Understanding Pandemic Driven Demand and Optimizing Patient Flow

Learning from the Pandemic to Improve Healthcare

July 26, 2021

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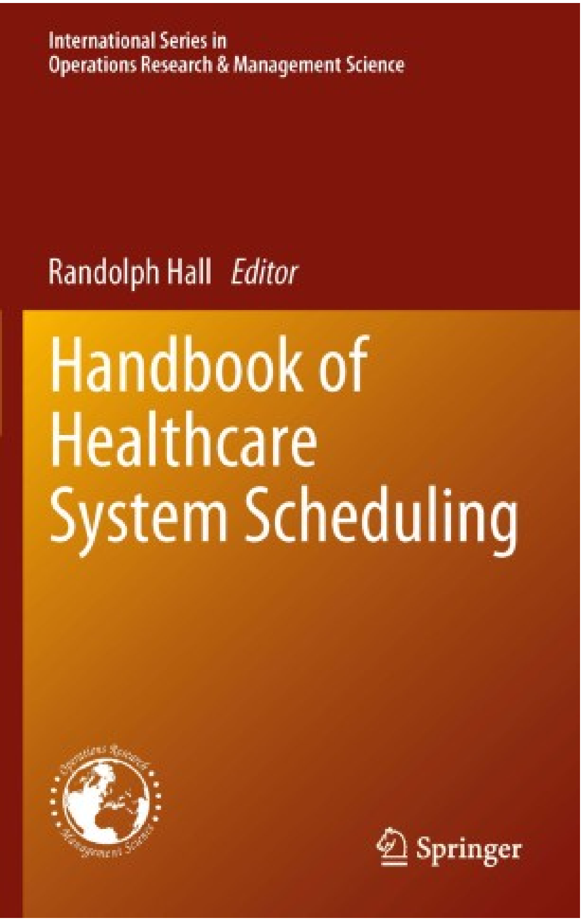
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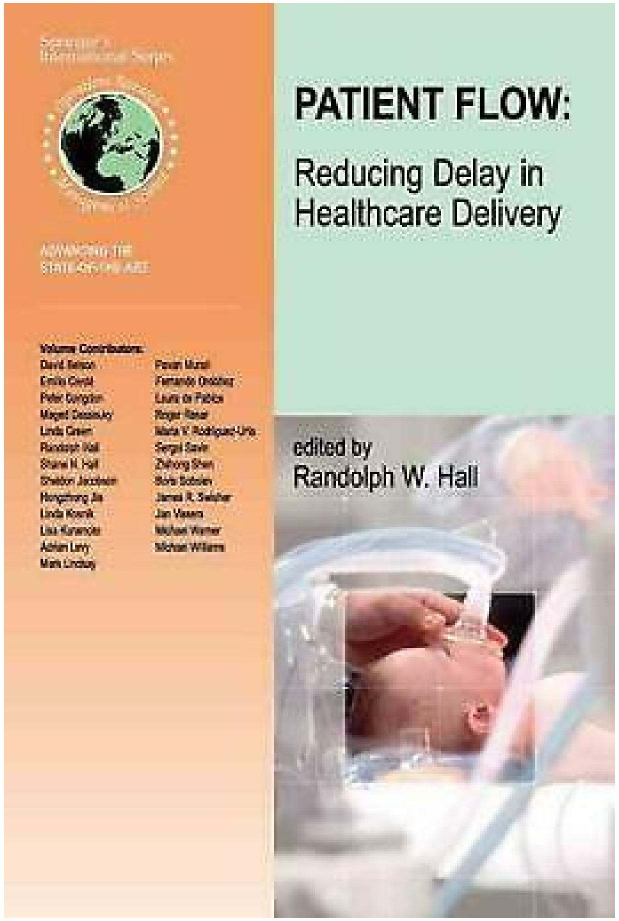
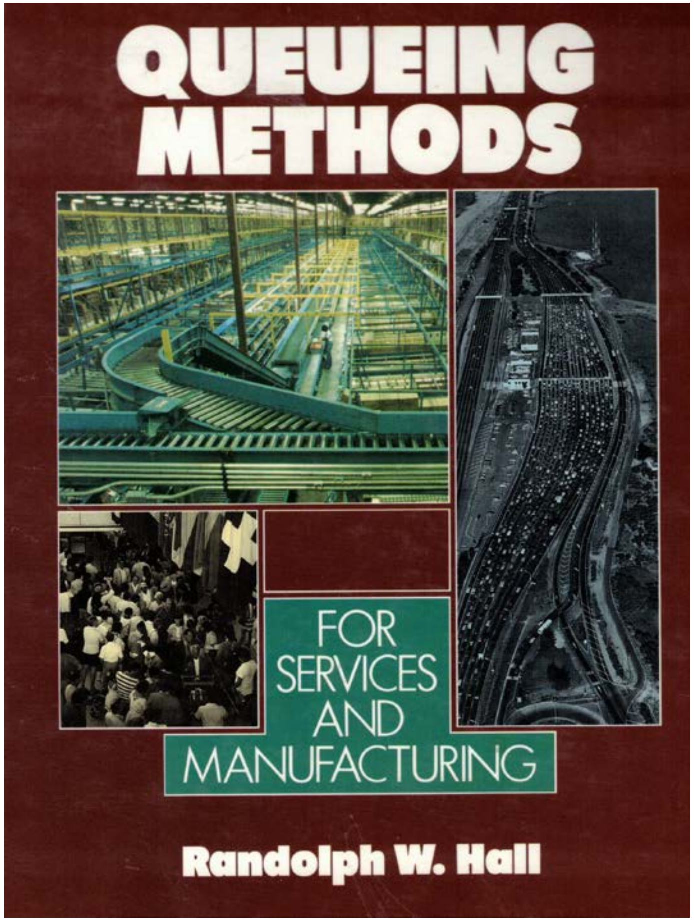

PATIENT FLOW:
Reducing Delay in Healthcare Delivery
edited by
Randolph W. Hall


QUEUEING METHODS
FOR SERVICES AND MANUFACTURING
Randolph W. Hall

Chapter 1
Modeling Patient Flows Through the Health care System

Randolph Hall, David Belson, Pavan Murali, and Maged Dessouky

Abstract Health care systems can be evaluated from four perspectives: macro, regional, center, and department. In each case, reduction of patient delay depends on improving interfaces as patients are transferred from activity to activity or department to department. This chapter presents basic tools for resolving delays at interfaces, through mapping the processes by which patients are served, and by developing and implementing measures of system performance. These tools are demonstrated through a case study of the Los Angeles County/University of Southern California Hospital.

Keywords Process charts • Performance measurement • Health care systems

BASICS

PATIENT FLOW

Processes and steps by which patients receive healthcare services

AIM

To efficiently provide services when and where needed by patient

HIERARCHY OF DELAY

Availability of services, by time and place, does not match patient needs

- Perpetual: inadequate capacity, creating perpetual delays
- Varying: capacity is predictably not aligned with variability in needs
- Random: mismatch between capacity/need is un-predictable

OPTIMALLY

- Care is timely and appropriate, meeting patient needs
- Wait once arriving for care is short, safe and pleasant
- Capacity is fully utilized (not idled often for lack of patients)

WHEN SHORTAGE IS PERPETUAL

Care is significantly delayed

Some patients will give up, or never receive service

Patients will suffer

BASIC STRATEGIES

Supply

- Workforce availability/scheduling
- Facilities
- Supplies and equipment

Demand

- Prevention
- Appointment scheduling (and follow-up)
- Pricing

Synchronization

- Triage
- Coordination of related services

WHAT ABOUT COVID-19?

Capacity

- New resource requirements for in person
- Change in service provision (telemedicine)
- Supply shortages
- Staff shortages

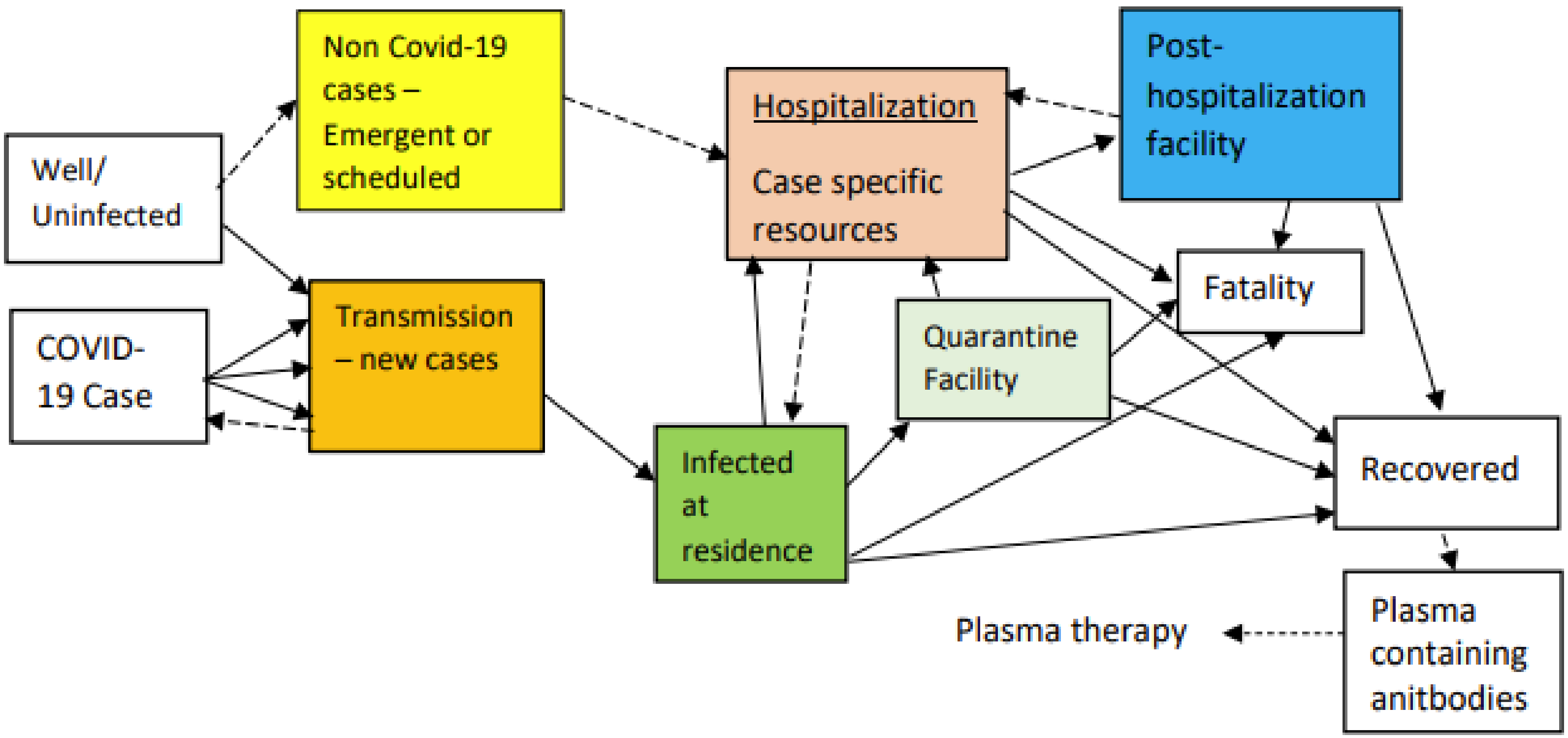
Demand

- Deferred care (possibly generating future needs)
- Difficult to predict
- Public behavior affects transmission and can create surges
- Controlling infections in facilities

Synchronization

- Co-morbidities
- Discharging infectious patients

Patient Flow



Interventions

COVID CASE	Non-COVID	AT HOME	QUARANTINE	HOSPITALIZED	POST-HOSPITAL
Detection Testing Monitoring Distancing Movement Contact tracing Hygiene/PPE Vaccine	Postponement Diversion Transfer Prevention Telemedicine for care continuity	Monitoring Testing Therapeutics Telemedicine Quarantine	Monitoring Testing Therapeutics Telemedicine Release from quarantine standard	Therapies Fast discharge Fast testing Substitute, adapt or re-use Surge capacity Optimize resource allo-cation/creation Diversion Transfer	Prepare for hospital discharges Monitoring Testing Therapeutics Telemedicine

Success Measures

COVID CASE	Non-COVID	AT HOME	QUARANTINE	HOSPITALIZED	POST-HOSPITAL
Reduced & Equitable Total cases Rate/Accel-leration of new cases R – Value Pandemic duration	**Reduced & Equitable** Non Covid-19 hospital-ization Comorbidities Fatalities in non-Covid-19 cases	**Reduced & Equitable** Hospital-ization Time to recovery Fatality %	**Reduced & Equitable** Transmission Hospital-ization Time to recovery Fatality %	**Reduced & Equitable** Length of stay Wait for bed Fatality % **Availability** Beds, ventilators, other resources	**Reduced & Equitable** Rehospital-ization Wait for bed Fatality % Time to recovery Length of stay **Availability** Beds, other resources

Hall/Lyu 4.15.20

DISEASE TRANSMISSION: ASSESSING NEEDS

Prevalence of Disease (current infections)

Susceptible Population (lacking immunity)

Level of Contact Between Susceptible and Infectious

- Proximity
- Duration
- Environment
- Hygiene

PROCESS IS NON-LINEAR

GEOMETRIC GROWTH

Suppose new cases grow 5% per day:

1 case becomes: 4 new cases per day in one month
80 per day in three months
7200 per day in six months
600,000 per day in nine months

Suppose new cases grow 8% per day:

1 case becomes: 10 new cases per day in one month
1000 per day in three months
1.2 million per day in six months

MODEST BEHAVIORAL CHANGES CAN RADICALLY CHANGE THE TRAJECTORY

STOPPING THE CYCLE OF GROWTH

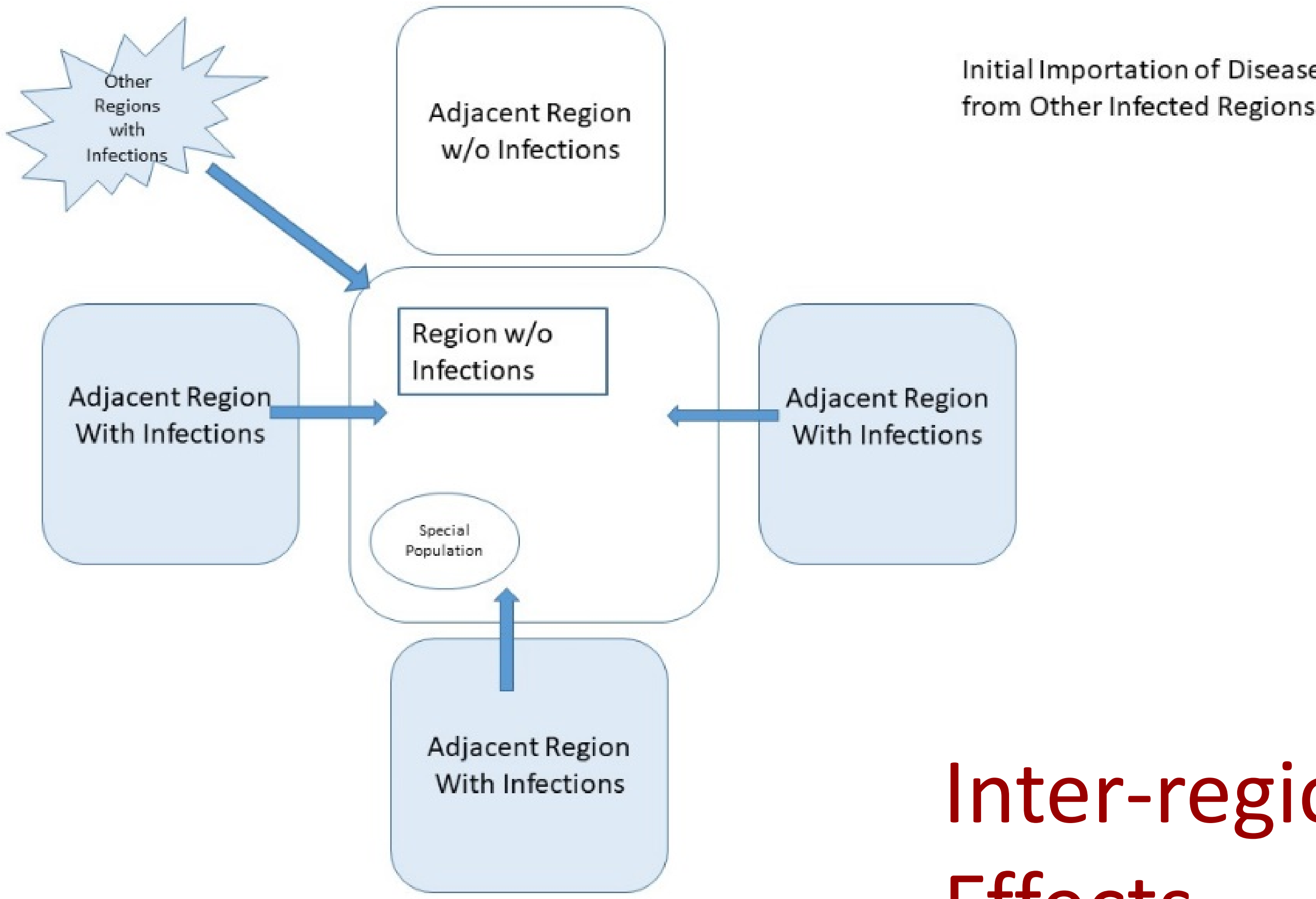
Reducing the susceptible population

- Acquired immunity
- Vaccination

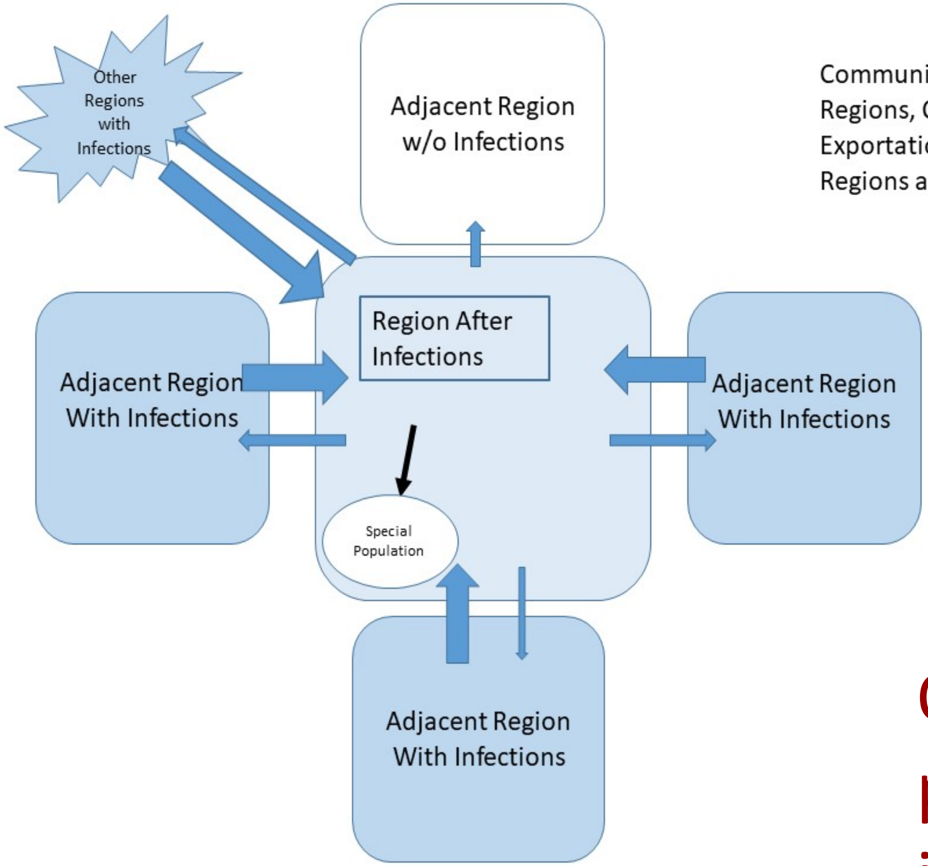
Changing *Collective* Behavior to Reduce Contact

RESTARTING THE CYCLE OF GROWTH

- Changing *Collective* Behavior to Increase Contact
- Variants that Reduce Immunity



Inter-regional Effects



Community Spread Within Infected Regions, Continued Importation + Exportation of Disease to Other Regions and Special Populations

Once disease is prevalent in region, importation may have insignificant effect

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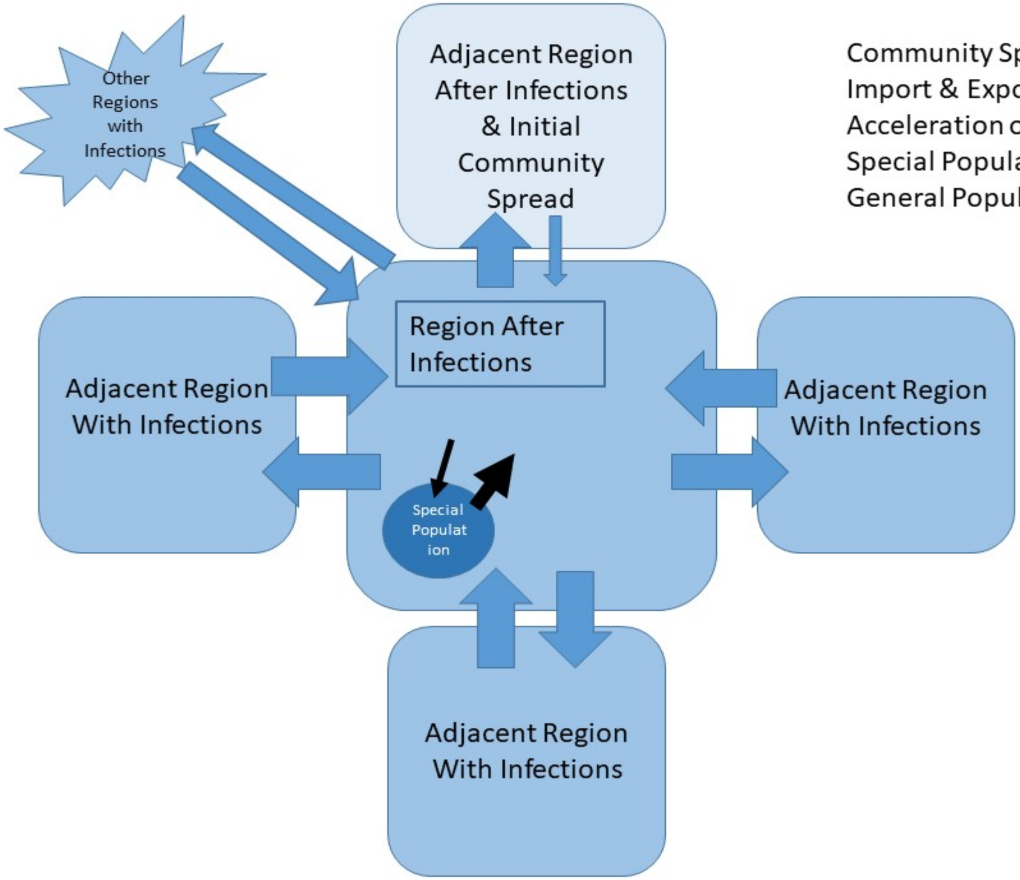
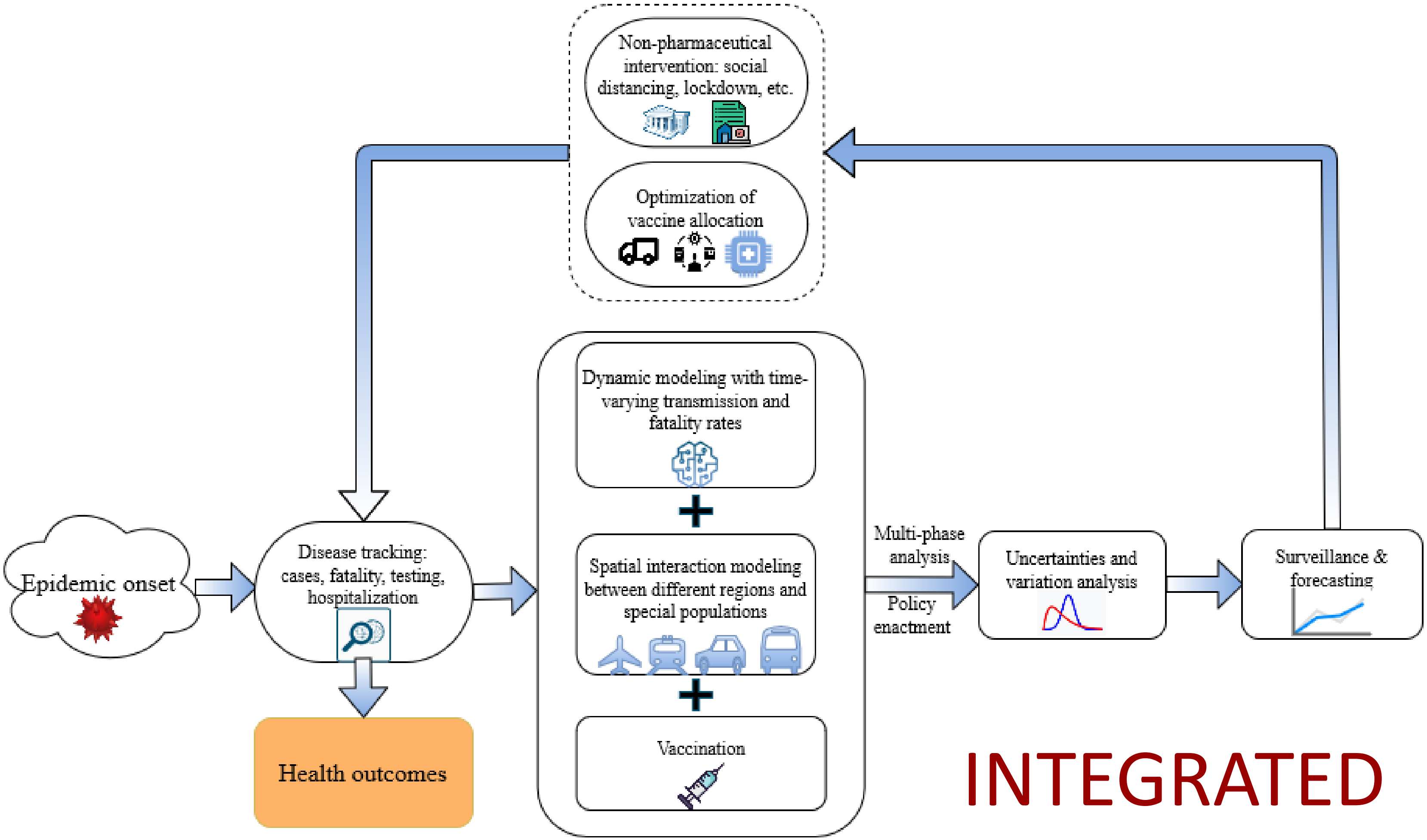


Community Spread, Equilibration of Import & Export of Disease, & Acceleration of Community Spread Within Special Populations, Now Exporting to General Population



INTEGRATED MODELING

Tracking Covid-19 Cases and Deaths in the United States: Distribution of Events by Day of Pandemic

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Article Type: Original Research

ABSTRACT

In this paper, we analyze the progression of COVID-19 in the United States over a nearly one-year period beginning March 1, 2020, with a novel metric representing the partial-average day-of-event, where events are new cases and new deaths. The metric is calculated as a function of date and location to illustrate patterns of disease, showing growing or waning cases and deaths. The metrics enable the direct comparison of the time distribution of cases and deaths, revealing data coherence and revealing how patterns varied over a one-year period. We also compare different methods of estimating actual infections and deaths to get a better perspective on the timing and dynamics of the pandemic by state. We used

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Dynamic Modeling of Reported COVID-19 Cases and Deaths with Continuously Varying Case Fatality and Transmission Rate Functions

Mingdong Lyu, Randolph Hall

doi: https://doi.org/10.1101/2020.09.25.20201905

This article is a preprint and has not been peer-reviewed [what does this mean?]. It reports new medical research that has yet to be evaluated and so should *not* be used to guide clinical practice.

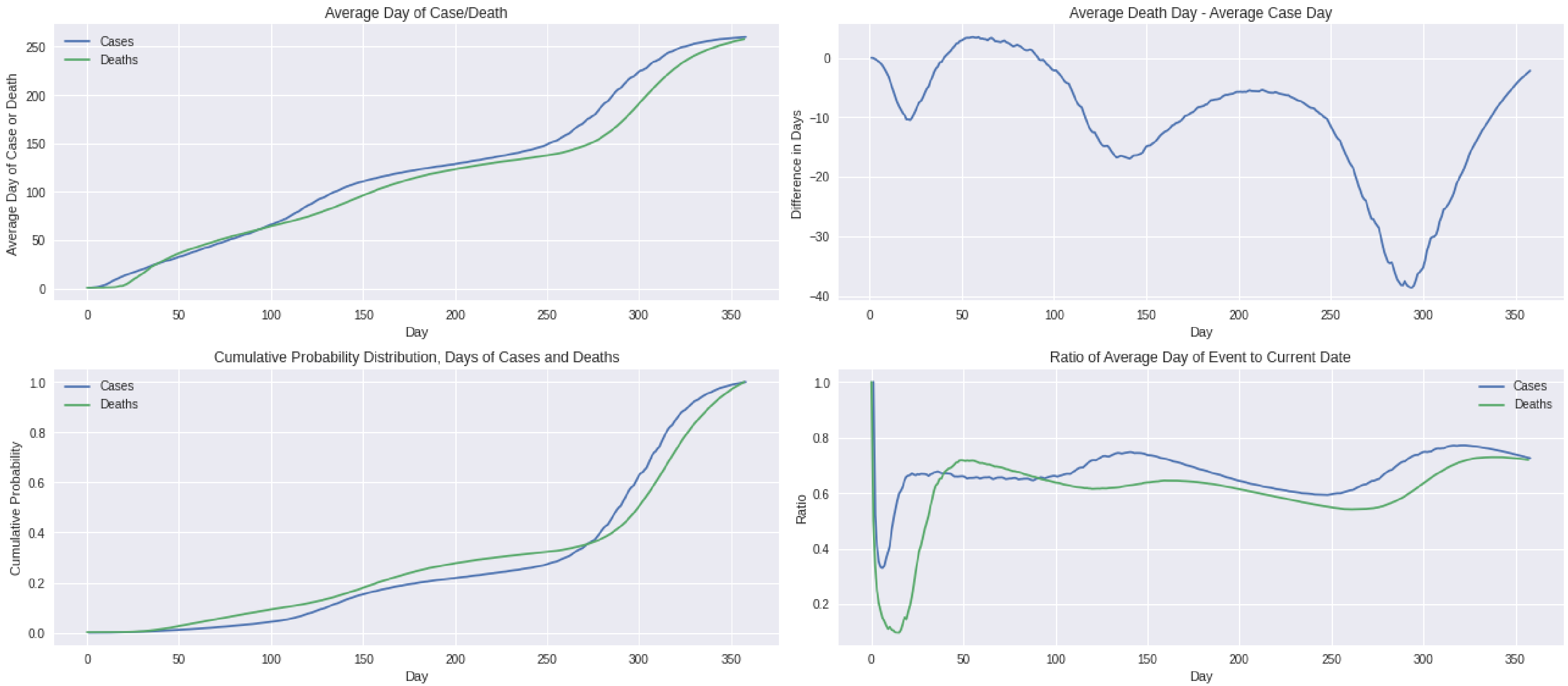
Abstract | Full Text | Info/History | Metrics | Preview PDF

Abstract

In this paper, we propose an enhanced SEIRD (Susceptible-Exposed-Infectious-Recovered-Death) model with time varying case fatality and transmission rates for confirmed cases and deaths from COVID-19. We show that when case fatalities and transmission rates are represented by simple Sigmoid functions, historical cases and fatalities can be fit with a relative-root-mean-squared-error accuracy on the order of 2% for most American states over the period from initial cases to July 28 (2020). We find that the model is most accurate for states that so far had not shown signs of multiple waves of the disease (such as New York), and least accurate for states where transmission rates increased after initially declining (such as Hawaii). For such states, we propose an alternate multi-phase model. Both the base model and multi-phase model provide a way to explain historical reported cases and deaths with a small set of parameters, which in the future can enable analyses of uncertainty and variations in disease progression across regions.

CALIFORNIA

State:California, CDC Data, as of Date Day 1 = 03/01/2020, Date Ran: 07/25/2021



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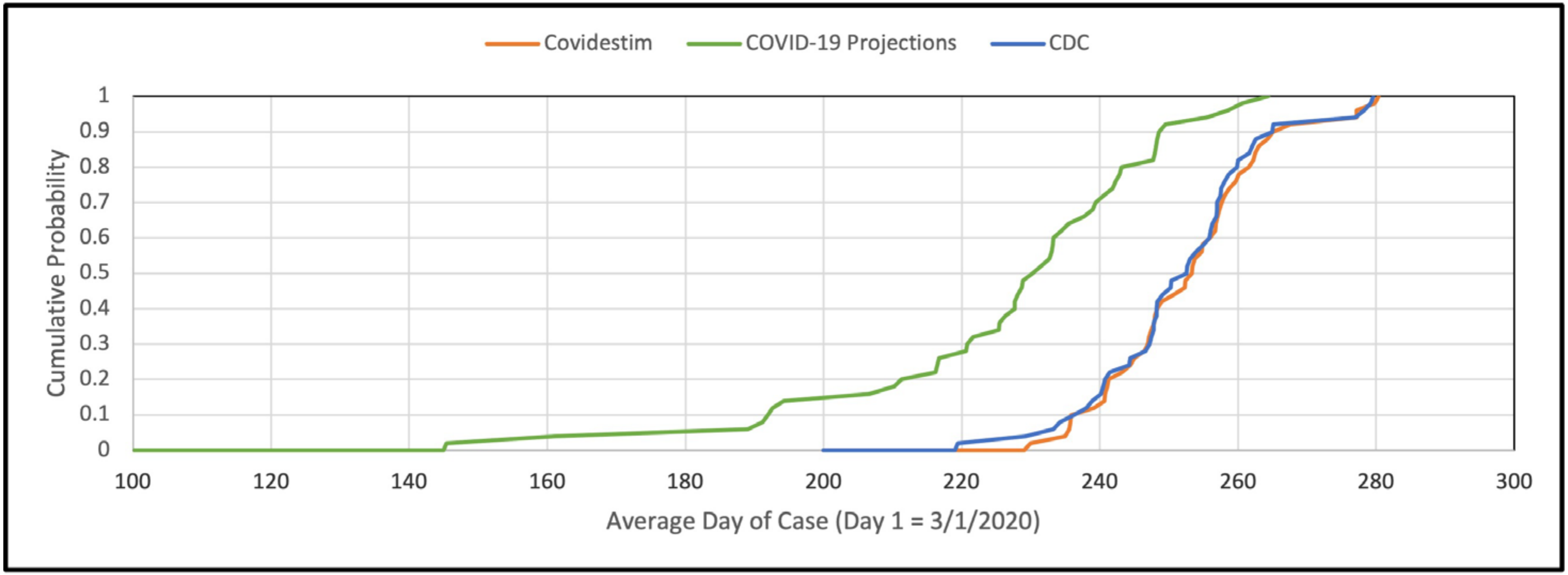
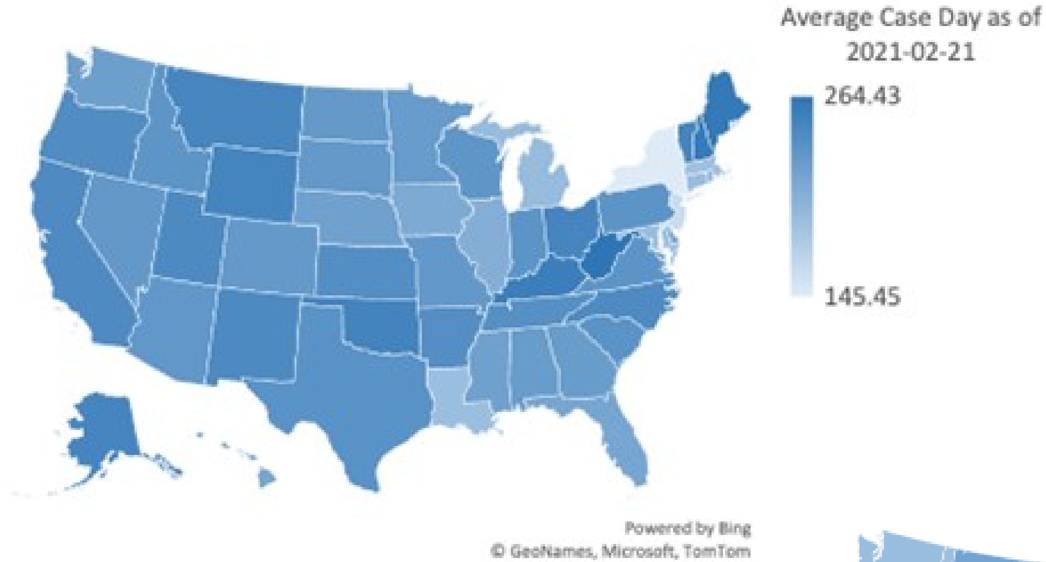
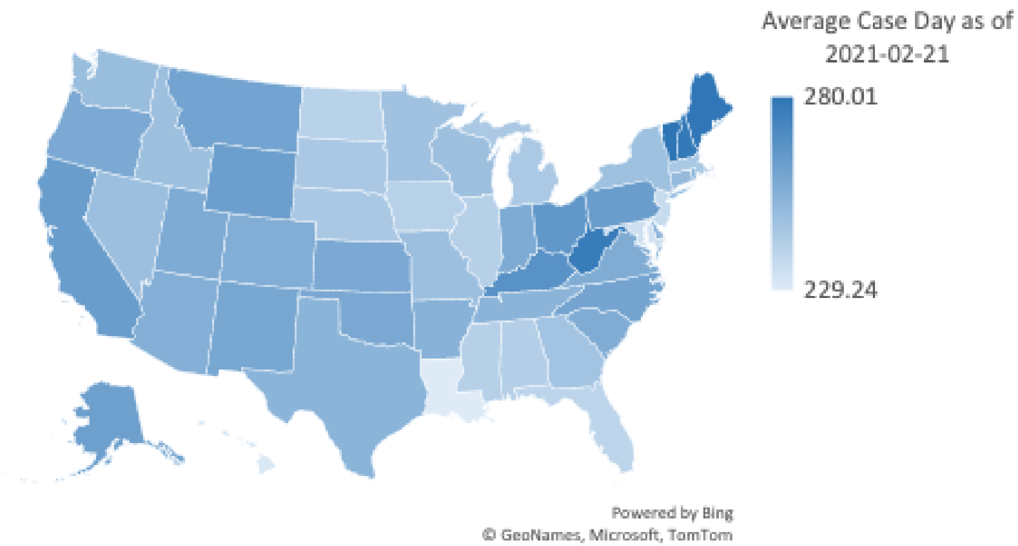
Distribution of Average Case Day by State and Data Source





COVID-19 Projections

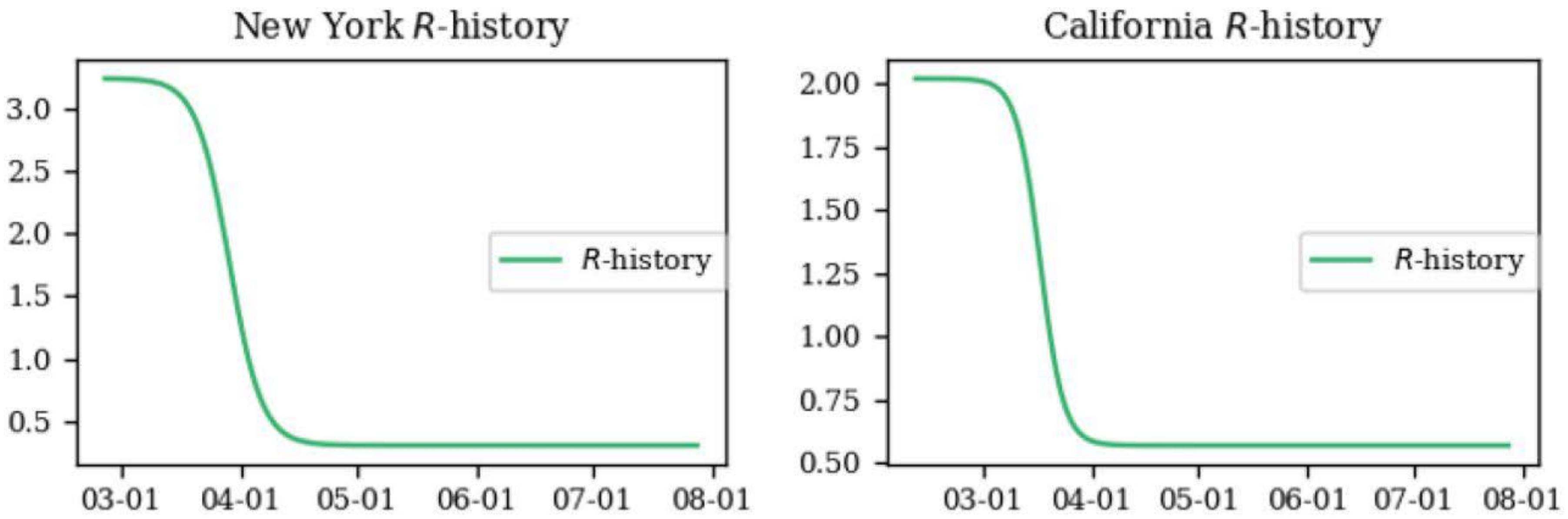


CDC

Table 1 Statistics for Average Case and Death Day by State

	Covidestim		Covid-19 Projections		CDC	
	Average Day of Case in State	Average Day of Death	Average Day of Case in State	Average Day of Death	Average Day of Case in State	Average Day of Death
National Average	253	236	227	235	252	235
SD Among States	12	34	24	33	12	31
Minimum Among States	230	133	145	139	219	144
Maximum Among States	280	282	264	283	280	283

DECLINING EFFECTIVE REPRODUCTION NUMBER IN 2020



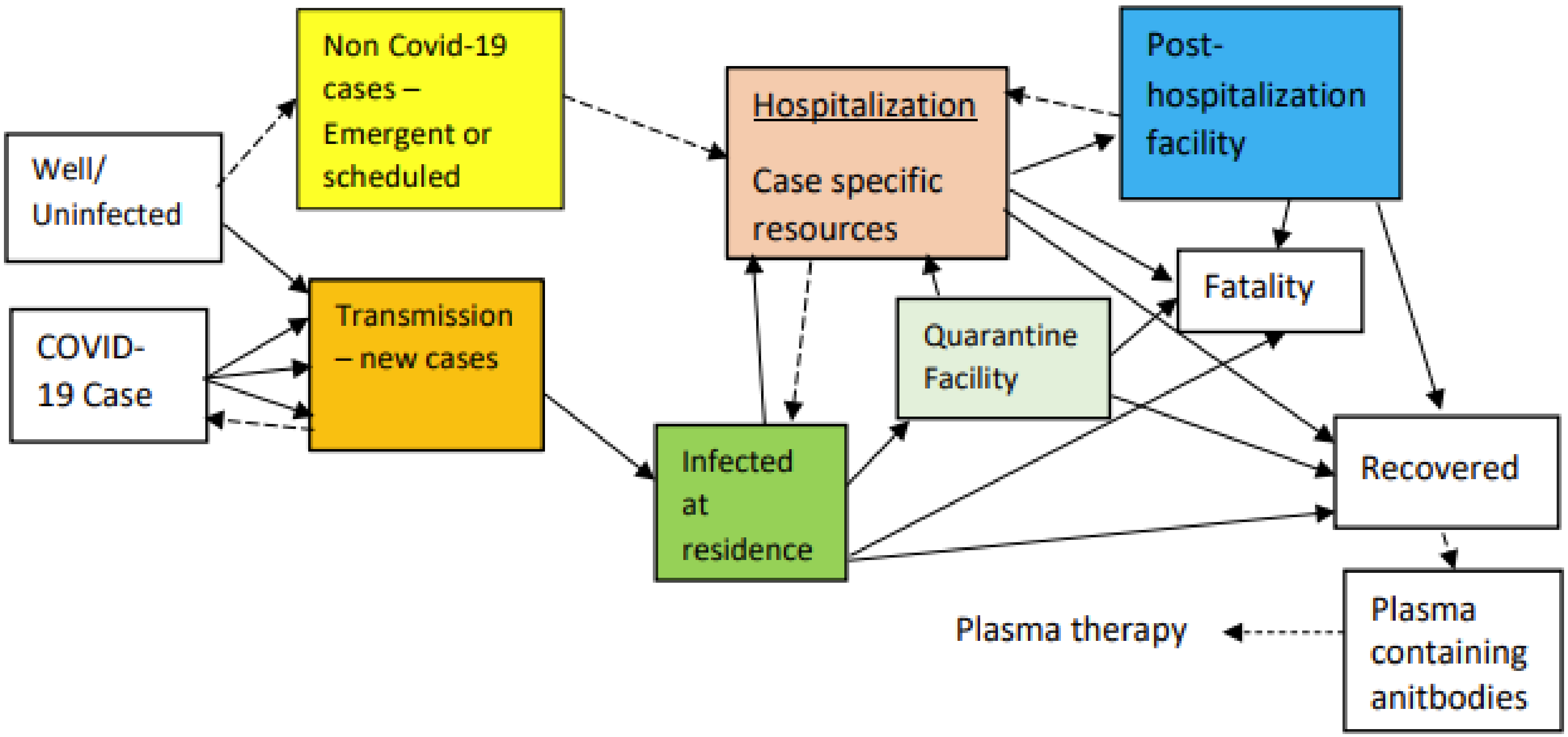
TAKE AWAYS

- Patient flow options

Supply	COVID transmission
Demand	Non-COVID
Synchronization	At home
	Quarantined
	Hospitalized
	Post-hospitalized

- Demand highly sensitive to collective human behavior and conditions
- Surges experienced at different times at different places
- Behavior has changed (and will change) course of pandemic: acceleration vs. deceleration (declining rate of growth)

PATIENT FLOW SYSTEM



COVID-19 Data Source

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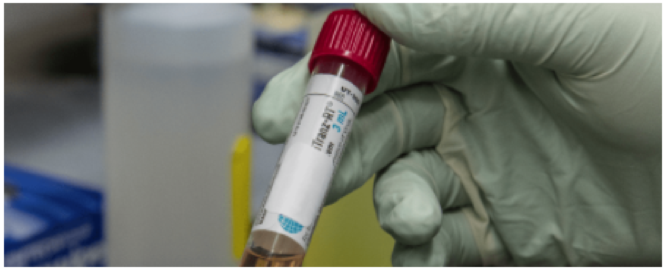
ABOUT | PROJECT | DATA | PATIENT FLOW MODEL | DATA VISUALIZATIONS | PARTICIPANTS | CONTACT US

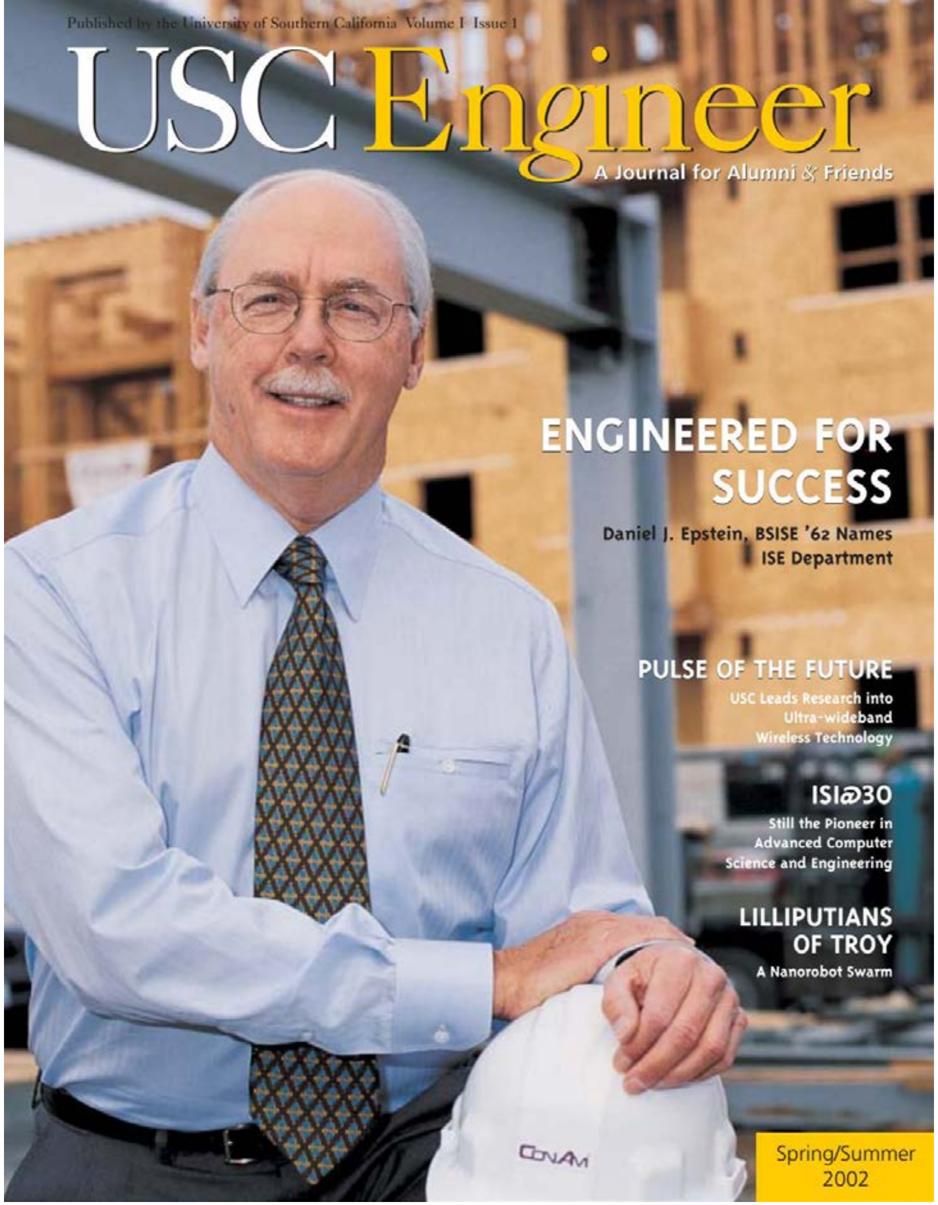
Our Goal

We aim to reduce the consequences of viral disease through interventions that simultaneously affect the rates at which new cases occur and affect the provisioning of healthcare resources to serve patient needs. Toward that end, we are developing models of disease transmission and capacity allocation, considering:

- Sensitivity to interventions that limit disease spread by constraining the movement of people and imposing their isolation
- Uncertainties that influence the growth in cases, and how these uncertainties are resolved or change over time
- Needs of skilled nursing and other congregate living settings



Want to find out more about the project? Check out some of the links below.



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CREATE at DHS Summit

Researchers active at DHS Center of Excellence Summit

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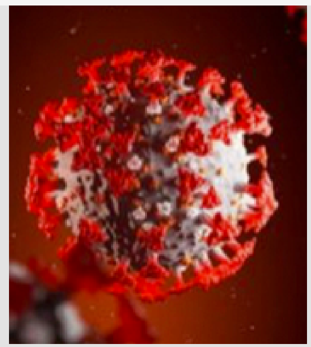

Coronavirus Updates

CREATE begins study of coronavirus health threat

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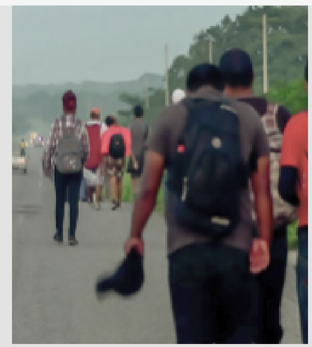

Migration Study

Research examines motivations of Northern Triangle migrants

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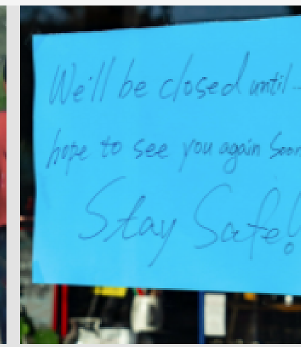

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