



AHRQ Surge Model

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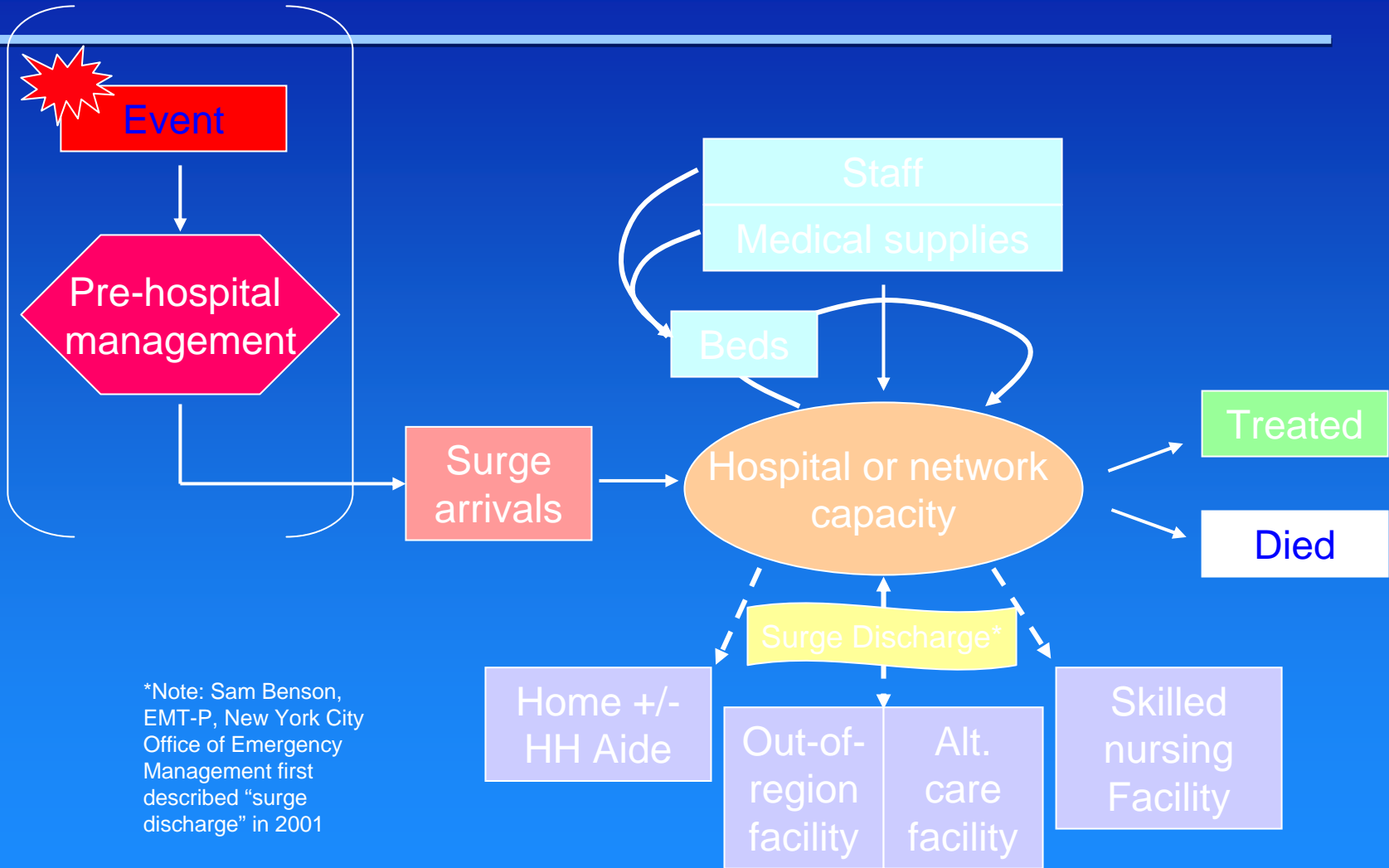
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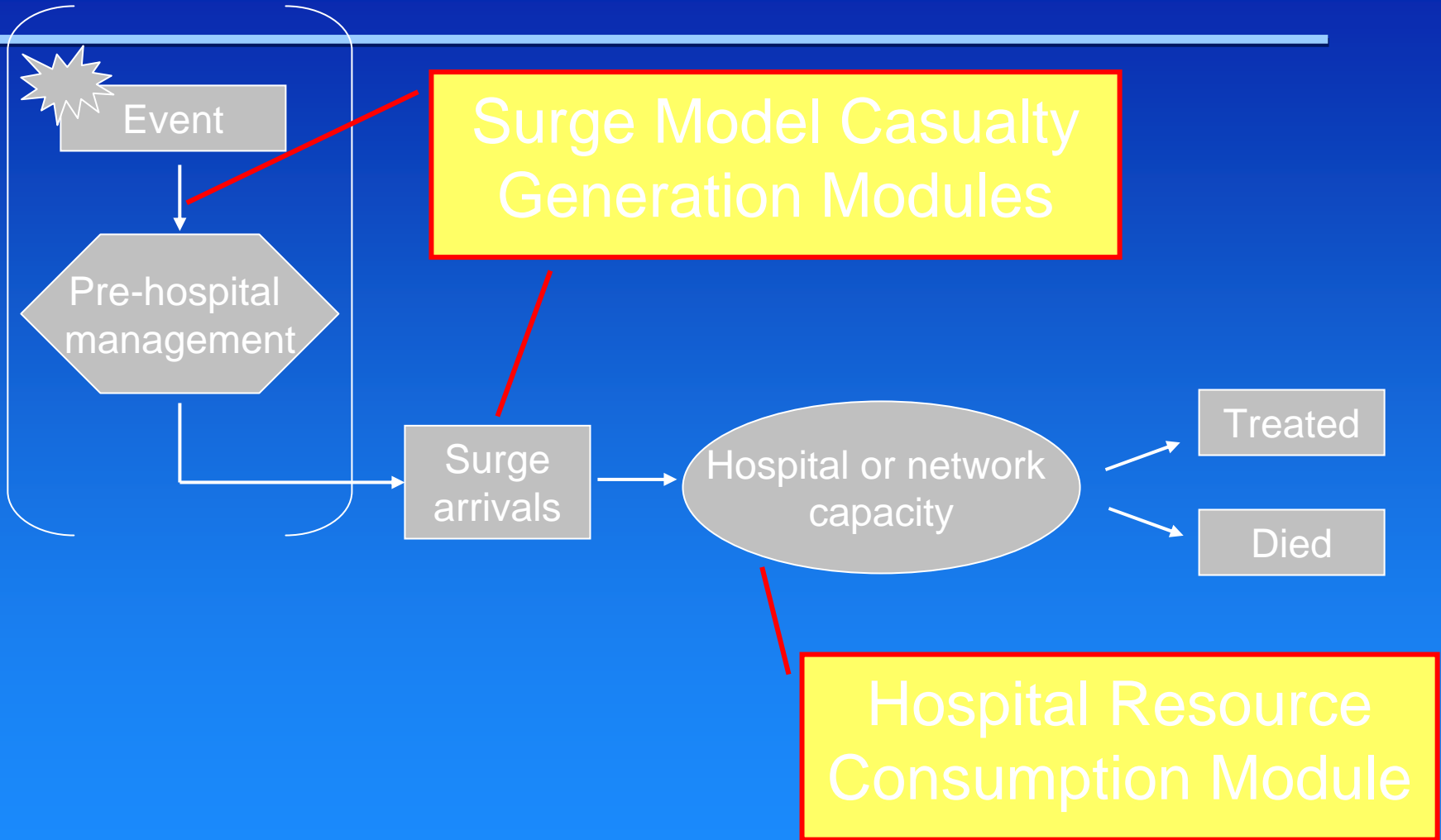
Modeling Schema



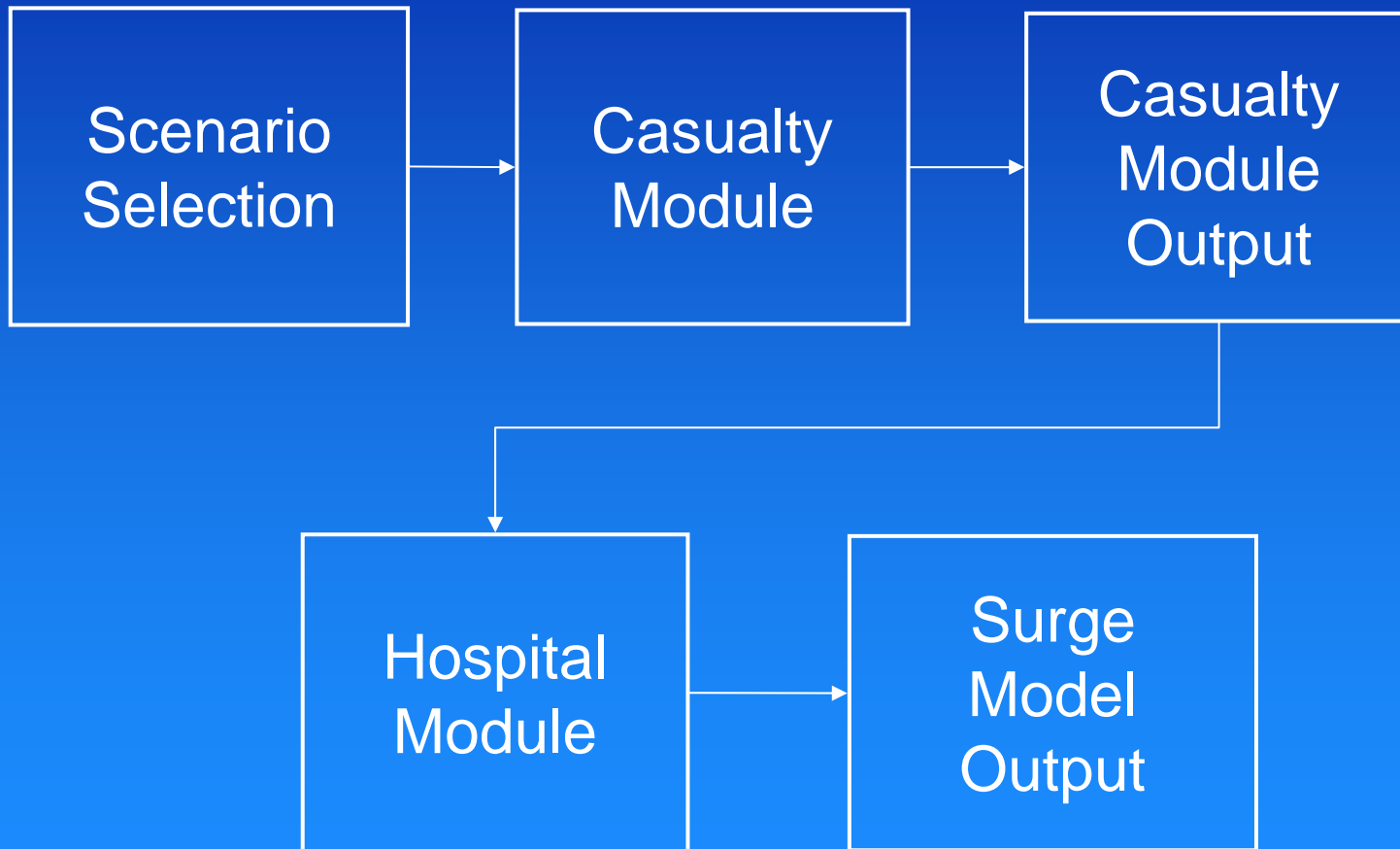
*Note: Sam Benson, EMT-P, New York City Office of Emergency Management first described "surge discharge" in 2001



AHRQ Surge Model Components



Surge Model Overview



Scenarios

■ Biological

- Anthrax
- Smallpox
- Flu Pandemic

■ Chemical

- Chlorine
- Mustard
- Sarin

■ Nuclear / Radiological

- 1 KT or 10 KT nuclear device
- Radiological dispersion device (“Dirty bomb”)
- Radiological point source

Factors Considered in the Casualty Module



- Attack location characteristics (e.g., population density)
- Time delay between attack and when symptoms present (biological and radiological scenarios)
- Optional mass prophylaxis (biological and radiological scenarios)
- Condition of casualties upon arrival at the ED (e.g., mild vs. severe symptoms)

Select a scenario

AHRQ Surge Model

Scenario Selection Screen

Choose a Scenario:

- Anthrax** spray device mounted on a van traveling through a city center.
- Smallpox** cold-air burst inside a theater.
- Liquid Chlorine** explosion on a railroad tanker in a suburb.
- Sulfur Mustard** bomb detonated at an outdoor event.
- Sarin** released via a fogger in an indoor arena.
- 1KT Nuclear Explosion** in a city center.
- 10KT Nuclear Explosion** in a city center.
- Radiological dispersal device** detonated in a city center.
- Radiological point source** covertly placed in a large train station.

Scenario Options: Anthrax

AHRQ Surge Model

Previous

Load Default Values

Run Model

Anthrax Scenario Options

Estimated Number of Casualties:

Attack occurs in:

mass prophylaxis campaign?

If yes, provide the following information about the campaign:

Percent of MSA population to be provided prophylaxis: percent.

Campaign start date: days after the attack.

Campaign duration: days.

Campaign effectiveness: percent.

Scenario Options: Sarin

AHRQ Surge Model

Previous

Load Default Values

Sarin Scenario Options

Estimated Number of Casualties:

Attack occurs in:

Indoor attack location characteristics:

Number of people in the arena: people

Average arena ceiling height: feet

Arena size square feet

Surrounding area characteristics:

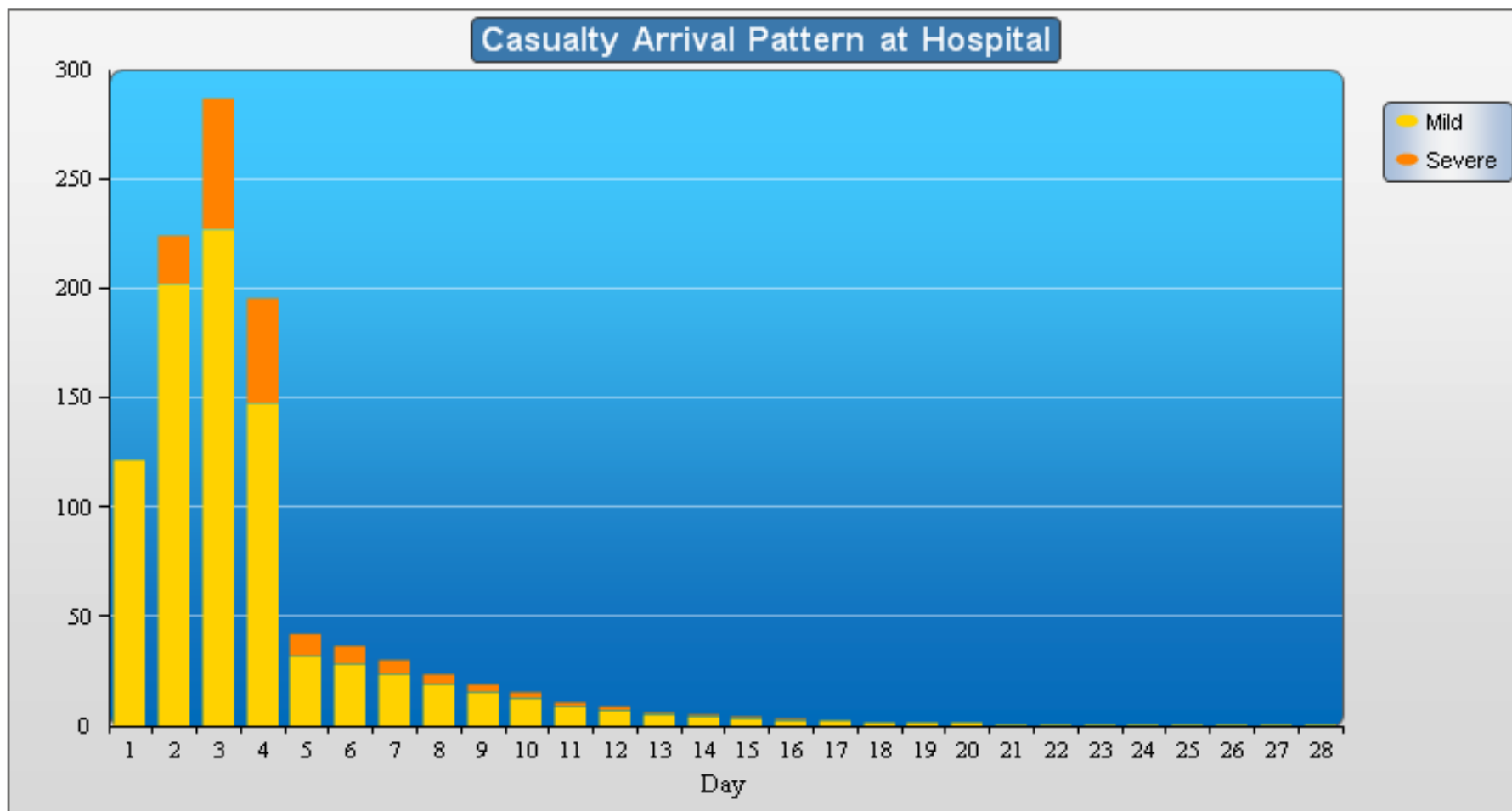
Distance from indoor attack location to population: feet

Population density of surrounding area: people per 1000 square feet

Output – Arrival Pattern at Hospital



Casualty Arrival Pattern at Hospital





Health Resource Data Sources

- Medical literature
 - Limited resource use data
- Expert consensus documents (DHHS)
 - Ventilation requirements
 - Critical ICU supplies
- Expert consultation
 - Medical resource requirements in ICU
- AHRQ HCUP data
 - e.g., length of stay



Surge Model Resources

- Durable equipment
- Human resources
- Pharmacy
- Consumable supplies
- Personal protective equipment
- Psychological Support
- Housekeeping
- Lab / Radiology
- Mortuary
- Nutrition



Adult Med/Surg Bed	Adult Mechanical ventilator
Adult ICU Bed	Pediatric Mechanical ventilator
Pediatric Med/Surg Bed	Adult Ventilator Circuit
Pediatric ICU Bed	Pediatric Ventilator Circuit
Burn Bed	Closed circuit suction catheter 14F
Operating Room	Closed circuit suction catheter 8-12F
Airborne Isolation Room	Humidification and Filtration Unit (HMEF)
Intensivists (CCM)	Endotracheal tube, 3mm ID
Critical care nurses (CCN)	Endotracheal tube, 4mm ID
Surgeons	Endotracheal tube, 5mm ID
Non-intensivists (MD)	Endotracheal tube, 6mm ID
Non-critical care nurses (RN/LPN)	Endotracheal tube, 7mm ID
Pharmacists (PharmD/RPh)	Endotracheal tube, 8mm ID
Respiratory Therapists (RT)	Laryngoscope blades, adult
Mortuary	Laryngoscope blades, pediatric
Ventilator Oxygen (O2)	Laryngoscope handles
NC Oxygen (O2)	Endotracheal stylette
Pulse oximeter	Resuscitation Bag, adult
Finger pulse oximeter strip	Resuscitation Bag, pediatric
End tidal CO2 detector, adult	Radiology machines
End tidal CO2 detector, pediatric	Radiology supplies
Temperature monitoring equipment	Chemistry Laboratory machines
Urine output--Foley catheter 8F-12F	Chemistry Lab supplies
Urine output--monitor bag	Hematology Laboratory machines
BP cuffs, adult	Hematology Lab supplies
BP cuffs, pediatric	Micro/Virology Laboratory machines
	Microbiology/Virology Lab supplies

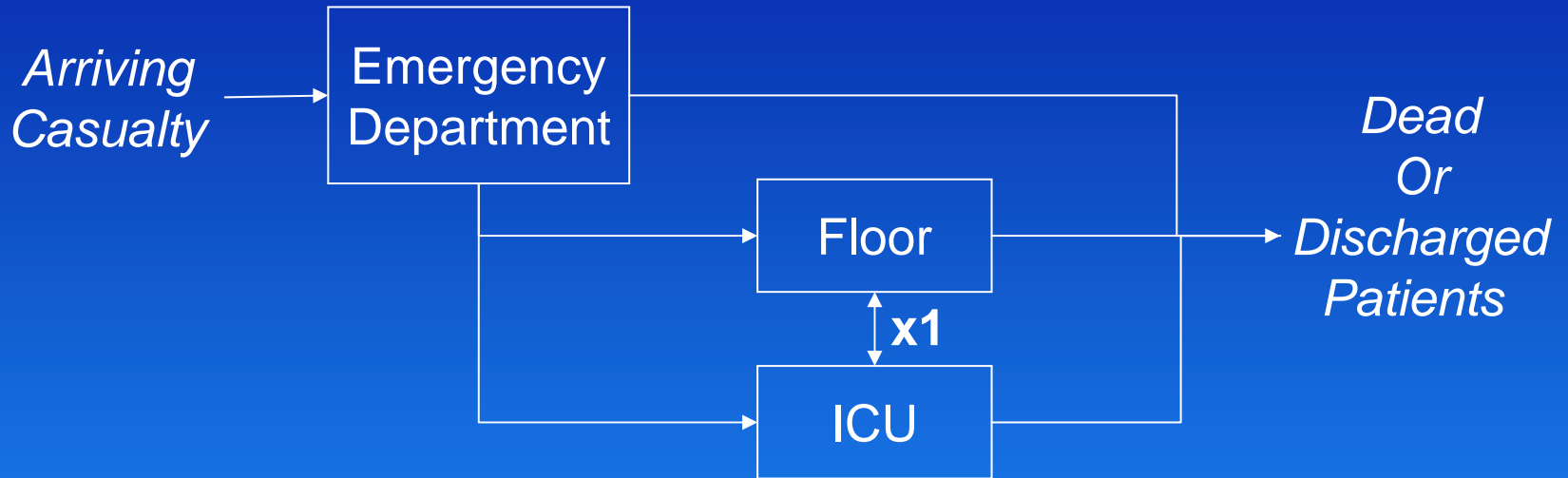


Tube, Drainage, Surgical, Pleurovac System (LATEX FREE)	Syringes 3cc 21G 1"
Tube, Drainage, Surgical, Thoracic, 12-28, Fr, Straight (LATEX FREE)	Sodium Chloride Flush 0.9% Preservative Free 3ML Carpuject
Tube, Drainage, Surgical, Thoracic, 32-36, Fr, Straight (LATEX FREE)	Sterile Water For Injection Preservative Free 10ML Vial
NG Tubes Sizes 6F-16F	Providine Iodine 10% Swab sticks Triples
Crystalloids	Tincture of Benzoin, 4 oz.
Sodium Bicarbonate Injection 50mEq; 50mL; 10s Syr	Intravenous catheter & needle unit, 18G x 1 ¼"
Lactated Ringers Solution, IV 1000ML	Intravenous catheter & needle unit, 18G x 2"
Sodium Chloride 0.9% Solution IV, 1000ML	Intravenous catheter & needle unit, 20G x 1 ¼"
Dextrose 5% Sodium Chloride 0.9Inj. 1000 ml	Intravenous catheter & needle unit, 24G x 5/8"
1/2 NS Solution IV, 1000ML	Intravenous set, butterfly, 12" tubing, 21G x 3/4"
Dextrose 5% Sodium Chloride 0.45Inj. 1000 ml	Triple Lumen Catheter, Intravenous
Dextrose 5% 250 ml	IV admin set, 10 drops/ml, y-site
Blood & Renal Products	IV admin set, 60 drops/ml, 2 y-sites
PRBC, Unit	IV site transparent dressing, 2" x 3" (Tegaderm or equivalent)
Platelets, Unit	IV site transparent dressing, 2 3/8" x 2 3/4" (Tegaderm or eqvInt)
FFP, Unit	IV Pump
Hemodialysis dialysate, Unit	Heparin Lock Flush Kit, 100 units/ml
GOWN COVER UNIV YELL	N95/surgical masks
GOWN ISOLATION FLUID RESIS	Face shields
SANITIZER ALCOHOL GEL (L)	Latex, non-sterile gloves
CLEANER BLEACH CLEAN UP (L)	Latex-free, non-sterile gloves
BAG LINER RED 15X9X24	Latex-free, sterile gloves
BAG LINER RED 30X36	
BAG LINER RED 39X48	



PHARMACEUTICALS	Paralytics
Antivirals	Succinylcholine Chloride Injection 20 mg/ml 10ml
Oseltamivir 75mg po	Vecuronium Bromide Injection 10 mg, 10 ml vial, 10's
Zanamivir 10mg po	Hemodynamic support
Amantidine 100mg	Vasopressors
Acyclovir Capsules, 200 mg	Dopamine HCL 400MG (80MG/ML) Vial for Injection
Antibiotics	Inotropes
Oral beta lactams (amoxicillin, amoxicillin/clavulanate)	Dobutamine Hydrochloride Inj. 250 mg/20 ml, 10 vials
Amoxicillin 500mg Tablet	DVT Prophylaxis
Amoxicillin Chewable Tablets 250 mg	Enoxaparin Sodium 40 mg/0.4mL syringe (Lovenox)
Amoxicillin Oral Susp. 250mg/5mL	SQ Heparin (unfractionated)
Amoxicillin/Clavulanic Tablets 875 mg/125 mg	Aerosol drugs and equipment (to include saline)
Amoxicillin/Clavulanic Chewable Tablet 400 mg/57 mg	Bronchodilators
Amoxicillin/Clavulanic Oral Susp 200 mg/28.5 mg/5 mL	Albuterol
Oral macrolides (azithromycin, clarithromycin)	Atrovent
Azithromycin Syrup 200 mg/ 5 ml, 30 mL	Analgesics/Antipyretics
Azithromycin Tabs. 250 mg, 18's	Acetaminophen
Clarithromycin Tablets (BIAXIN XL) 500 mg, 14's x 4	ASA
Oral fluoroquinolones (moxifloxacin, gemifloxacin, levofloxacin)	Ibuprofen
Levofloxacin Tablets 500 mg, 50s (Lеваquin)	Antiemetics
Ciprofloxacin HCL 500MG Tablets 100 Tablets per unit	Prochlorperazine Pediatric Suppository 5mg
Ciprofloxacin HCL PO Suspension 250 MG/5ML 100 ML Btl	Prochlorperazine Suppository 25mg
Intravenous beta-lactams (e.g., ceftriaxone, cefotaxime, ampicillin/sulbactam)	Prochlorperazine Tablets 10mg, 100's
Ceftriaxone 1g	GI Prophylaxis
Cefotaxime	Famotidine Tablets 20mg; 100's
Ampicillin/sulbactam	Felodipine Tablets 5 mg, 100s
Intravenous fluoroquinolones (moxifloxacin, gemifloxacin, levofloxacin)	Steroids
Moxifloxacin	Methylprednisolone SOD SUC 125mg (2ml) Vial
Gemifloxacin	Dexamethasone Na Phosphate Injection 4 mg/ml, 5ml, 25's
Levofloxacin 750mg	Methylprednisolone Injection 125mg; 2mL 25s
Intravenous nafcillin	Methylprednisolone Sodium Injection 1000mg
Nafcillin Sodium for Injection 1 Gml	Methylprednisolone Tablets 4 mg; 21's
Intravenous vancomycin	Prednisolone Acetate Ophth Suspension 0.12% (Pred Mild) 5mL
Vancomycin Injection 1 g eq.	Prednisolone Syrup 15 mg / 5 mL, 240 mL
linezolid	Prednisone Tablets 20mg; 100's
Other Antibiotics	Prednisone Tablets 5mg; 100s
Doxycycline Hyclate, 100mg Tablets, 20 Unit of Use	Sedatives
Doxycycline Hyclate Suspension 25MG/5ML 60ML	Diazepam HCL 10MG (5MG/ML) SDV for injection SCIV
Doxycycline Hyclate 100MG Powder Vial for Injection	Lorazepam HCL 2mg/ml (1ML) 22G ndl Carpuject CSIV
Doxycycline Hyclate 100MG Tablets 500 Tablets per unit	Morphine (especially for palliative care)
Doxycycline 100mg IV (Vial)	Morphine 10mg/ml 1ml Carpuject
	Fentanyl Citrate inj 50mcg/ml 2ml
	Morphine Sulfate 10mg/ml 1ml 25G Needle Carpuject CSII

Surge Model Treatment Paths



LoS value	Mortality rate
Mean	Low
Calculate	

SCENARIO	STREAM
Flu Moderate Hospitalized	moderate
Flu Severe ICU	severe

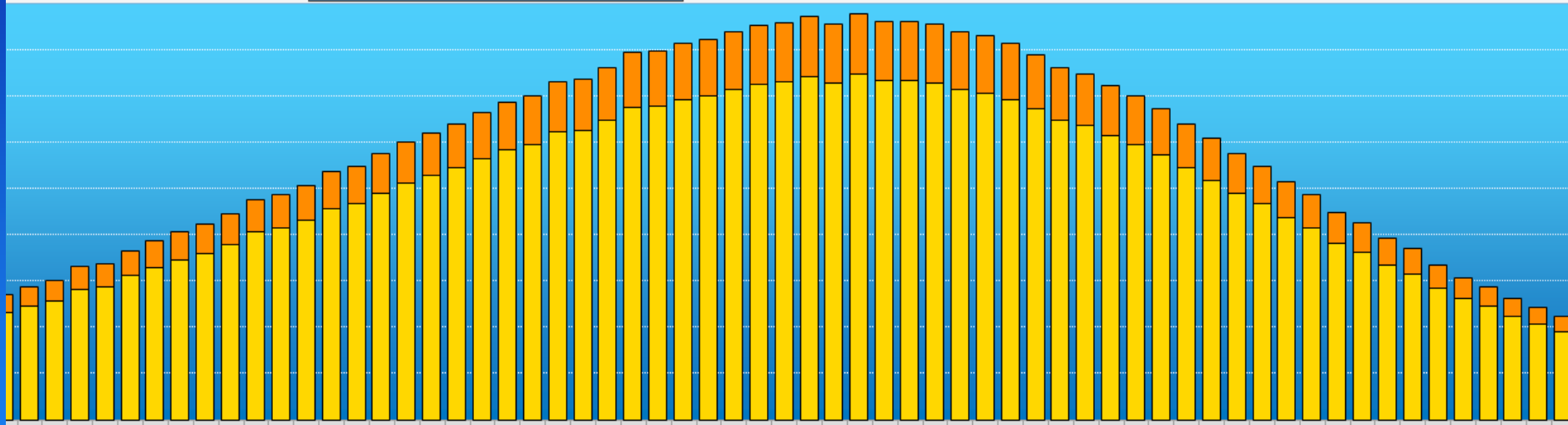
Path Probabilities											Overall probabilities			Expected Length of Stay		
ED Disch	ED Death	ED Floor Disch	ED Floor Death	ED ICU Death	ED Floor ICU Disch	ED Floor ICU Death	ED ICU Death	ED ICU Disch	ED ICU Disch	ED ICU Death	P(Disch)	P(Death)	Sum	E[LoS] Disch	E[LoS] Dead	E[LoS] Overall
0%	0%	89%	5%	1%	4%	0%	0%	1%	0%	94%	6%	100%	6.48	5.10	6.39	
0%	0%	4%	0%	0%	1%	0%	21%	71%	4%	75%	25%	100%	13.64	6.35	11.84	

AHRQ Surge Model uses NIGMS



MIDAS (Epicast) Flu Model Output

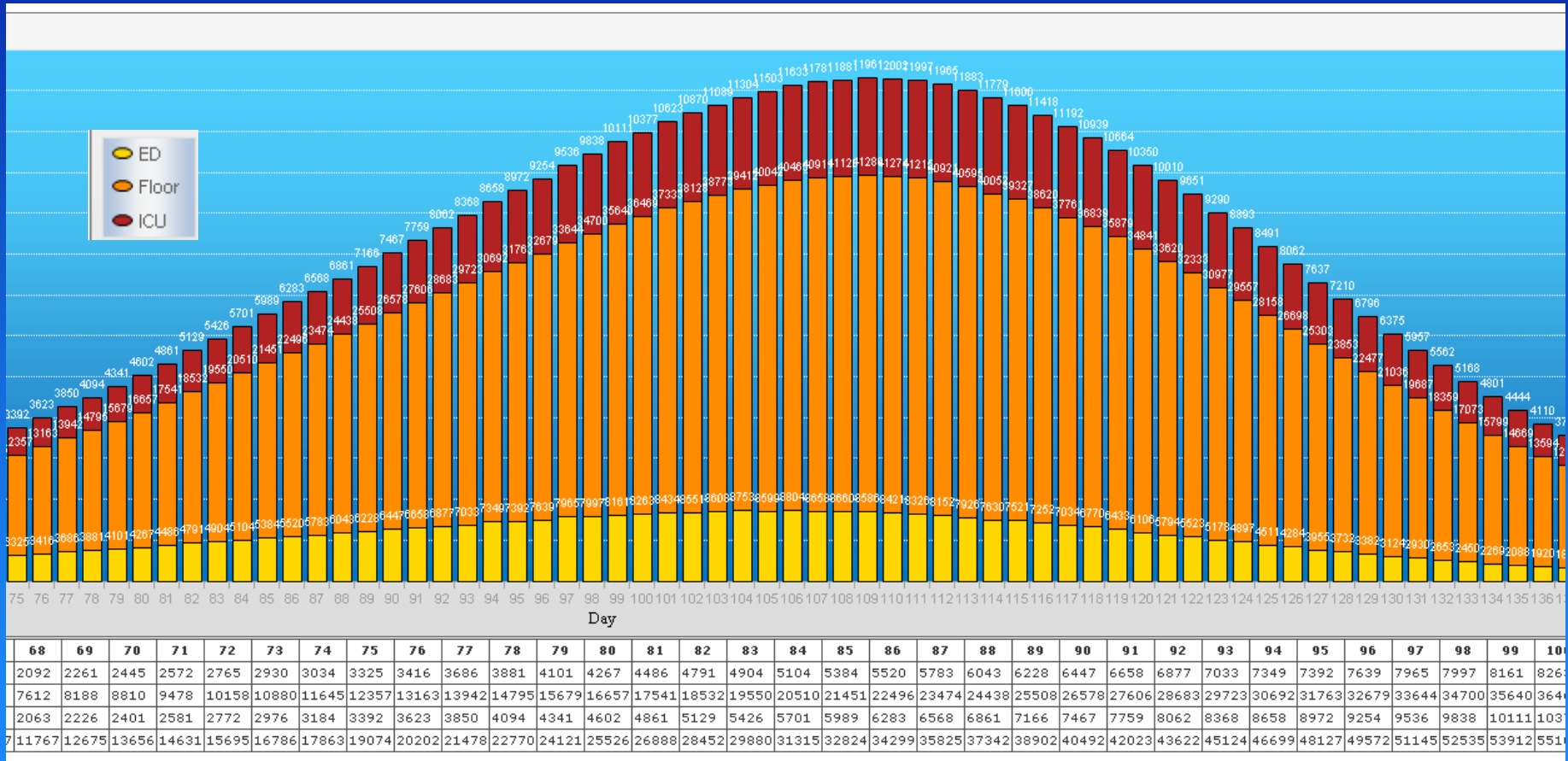
Casualty Arrival Pattern at Hospital



Day	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109
2079	2187	2351	2490	2579	2826	2904	3133	3299	3486	3627	3813	4073	4168	4338	4576	4692	4915	5136	5294	5480	5659	5845	5978	6247	6283	6493	6771	6798	6937	7023	7169	7268	7317	7440	7309	7484	7360	7361	7298	
367	386	415	439	455	499	512	553	582	615	640	673	719	736	766	808	828	867	906	934	967	999	1031	1055	1102	1109	1146	1195	1200	1224	1239	1265	1283	1291	1313	1290	1321	1299	1288		
2446	2573	2766	2929	3034	3325	3416	3686	3881	4101	4267	4486	4792	4904	5104	5384	5520	5782	6042	6228	6447	6658	6876	7033	7349	7392	7639	7966	7998	8161	8262	8434	8551	8608	8753	8599	8805	8659	8660	8588	



Epicast Flu Model Anticipates Very Extended (~180 day) Event



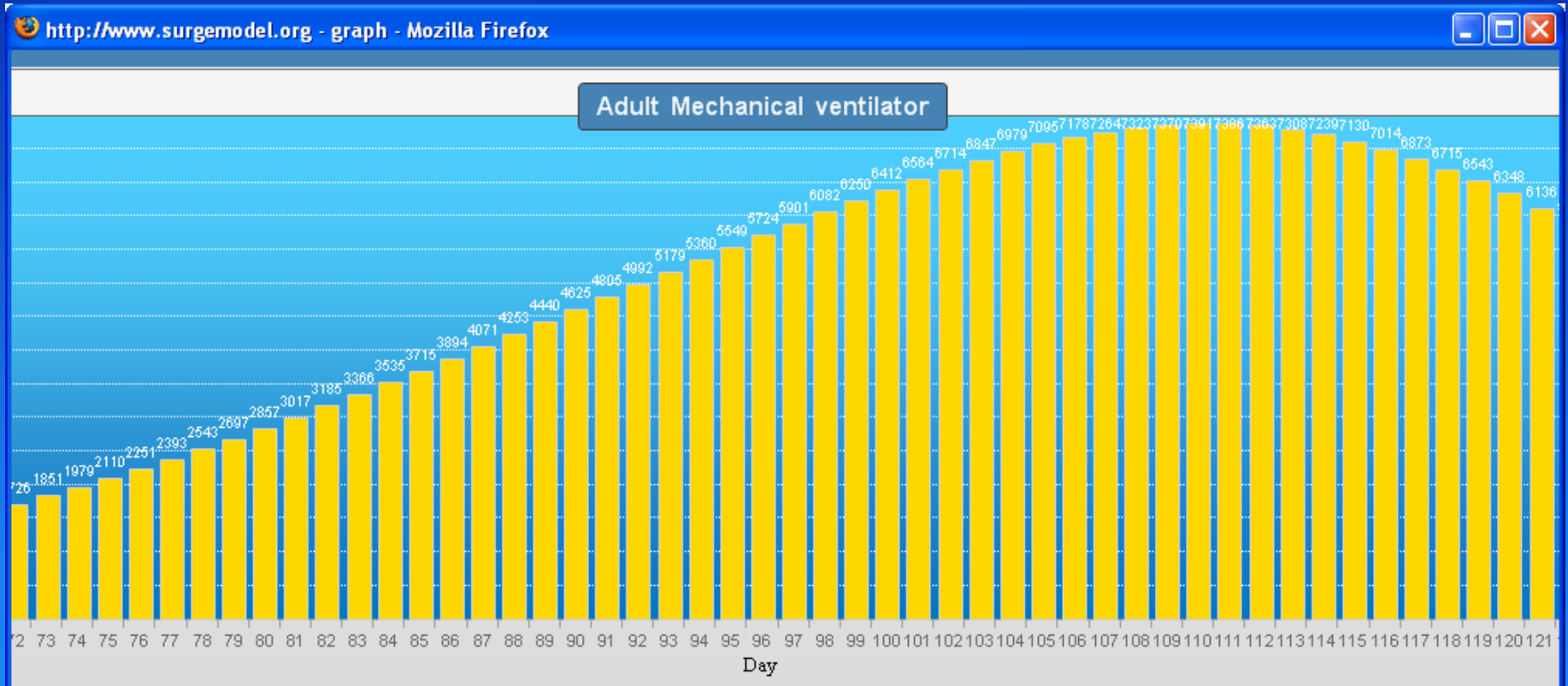


Calculating Daily Resource Requirements

Resource	Units	Category	Subcategory	Influenza Daily Consumption					
				Moderate			Severe		
				ED	ICU	Floor	ED	ICU	Floor
Adult Med/Surg Bed	EA (Each)	Capacity	Adult Med/Surg	0.167	0	0.667	0.167	0	0.667
Adult ICU Bed	EA (Each)	Capacity	Adult ICU	0	0.667	0	0	0.667	0
Pediatric Med/Surg Bed	EA (Each)	Capacity	Pediatric Med/Surg	0.083	0	0.333	0.083	0	0.333
Pediatric ICU Bed	EA (Each)	Capacity	Pediatric ICU	0	0.333	0	0	0.333	0
Burn Bed	EA (Each)	Capacity	Burn	0	0	0	0	0	0
Operating Room	EA (Each)	Capacity	OR	0	0	0	0	0	0
Airborne Isolation Room	EA (Each)	Capacity	Isolation	0	0	0	0	0	0
Intensivists (CCM)	FTE	Staff	CCM	0.021	0.042	0	0.042	0.042	0
Critical care nurses (CCN)	FTE	Staff	CCN	0	0.33	0	0.167	0.33	0
Surgeons	FTE	Staff	Surgeon	0	0.0546	0	0	0.0546	0
Non-intensivists (MD)	FTE	Staff	MD	0.042	0	0.021	0.042	0	0.021
Non-critical care nurses (RN/LPN)	FTE	Staff	RN	0.167	0	0.146	0	0	0.146
Pharmacists (PharmD/RPh)	FTE	Staff	Pharmacist	0	0.021	0	0.021	0.021	0
Respiratory Therapists (RT)	FTE	Staff	RT	0	0.042	0	0.021	0.042	0
Mortuary	FTE	Staff	Mortuary	0	0.021	0	0	0.0315	0
Adult Mechanical ventilator	EA (Each)	Capacity	Ventilator	0	0.307	0	0.166	0.307	0.042
Pediatric Mechanical ventilator	EA (Each)	Capacity	Ventilator	0	0.12	0	0.083	0.12	0.042
Adult Ventilator Circuit	EA (Each)	Equipment	Ventilator Kit	0	0.399	0	1	0.399	0
Pediatric Ventilator Circuit	EA (Each)	Equipment	Ventilator Kit	0	0.156	0	1	0.156	0
Closed circuit suction catheter 14F	EA (Each)	Equipment	Ventilator Kit	0	0.307	0	0.667	0.307	0
Closed circuit suction catheter 8-12F	EA (Each)	Equipment	Ventilator Kit	0	0.12	0	0.333	0.12	0
Humidification and Filtration Unit (HMEF)	EA (Each)	Equipment	Ventilator Kit	0	0.285	0	0.5	0.285	0
Endotracheal tube, 3mm ID	EA (Each)	Equipment	Intubation	0	0.039	0	0.039	0.0117	0
Endotracheal tube, 4mm ID	EA (Each)	Equipment	Intubation	0	0.039	0	0.039	0.0117	0
Endotracheal tube, 5mm ID	EA (Each)	Equipment	Intubation	0	0.039	0	0.039	0.0117	0
Endotracheal tube, 6mm ID	EA (Each)	Equipment	Intubation	0	0.039	0	0.039	0.0117	0
Endotracheal tube, 6.5mm ID	EA (Each)	Equipment	Intubation	0	0.100	0	0.1	0.03	0
Endotracheal tube, 7-8mm ID	EA (Each)	Equipment	Intubation	0	0.300	0	0.3	0.09	0
Laryngoscope blades, adult	EA (Each)	Equipment	Intubation	0	0.307	0	0.334	0.1002	0
Laryngoscope blades, pediatric	EA (Each)	Equipment	Intubation	0	0.12	0	0.167	0.0501	0
Laryngoscope handles	EA (Each)	Equipment	Intubation	0	0.427	0	0.307	0.0921	0
Endotracheal stylette	EA (Each)	Equipment	Intubation	0	0.427	0	0.12	0.036	0
Resuscitation Bag, adult	EA (Each)	Equipment	Ventilator Kit	0	0.307	0	0.307	0.0921	0
Resuscitation Bag, pediatric	EA (Each)	Equipment	Ventilator Kit	0	0.12	0	0.12	0.036	0
Ventilator Oxygen (O2)	Liters Liquid O2	Supplies	Oxygen	0	3.57	0	0.894	3.57	0
NC Oxygen (O2)	Liters Liquid O2	Supplies	Oxygen	0.837	0	3.35	0	0	3.35
Pulse oximeter	EA (Each)	Equipment	O2 Monitoring	0.167	0.167	0.167	0.167	0.167	0.167
Finger pulse oximeter strip	EA (Each)	Equipment	O2 Monitoring	1	2	1	1	2	1
End tidal CO2 detector, adult	EA (Each)	Equipment	O2 Monitoring	0	0.307	0	0.307	0.0921	0
End tidal CO2 detector, pediatric	EA (Each)	Equipment	O2 Monitoring	0	0.12	0	0.12	0.12	0
Radiology machines	EA (Each)	Radiology	CXR	0.021	0.021	0	0.021	0.021	0
Radiology supplies	EA (Each)	Supplies	XR Film	1	1	0	1	1	0
Chemistry Laboratory machines	EA (Each)	Laboratory	Chemistry	0.021	0.021	0	0.021	0.021	0
Chemistry Lab supplies	EA (Each)	Supplies	Chem Supplies	1	1	0	1	1	0
Hematology Laboratory machines	EA (Each)	Laboratory	Hematology	0.021	0.021	0	0.021	0.021	0
Hematology Lab supplies	EA (Each)	Supplies	Heme Supplies	1	1	0	1	1	0
Micro/Virology Laboratory machines	EA (Each)	Laboratory	Micro/Virology	0.021	0.021	0	0.021	0.021	0



Example of Surge Model Output: Ventilator Requirement over Time





Calculating Patient Type-Specific Resource Consumption

- First define average resource requirements per *unit*, per *patient type*, and per *time interval*
- Calculate, based on LOS and death/transfer rates, the number of patients in any resource consumption category at any given time



Existing Summary Calculations to Validate with Surge Model

Table 5: Aggregate Number of Episodes of Illness, Health Care Utilization, and Death During Moderate and Severe Influenza Pandemic Scenarios*

Characteristic	Moderate (1958/68-like)		Severe (1918-like)	
Illness	90 million (30%)		90 million (30%)	
Outpatient medical care	45 million (50%)		45 million (50%)	
Hospitalization	865,000	1% of total	9,900,000	11% of total
Intensive Care Unit (ICU) care	128,750		1,485,000	
Mechanical ventilation	64,875	50% of ICU	745,500	50% of ICU
Deaths	209,000		1,903,000	

*Estimates based on extrapolation from past pandemics in the United States. Note that these estimates do not include the potential impact of modern interventions.

--<http://www.pandemicflu.gov/plan/pandplan.html>



Limitations:

- The model does not sufficiently distinguish varying time frames and locations of events (for example, bioterrorist attacks may be discrete in time and locale vs. a pandemic of influenza which would be widespread over weeks or months and would have a global impact)
- The model does not include any impact of resource availability on clinical outcomes
- The model does not reflect the capabilities of the current or augmented supply chain in the event of a sustained emergency event



Next Generation Modeling Framework: Integrating Response Logistics

- Create an integrated *response logistics* model of disaster response and treatment for the United States, adding to current model
 - Epidemiological modeling of disease transmission with estimates of burden of disease
 - Multiple field interventions (extrication, EMS, mass prophylaxis (vaccine, antivirals), social measures)
 - Distribution of casualties to existing/augmented facilities
 - Realistic temporal factors (human and materiel mobilization, supply chain delays)

