Pandemic Influenza Modeling: Effects on Community and Hospital Surge

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Los Angeles County Public Health

Emergency Preparedness and Response Program

Outline

- Modeling in Los Angeles
  - Big County, Distinct Challenges
  - So Many Questions
  - Unique Project
- Community Mitigation Model
  - History
  - Design Specifics
  - Results and application
- Surge Model
  - Brief Overview
  - Results and application
- H1N1 Adjusting On the Fly

Modeling in Los Angeles

Big County

- 11 million citizens; 88 cities
- 11 primary languages
- 108 Hospitals;
  87 Emergency Depts.
- 3 Health Depts:
  - County (3,700 staff)
  - Long Beach
  - Pasadena

Distinct Challenges

- Population density & scarcity
- Urban v. rural
- 1/3 of <65 pop uninsured
- 100,000 homeless
- 36% foreign born
- Over 200+ languages

So Many Questions…

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Modeling in Los Angeles: So Many Questions

- How will the pandemic spread throughout the County?
- How can we slow it down?
- How effective are:
  - Vaccines?
  - Anti Virals?
  - Social Distancing Measures?
- How many people will get sick?
- How many will go to the hospital?
  - Place and time?
- Will all hospitals experience “surge” at the same time?
- What can hospitals do to maximize their resources?

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Modeling in Los Angeles

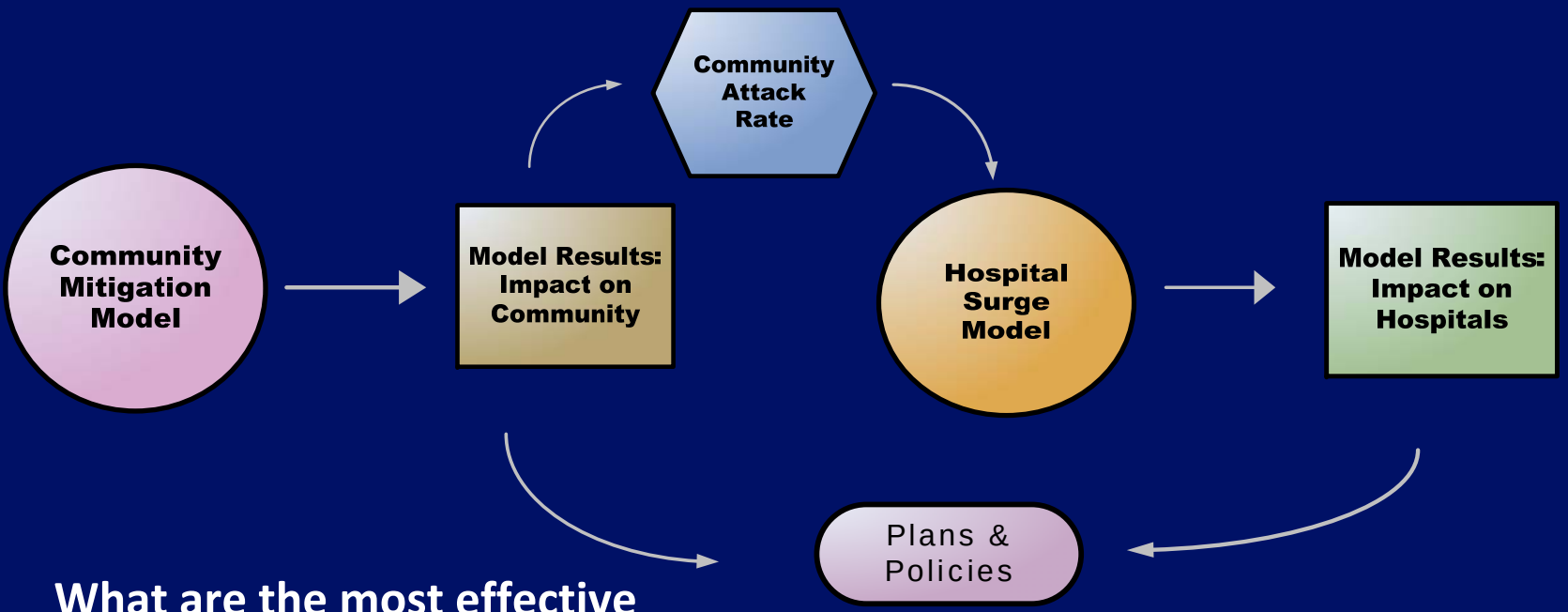
Unique Project

- 2 ½ year project
- Predictive mathematical disease models to:
  - Understand spread within community and hospital systems
  - Drive planning and policy development
- Explicitly designed for local health department;
  - Local data, objectives
- Incorporation of cutting edge methods and technology
- Output from Community Model, input to Surge Model

Integration of Models

How will a pandemic affect LA County?

How will a pandemic affect LA County hospitals?



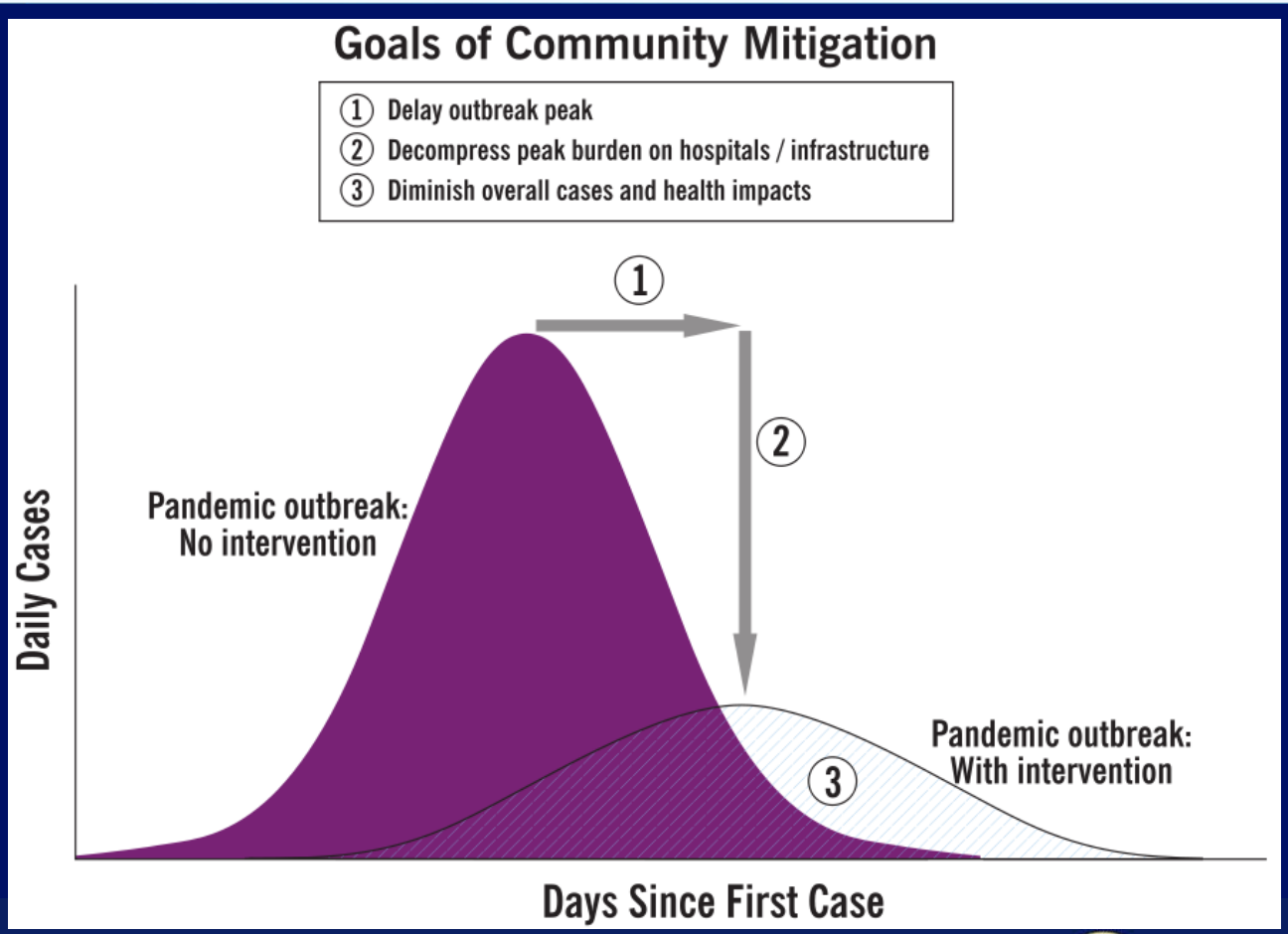
What are the most effective interventions and policies?

Community Mitigation Model: History

Models of Infectious Disease Agents Study (MIDAS)

- NIH Commissioned, 2004
  - 7 multi-institutional research groups
  - Ira Longini-U. Emory/Washington, Fred Hutchinson Cancer Research Center
- 2006 Contracted with Longini group
  - H5N1 Focus: Disease spread, specific vaccines
- April-Oct. 2009: Retooled model to reflect Pandemic H1N1 Situation

Community Mitigation: Goals



Centers for Disease Control. Interim Pre-Pandemic Planning Guidance: Community Strategy for Pandemic Influenza Mitigation in the United States Department of Health & Human Services, USA, 2007.

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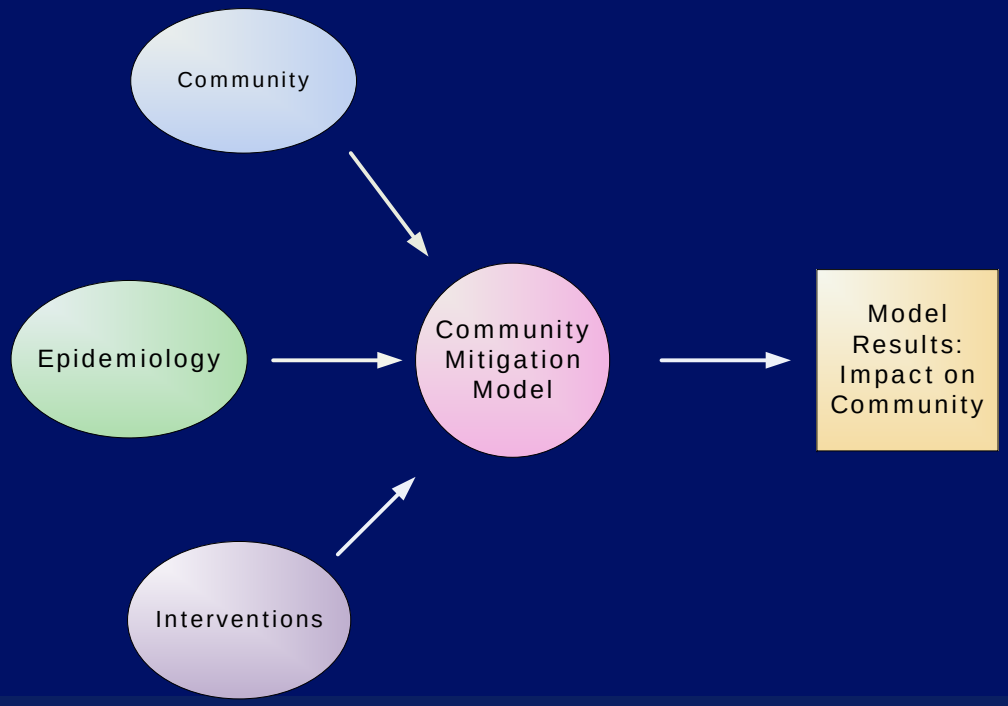
Community Mitigation Model: Design Specifics

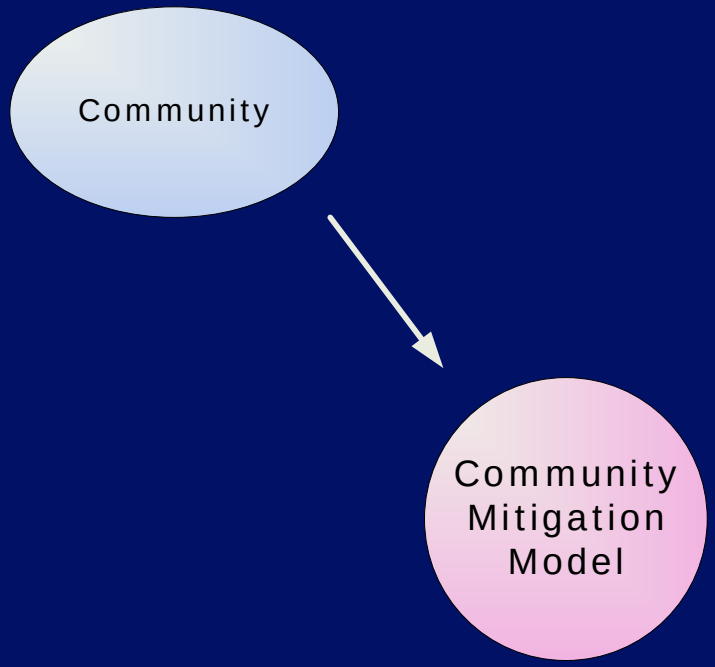
- "Model" is a composite of:
  - Computer codes
  - Statistical probabilities
  - Disease transmission parameters
  - Mathematical equations
- Parallelized-Stochastic Model
  - Concurrent elements
  - Elements of randomness
  - 180 days long
- 3 general components:
  - Community
  - Epidemiology
  - Interventions

Community Mitigation Model: General Design



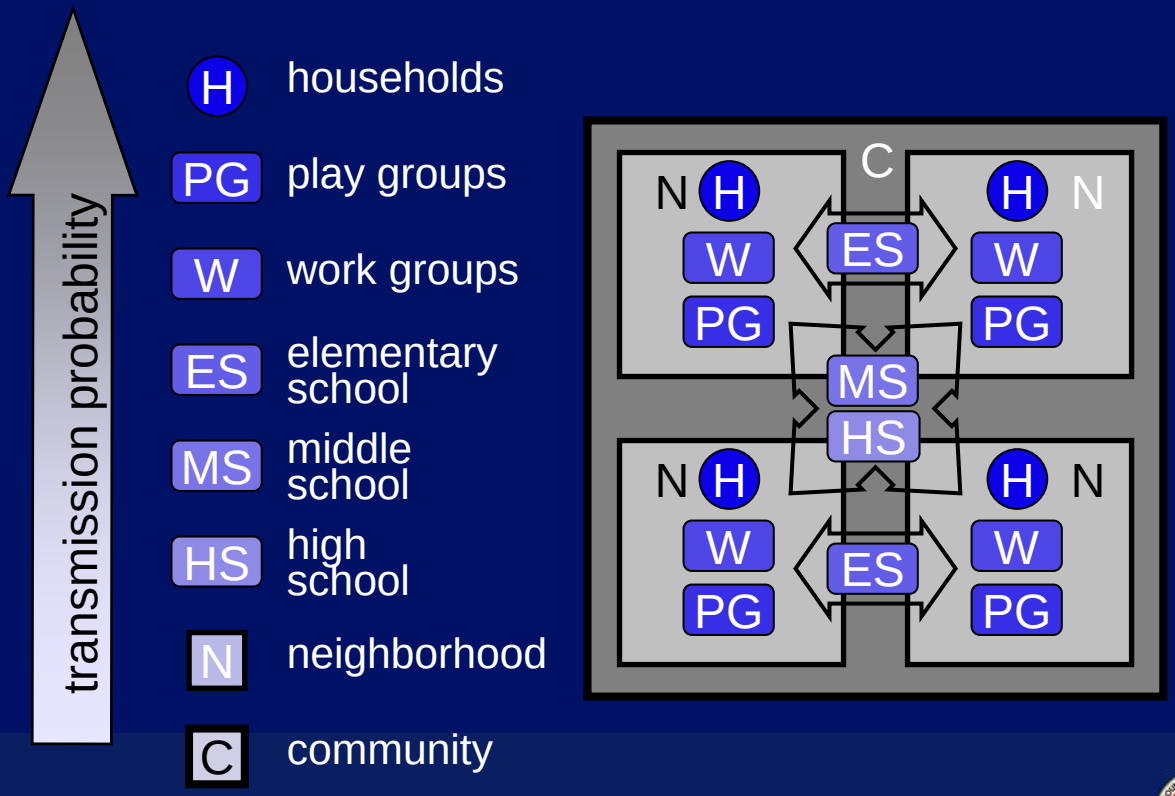
Design Specifics: Community

- Synthetic Population
- Population Demographics
  - Census Tracts (2007 est)
    - Gender, age, geog.
  - Commuter data and transportation patterns
    - 12 hour day/night cycles
  - Undocumented worker totals included
- Mixing groups drive population interaction



Design Specifics: Community

Halloran-Longini Community Mixing Model



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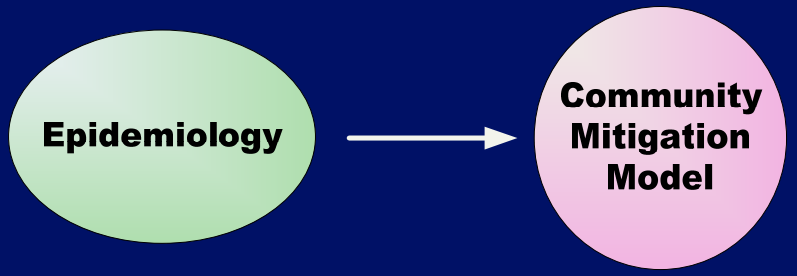
Design Specifics: Epidemiology

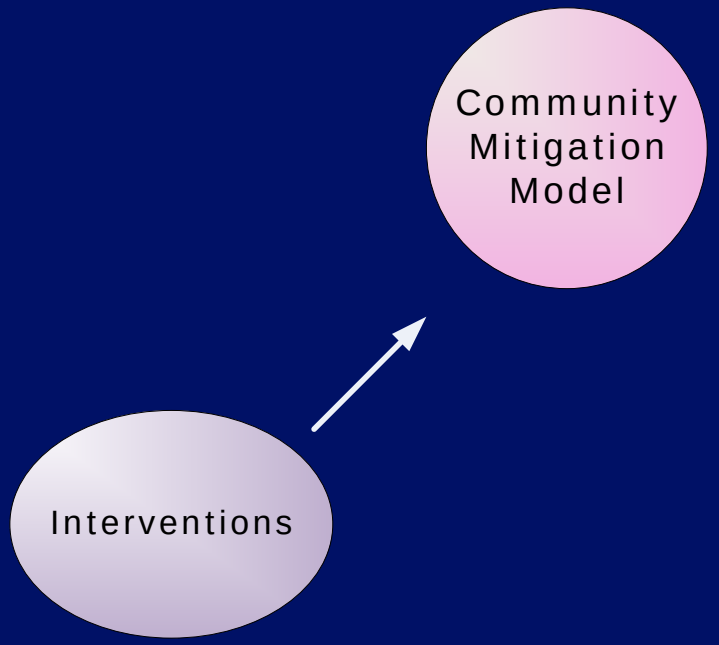
Spread of disease throughout community

- Infectious of disease (R_o)
  - Mild = R_o 1.6
    - (H1N1 R_o = 1.3?)
  - Moderate = R_o 1.8
  - Severe = R_o 2.0 (H5N1)
- Time varying infectiousness
  - different viral loads
- Stochastic spread within multiple contact groups
- Age-dependent transmission probabilities
- Time-varying infectiousness (viral production rate)
- Behavioral modification of symptomatic individuals



Design Specifics: Interventions

- 3rd Component of Model
- Variety or "menu" of options
- Dynamic process
  - Latest research findings
- Two Intervention Types:
  1. **Pharmaceutical**
  2. **Non-Pharmaceutical (NPI)**



Design Specifics: Pharmaceuticals

Vaccine

- Different efficacies (well v. poor match)
- Coverage levels: 30%, 40%, 70%
- Time delay in intervention

Anti-Viral

- Treatment only v. Prophy (Household TAP)
- 2.527 million courses (84% Tamiflu 16% Relenza)
- HTAP:
  - Ascertained ill: 2 doses/day/5 days
  - Members of ill's household: 1 dose/day/10 days
  - Limited response, first 100 cases only

Design Specifics: Non-Pharmaceutical

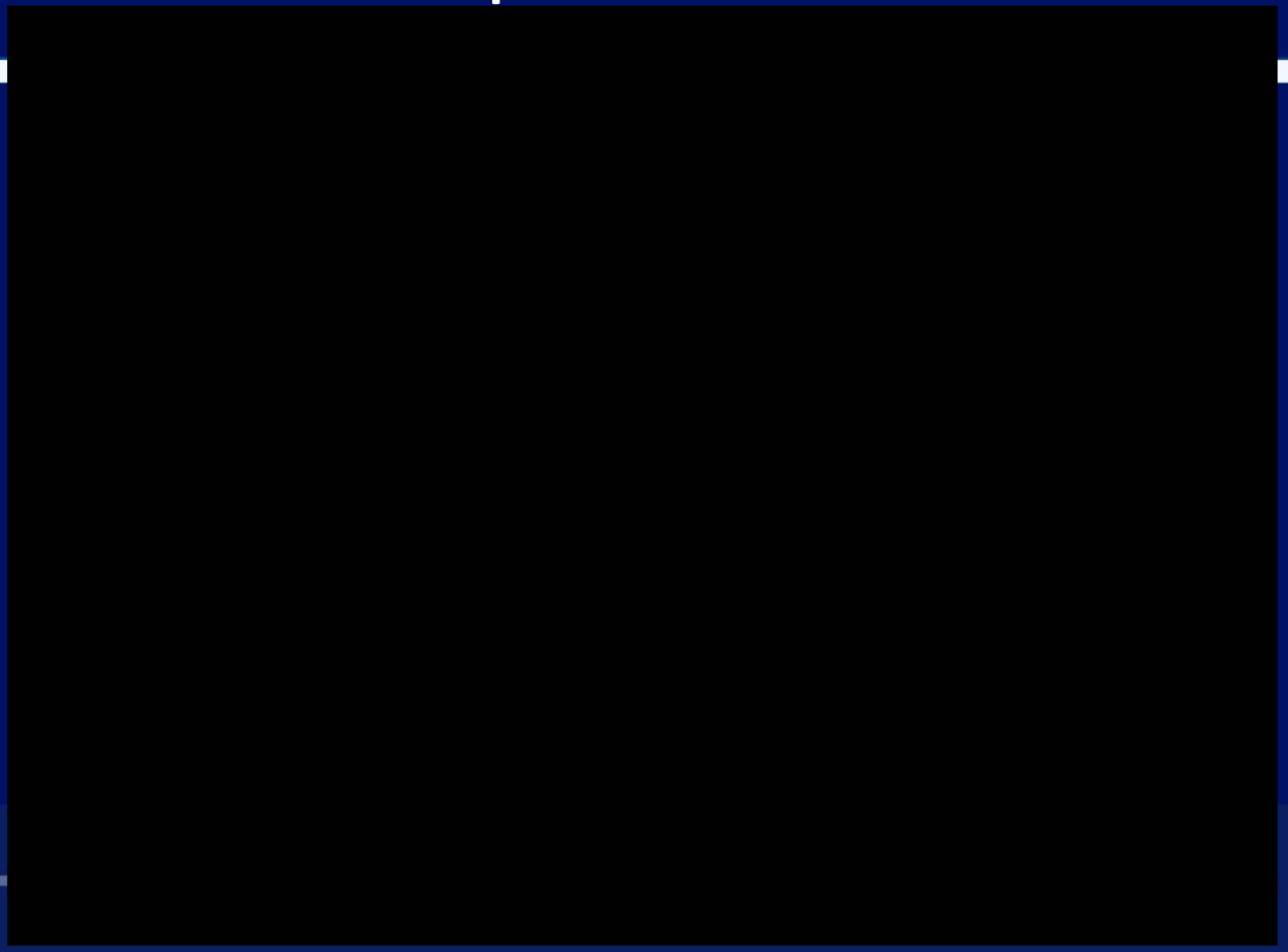
School Dismissal

- Multiple variations tested: when closed, duration of closure, etc.

Social Distancing

- Quarantine and Isolation
  - Compliance data: LA County Health Survey (2007)
- 60% of ill have contact with only household members
- "Liberal Leave" policy: symptomatics retire to home one day after becoming ill; 60% compliance

Sample Results



Results and Application

Spring 09

Results Influencing Planning and Response:
Anti Virals

$R_o = 1.6$

Strategy	Avg AR	0-4	5-18	19-29	30-34	65+	Cases (x10,000)
No intervention	36.0 %	40.8%	55.0%	29.1%	31.8%	25.8%	399.6
HTAP	30.8	34.2	49.6	24.3	26.4	21.5	342
Tx Only	33.0	37.6	52.8	25.9	28.4	22.9	366

Early, Aggressive, and Targeted prophylactic use of anti virals can limit overall spread, particular in younger age groups

Results and Application

Spring 09

Results Influencing Planning and Response: NPI

R_o = 1.6

Strategy	Avg AR	0-4	5-18	19-29	30-34	65+	Cases (x10,000)
No intervention	36.0 %	40.8%	55.0%	29.1%	31.8%	25.8%	399.6
County Wide School Closure	2.1	1.9	1.9	2.1	2.3	1.9	23.1
Closure by Tract and Age	35.9	40.7	54.8	29.1	31.8	25.8	398.6
Combined NPI	0.2	0.2	0.2	0.2	0.2	0.1	1.8

Aggressive school closure, where feasible is effective. Layered NPI extremely effective.

Results and Application

Spring 09

Results Influencing Planning and Response:
Vaccine

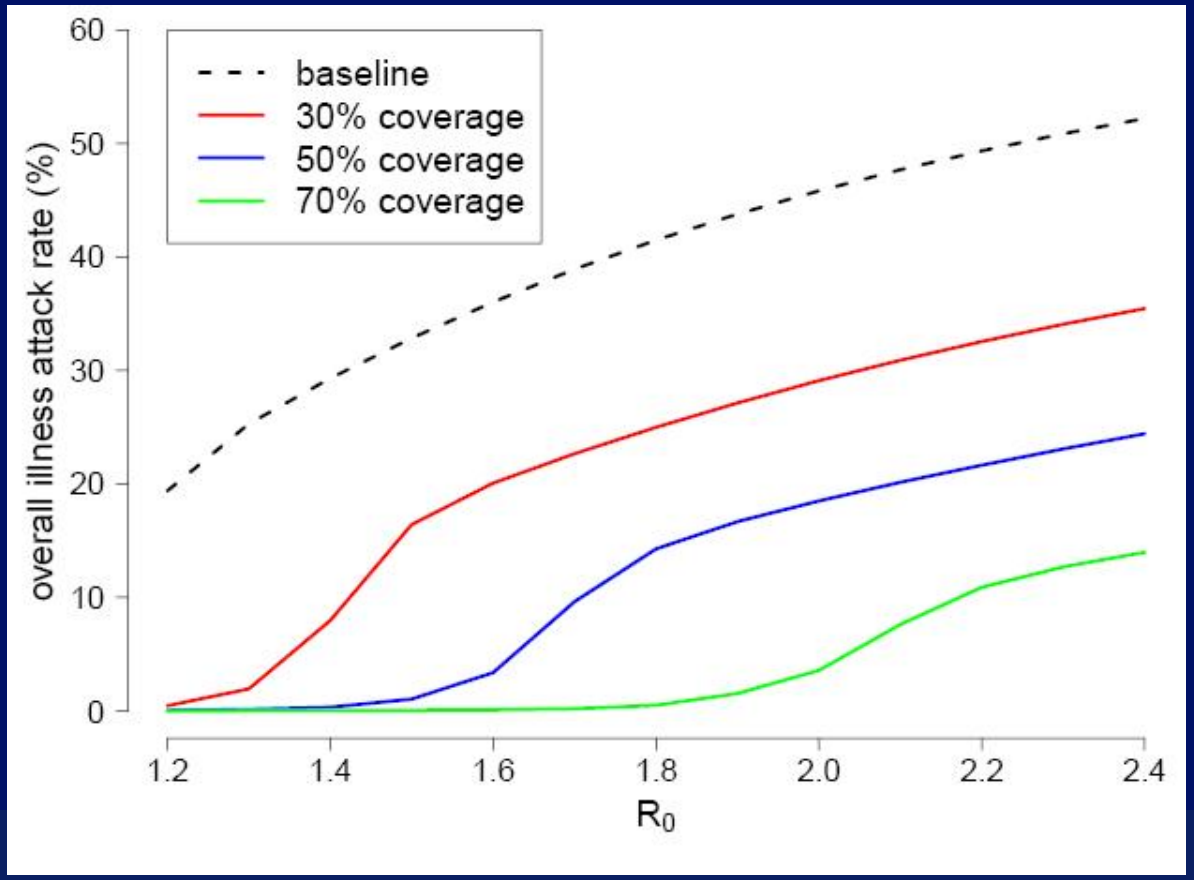
$R_o = 1.6$

Strategy	Avg AR	0-4	5-18	19-29	30-34	65+	Cases (x10,000)
No intervention	36.0 %	40.8 %	55.0 %	29.1 %	31.8 %	25.8 %	399.6
Pre Vac 30 %	18.7	21.0	34.4	13.2	14.9	11.4	207.4
Pre Vac 50 %	0.8	0.8	1.7	0.5	0.6	0.4	8.8
Pre Vac 70 %	0.0	0.0	0.1	0.0	0.0	0.0	0.4

Each subsequent level of vaccine coverage greatly reduces both Attack Rate and Total Cases

Results and Application: Vaccine Efficacy

Well Matched Vaccine



Integration of Models

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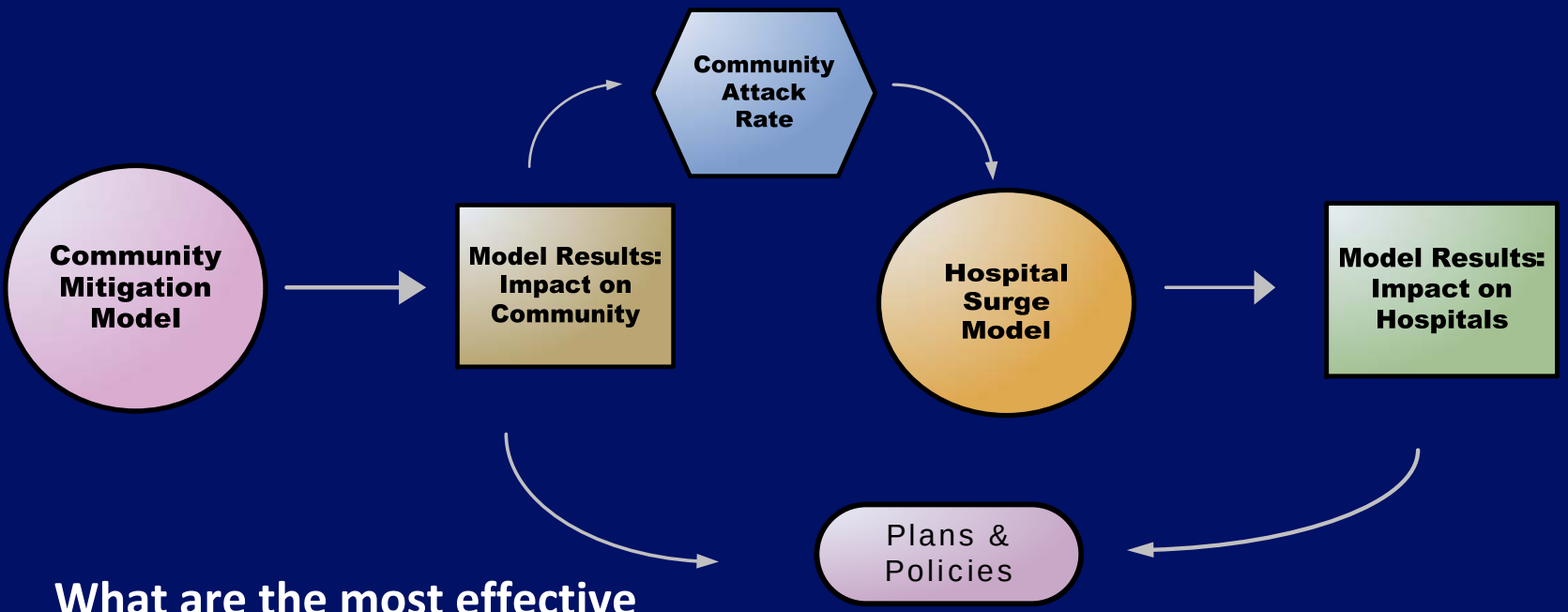


What are the most effective interventions and policies?

Surge Model History

- 2003: Cuts in LA County Health Services
  - Anticipated loss of hospitals
  - How will loss affect hospital delivery system?
    - Recreate hospital environment; "turn off" hospitals

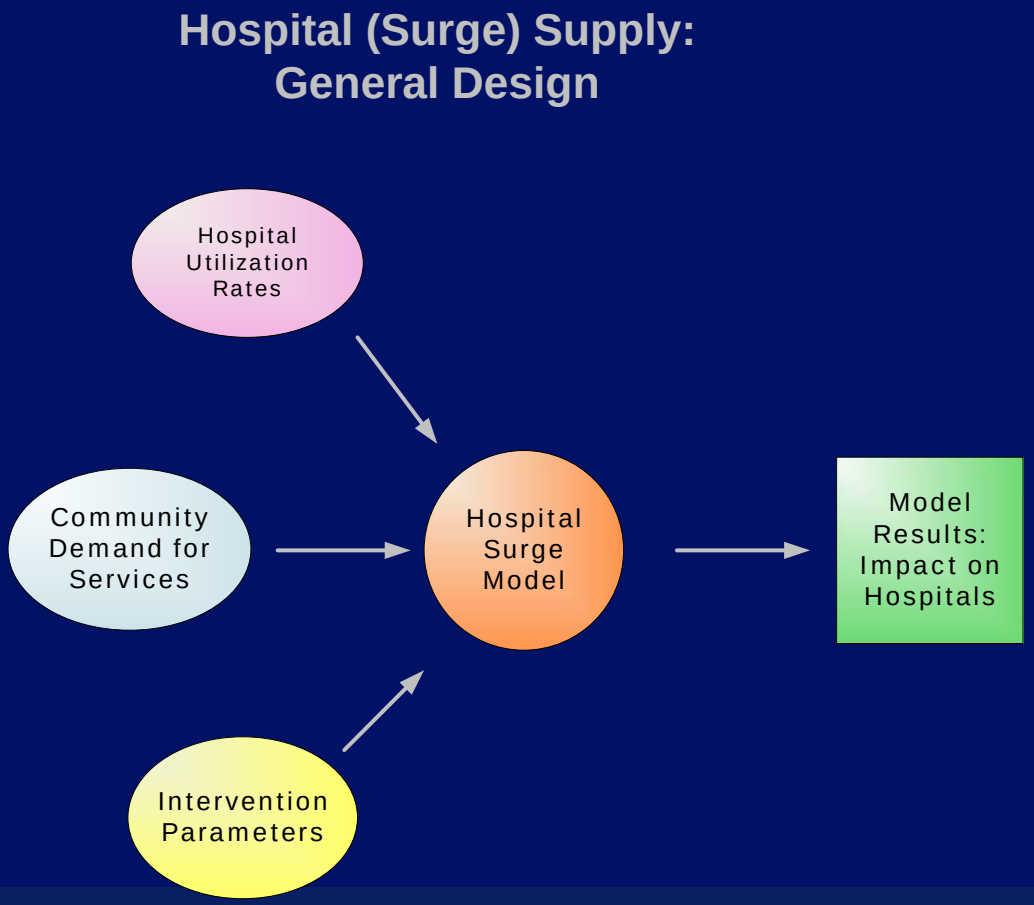
    Adjust plans and policies
  - 2005 HASC White Paper
    - ID potential issues for Hospital response to PI
  - 2007: Begin adjusting model for Pan Flu Planning
    - Expand focus to public health interventions

Design Overview: Model Type

- Discrete event
  - Models events that either happen or don't
- A Queuing model
  - Patients wait to be served in beds
- A micro-simulation
  - Uses patient level data
- Stochastic
  - Includes randomness to account for variation and uncertainty in estimates

Design Overview: Components

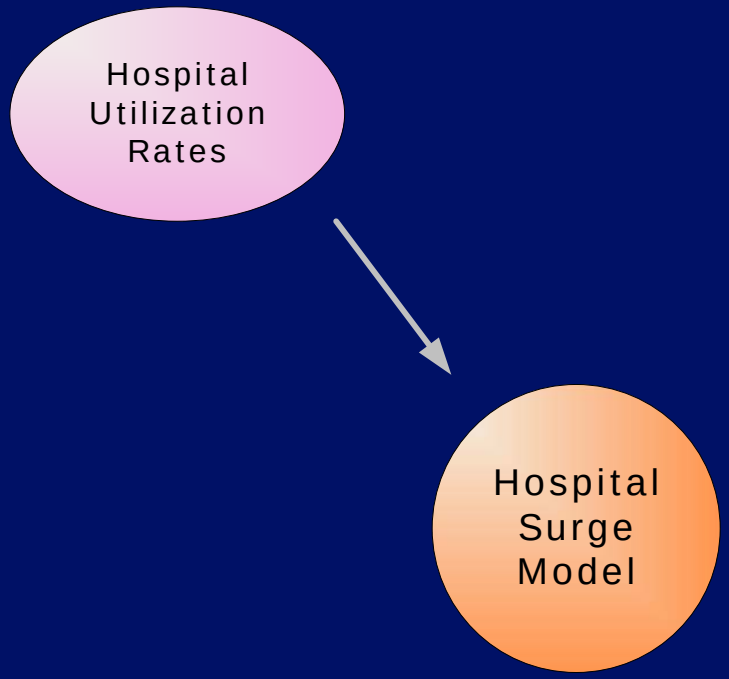
- 106 Hospitals
- Adjusted Patient Level Data
- 25 week cycle
  - Moderate Flu (R_o = 1.7-1.8)
  - Severe (R_o =2.0)



Recreating the Hospital "System"

Hospital Utilization Rates

- 2006 OSHPD Data*
  - Patient level utilization:
    - Age, gender, ZIP
    - Procedure (ICD 9 Codes)
    - Insurance status, carrier
  - Hospital level capacities
    - Bed types and numbers
    - Occupancy rates by day



*Hospital Financial Data Sets; Patient Discharge Data sets; Hospital Utilization Data Sets

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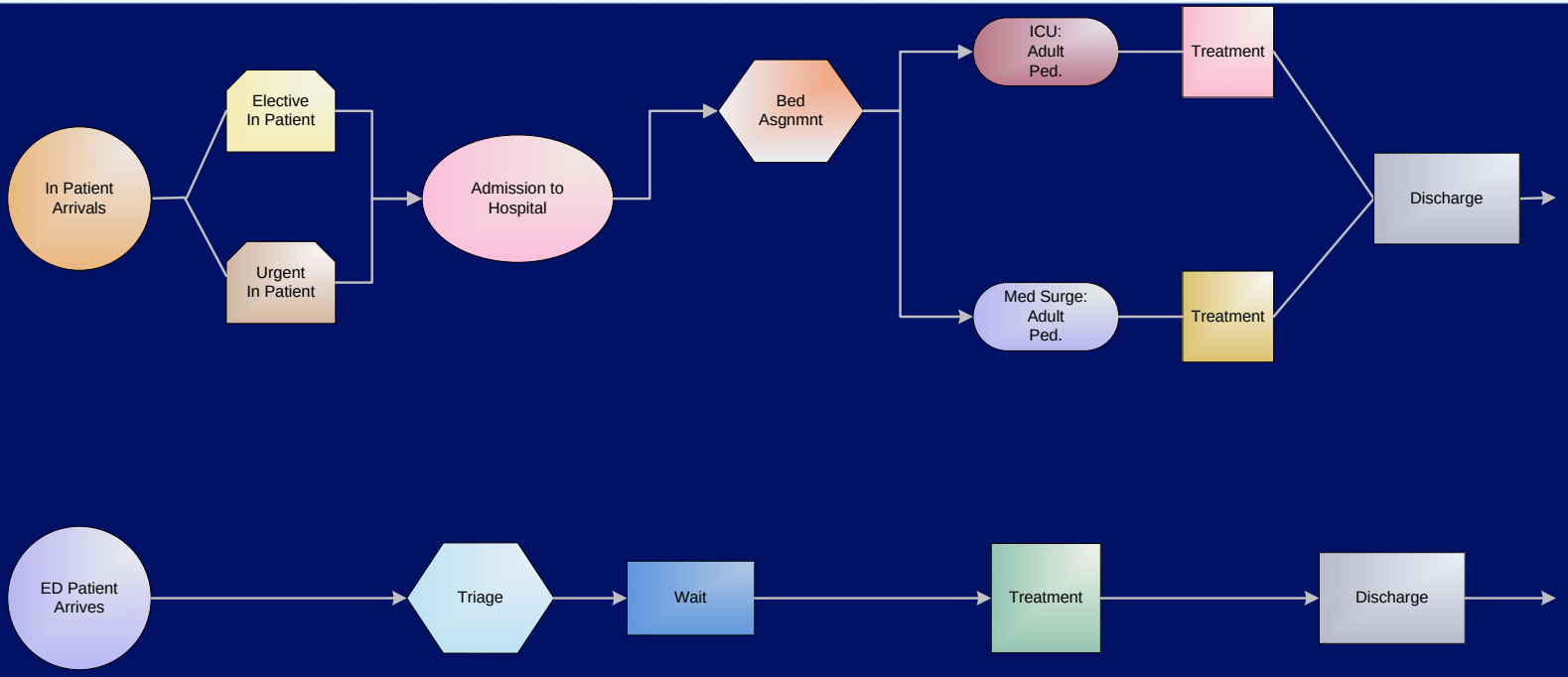
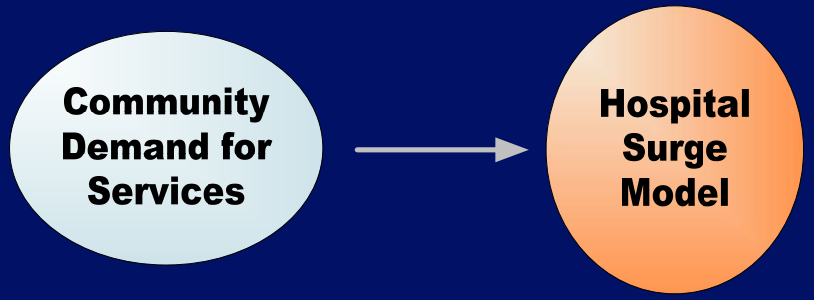
Baseline: No Flu, No Intervention



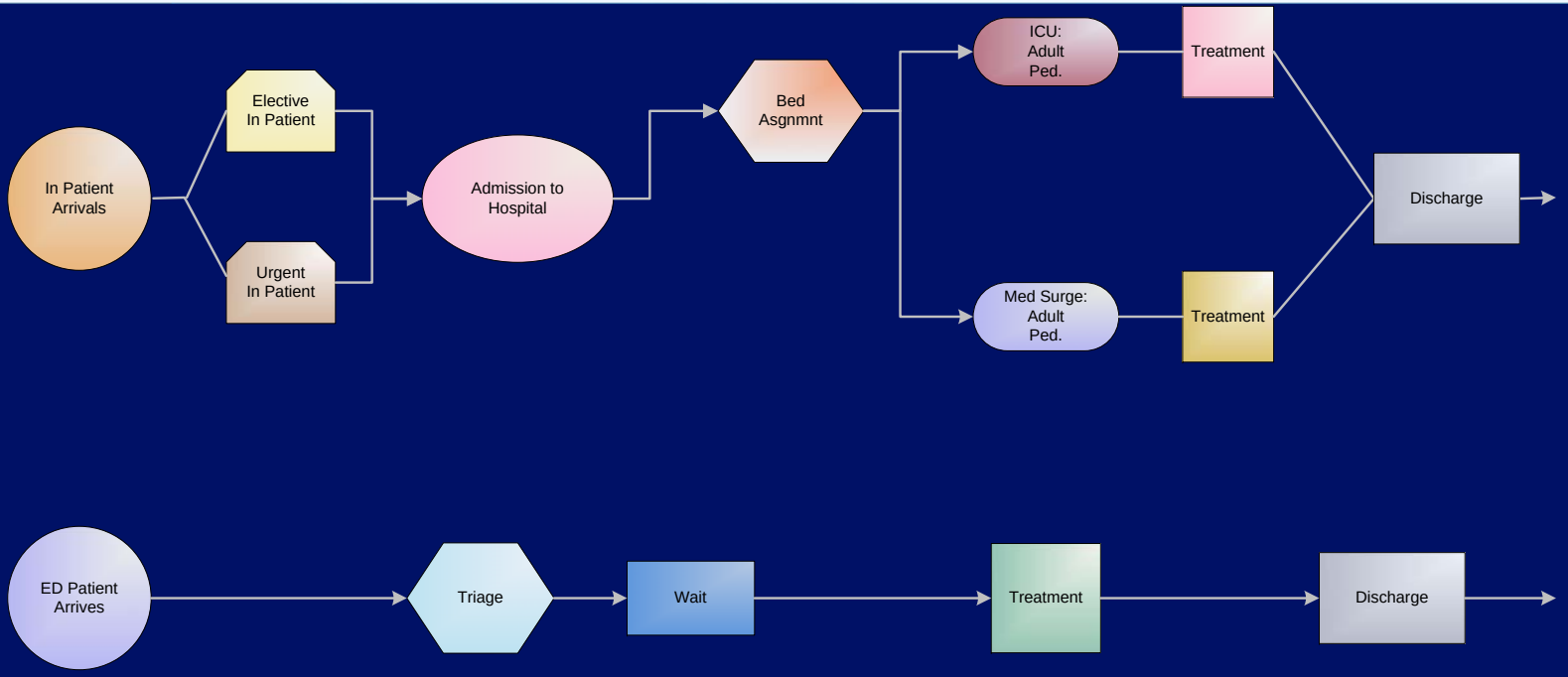
Creating Flu Demand: Integration of Comm. Model Data

- OSHPD data:
  - # patients/day/hospital
  - No Pan Flu

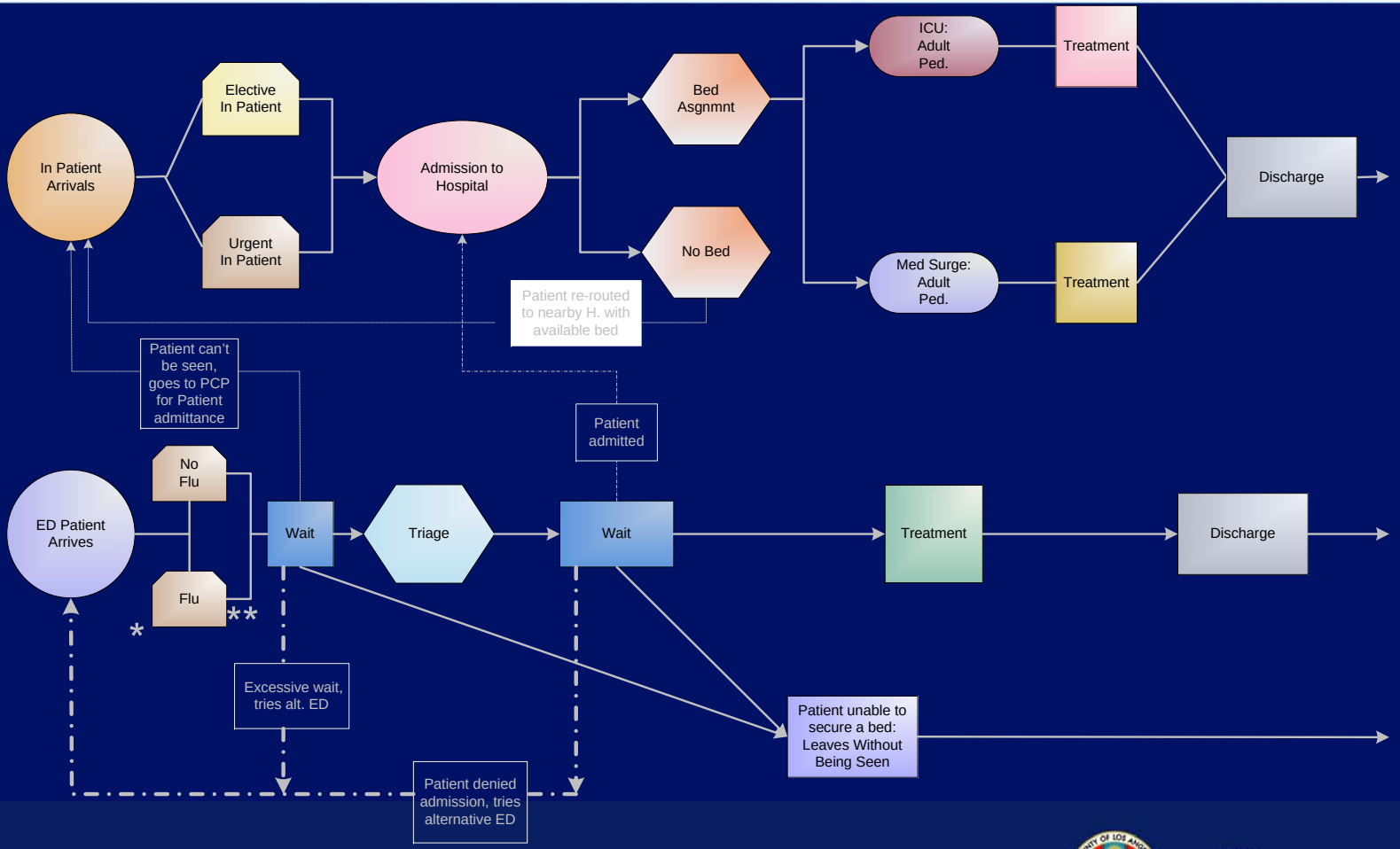


- Community Mitigation Model
  - Community Attack Rate, by geography and time
  - Calibrated against OSHPD data to provide probability of influenza patients who seek care at hospital → Demand for Services

Baseline: No Flu, No Intervention



Baseline Pan Flu-No Intervention



***Flu patients adjusted based on UW Community Mitigation Model**

**** Flu patients acuity changed to increase probability of ED admission**

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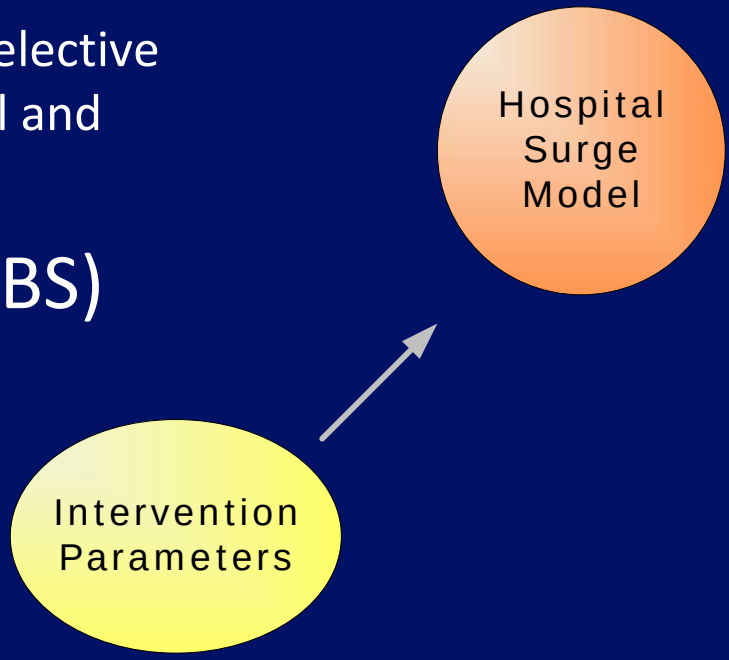
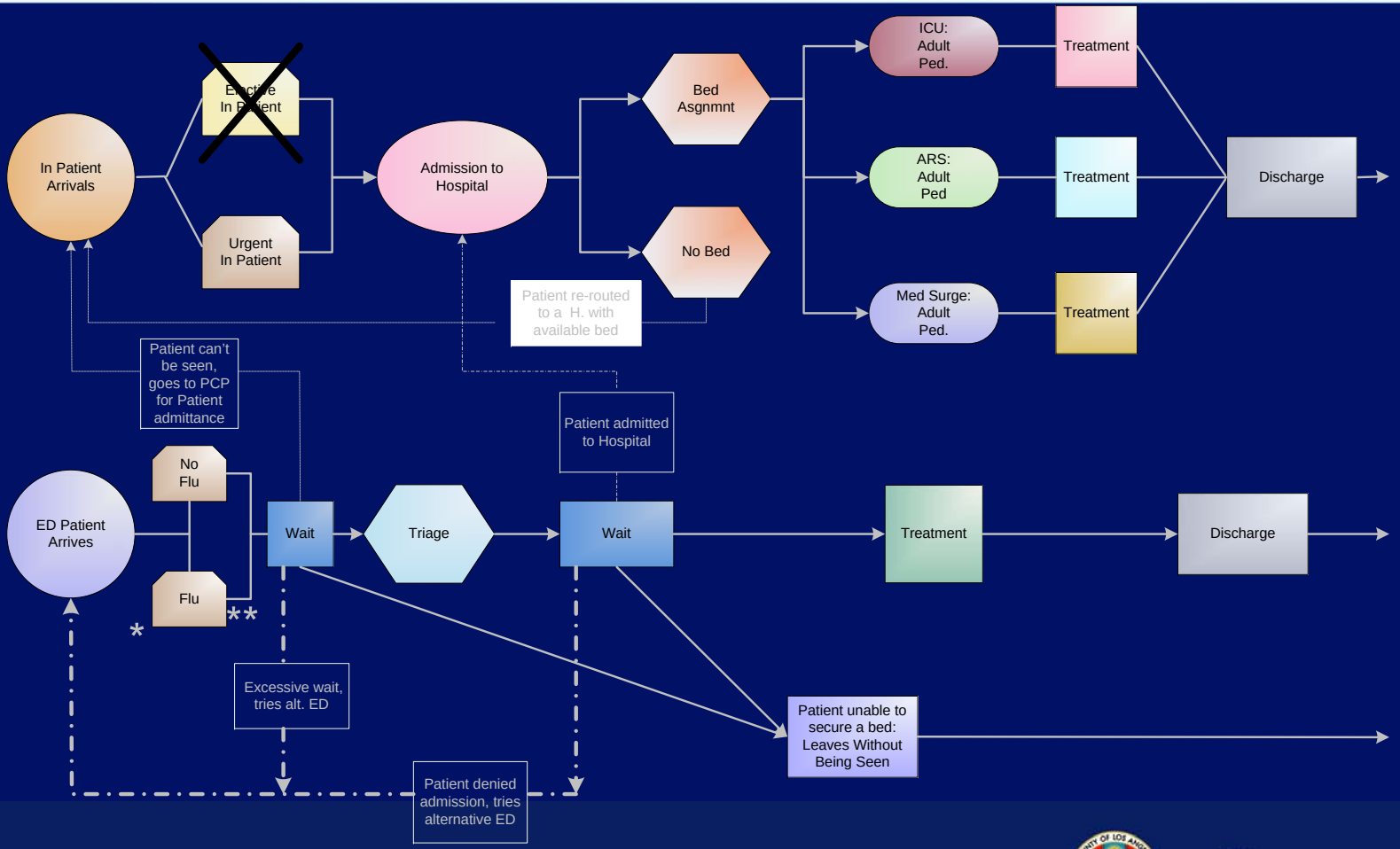
Interventions

1. Eliminate Elective Admissions (EES)
   - Probabilities were created that a pending elective will be denied admission based on hospital and bed type
2. Increase hospital Bed Supply (IBS)
   - Hybrid of ICU & Med/Surg beds called acute respiratory support (ARS) beds are added to each hospital
3. Ignore payer status (IPS)
   - If hospital is full, patients can go to the nearest hospital with an open bed regardless of patient's insurance type



Pan Flu-EES & IBS Interventions



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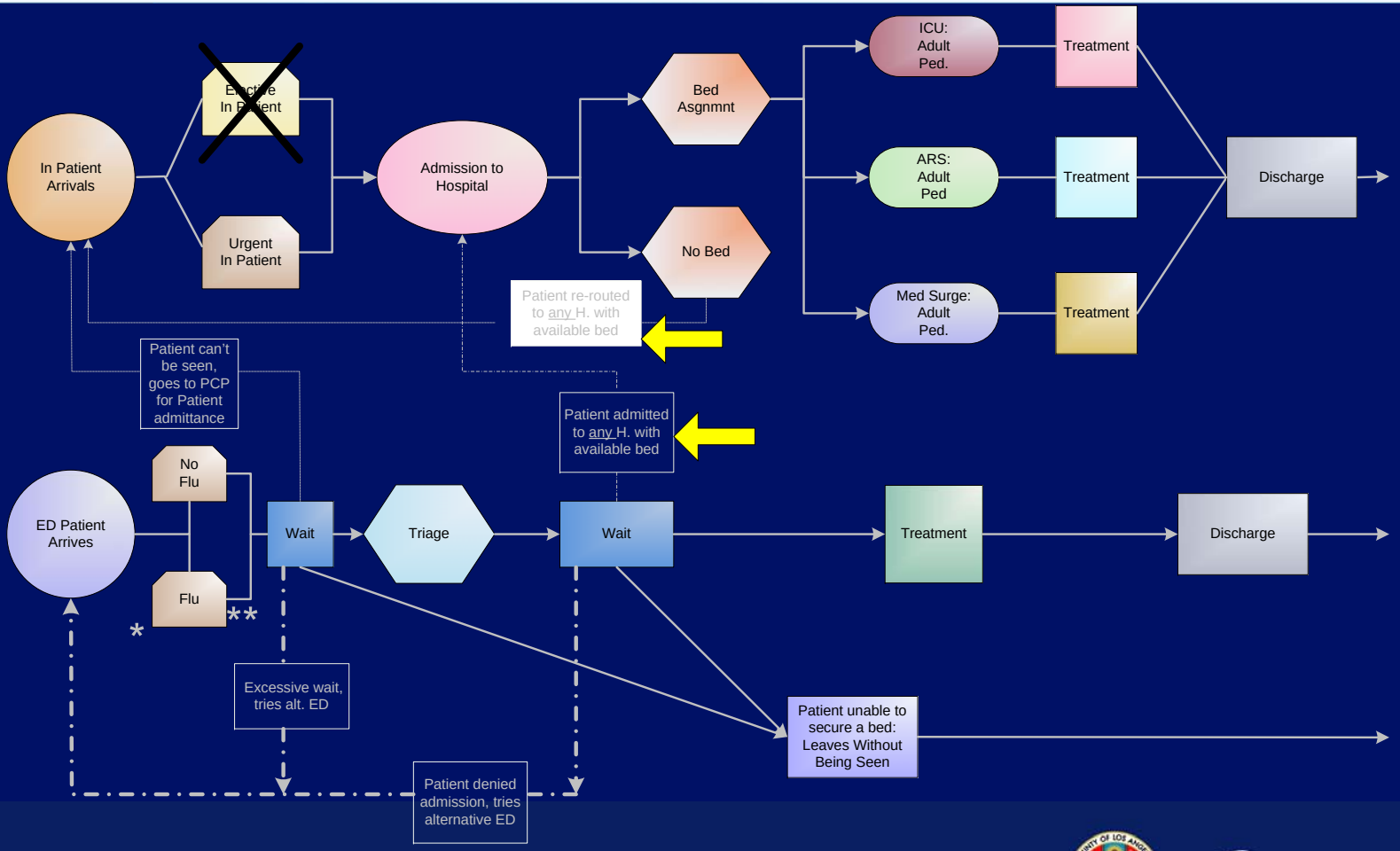
Pan Flu-EES, IBS & IPS Interventions



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Results

Hospital Utilization

Scenario	Ed Visits	Patient Days	Ventilator Demand
Baseline	1,351,937	1,794,056	14,290
Moderate	+201,843	+85,255	+1,358
Moderate EES, IBS, IPS	-10,674	+3,686	+353
Severe	+494,664	+332,281	+2,210
Severe EES, IBS, IPS	-19,755	-129,660	-366

* 25 week scenario, Interventions at Week 0

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Results

Hospital Utilization

- Moderate
  - ~202,000 additional ED Visits (avg 8,080/wk)
  - Ventilator Demand additional 1,358 (avg. 55/wk)
- Interventions reduce ED demand by 5% (~11,000)
- Patient Days
  - Interventions increase by ~3,700
  - Adding beds, extending services (Length of Stay)
- Severe is bad

Results

Unmet Need

Scenario	Can't Find a Bed-ED	Can't Find a Bed-IP	Leave ED w/o Tx
Baseline	5,437	271	3,516
Moderate	+23,969	+2,007	+17,654
Moderate EES, IBS, IPS	-4,508	-79	-2,389
Severe	+88,031	+4,177	+84,953
Severe EES, IBS, IPS	-16,217	-533	-10,769

* 25 week scenario, Interventions at Week 0

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Results

Unmet Need

- Moderate
  - ~24,000 ED patients need a bed, can't find one (960/wk)
    - Interventions "buy back" service to 19%
  - ~2,000 In patients need a bed, can't find one (80/wk)
    - Interventions: 4% reduction
  - ~17,700 ED patients leave without receiving Tx (706/wk)
    - Interventions buy back service to 14%
- Severe is Bad

Surge Model Application

- "Surge is Surge"
  - Both Moderate and Severe produce significant surge on the system
- Surge follows epidemic curve
  - Have 6 weeks to prepare policies and interventions
- Careful management of hospital services could yield 16% increase in patients served
- Emphasizes value of community mitigation to alleviate burden on hospital system
- Engagement of Hospital and EMS Communities
- Unmet Need
  - By time and geography → Alternate Care Site planning

H1N1: Adjusting On the Fly

September 2009:

- Longini updates model:
  - National Level → Extrapolated to LA
- To HHS, BARDA & CDC
  - Influenced PCAST report
- Epidemic peak late October
- Included hospitalizations and mortality estimates
  - Correlation to NHF model?

H1N1: Adjusting On the Fly

Model Correlation-Hospitalizations: (Sept. 2009)

UW:

	0-4	5-18	19-29	30-64	65+	Total
Total Hospitalized	3,180	4,730	3,440	12,700	8,400	32,450

NHF:

Bed Type	Baseline No Flu	Mod. Flu
ICU	1,866	9,127
Med/Surge	3,571	20,279
Total	5,437	29,406

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H1N1: Adjusting On the Fly

Early October 2009: Re-run Community Mitigation Model

- Smaller R_o ? H1N1 adjusted transmissibility
  - $R_o = 1.6$
  - $R_o = 1.3$
- Expected Peak?
  - 3 Scenarios:
    1. Late Oct. (1957)
    2. Late Nov. (1968)
    3. Late Dec.
- ACIP Priority Groups

H1N1: Adjusting On the Fly

Results:

- Oct Peak-Limited vaccine efficacy
- Nov and Dec Peak-Increased vaccine availability, Decreased:
  - Illness
  - Hospitalization
  - Mortality
- High risk first, Children second most effective combination
- *Continued update and revision of model; expected picture of response*

H1N1: Adjusting On the Fly

LA County Results*:

R_o	Attack Rate	Hospitalizations	Mortality
1.6	32%	5,858	580
1.3	22%	3,843	359

* Baseline

H1N1: Adjusting On the Fly

LA County Hospitalization Results:

R_o	Strategy	--	Oct Peak	Nov Peak	Dec Peak
1.6	Baseline	5,858			
1.6	Universal		5,738	4,815	
1.6	High Risk first, Child Second		5,658	4,379	
1.3	Baseline	3,843			
1.3	Universal			2,742	1,783
1.3	High Risk first, Child Second			2,607	1,685

H1N1: Adjusting On the Fly

LA County Mortality Results:

R_o	Strategy	--	Oct Peak	Nov Peak	Dec Peak
1.6	Baseline	580			
1.6	Universal		567	477	
1.6	High Risk first, Child Second		564	447	
1.3	Baseline	359			
1.3	Universal			255	167
1.3	High Risk first, Child Second			249	162

Thank you

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