Screening Travelers at Borders During a Pandemic: Some Thoughts About Tools

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Disclaimer

The following material does not necessarily represent current or future US Government or CDC policy. It is presented solely to stimulate discussion.

Agenda

- Why screen?
  - Exit screening
  - Entry screening
- Passive Screening
- Active Screening
  - Visual inspection
  - Health declarations
  - Thermal imaging
  - Rapid tests for influenza
- Discussion of issues

Screening in a Layered Pandemic Defense

- Quarantine, isolation
- Health screening at port of entry
- En route screening
- Health screening at port of embarkation

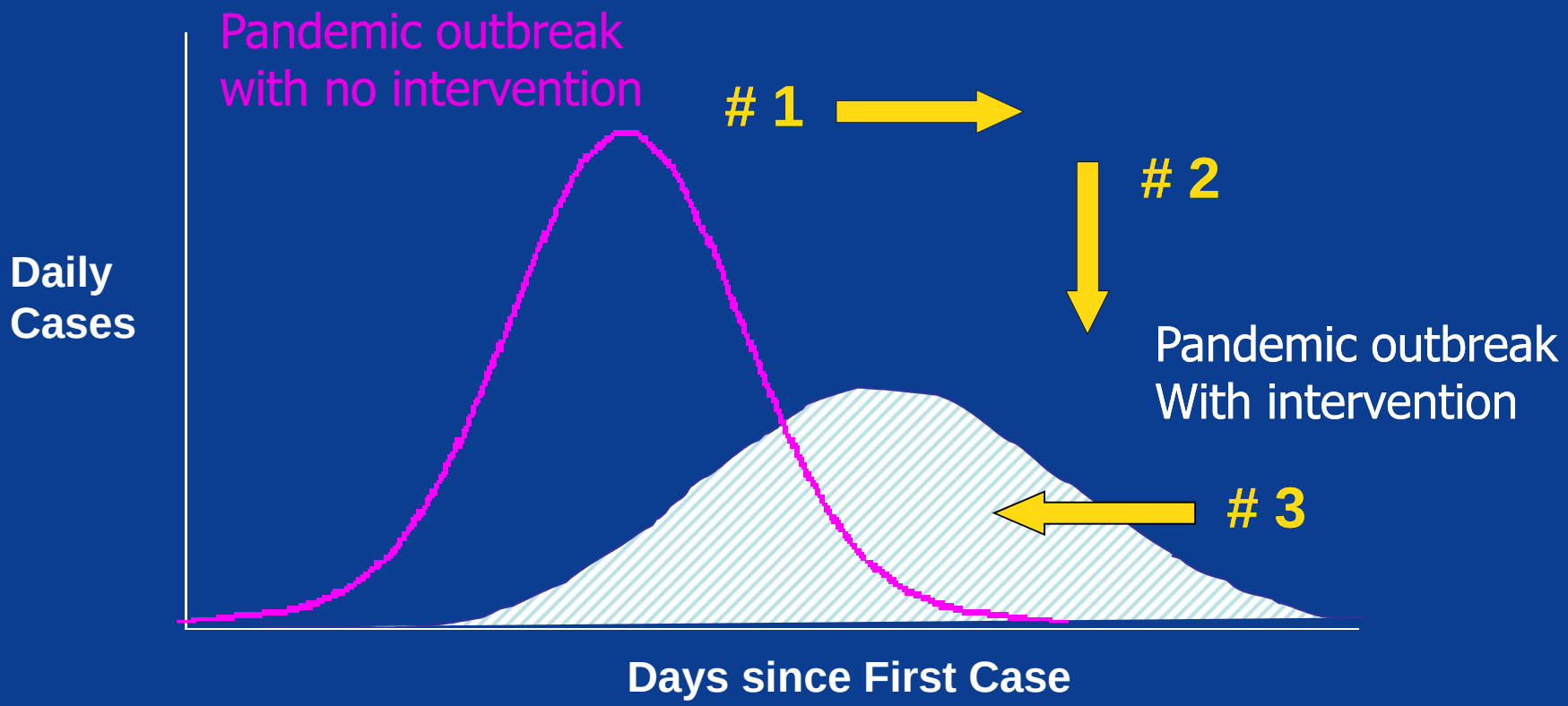
- Containment at source (WHO Rapid Reaction): e.g., travel restriction, antivirals, quarantine and isolation

Exit Screening

- Goal to prevent spread from “hot” zone to “cold” zone
- Addressed by International Health Regulations (WHO)
- Tools could be same as used for entry screening
- Issues largely the same as for entry screening
- Not currently recommended by WHO

Goals of Entry Screening

1. Delay disease transmission and outbreak peak
2. Decompress peak burden on healthcare infrastructure
3. Diminish overall cases and health impacts
4. Do NOT expect to prevent entry into country



Primary and Secondary Screening at Borders

Primary Screening

- Visual
- Health declaration (questionnaire)
- Possibly thermal imaging (?)

Secondary Screening

- Extensive interview
- Physical examination
- Oral/otic temperature measurement
- Diagnostic testing (rapid test/PCR)
- Detainment, isolation, quarantine (includes conditional release)

Some Important Definitions

- **Sensitivity: Ability to identify persons who *have* a disease**

$$\frac{\text{\# of persons with true positive screening results}}{\text{\# of persons who really have the disease}}$$

- **Specificity: Ability to identify persons who *do not have* a disease**

$$\frac{\text{\# of persons with true negative screening results}}{\text{\# of persons who really do not have the disease}}$$

More Important Definitions

- **Positive Predictive Value (PPV): How likely a person with a positive screening result is to *really have* the disease.**

$$\frac{\text{\# of persons with true positive screening results}}{\text{Total \# of persons with a positive screening result}}$$

- **Negative Predictive Value (NPV): How likely a person with a negative screening result is to *really not have* the disease.**

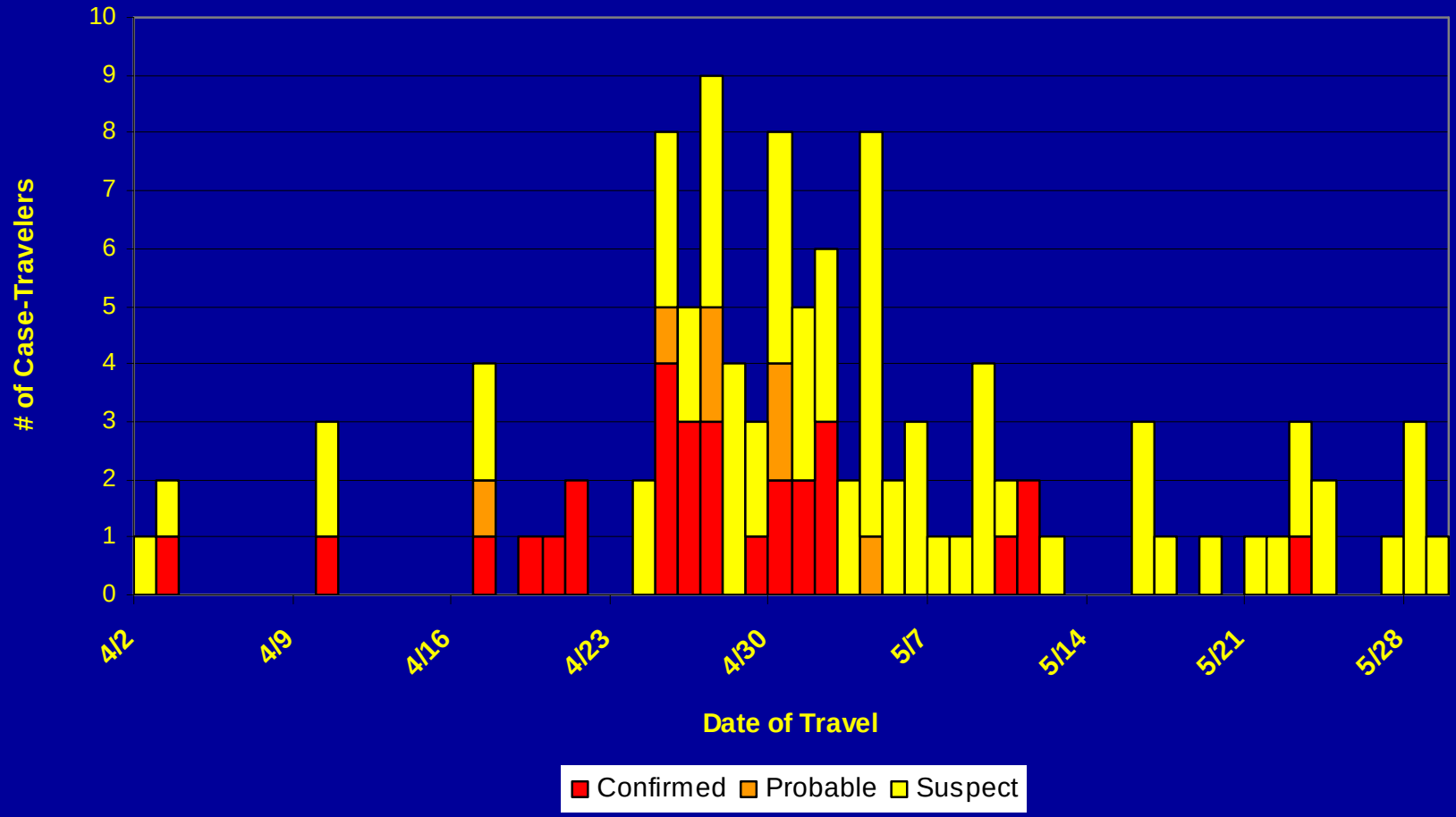
$$\frac{\text{\# of persons with true negative screening results}}{\text{Total \# of persons with a negative screening result}}$$

Passive Screening

- **Enhanced awareness, but no special actions taken**
  - **Respond to reports from:**
    1. **Flight and ship crew**
    2. **Customs and immigration officers**
    3. **Ill passengers**
    4. **Health departments or physicians after travel completed**

Where?: Current CDC Quarantine Stations

Date of Travel for Novel H1N1 Case-Travelers Reported to CDC Quarantine Stations, April 1 - May 31, 2009 (n=107)



Screening Results, April-May 2009

- 107 cases during two month period
- 30% confirmed
- 50% of reports in California and Texas
- 55% associated with air travel
- 52% reported during travel, 48% after
- ~20% asymptomatic during travel

Passive Screening….Impressions

- Doesn’t require additional resources
- Sensitivity unknown because we don’t know how many cases it missed
- Limited by number of infected travelers who had no symptoms
- Did not detect very many cases, but may have met our goals

Visual Inspection

Scott Stantis, *The Birmingham News*, 4/2/03

Draft Health Declaration

U.S. HEALTH DECLARATION FORM
PASSENGER & CREW

DRAFT

Today's date: day ☐☐ month ☐☐ year ☐☐

Airline: ☐ Flight number: ☐

Seat Number: ☐ Seat number if moved: ☐

Family name: ☐

First name (given): ☐

Middle name: ☐

Passport issued by (country): ☐

Passport number: ☐

A. To answer each question, please mark an X in the YES or NO box:

	YES	NO
Have you felt like you had a fever or chills in the last 24 hours?	☐	☐
Do you have a cough or have difficulty breathing?	☐	☐
In the last 7 days, have you been near or spent time with someone who had a fever and cough?	☐	☐

*If **YES** to any of the questions above, please inform the crew on your plane.*

B. Please list all the countries where you have been (including where you live) in the last 7 days:

- List in order with most recent country first.
- List countries where your plane stopped if you got off the plane

1. ☐ 4. ☐
2. ☐ 5. ☐
3. ☐ 6. ☐

1. Please list the names of all persons traveling with you on this flight:

☐ ☐
☐ ☐
☐ ☐

2. Are you traveling with a group on this flight? YES ☐ NO ☐

3. If yes, name of group: ☐

Continued on other side...

4. Birth date: day ☐☐ month ☐☐ year ☐☐

5. Sex: Male ☐ Female ☐

6. Home address: ☐

City: ☐ State/Prov.: ☐

Country: ☐

7. Full U.S. addresses for the next 7 days: ☐

8. Phone numbers (where you can be reached in the next 7 days): ☐ ☐

9. E-mail address: ☐

10. Contact information of another person who can reach you in the next 7 days:

Name: ☐

Address: ☐

Phone (home): ☐ (mobile): ☐

E-mail: ☐

Under Title 18 U.S. Code section 1001, making any false statement is a criminal offense.

11. Signature (or parent's signature if passenger is younger than 18 years) ☐

For U.S. Port of Entry Staff Only

For DHS use (Primary Screening)	For HHS use (Secondary Screening)
Thermal Scanner: positive ☐ negative ☐ PH Secondary: YES ☐ NO ☐	

A. To answer each question, please mark an X in the YES or NO box:

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Do you have a cough or have difficulty breathing?		
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1.		4.	
2.		5.	
3.		6.	

Health Declaration

- Usefulness depends on honesty
- Sensitivity varies with the questions asked

Predictive Value of Clinical Findings for Laboratory Confirmation of Influenza in 1,934 Clinic Patients

Sign/symptom	PPV	NPV
1. Multiple criteria*	0.36	0.88
2. Fever	0.30	0.92
3. Cough	0.20	0.87
4. Sore throat	0.19	0.83

PPV = Positive predictive value

NPV = Negative predictive value

*Influenza epidemic plus 4 of: sudden onset, cough, chills, fever, weakness, headache, myalgia, absence of red throat, influenza in close contacts

Navarro-Mari, JM et al. J Clinical Epidemiol. 2004;58:275-79

Clinical Influenza Definitions vs. Laboratory Confirmation in Household Population

Definition	Sensitivity	Specificity
1. Fever 38C or 2 of symptoms *	0.57	0.81
2. At least 2 of symptoms †	0.57	0.90
3. Fever ‡ plus cough or sore throat	0.48	0.97
4. Fever ‡ plus cough or runny nose	0.48	0.98
5. Fever ‡ only	0.48	0.98

* Symptoms are headache, runny nose, sore throat, aches or pains in muscles or joints, cough, or fatigue.

† Symptoms are fever, cough, headache, sore throat, aches or pains in muscles or joints.

‡ Temperature $\geq$ 37.8C.

Cowling et al. PLoS ONE. 2008;3:e2101.

Infrared Thermal Detection Systems (ITDS): Fever Screening to Detect Infectious Disease

Hand-held “point and shoot” devices to …

… sophisticated thermal cameras.

Estimating Temperature: ITDS Sample Output

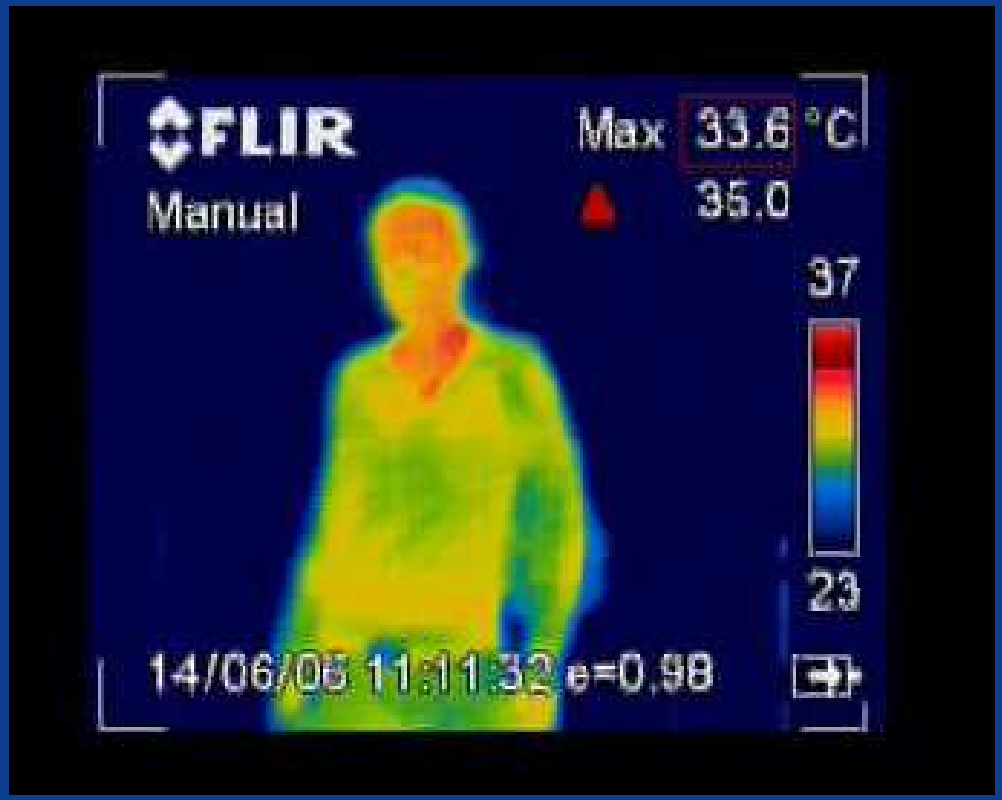
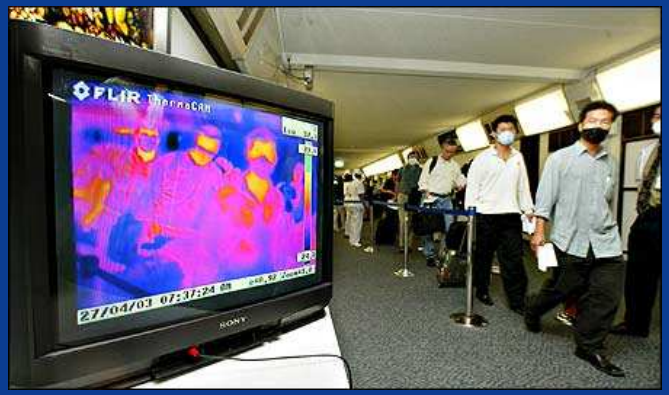


Image from McBride et al, 2007

Initial Use of ITDS in a Public Health Setting – SARS, 2003



- First used in Singapore
- Combined data: Singapore, China, Hong Kong, and Canada
  - Entry: > 35 million travelers
  - Exit: > 7 million travelers
  - No SARS detected (but detected fevers)
  - Low prevalence among travelers

Bell MB. Emerg Infect Dis 2004;10:1900-6.

“Normal” Body Temperatures

- “Normal” temperature isn’t a point, but a range
- Varies within and between individuals
  - Age
  - Diurnal variation
  - Ovulation, pregnancy, menopause
  - Chronic disease
  - Medications
- Accuracy of temperature measurements:
  - Pulmonary artery > urinary bladder > esophageal > rectal > oral > tympanic > axillary *

* O’Grady et al. Crit Care Med. 2008; 36:1330-49

“Fever”

- **Many definitions, but essentially “*above normal*” core body temperature**
- **Single temperature measurement may be misleading**
  - **For any infection, fever is affected by natural progression of disease**
  - **May be affected by use of antipyretic medications**

ITDS as Instruments of Human Temperature Measurement

- ITDS measure surface temperature using infrared radiation
- Core temperature is estimated from surface temperature
  - Surface temperature usually lower than core temperature
  - Relationship between surface and core temperatures varies by individual

ITDS: Subject to Many Variables

- **Camera**
  - Differences between models
  - Operator training and experience
  - Distance and angle between camera and passengers
  - Pre-set cutoff temperature vs. “moving reference”
- **Environment**
  - Ambient temperature
  - Humidity
- **Passenger**
  - Physical activity
  - Perspiration
  - Alcohol
  - Hot beverages
  - Smoking
- **Passenger behavior**
  - Rapidity of screening process
  - Make up, glasses

Sensitivity and Specificity for Fever

- Sensitivity and specificity chosen using a “cutoff” temperature value
  - Low cutoff → detect everyone who has a “fever,” i.e. maximum sensitivity
  - High cutoff → minimize false positives, i.e. maximum specificity
- Sensitivity can only be increased at the expense of specificity

ITDS Sensitivity and Specificity for Fever

Cutoff	Sens. (95% C.I.)		Spec. (95% C.I.)	
≥ 33	100	(93 – 100)	0	(0 – 2)
> 36.1	85	(72 – 94)	93	(89 – 96)
> 36.3	85	(72 – 94)	95	(92 – 97)
> 36.6	75	(60 – 86)	99	(96 – 100)
> 37	68	(52 – 80)	100	(98 – 100)

C.I. = confidence interval

Sample data from Ng et al. Microvasc Res. 2004; 68: 104-9.

Projected Positive Predicted Value for Fever Based on Prevalence

Prevalence (No. per 1000)	PPV
0.1	0.002
1	0.017
10	0.147

Assumptions (from Ng 2004)

- Sensitivity 85%
- Specificity 95%

International SARS Experience with ITDS

Country	No. scanned (millions)	No. febrile by scan (per 100,000)	PPV for fever *
Canada*	4	31	0.07 (subset)
Taiwan†	8	275	0.14
Australia‡	0.18	579	0.12

PPV = positive predictive value

* Confirmatory fever cutoff range: 37.5 – 38°C

* Public Health Agency of Canada. Can Commun Dis Rep. 2004; 30: 165-7.

† Shu et al. Emerg Infect Dis; 2005: 460-2.

‡ McBride et al. 2007; Final report (118 pp).

Advantages of ITDS for Mass Fever Screening

- Rapid
- High volume
- Non-contact
- Non-invasive
- Objective
- ? Effect on honesty

Disadvantages of ITDS for Mass Fever Screening

- Personnel requirement
  - 100–500+ to run system at 20–25 IPOE
  - Trainers
  - Technicians
  - Used when human resources will be very limited
- Delay to travelers
- Space requirements

Fever Screening for Influenza Detection

- Proportion of travelers with fever or influenza-like illness (ILI) * is unknown
- Estimated community prevalence of fever †
  - Summer 0.8%
  - Winter 2%
- Many influenza infections do not result in fever

* CDC definition of ILI: Fever ≥100°F (37.8ºC) AND cough and/or sore throat (in the absence of a known cause other than influenza) http://www.cdc.gov/flu/weekly/fluactivity.htm

† Kaufman et al. IMAJ. 2006; 8: 563-7

Sensitivity and Specificity of Individual Symptoms for Influenza

	Sensitivity	Specificity	PPV	NPV
Fever*	0.67	0.56	0.59	0.67
Cough*	0.92	0.23	0.52	0.75
Sore throat†	0.83	0.24	0.52	0.58
Rhinorrhea‡	0.76	0.32	0.22	0.84

PPV = positive predictive value NPV = negative predictive value

Combined data from:

Navarro-Mari et al. J Clin Epidemiol 2005;58:275-9.
Monto et al. Arch Int Med 2000;160: 3243-7.
Carrat et al. Clin Infect Dis 1999; 28: 283-90.

* N = 6278
† N = 5678
‡ N = 2534

Limitations of ITDS for Influenza Screening

- Detect fever, not infections
- Cannot detect incubating or afebrile infected individuals (low sensitivity)
- Cannot distinguish infection of interest from other febrile conditions (low specificity)
- Results can have modest predictive value

Summary of surveillance for SARS at points of transit as of June 30, 2003, Beijing

Transit site	Number of people screened for fever	Number (%) febrile	Number (%) with SARS
Airport – international	275,600	496 (0.2%)	0 (0%)
Airport – domestic	952,200	1,449 (0.2%)	10 (0.001%)
Train stations	5,246,100	2,575 (0.05%)	2(<0.001%)
Roads	7,365,600	577 (0.008%)	0 (0%)

Zonghan Zhu, M.D., Beijing Municipal Health Bureau, IEIDC Quarantine Conf 2004

Secondary Screening

- Confirms primary result
- Makes more firm diagnosis
- Rapid influenza tests…modest sensitivity
- PCR not always available
- What to do with (-) rapid test result?

What Happens after We Screen?

- **Possible actions include:**
  - Isolation of ill passengers
  - Diagnosis and management of ill persons
  - Quarantine of contacts
  - Written and verbal notices and instructions
  - Denial of travel (exit screening)
  - Denial of entry
- **Actions implemented depending on:**
  - Perceived risk posed by the traveler
  - Pandemic severity
  - Timing and extent of pandemic disease, etc.

Approach is flexible and balances public health benefits, operational feasibility, and economic, social and international impacts

Screening Summary

- Any single tool has limitations
- Using several tools can overcome some individual limitations
- What to do with traveler when results at border uncertain?
- Decisions based on many factors, including:
  - Resources available
  - Severity of outbreak and disease
  - Costs: direct, “opportunity”, social, indirect economic
  - Potential benefits: health, social, economic
  - Balance of costs and potential benefits

Future Research

- What approaches were taken?
- What were the results around world?
- What effect did screening have on outbreak in different situations?

WHO and International Civil Aviation Organization (ICAO) developing a project to address these questions….Watch for it

Muchas Gracias!

Thank You!

USG Border/ POE Responses

Border Closures - No

Active Entry Screening - No

Active Exit Screening - No

Travel Advisories- Yes, Early

Level 4, 3 - Alert & Precaution Mexico,

Level 2 Outbreak Notices, US

Enhanced Passive Disease Surveillance - Yes

Active Educational Efforts - Yes

U.S. Exit Screening – Decision Briefing May 15

- US travel associated with ~ 5% of international cases outside of Canada and Mexico to date

- March 28* - May 11, ~6,477,377 passengers departed the US for countries other than Mexico and Canada

*Symptom onset of first suspect case U.S.; CDC received specimen on April 17

Rate per Million Travelers May 15

Confirmed International Cases Associated with Travel from North America (March 28 to May 11, 2009)

Country	# of Cases (%) N=315 (53% of International Cases)	Rate per million travelers
Mexico	220 (70%)	504
US	16 (5%)	2.5*
Canada	3 (1%)	9.4
No travel	76 (24%)	

*** 3200 travel-related cases in the U.S. would be needed to match the rate seen in Mexico**

Exit Screening in U.S. May 15?

33 countries had reported cases

- **Screening of all 8.4 million outbound U.S. travelers in May 2009**
  - → **129 true positive**
  - **84,227 false positives**

- **Test: 99% sensitive and 99% specific**

International Public Health Measures*
156 countries - June 29 –
55 countries with 70,893 confirmed cases

- 104 (67%) countries screening travellers for ILI
  - Thermal scanners used by 48/104 countries
    - 5/48 (10%) departing travelers
    - 21/48 (44%) arriving travellers from affected regions
    - 32/48 (67%) arriving travellers from all countries
- 17 (11%) countries cancel trips
- 57 (36%) countries have travel advisories
- 54 (35%) countries impose trade bans
- 38 (24%) countries impose quarantine measures

*Source: Global Public Health Intelligence Network

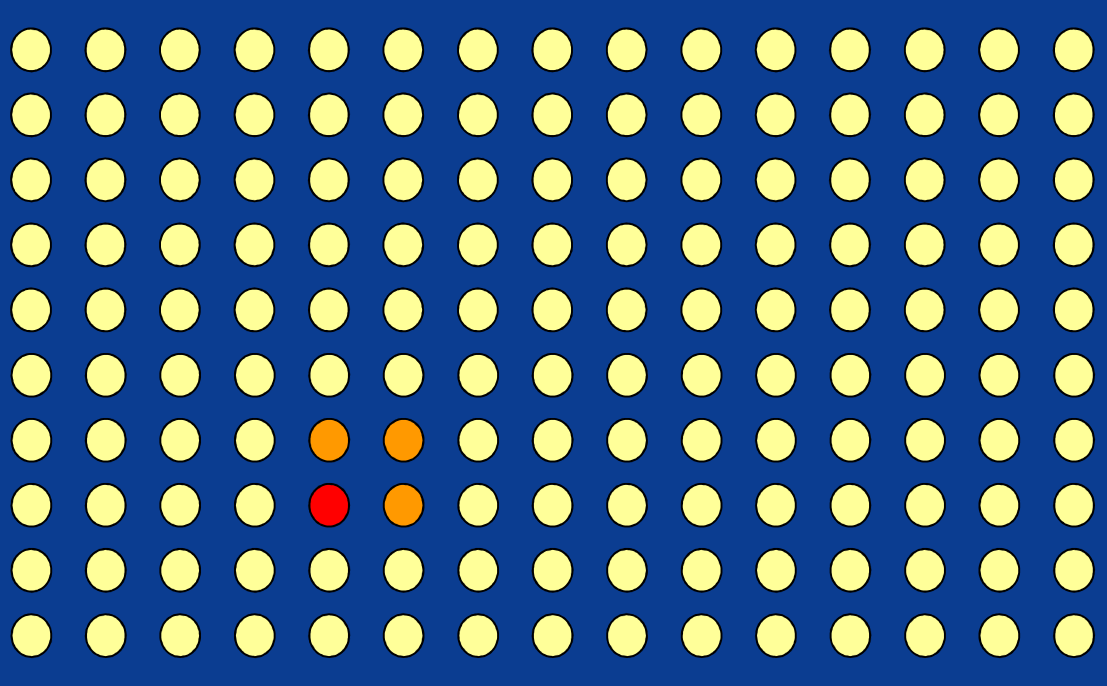
Quarantine and Migration Health

Immediate Consequences

- Hold aircraft
- Hold passengers and crew
- Flight disruptions
- Economic impact

Contacts: Risk Assessment

150 travelers arriving by air



- Ill traveler: Isolate and evaluate
- Long-term contact(s) (>24 hrs)
- Short-term contact(s) (<24 hrs)

But, Who is Really a Contact of an Ill Passenger?

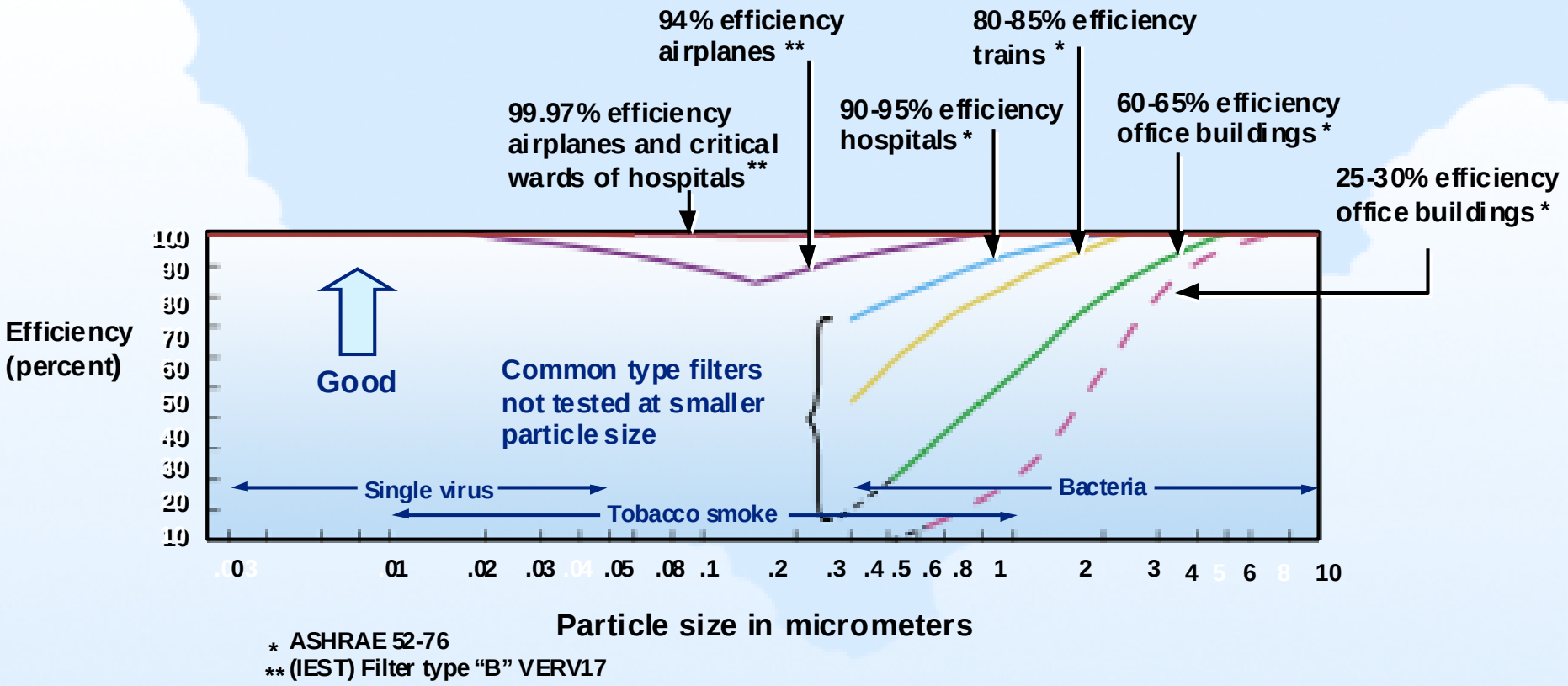
Who is at risk for infection?

Who should be quarantined?

The Filtration System

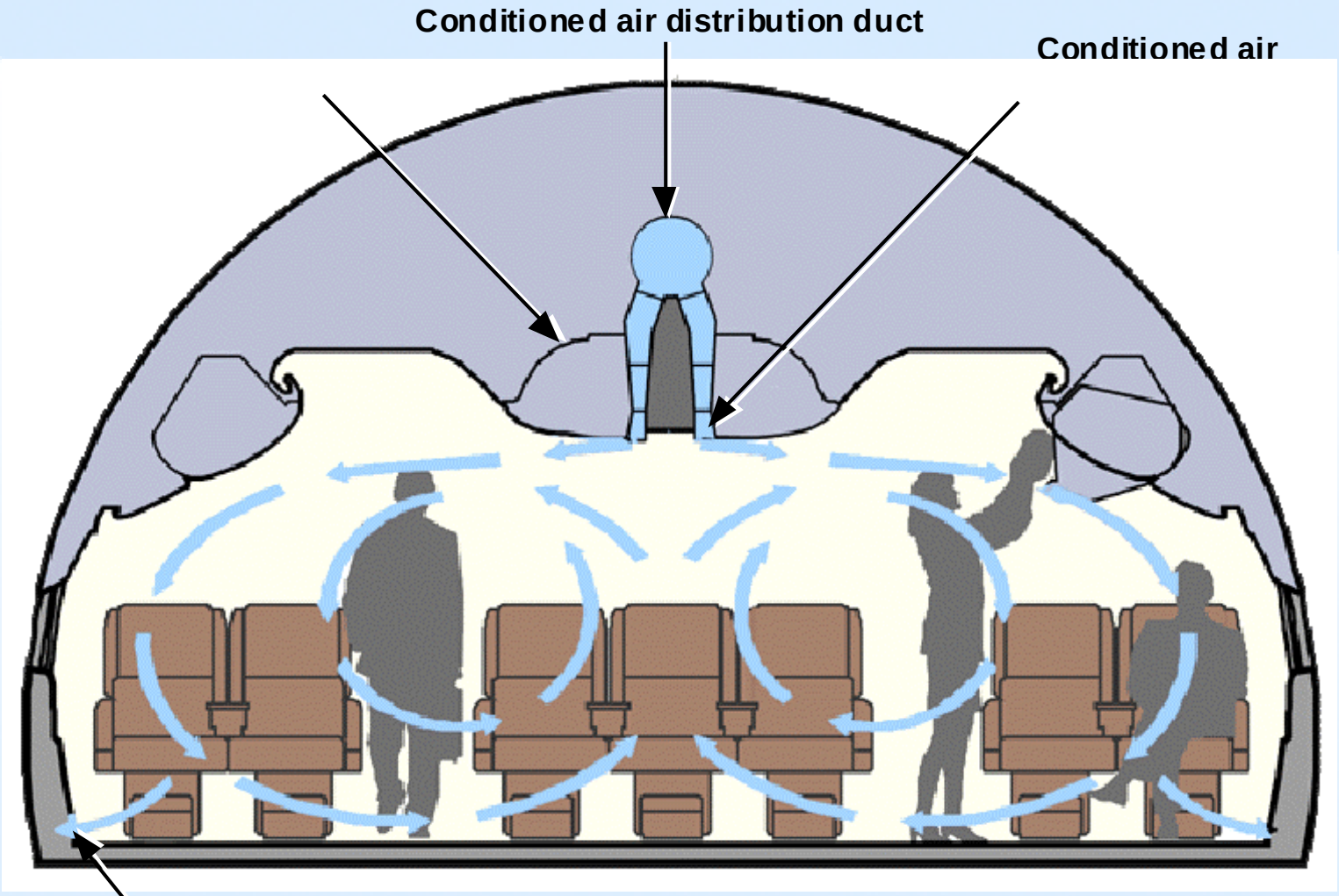
- High-efficiency particulate (HEPA-type) filters are used on Boeing aircraft
- Similar filters are used in critical hospital wards and industrial clean rooms
- Filters are rated at 0.3 micron-diameter particles
- Filter efficiency increases over time

Filter Efficiencies of Planes, Trains and Buildings



* ASHRAE 52-76
** (IEST) Filter type "B" VERV17

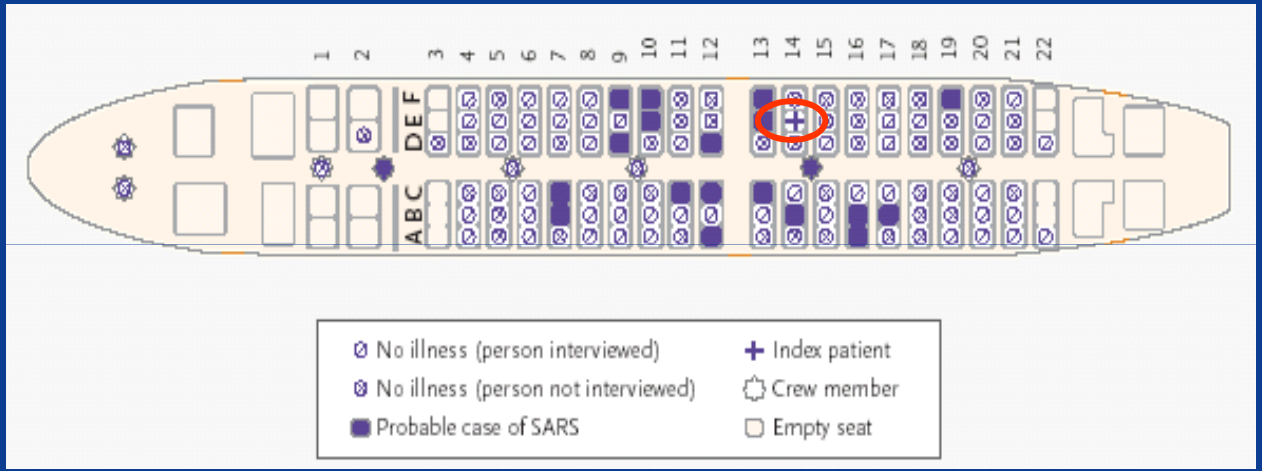
Cabin Air Flow



The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Transmission of the Severe Acute Respiratory Syndrome on Aircraft



Duration	Aircraft	Illness	No. on Flight	No. (%) Infected
3 hrs	737	Fever/cough (1)	120	22 (18.3)

Olsen SJ, et al. N Engl J Med 2003;349:2416-22.

Long-term Contacts* (≥ 24 hours)

- Likely to be only a small number of passengers (e.g. travel companions)
- Time from first exposure to final travel destination is ≥ 24 hours – possibly become infectious during onward travel
- Quarantine *in situ, (no forward travel)* - options may include on- or off-airport facilities, (i.e., hotels, civic centers), and other locally identified structures

*Of confirmed or suspect pandemic influenza

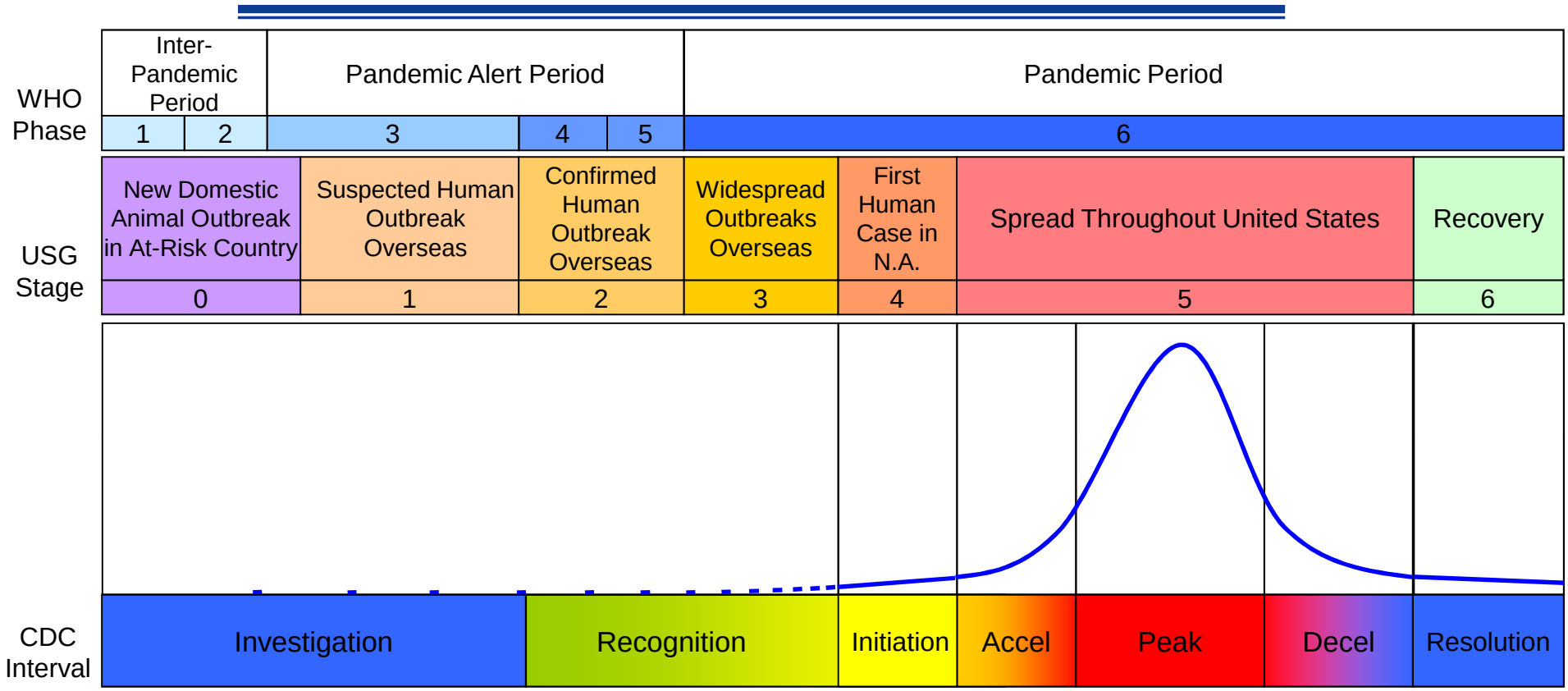
Short-term Contacts* (< 24 hours)

- Most passengers will be in this category
- Time from first exposure to travel destination is <24 hours – less likely to become infectious during onward travel
- Conditional release – send forward to destination with a number of requirements
  - HHS
    - Collects destination contact information and health information
    - Provides post-exposure prophylaxis if available
    - Distributes information and instructions to passengers
  - Passengers
    - Proceed home and self-quarantine/self-monitor
    - Report symptoms to local health authorities/provider

* Of confirmed or suspect pandemic influenza

What would trigger active surveillance under the U.S. Risk Based Border Strategy?

When Would We Perform Active Surveillance?



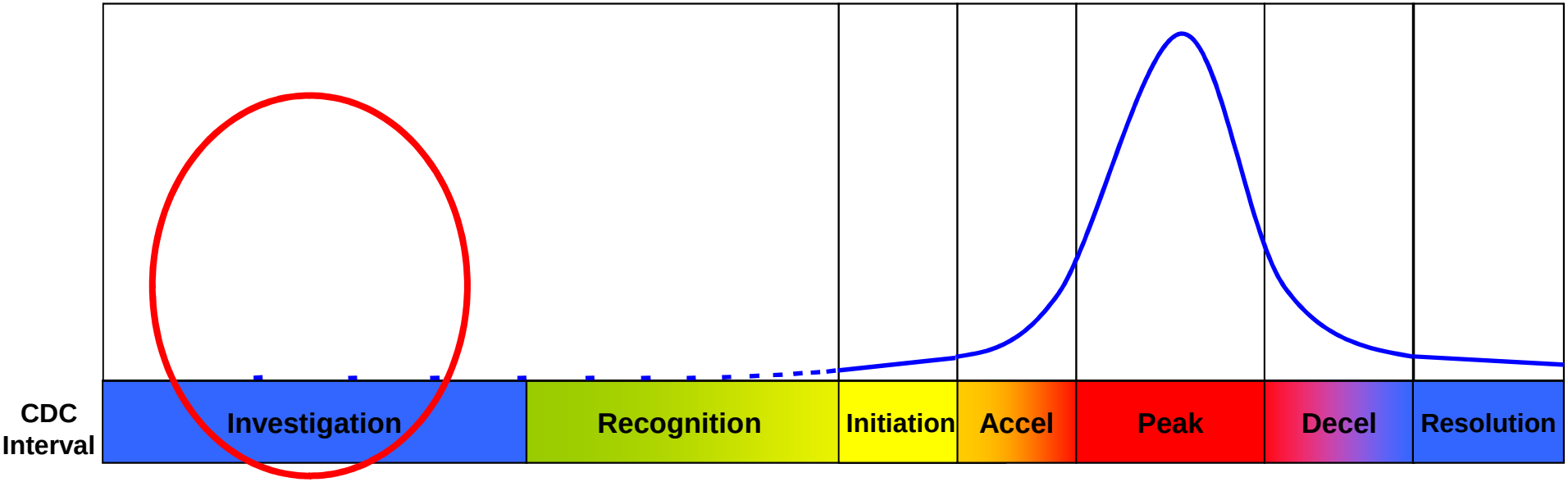
Pre- Pandemic Intervals

- Investigation
- Recognition

Pandemic Intervals

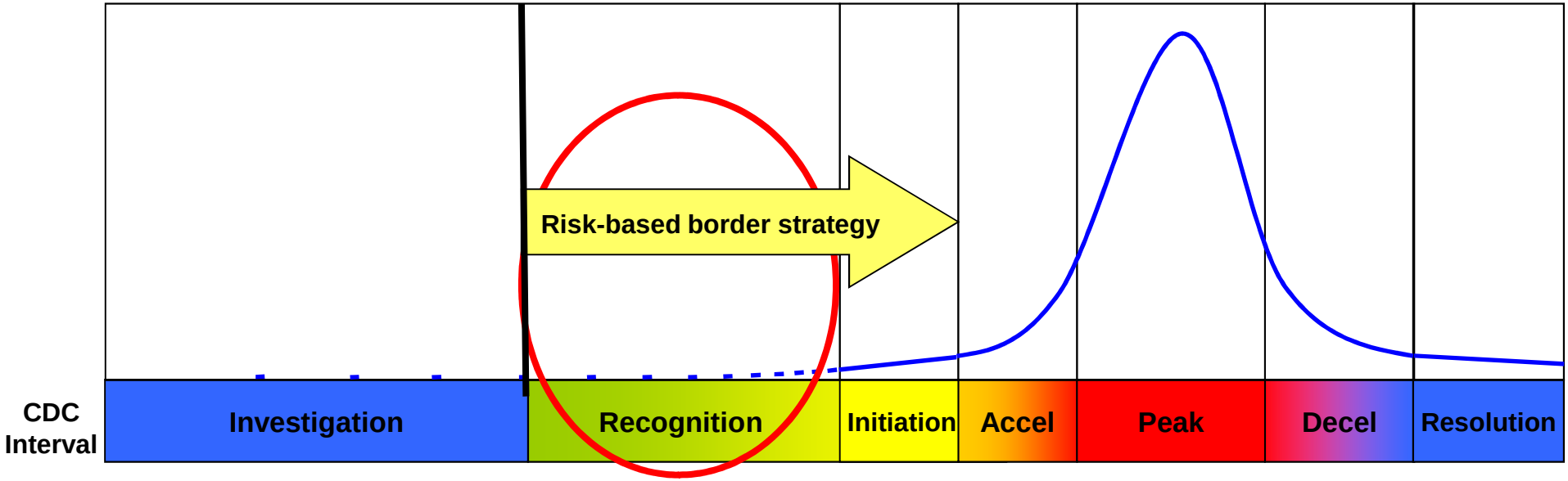
- Initiation
- Acceleration
- Peak Transmission
- Deceleration
- Resolution

When Would We Perform Active Surveillance?



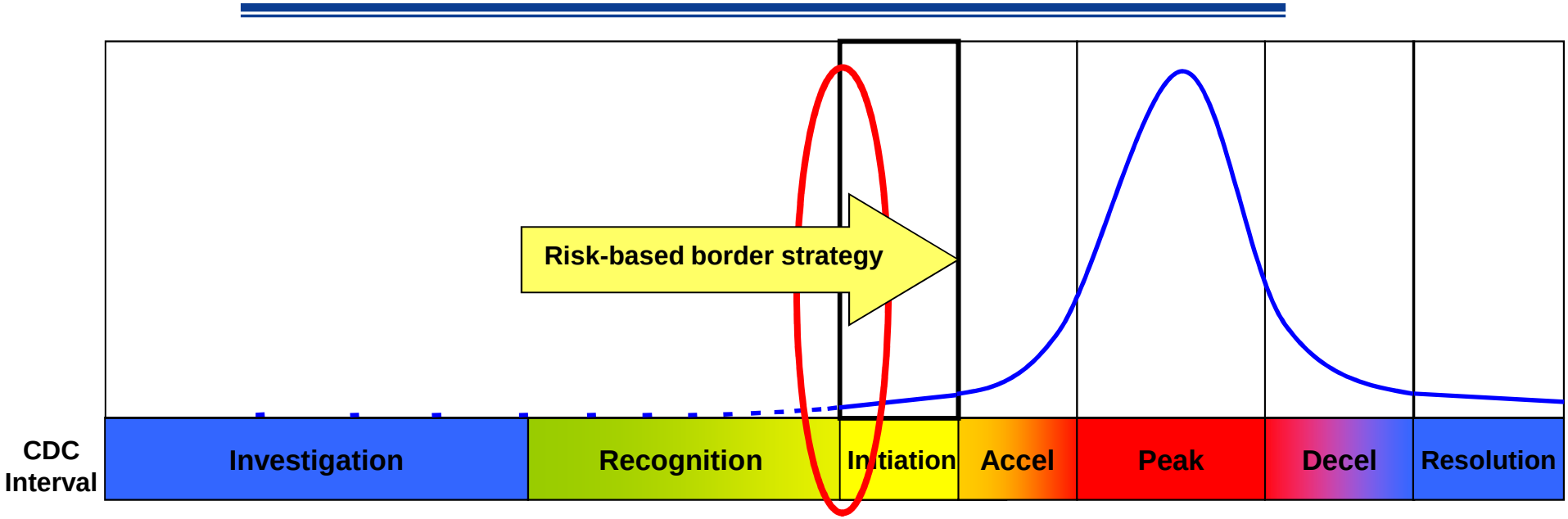
- Current pre-pandemic situation
- Identification of infection due to novel influenza viruses – focus on investigation and containment overseas
- Passive surveillance…no active screening

When Would We Perform Active Surveillance?



- Confirmation of human cases and demonstration of efficient and sustained human-to-human transmission overseas
- RBBS likely to be initiated in this Interval

When Would We Perform Active Surveillance?



- First laboratory confirmed case of pandemic influenza in N. America
- Active surveillance and screening at ports
- RBBS likely to be continued through the end of this Interval

The Big Question

- **What tool or combination of tools would have adequate sensitivity, specificity, and predictive values so as to provide benefits greater than costs?**

Questions

- What is the value of health declarations, interviews, examinations…sensitivity, specificity, predictive value?
- Do we take action based on screening results without laboratory confirmation?
- Who is really at risk for infection when there is one person on an aircraft with influenza? All the passengers? Those seated close to the ill person?

ITDS Questions

- What are the marginal costs of using ITDS as part of a risk based border strategy?
- What are the marginal benefits of ITDS?
- Could the people required to run ITDS be better utilized doing something else?
- What is appropriate response to positive findings ?

ITDS Questions

- **Would thermal screening provide reassurance OR cause excessive concern?**
- **Would prospect of thermal screening deter ill individuals from traveling?**
- **Would ITDS make people more honest?**
- **Would ill people take measures to mask fever to avoid detection?**

Border Travel Restriction Options

- **Nothing**
  - No restrictions on people or cargo
- **Complete Border Closure**
  - Stop people & cargo
- **Partial Border Closure**
  - Stop people
  - Allow cargo
- **Risk-based Border Strategy (RBBS)**
  - Allow people & cargo to flow
  - Conditional entry of people based on risk
  - Target high risk persons for earliest diagnostics and interventions