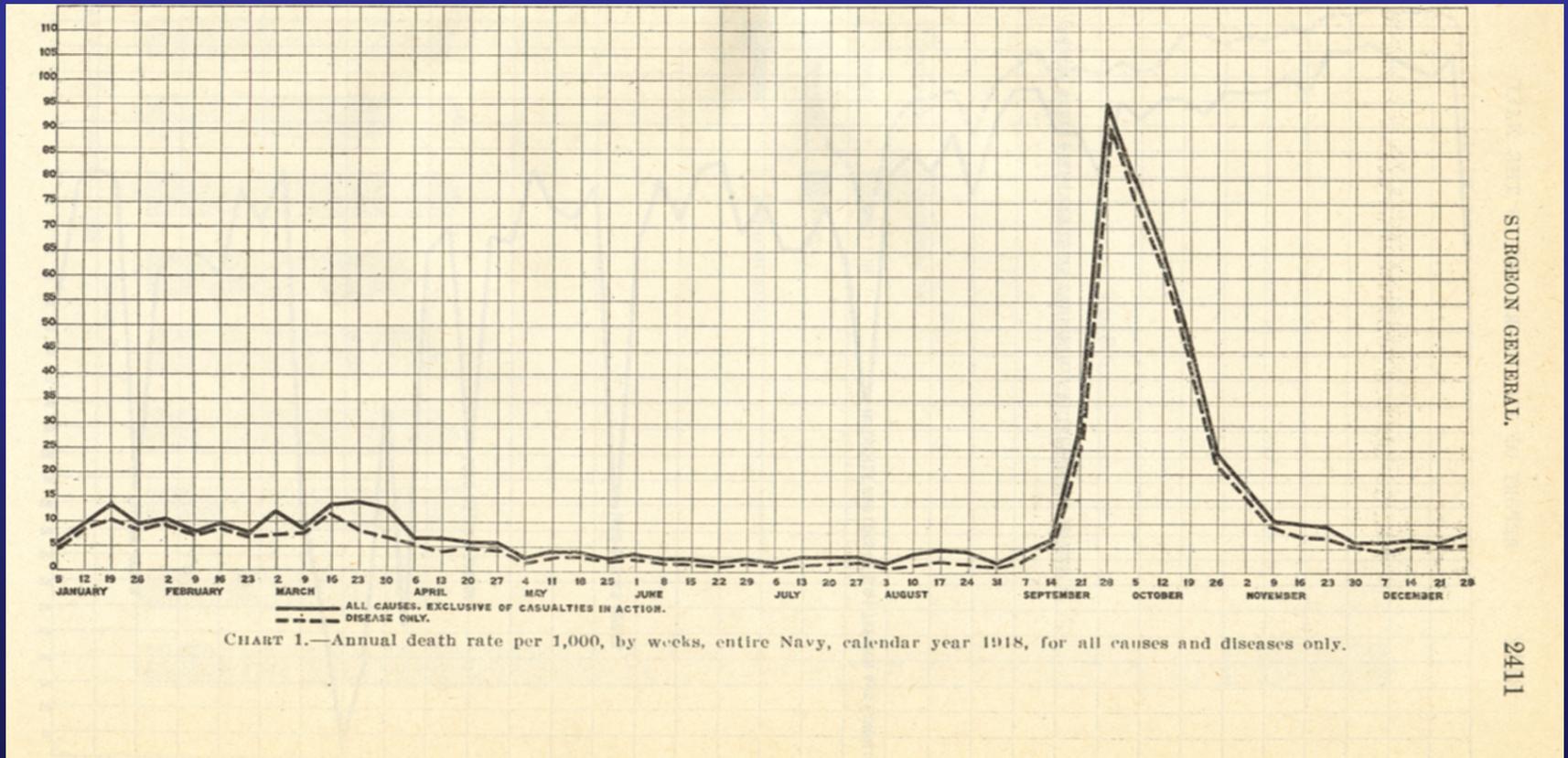
# Social Distancing and Infection Control

- **Social Distancing (Contact Interventions)**
  - School closure
  - Work closure (telecommuting)
  - Cancellation of public gatherings
- **Infection Control (Transmission Interventions)**
  - Facemasks
  - Cough etiquette
  - Hand hygiene

# Outline

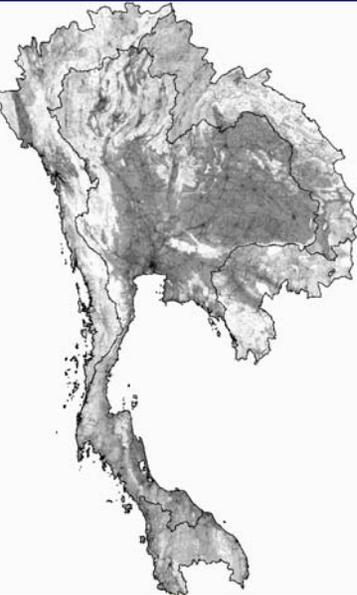
1. The challenge
2. Epidemiology: Breaking the cycle of transmission
3. What is to be done? A strategy for communities

# Pandemic Influenza Threat

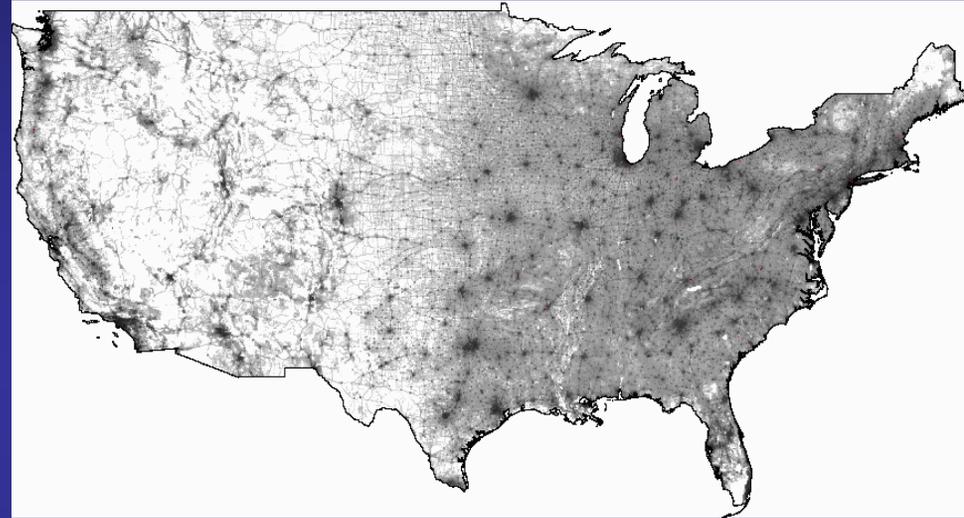


Admiral Benson, CNO, Annual Report to Congress, 1919

# Containment Unlikely



Without intervention,  
— expect international —→  
spread in 1 month and  
U.S. cases in 1 to 2  
months.



- Failed containment may still delay international spread by 1 month
- Severe travel restrictions may delay U.S. cases by 1-4 weeks

# Parameters

## Epidemiologic

- Incubation period
- Infectious period
- Mode of transmission
- Symptoms
- Age distribution
- Reproductive rate
- Intergeneration time

## Social

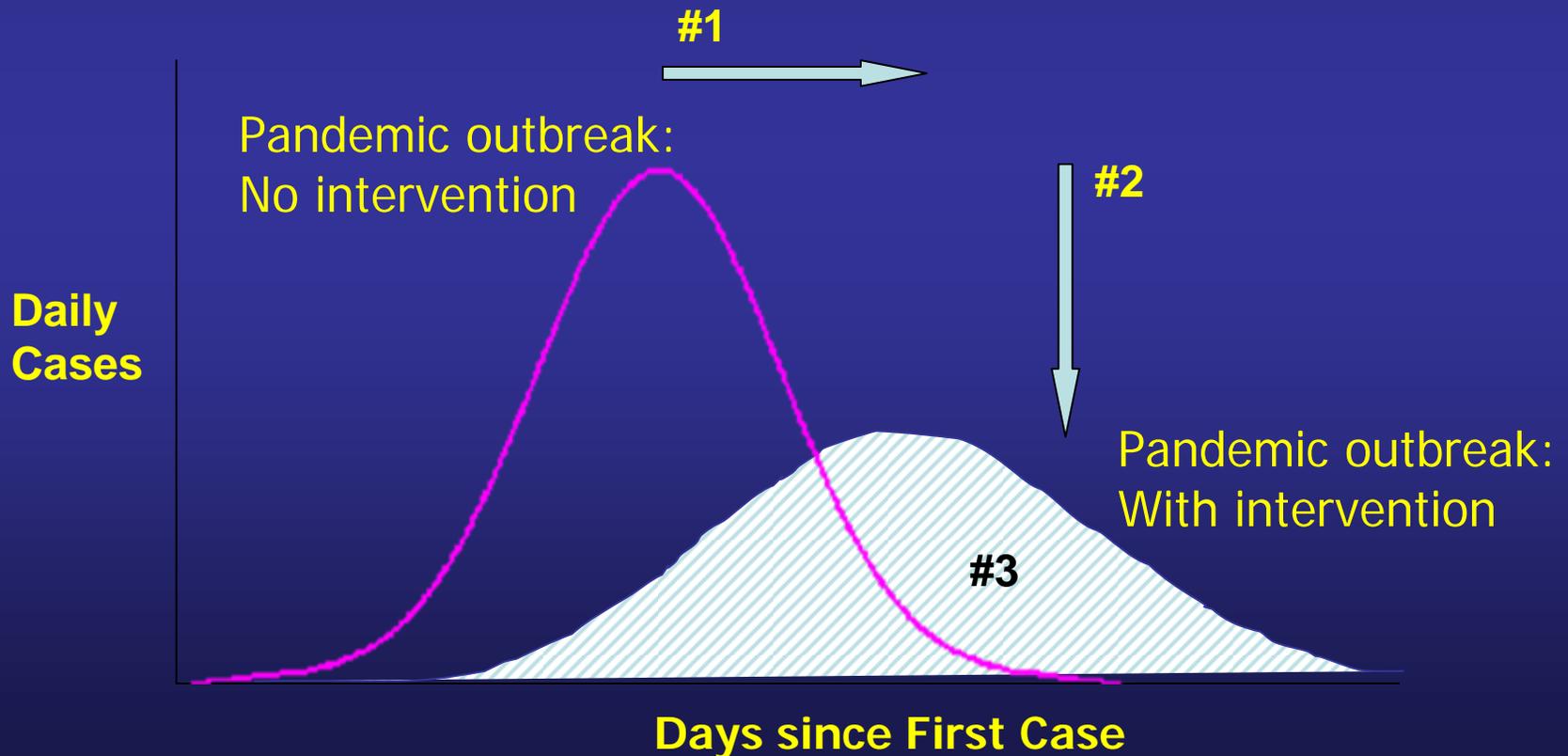
- Mixing patterns
- Mobility
- Acceptability of collective actions
- Acceptability of imposed restrictions
- Expectations
- Affordability
- Resiliency

# Potential Tools in Our Toolbox

- Our best countermeasure – vaccine – will probably be unavailable during the first wave of a pandemic
- Antiviral treatment may improve outcomes but will have only modest effects on transmission
- Antiviral prophylaxis may have more substantial effects on reducing transmission
- Infection control and social distancing should reduce transmission, but strategy requires clarification

# Community-Based Interventions

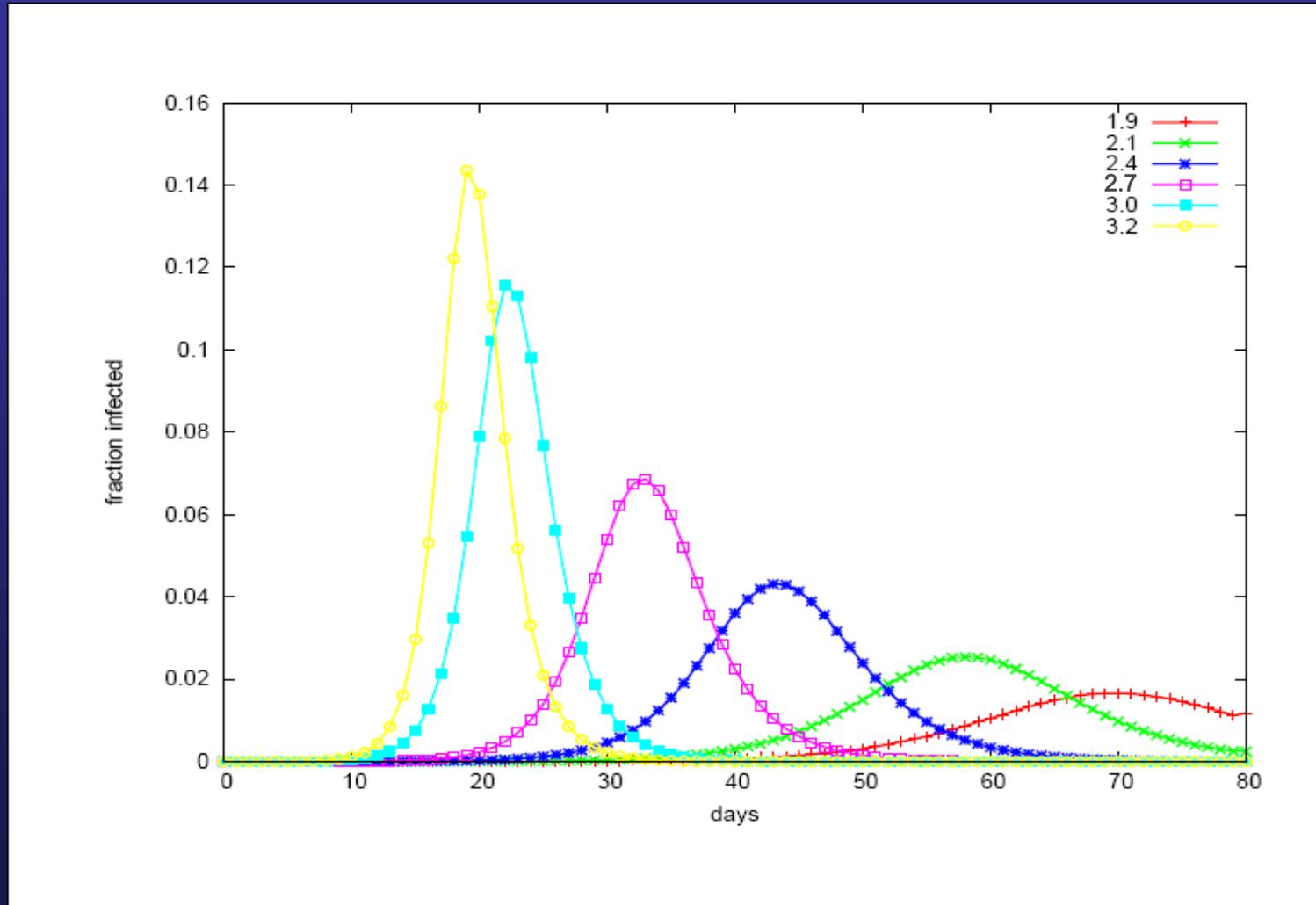
1. Delay disease transmission and outbreak peak
2. Decompress peak burden on healthcare infrastructure
3. Diminish overall cases and health impacts





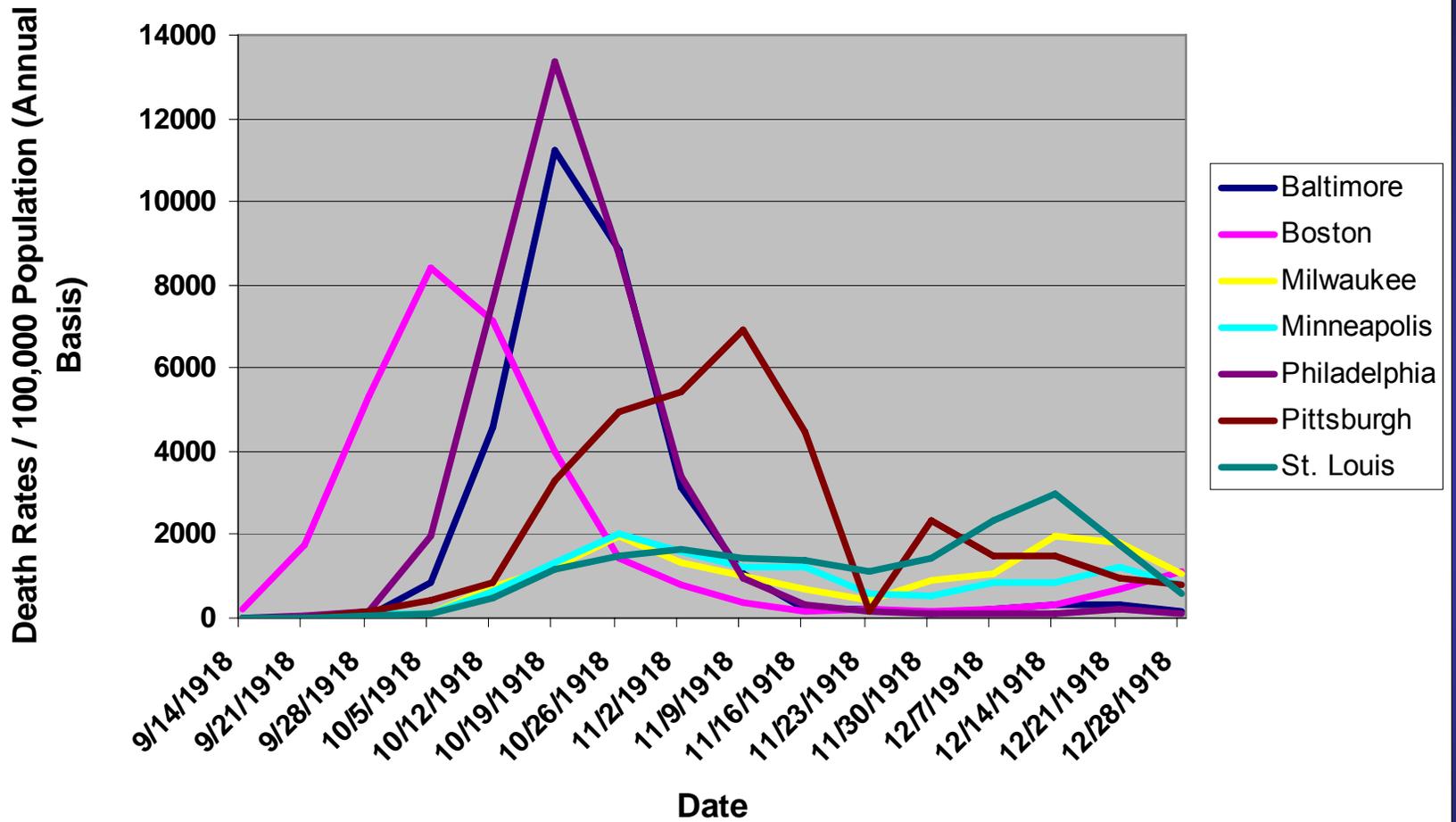
$R_0 = 2$

# Effect of $R_0$ on Epidemic Curve



Eubank S, personal communication

# 1918 Death Rates

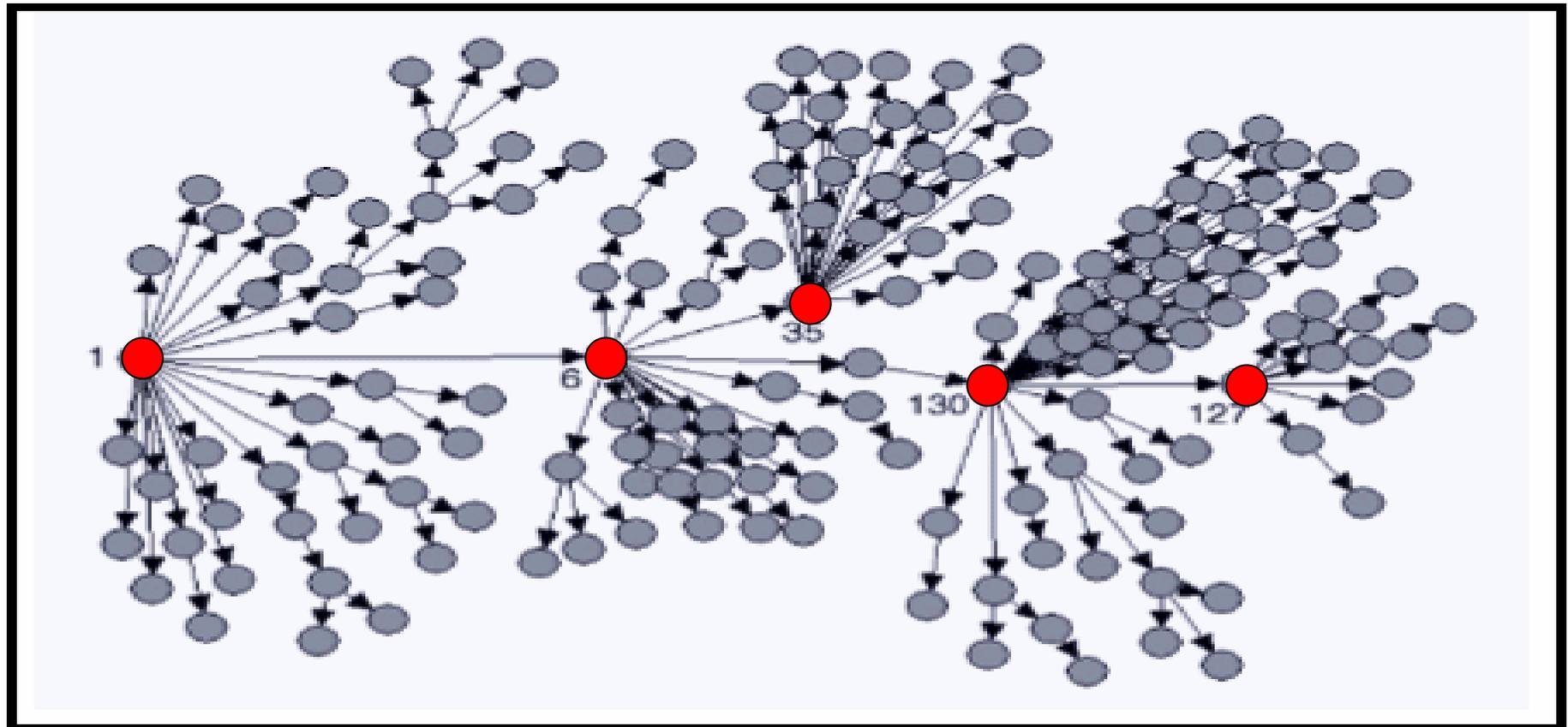


Weekly mortality data provided by Marc Lipsitch (personal communication)

# Breaking the Cycle of Transmission



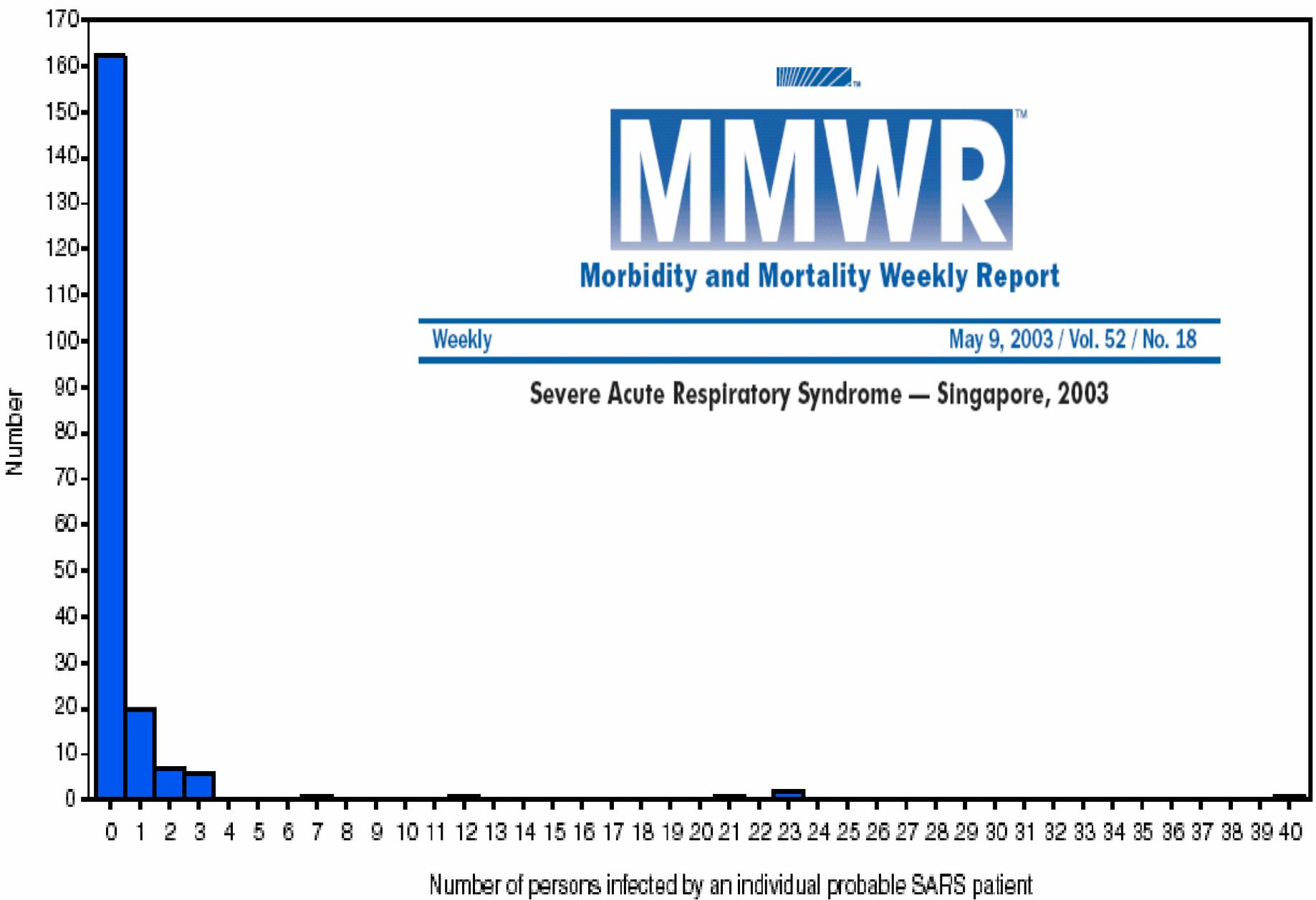
**FIGURE 2. Probable cases of severe acute respiratory syndrome, by reported source of infection\* — Singapore, February 25–April 30, 2003**



\* Patient 1 represents Case 1; Patient 6, Case 2; Patient 35, Case 3; Patient 130, Case 4; and Patient 127, Case 5. Excludes 22 cases with either no or poorly defined direct contacts or who were cases translocated to Singapore and the seven contacts of one of these cases.

*Reference:* Bogatti SP. Netdraw 1.0 Network Visualization Software. Harvard, Massachusetts: Analytic Technologies, 2002.

FIGURE 3. Number of direct secondary cases from probable cases of severe acute respiratory syndrome — Singapore, February 25–April 30, 2003

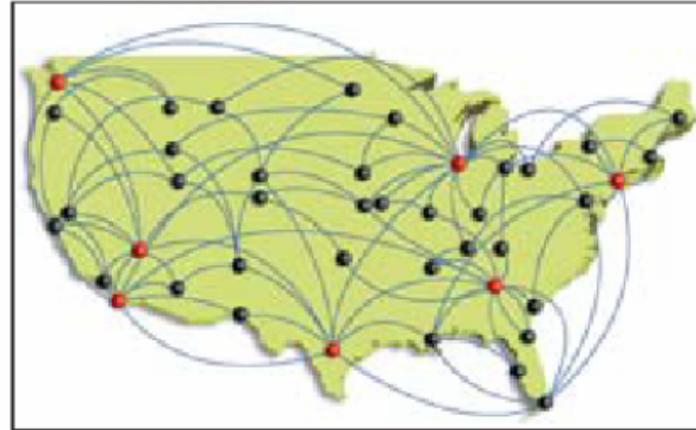


# Scale-free Networks

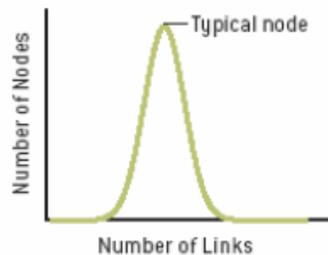
Random Network



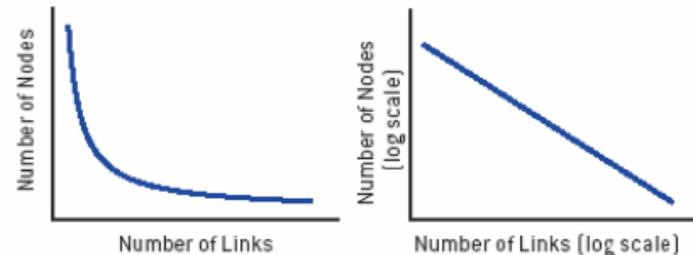
Scale-Free Network



Bell Curve Distribution of Node Linkages

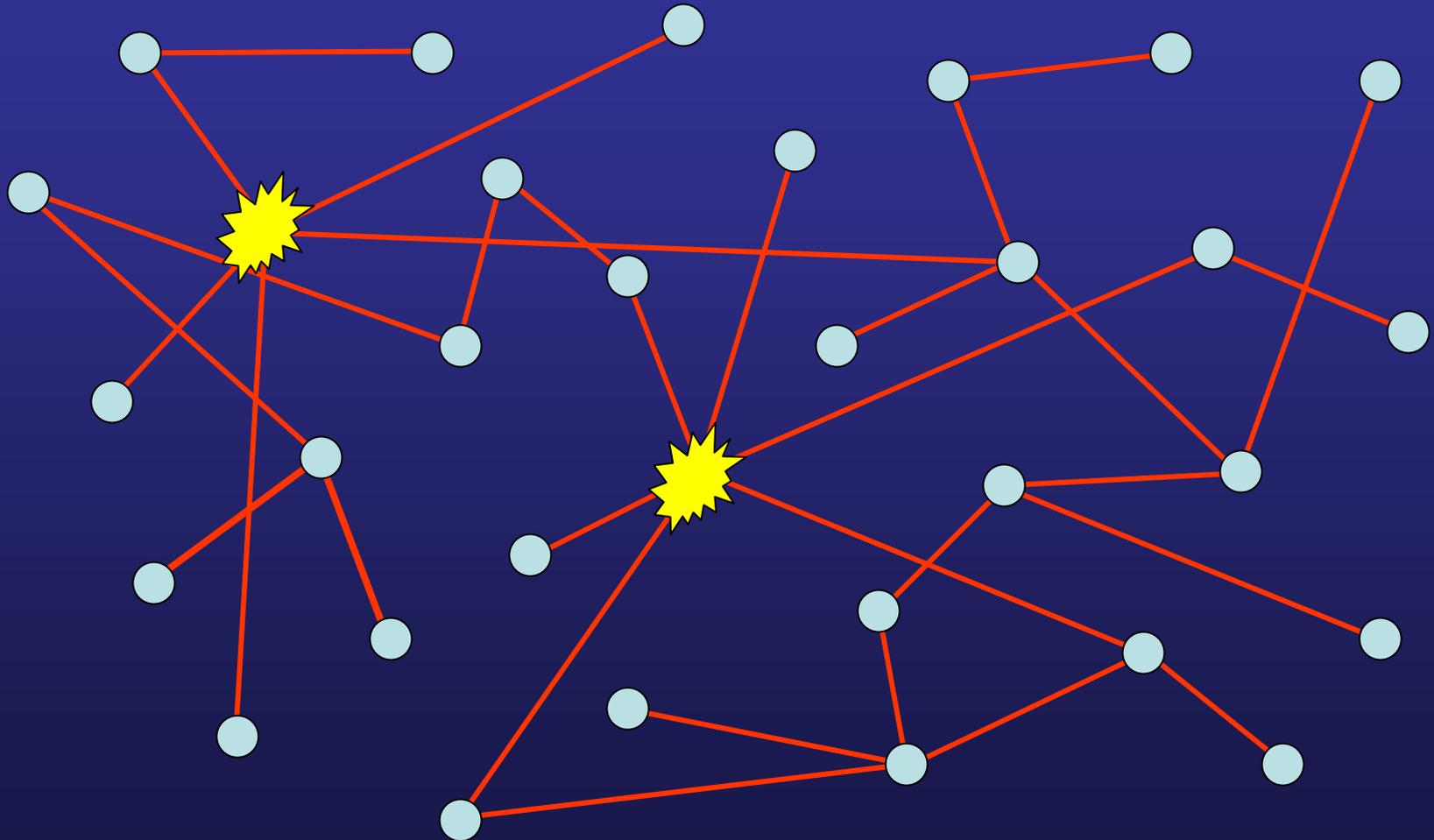


Power Law Distribution of Node Linkages

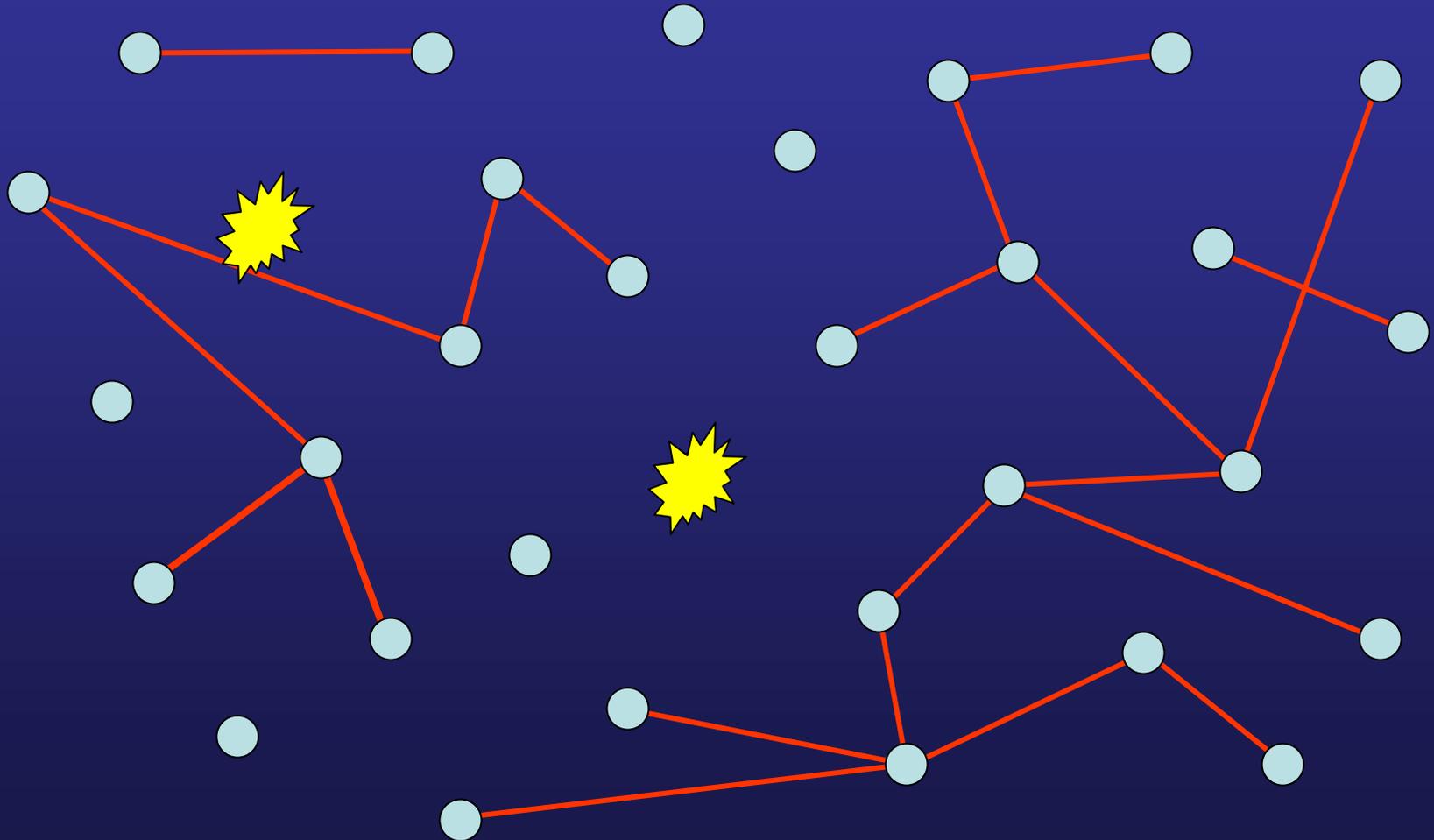


Barabasi AL, Bonabeau E. Scientific American 2003;288:60-69.

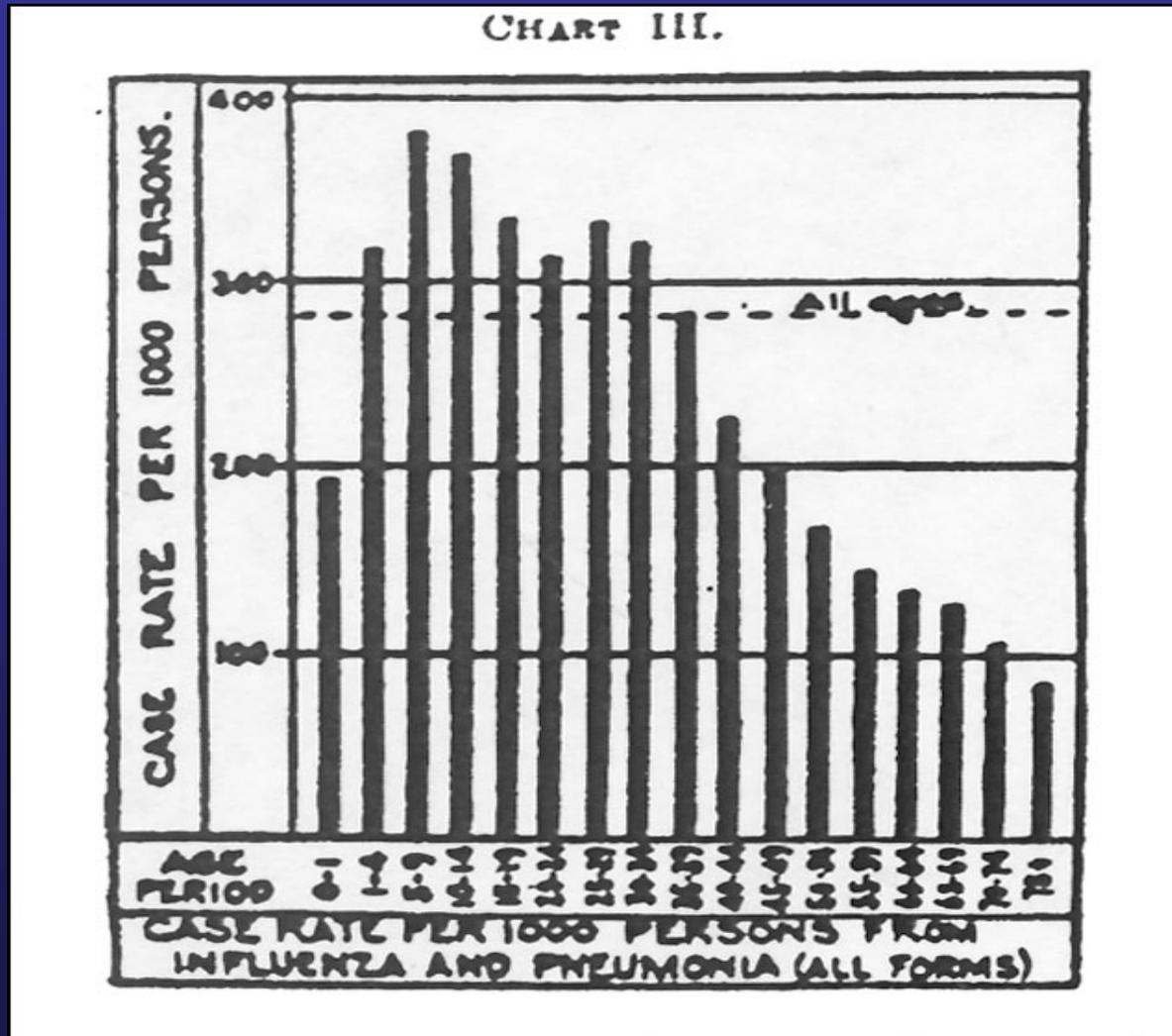
# Susceptible to Targeted Attack



# Susceptible to Targeted Attack



# 1918 Age-specific Attack Rates



# Who Infects Who?

	To Children	To Teenagers	To Adults	To Seniors	Total From
From Children	21.4	3.0	17.4	1.6	43.4
From Teenagers	2.4	10.4	8.5	0.7	21.9
From Adults	4.6	3.1	22.4	1.8	31.8
From Seniors	0.2	0.1	0.8	1.7	2.8
Total To	28.6	16.6	49.0	5.7	

## Likely sites of transmission



School



Household



Workplace

## Demographics

Children/Teenagers

29%

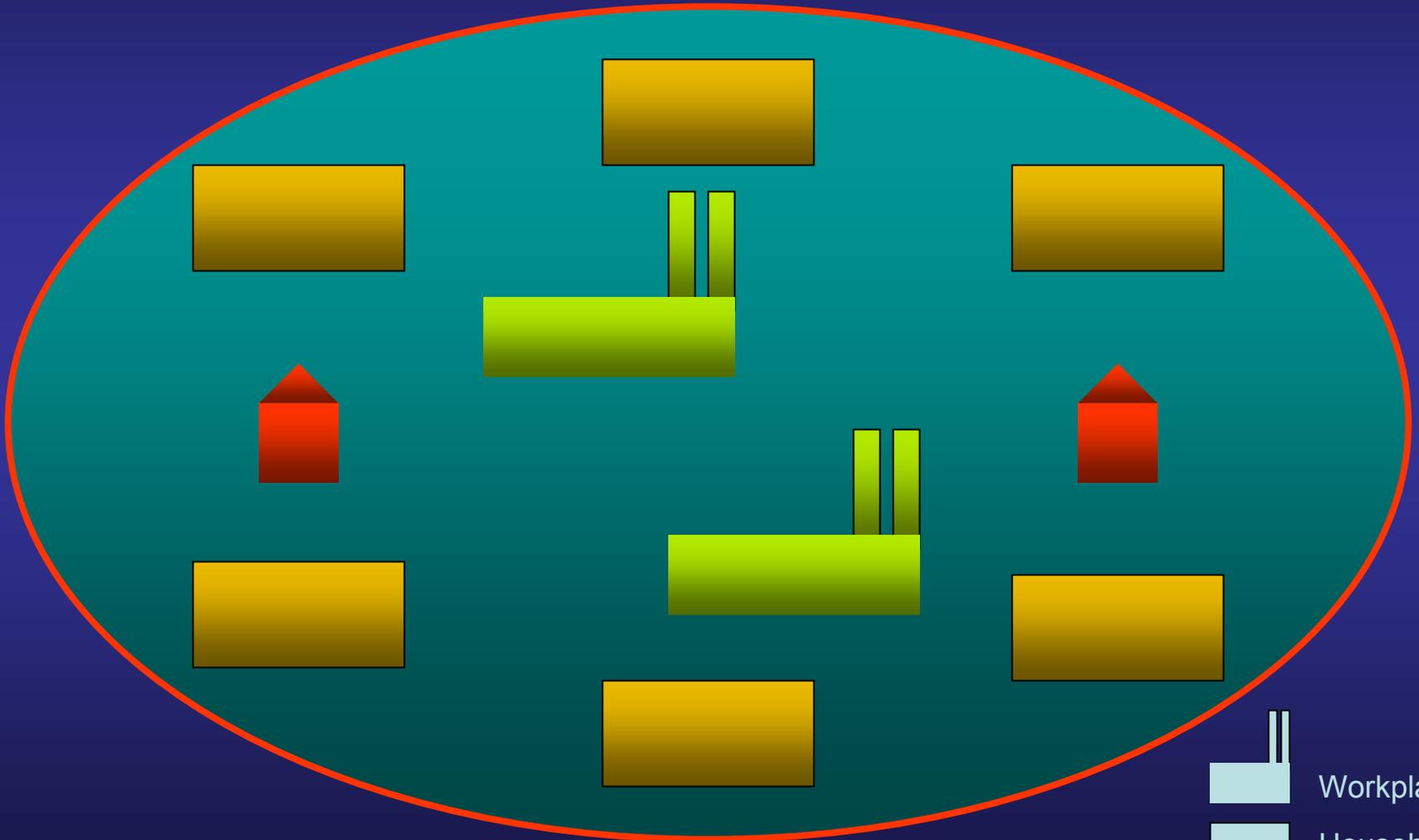
Adults

59%

Seniors

12%

# Social Compartments

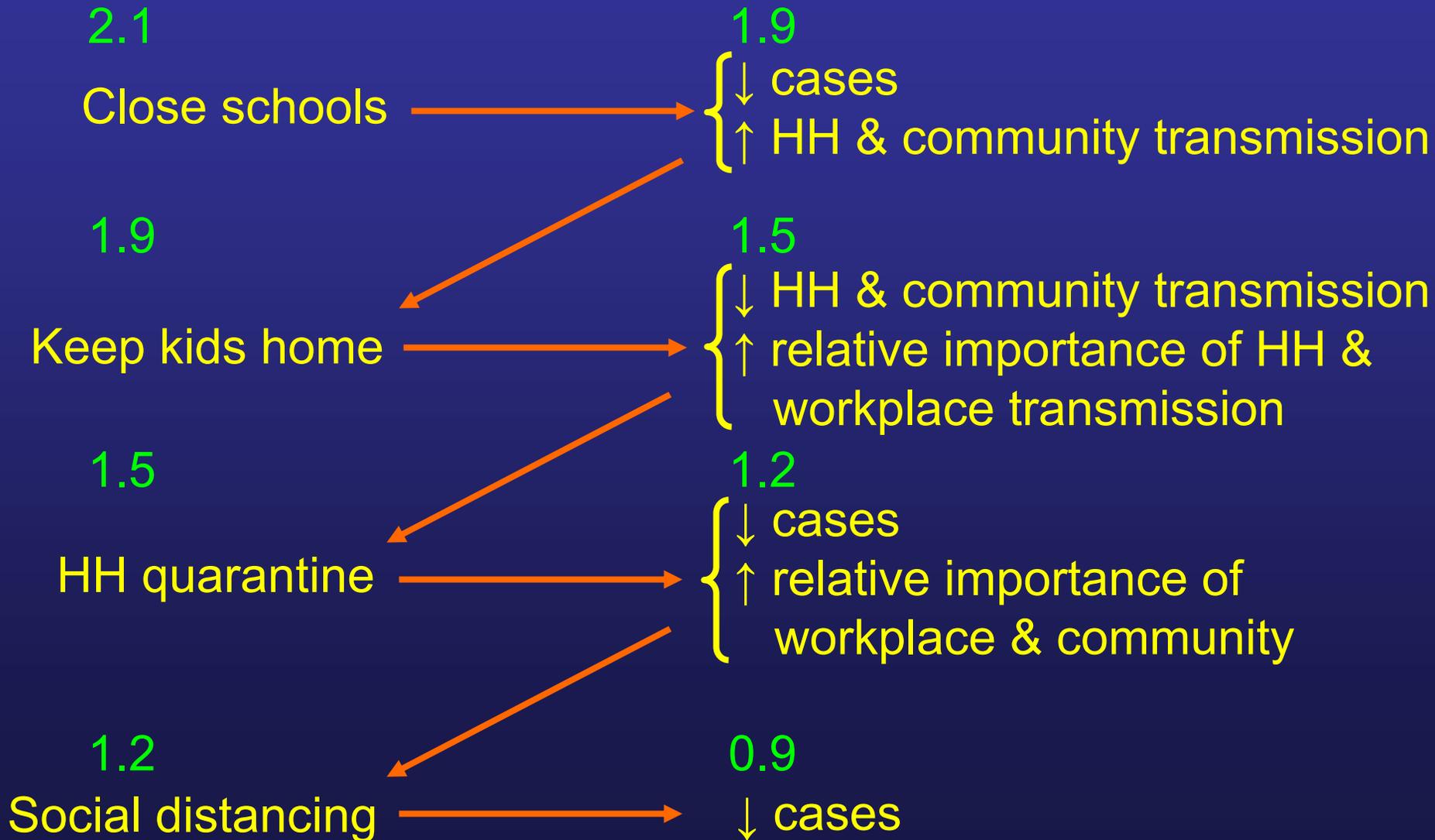


-  Workplace
-  Household
-  School

What is to be done?

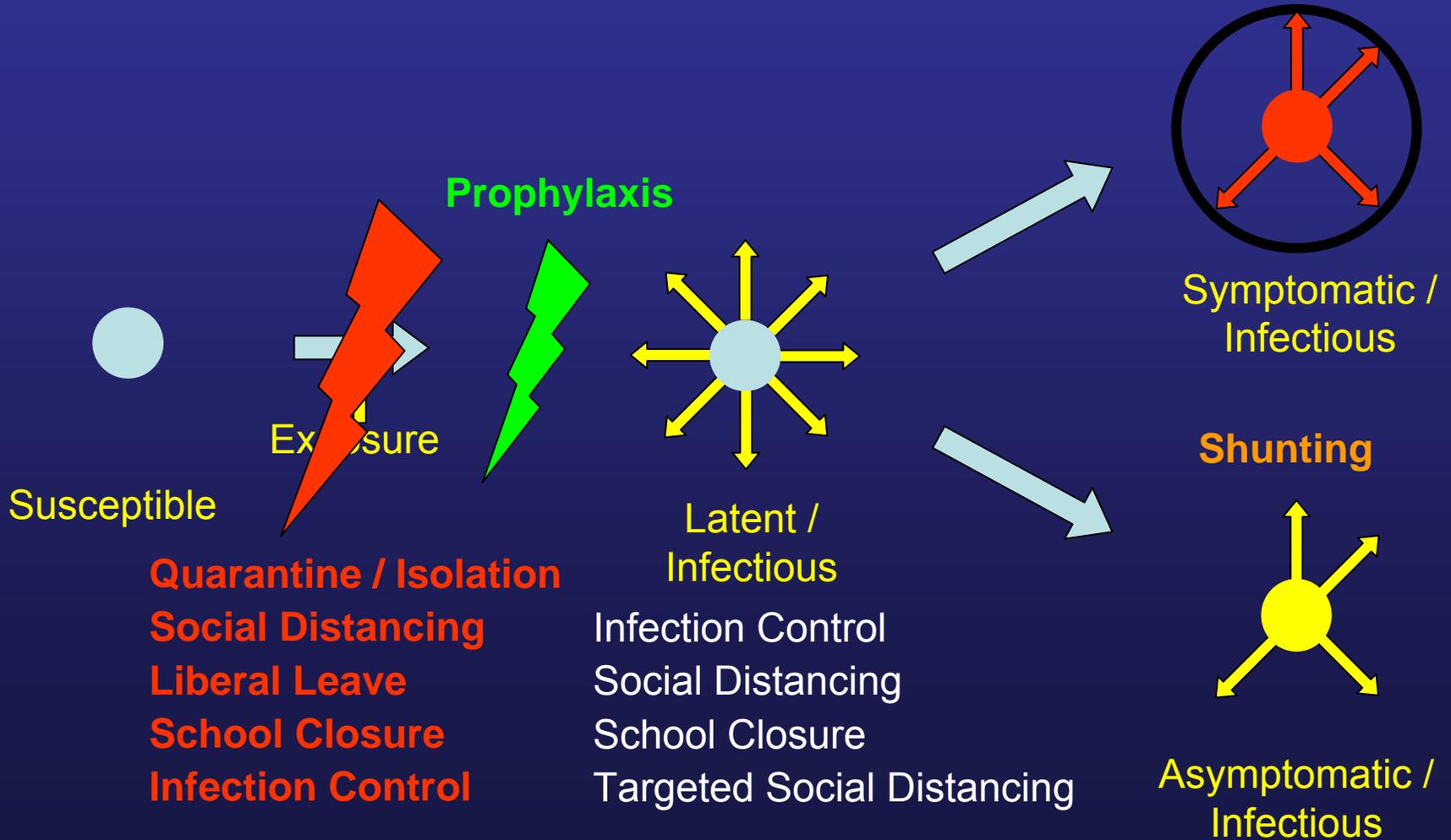
# Targeted Layered Containment: A Strategy for Communities

# Layered Interventions

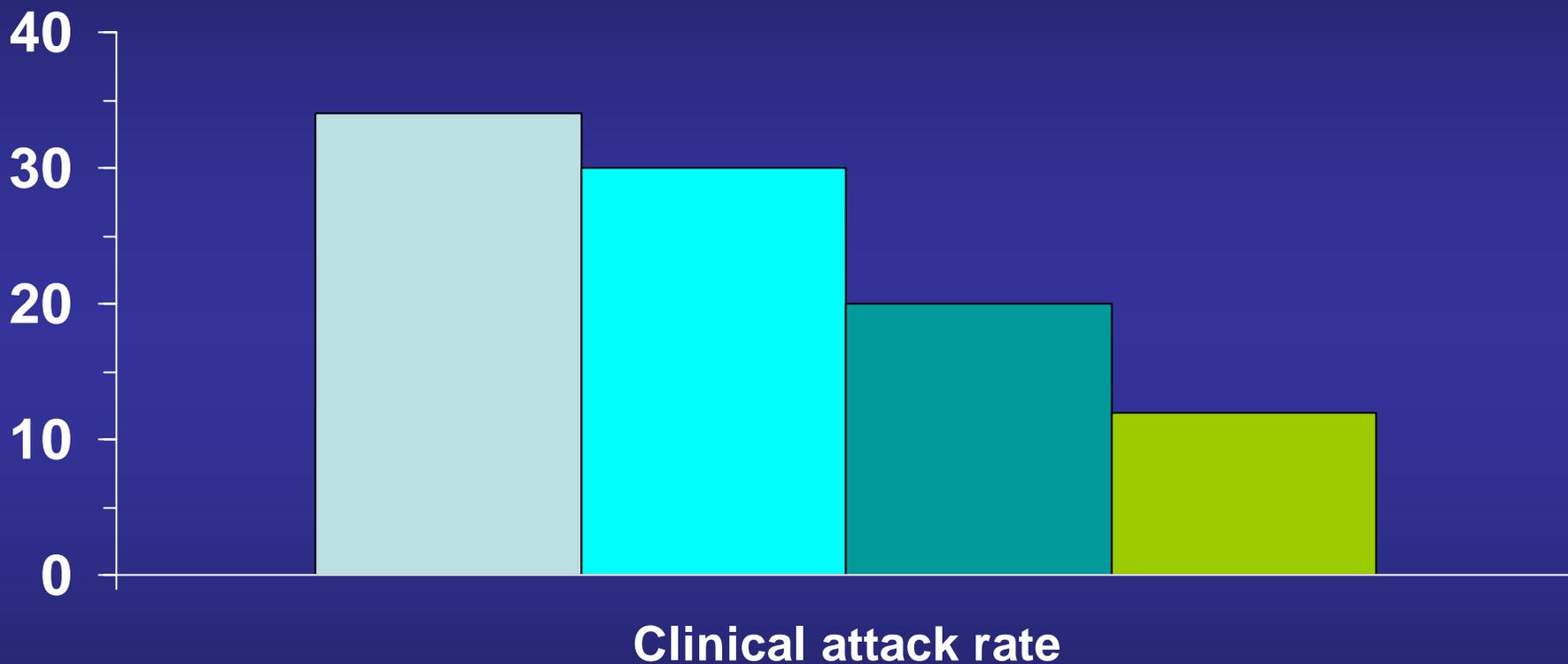


# Population-based Containment

Influenza



# Value of Combining Strategies – Ferguson Model



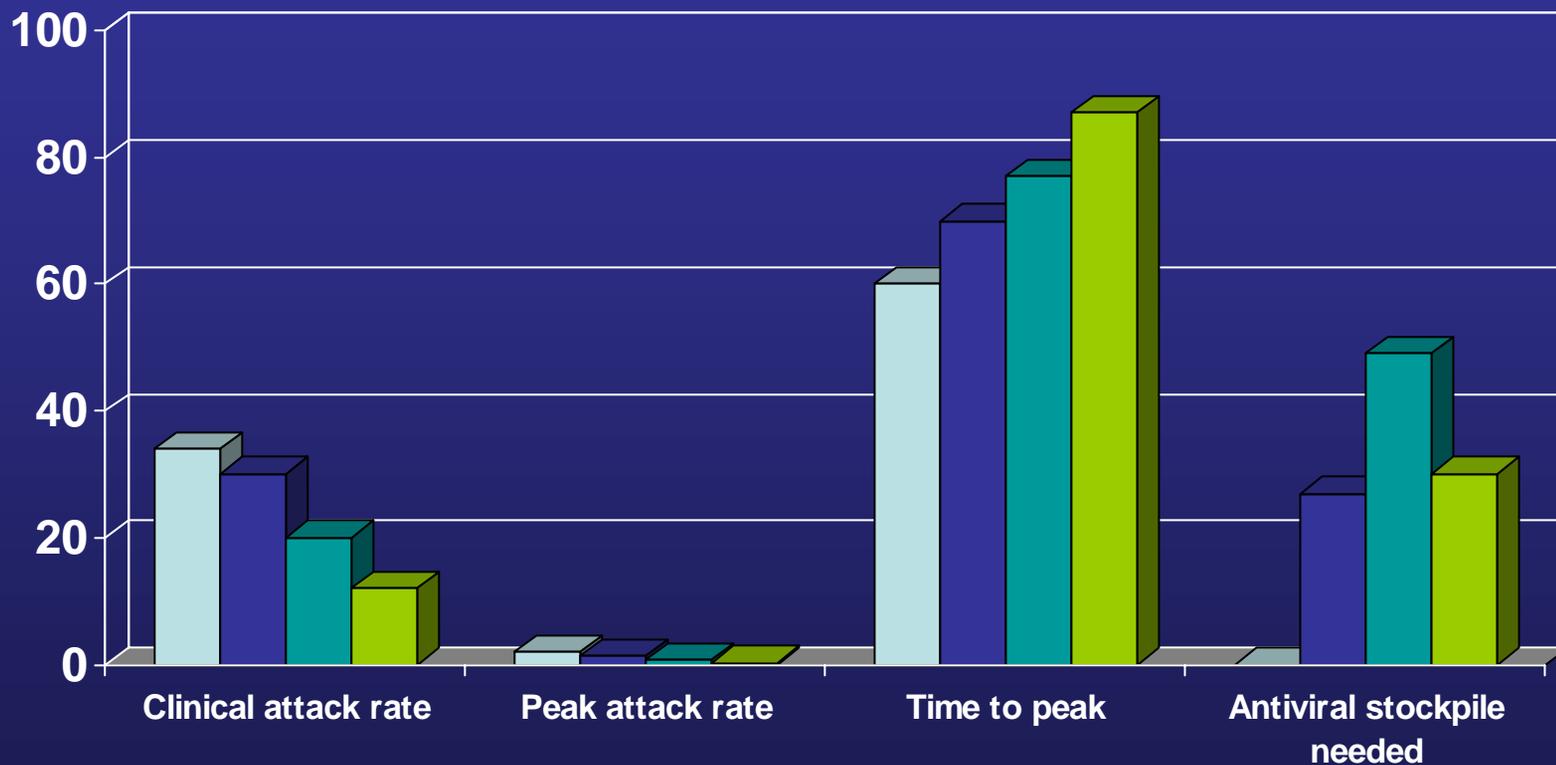
■ Base case ( $R_0=2.0$ )

■ 90% case treatment + school closure

■ 90% case treatment + school closure + 90% household prophylaxis

■ 90% case treatment + school closure + 90% household prophylaxis + 70% household quarantine

# Value of Combining Strategies – Ferguson Model



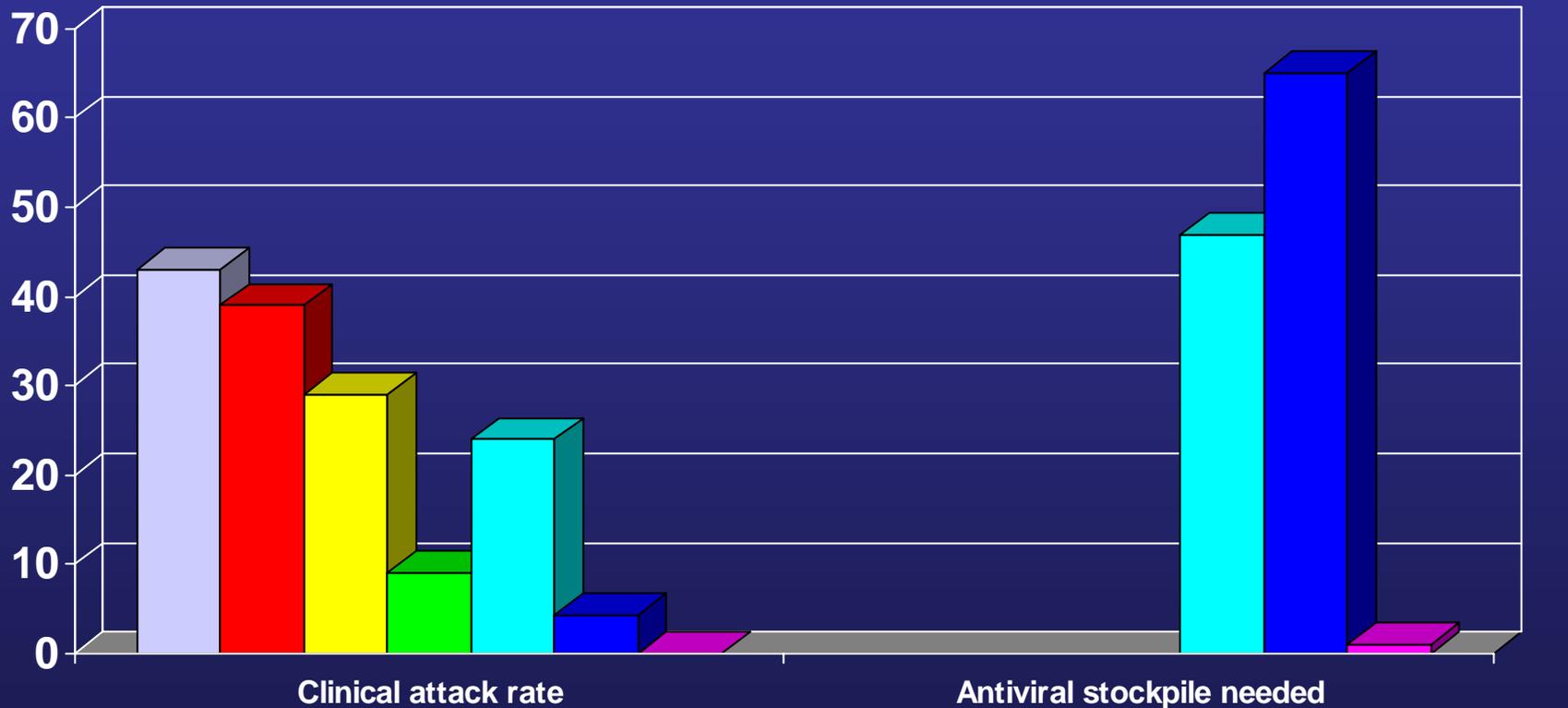
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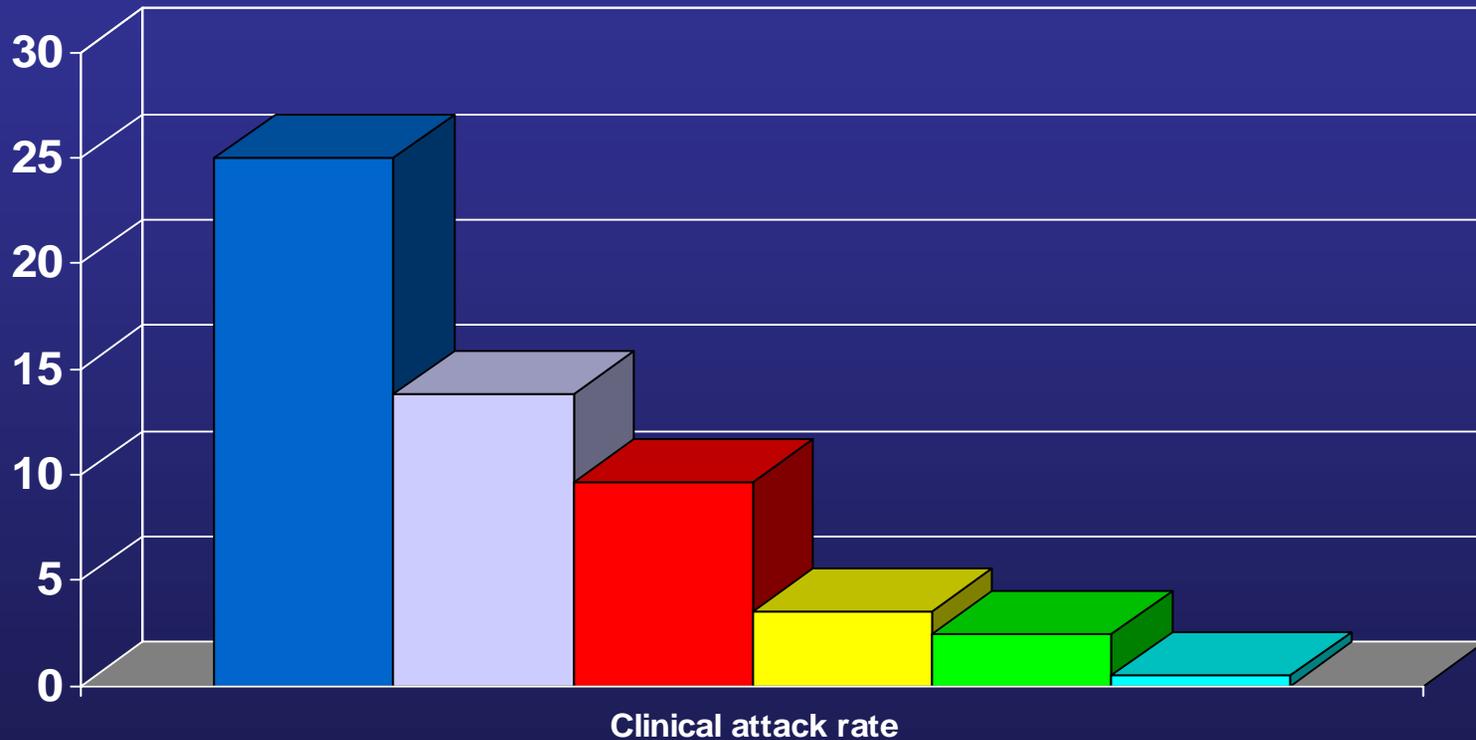
■ 90% case treatment + school closure + 90% household prophylaxis + 70% household quarantine

# Value of combining strategies – Longini model



- Base case ( $R_0=1.9$ )
- Generic social distancing
- School closure
- School closure + generic social distancing
- 60% Case treatment + 60% household prophylaxis
- 60% Case treatment + 60% household prophylaxis + 60% social prophylaxis (60% TAP)
- 60% TAP + School closure + generic social distancing

# Combining strategies – Glass model: Targeted Social Distancing



- Base case ( $R_0 \sim 1.6$ )
- School closure alone
- School closure + targeted social distancing (10% compliance)
- School closure + targeted social distancing (30% compliance)
- School closure + targeted social distancing (50% compliance)
- School closure + targeted social distancing (90% compliance)

# Community Planning for Pandemic Influenza

# WHO Pandemic Influenza Phase

3

Human infections  
with new subtype

No clusters

No human-to-  
human  
transmission

Virus with low pandemic potential

4

Rare clusters

Small number of  
cases per cluster

Very limited  
human-to-human  
transmission

Localized

5

Frequent clusters

More cases  
per cluster

Common  
human-to-human  
transmission

Localized

6

Continuous  
transmission

Regular  
human-to-human  
transmission

Involves general  
population of  
large regions  
(worldwide)

Virus with high pandemic potential

No sustained human transmission

Sustained human transmission

# WHO Pandemic Influenza Phase

## Proposed U.S. public health response in relationship to WHO Phases

3

4

5

6

Early

Late

Imported cases possible

Social distancing:

Individual

Community

Quarantine:

No

Yes

Household

Isolation:

Individual

Community

Virus with low pandemic potential

Virus with high pandemic potential

No sustained human transmission

Sustained human transmission



# Summary I:

## Non-pharmaceutical Interventions

- Depend on virus transmission characteristics and illness severity
- Measures at borders (international or within countries)- *limited early focus, phase 5-6a*
  - Health alert notices
  - Entry screening of international travelers
  - Exit screening from affected countries is recommended, especially if most countries not yet affected

# Summary:

## Non-pharmaceutical Interventions

### TLC

- Ill patients should stay home
- Home quarantine for household contacts
- Social distancing measures
  - School closures may have profound impact
  - Workplace COOP (liberal leave vs. closure)
  - Cancellation of public events
- Individual infection control measures
  - Hand washing and cough etiquette
  - Mask use for ill persons
- Disinfection of contaminated surfaces
- Antiviral for treatment & targeted prophylaxis

# Additional Considerations

- Planning for second-order effects
- Duration of implementation
- Intervention fatigue
- Socioeconomic disparities
- Sustained, predictable absenteeism
- Economic impact

# Acknowledgements

**Rachel Eidex, CDC**

**Anthony Marfin, CDC**

**David Bell, CDC**

**Richard Hatchett, NIH**

**Carter Mecher, VA**

**Ben Schwartz, HHS**

**Rajeev Venkaya, HSC**

## Modelers

**Stephen Eubank, PhD**

**Neil Ferguson, PhD**

**Robert Glass, PhD**

**Nathaniel Hupert, MD**

**Ira Longini, PhD**

# Evidence to Support School Closure

- Children are thought to be the main introducers of influenza into households.
- Children appear to be more susceptible to influenza and more infectious than adults in well-designed prospective studies of risk factors of influenza transmission in households.
- Nationwide school closure in Israel during an influenza epidemic resulted in significant decreases in the diagnoses of respiratory infections (42%), visits to physicians (28%) and emergency departments (28%), and medication purchases (35%).

# Population-based Containment

## VACCINES

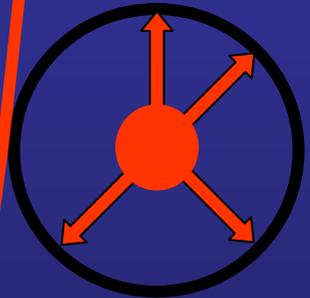
- Pre-priming
- Pre-pandemic

Influenza

## DIAGNOSTICS

Treatment Isolation

Prophylaxis



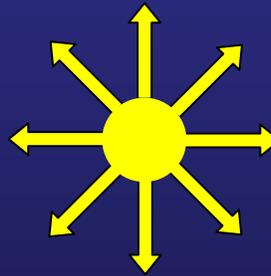
Symptomatic / Infectious



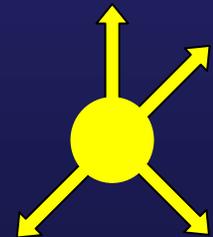
Susceptible



Exposure



Latent / Infectious



Asymptomatic / Infectious

Quarantine / Isolation

Liberal Leave



# Critical Insight

Averaging over a highly heterogeneous contact network can hide critical features that could be exploited to design effective mitigation strategies

# Baseball 2005 – Using Tools Effectively

Team Batting Average	On-base Percentage	Runs Scored	Team	Record
.262	.322	741	White Sox	99-63
.263	.320	701	Royals	56-106

TRIVIA QUESTION: Between them, how many times have clubs that Mark McGwire, Sammy Sosa, and Barry Bonds played for won the World Series?

ANSWER: 1 (Oakland Athletics, 1989)