# Consequence Assessment for Systems-based Infrastructure

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# What is a Consequence?

- A description of a scenario, in terms of measurable factors, that decision makers may consider in assessing preferences over different scenarios (NAS, 2008)
  - lives lost, morbidities, direct and indirect dollar losses, and others
- Direct Impacts - are damage and losses that can be directly attributed to the attack
  - Fatalities, illnesses, damages to property …
- Indirect or secondary impacts occur over time
  - family trauma, business interruptions, and shortages of critical human services

# What is Consequence Assessment?

- Structured approach that results in a logical and systematic examination of the knowledge base
- Can serve (at least) three purposes:
  - as a scientific exercise to improve understanding of physical phenomena ( in terms of the consequences)
  - as a tool to support decisions to mitigate consequences (and control risk)
  - as a tool to communicate about the likely consequences of events
- 2 examples – different types of consequences considered, and different requirements to use the tools

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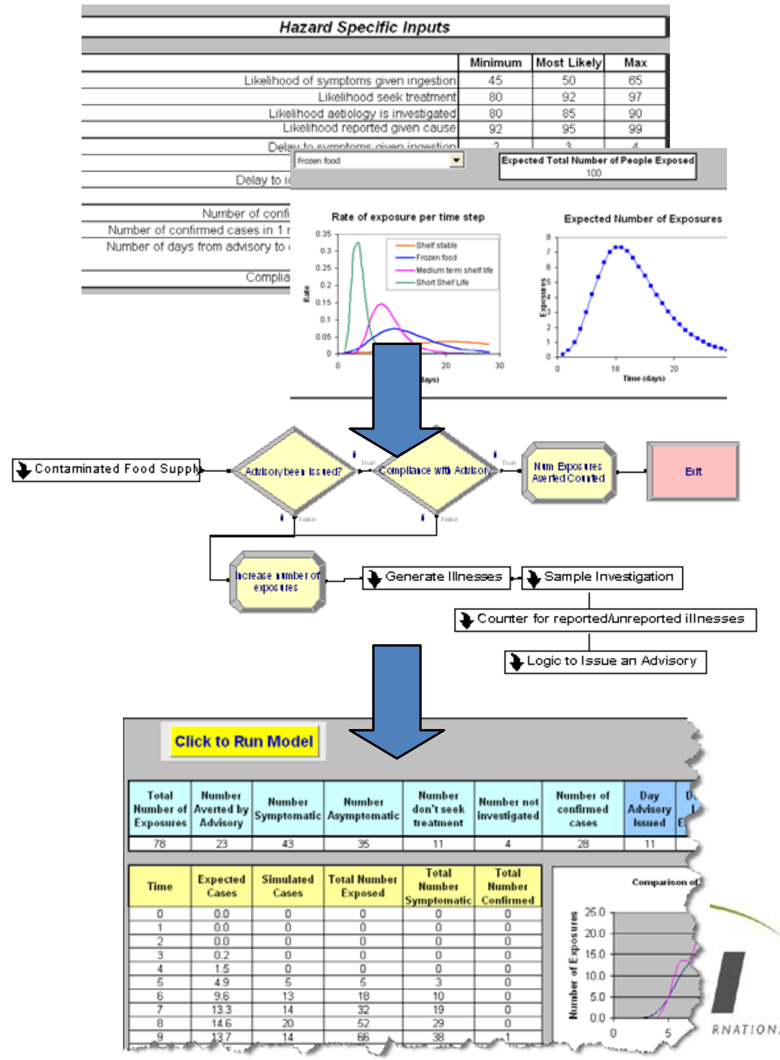
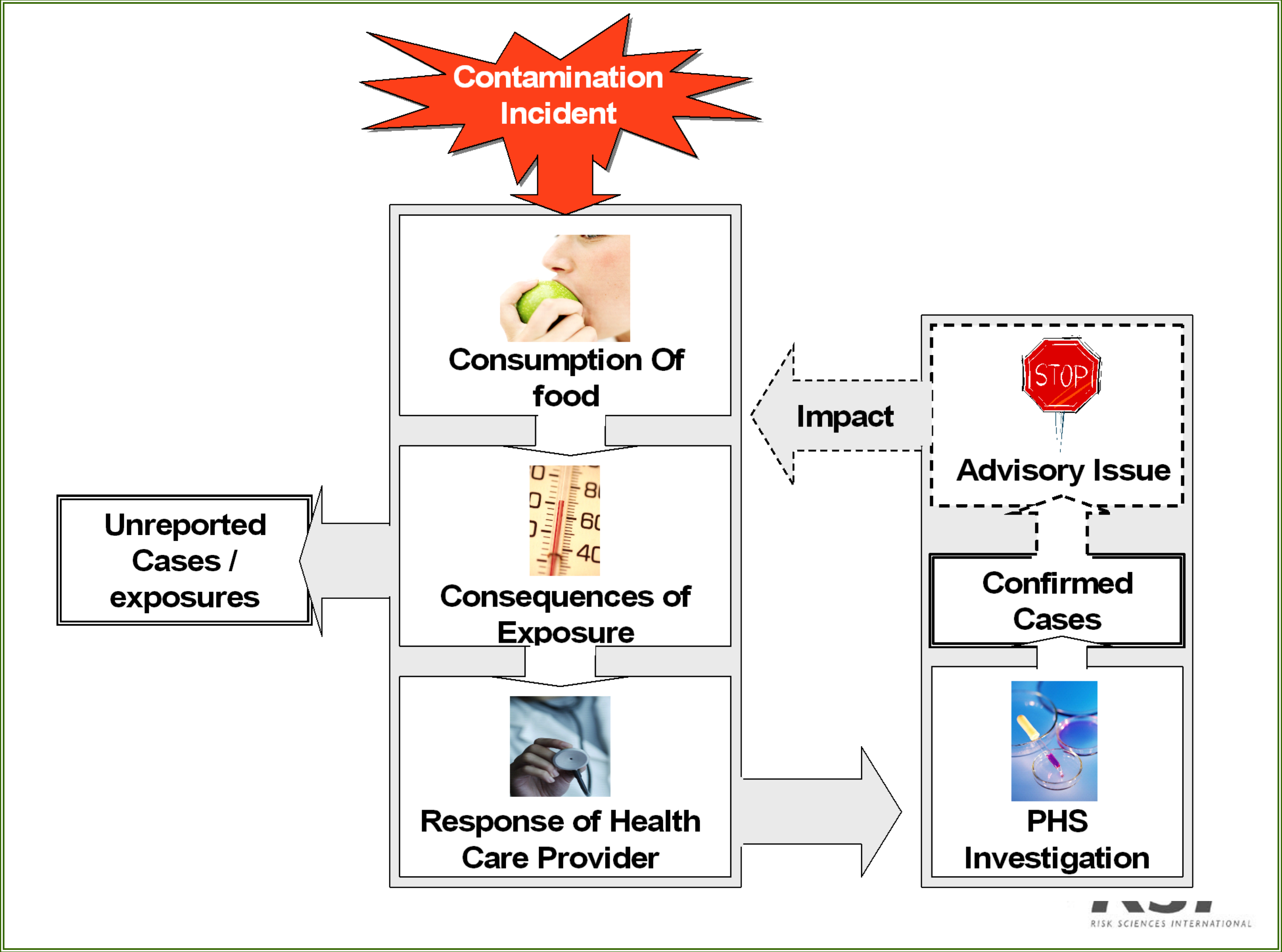
# Example 1: Public Health System Response to a Terrorist Event

- Examines PHS response to bioterrorism in food supply
  - Funded by NCFPD
- User-based decision-support tool for health agencies
- Educational tool to understand interaction of components of system
- Consequences measured in terms of illnesses





Contamination Incident
Consumption Of food
Consequences of Exposure
Response of Health Care Provider
Unreported Cases / exposures
Impact
STOP
Advisory Issue
Confirmed Cases
PHS Investigation
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# What is the Public Health System Model?

- Probabilistic, discrete event simulation of the events that occur following contamination in the food supply
  - Model individuals exposed to the contaminated food
- Dynamic model, keeping track of individual exposures and the outcomes, across the complete time-course of the event
  - time exposure occurs, time they get ill, time seek treatment…

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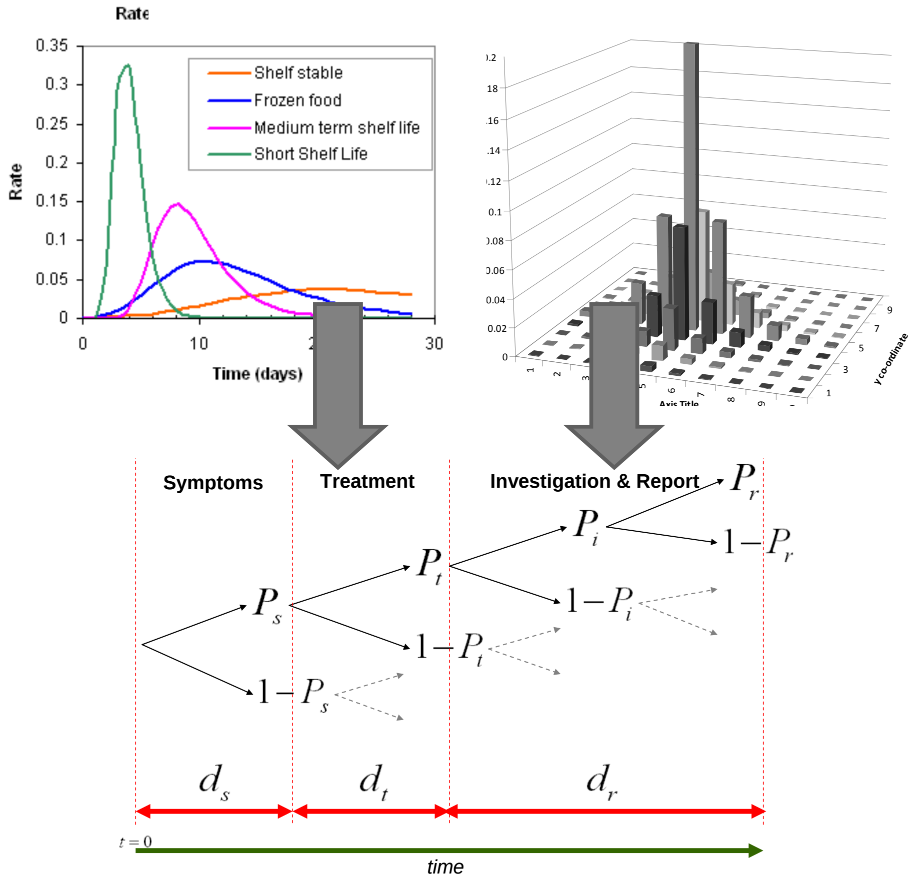
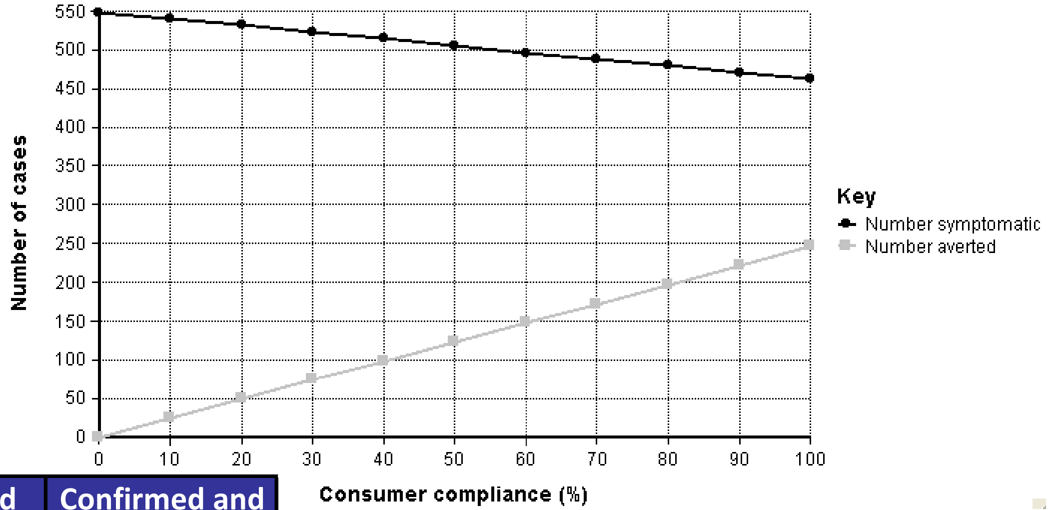
# Structure of the Model

- The model is initially driven by the pattern of exposures of individuals over time
- The exposures are geographically dispersed
- Exposures are then followed through the public health system
- Advisory may be issued
- Exposures continue until either
  - All food consumed, or
  - All food removed from supply



# Case Study Outcomes

| Hazard-Food combination | Time advisory is issued (days) | Number of exposures averted |
|---|---|---|
| ***Salmonella*** | | |
| **Spinach** | 22 | 0 |
| **Hotdogs** | 25 | 7 |
| **Peanut butter** | 37 | 124 |
| ***E. coli*** | | |
| **Spinach** | 21 | 0 |
| **Hotdogs** | 23 | 13 |
| **Peanut butter** | 30 | 195 |




| Hazard-Food combination | Symptomatic | Not investigated | Confirmed and reported |
|---|---|---|---|
| ***Salmonella*** | | | |
| **Spinach** | 420 | 66 | 14 |
| **Hotdogs** | 418 | 66 | 14 |
| **Peanut butter** | 342 | 54 | 11 |
| ***E. coli*** | | | |
| **Spinach** | 697 | 175 | 125 |
| **Hotdogs** | 688 | 172 | 112 |
| **Peanut butter** | 481 | 121 | 62 |

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# What can we Learn?

- Model collects estimates of numerous response parameters of the system, including:
  - Number of exposures that remain asymptomatic, or become symptomatic
  - Individuals that seek treatment and are investigated and reported (or not)
  - Time an advisory is issued
  - Number of cases averted by an advisory
  - Proportion of cases that remain unrecognized
  - Impact of geographical dispersal on outcomes of event
  - and many more….
- Allows risk managers to understand and explore the “anatomy” of an event
- Identify strategies to reduce the impact (number of cases)
  - Speed up laboratory processing time, change limits to classify an “event”, improve consumer compliance with advisories…

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# Example 2: Surge Capacity Simulator

- General health capacity planning tool where consequences are the inability to give patients "appropriate" treatment
  - No treatment at all, downgraded treatment
  - No available bed, ventilators, too long queues….
- Example predicts the pandemic spread and considers hospital resource use in event of a pandemic
- Can help managers identify how treatment and resource decisions affect consequences of the event
  - How does buying more equipment/supplies affect the number of patients who receive appropriate treatment?
  - How do changes in triage and treatment protocols affect the number of patients who receive appropriate treatment?
  - Does using exclusion criteria increase the number of patients who receive appropriate treatment?

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# Components of the Surge Capacity Simulator

- Spatial simulation which generates a list of patients over time and space
  - epidemic
- Database of public health and health care system resources
- User interface to describe triage and treatment protocols
- Discrete event simulation which processes each patient
- Customizable report generation

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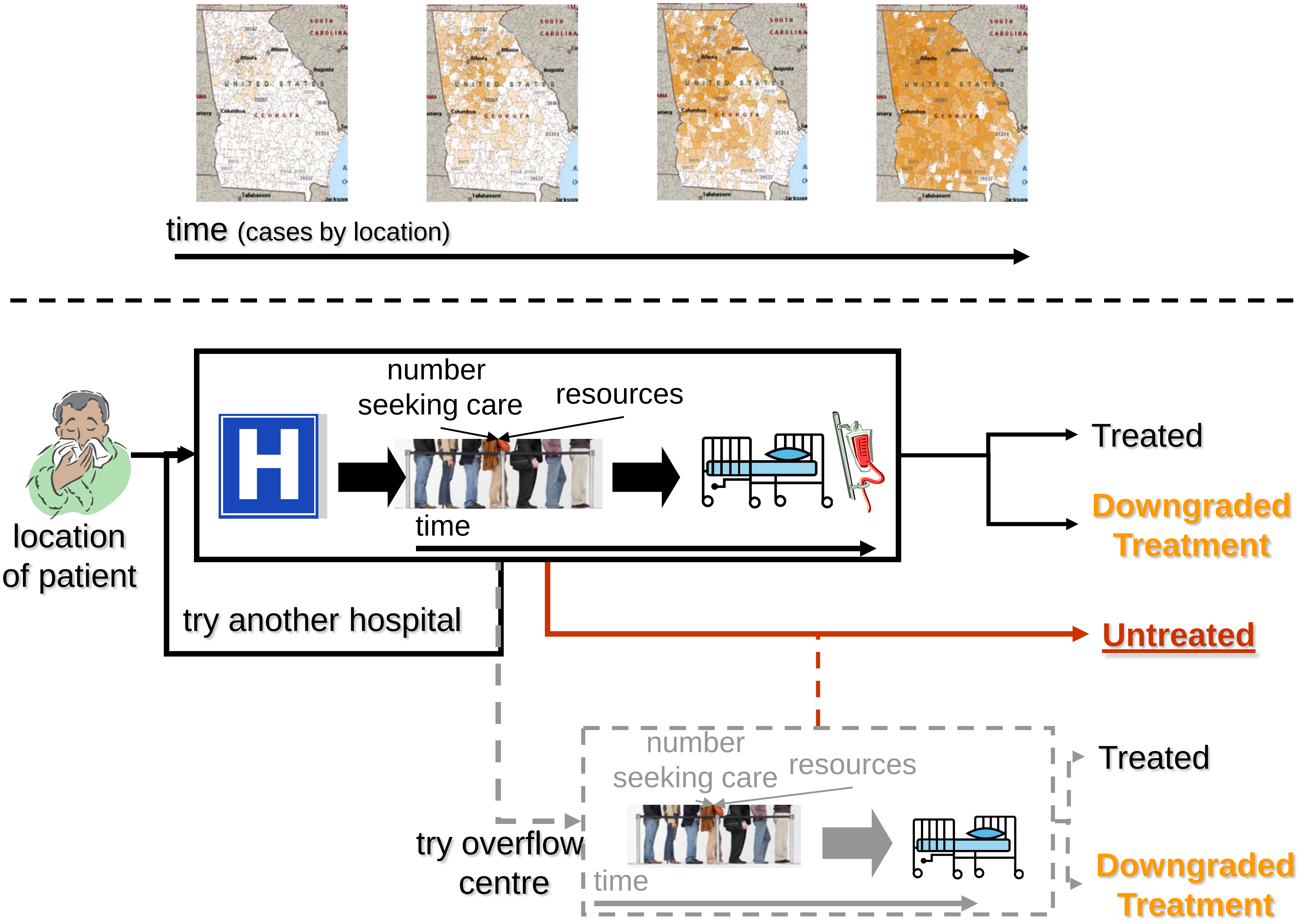
time (cases by location)
number
seeking care
resources
time
location
of patient
Treated
Downgraded
Treatment
try another hospital
Untreated
number
seeking care
resources
time
try overflow
centre
Treated
Downgraded
Treatment

# Information Gained

- Provides a vast database of information on the scenario(s) being explored
  - Tracks all the patients in the system over time
  - Stores information at the patient level on variables including time spent waiting in queues, resources utilized, ultimate fate (treated, untreated, die…)
  - Tracks resource use by time and location
- Can aid in understanding of how the features of different events affect the likely consequences
  - e.g. pandemic severity, speed of spread, areas affected etc.
  - “by day X of event Y% of hospitals are at full capacity”
  - “Z% of patients were untreated or turned away”

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# Challenges for Consequence Assessment

- It still requires a sales pitch
  - Many risk managers still need to be convinced of the power of these tools in decision-making
- Balancing the need for tools in the short-term with the complexity of the problem
  - ….and the desire to build more “realistic” models
- Distilling a complex system into its critical components
  - Requires knowledge of the system and access to skills required to describe that system mathematically

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# More Challenges

- The idea that models must have lots and lots of perfect data to be "valid"
  - Tools can be very useful in the absence of "hard data" – exploration and understanding of systems
  - Very important for bioterrorism situations where data are sparse but decisions still need to be made

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# Thankyou for Listening!

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