### WEBINAR SERIES PARTNERS

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ON-DEMAND RESOURCES

All webinars are recorded and posted to the ACMT webinar page www.acmt.net/covid19web

Webinar Q&A
www.acmt.net/C19FAQ

Questions?
Write to: info@acmt.net
Q&A will be at end of the Webinar

Please type your questions into the Q&A or Chat function during the webinar and we will get to as many as we can

We monitor all platforms, including YouTube and Facebook, for questions
MODERATORS

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- Executive Director, American College of Medical Toxicology (ACMT)

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- Board Member, American College of Medical Toxicology (ACMT)
Lisa Moreno, MD, MS, MSCR, FAEEM, FIFEM

- President of American Academy of Emergency Medicine (AAEM);
- Professor of Emergency Medicine, Director of Research and Director of Diversity, Section of Emergency Medicine, Louisiana State University Health Sciences, Center New Orleans, LA
Epidemiological Modeling of the Impact of COVID-19 on Hospital Systems: Maryland Case Study

Medical and Public Health Considerations of COVID-19

Eili Y. Klein, PhD, MA

Associate Professor, Department of Emergency Medicine
Johns Hopkins School of Medicine, Baltimore, MD
Disclaimer

- These are unpublished preliminary results of a fast-moving epidemic with many uncertain parameters. All results are subject to change.
- The work was funded by the Centers for Disease Control, Modeling in Infectious Disease (MInD) Network.
- Computational assistance provided by CCDC U.S. Army Research Laboratory and The National Center for Supercomputing Applications (NCSA).
- No other disclosures.
First Disease Model
1911

\[ S \xrightarrow{h} I \]

Life Cycle of the Malaria Parasite

1. Transmission by mosquito (injects gametocytes into skin)
2. Gametocyte maturation
3. Gametocyte maturation
4. Gametocyte maturation
5. Gametocyte maturation
6. Gametocyte maturation
7. Gametocyte maturation
8. Gametocyte maturation
9. Gametocyte maturation
10. Gametocyte maturation

\[ \frac{a}{g} \] \# Human Bites per Mosquito over its lifetime

\[ \epsilon \] % of Bites that Infect Mosquitoes

\[ \eta \] % that Survive Sporogony

\[ b \] % of Bites that Infect Humans

\[ n_a \] # Bites, per Human per Day

Sir Ronald Ross
“Simple” model of infection assumes individuals are like molecules in a glass of water. Susceptible individuals become infected when the “bump into” already infected individuals.
SIR Model

Progression of population can be described by a set of ordinary differential equations where:

- $\beta$ is the effective transmission rate
- $\gamma$ is the rate the individuals recover

\[
\begin{align*}
\frac{dS}{dt} &= -\beta SI \\
\frac{dI}{dt} &= \beta SI - \gamma I \\
\frac{dR}{dt} &= \gamma I
\end{align*}
\]
SIR Model

\[
\frac{dS}{dt} = -\beta SI \\
\frac{dI}{dt} = \beta SI - \gamma I \\
\frac{dR}{dt} = \gamma I
\]
SIR Model: Measles

Measles is a nearly perfect example of an SIR modeled disease …

https://plus.maths.org/content/mathematics-diseases
SIR Model: Measles

However, the disease does not go extinct …

Source: http://www.zoo.cam.ac.uk/zoostaff/grenfell/measles.htm
What are models good for?

“All models are wrong … but some are useful”

George Box
Basic Reproductive Number ($R_0$)

\[
\frac{dS}{dt} = -\beta SI \\
\frac{dI}{dt} = \beta SI - \gamma I \\
\frac{dR}{dt} = \gamma I
\]

Can be rearranged to show that infections can only be increasing when

\[
\frac{\beta S_0}{\gamma} > 1
\]
Since the infection depletes the pool of susceptibles, the effective reproductive number drops in line with the proportion of susceptibles in the population (S), i.e. $R = R_0 S$

When $R < 1$, the number of infected cases starts to fall and the epidemic dies out (i.e., herd immunity)
Why does R0 matter?

Drives dynamics and can aid in understanding concepts, such as how many people need to be vaccinated to stop transmission …
Why does R0 matter?

Drives dynamics and can aid in understanding concepts, such as how many people need to be vaccinated to stop transmission … but the same R0 can produce different dynamics depending on transmission/recovery.
R0 and SARS-CoV-2

- Heterogeneity in transmission
- Superspreader events
- How to model?
Individual Based Model of Transmission

- Individual Agent Model of Maryland
  - All Maryland zip codes
  - Includes surrounding zip codes with patients that visit MD hospitals
- Individuals are assumed to live in households and are spread across the state based on zip code level Census data
  - Total population is ~9 million in 500+ zip codes
Model Assumptions

• Initial infections first arrived in Maryland between 2/1/2020 and 2/15/2020
• Continual seeding of infections is assumed to occur based on population size assuming largest zip codes more likely to get initial infections
• Contacts between non-household members are based on distance and population size of each zip code
Model Assumptions

- Contact and Transmission depends on type of contact and with whom contact is made
  - Individuals have highly variable contact patterns by age
    - Gamma distributed with kids having higher rates of contact
    - Age-related assortative contact patterns

Contact Rates by Age

Age Assortative Contact

1. 10.1371/journal.pmed.0050074
Patients in general visit hospitals near them, particularly for emergency visits. More hospitals in an area spread out case load
• We based likelihood of patients visiting a hospital based on average wintertime visits for respiratory viruses
Models is first fit to data on the epidemic to date

Model Results

State Hospital Occupancy

Total Beds Needed for COVID-19 Patients
Modeling Projections for Operational Planning: Can we control surge 2.0?

Changes in transmission driven by either (a) behavioral changes or (b) seasonal changes in transmission potential

The model assumes that phased reopening leads to increases in potentially transmissible contacts through a combination of increases in the probability of transmission and the number of contacts either quickly (by 9/7/202, as shown) or moderately by 10/31 or slowly by 12/31.
Modeling Projections for Operational Planning: Can we control surge 2.0?

Two analyses

- “Three Maryland” Analysis
  - In addition to essential workers, who are assumed to not be able to isolate at the same rate as everyone else, this analysis assumes that older individuals (65+) maintain reduced contact rates that are relatively lower than other groups (thus as other groups reduce their distancing the older individuals are able to maintain relatively lower contact but not absolutely lower).

- Reduced Contacts
  - Restricting gathering sizes and closing venues that may lead to congregating individuals inside (e.g., restaurants, bars, movie theaters, religious services, etc.)
  - This cuts off the tail of contact patterns (below) so that individuals who typically have high numbers of contacts do not have that number. In essence this severely restricts the likelihood of super spreader events.
Scenario: Reductions in Social Distancing

- The larger and faster the decrease in social distancing the greater the probability and size of a surge in the fall.

30% reduction in social distancing leads to large surges. The faster that reduction the greater the increase in the fall.

50% reduction in social distancing

Speed of reduction refers to how quickly reductions in social distancing occur:
- Fast: 9/7/2020
- Moderate: 10/31/2020
- Slow: 12/31/2020
Scenario: Reduction Social Distancing Older Protection

- If older individuals don’t reduce social distancing as much, this has an effect, but only marginally reduces the surge

Older individuals are assumed not able to completely cut themselves off from others, but maintain relatively better social distancing. This reduces the surge somewhat, but though they are more likely to be hospitalized, they only make up a small proportion of the population thus don’t drastically reduce total hospitalizations.
Modeling Projections for Operational Planning: Can we control surge 2.0?

Restricting the potential for super spreader events to less than 10 daily contacts drastically reduces the potential and size of secondary surge in the fall compared to other strategies.

In other words, cutting off the ability of individuals to have large numbers of transmissible contacts can result in disease containment. Examples include bars, restaurants, religious gatherings, parties, and anywhere where more than 10 people are gathered without masks in an indoor environment.
• Restrictions on gatherings can avoid increases over the month of August
• Restrictions on gatherings can avoid increases over the month of August
Is the summer weather associated with lower severity of infection? Could warmer weather also be reducing transmission?

A recent preprint argues that lower mortality rates from COVID-19 since May in Europe may be explained by the summer weather. If true, that suggests that hospitalizations/deaths could increase in the fall and winter.

“Severity of COVID-19 in Europe decreased significantly between March and May and the seasonality of COVID-19 is the most likely explanation. Mucosal barrier and mucociliary clearance can significantly decrease viral load and disease progression, and their inactivation by low relative humidity of indoor air might significantly contribute to severity of the disease.”

medRxiv preprint doi: https://doi.org/10.1101/2020.07.11.20147157
Will Flu and COVID-19 overlap?

Evidence from Australia: ILI has increased in last few weeks

Figure 1. Per cent of calls to Healthdirect related to ILI, Australia, 1 January 2015 to 14 June 2020, by month and week of call

However, sentinel sites are not picking up influenza

In an environment with significant social distancing, mask wearing, and school closures, influenza is unlikely to be as significant as in prior years. However, detection will be difficult as symptoms will overlap with COVID-19 symptoms and we do not know whether the two are antagonistic or synergistic in any way.
Modeling Scenario: Baseline
Estimated COVID-19 Occupancy 2020-08-15

Estimated COVID-19 occupancy for each hospital based on current trends assuming no change in behavior on 2020-08-15
Contact Information

Eili Y. Klein
Department of Emergency Medicine
Johns Hopkins School of Medicine
5801 Smith Ave., Davis Suite 3220
Baltimore, MD 21209
eklein@jhu.edu
410-735-7559
UPDATE FROM THE FRONT LINES:
RIO GRANDE VALLEY

MEDICAL AND PUBLIC HEALTH CONSIDERATIONS OF COVID-19

Minerva A. Romero Arenas, MD, MPH
Assistant Professor, Department of Surgery
The University of Texas Rio Grande Valley, Edinburg, TX
Rio Grande Valley, Texas
COVID-19 in the Rio Grande Valley

Total Cases: Hidalgo, Cameron, Willacy & Starr

- **RGV Cases:** 40k
- **RGV Deaths:** 1335
- **RGV Hospitalized:** 1109

- **TX Cases:** 490k
- **TX Deaths:** 8490
- **TX Hospitalized:** 7437

Governor mandated Reopening
Facemasks
Hanna
Rio Grande Valley

1.2 million people

75,000 mixed status families

Median HH income $38k
Poverty 29%

High-school graduates 65%

37% Obesity
Uninsured 46%

Households with broadband internet 50-65%

Limited English Proficiency

Multigeneration Households
Rio Grande Valley, Texas

Starr County 1 hospital
Willacy 0 hospitals
No public hospitals
Nearest Level 1 trauma center >300 miles
Medically Underserved
THANK YOU!

Minerva A. Romero Arenas, MD, MPH
Assistant Professor, Department of Surgery
The University of Texas Rio Grande Valley, Edinburg, TX
Q&A
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NEXT IN OUR COVID-19 WEBINAR SERIES

- **Wednesday, August 19, 2020 at 3:00 PM EDT**

- **An Alternative to Disposable N95s: The Reusable Elastomeric Half-Mask Respirator Experience**

  Stella Hines, MD, MSPH, Associate Professor, University of Maryland School of Medicine, Baltimore, MD

  Hope Waltenbaugh, MSN, RN, CNOR, CN-BC, Vice President of Perioperative Services, Allegheny Health Network, Pittsburgh, PA

  Sara Angelilli, MSN, RN, CNOR, Operating Room Education Manager, Allegheny Health Network, Pittsburgh, PA

  Lee Greenawald, PhD, Physical Scientist, National Personal Protective Technology Laboratory, National Institute for Occupational Safety and Health, Pittsburgh, PA

  Maryann D’Alessandro, PhD, Director, National Personal Protective Technology Laboratory, National Institute for Occupational Safety and Health, Pittsburgh, PA

  Sricharan Chalikonda, MD, MHA, FACS, Chief Medical Operations Officer, Allegheny Health Network, Pittsburgh, PA

*Photo Courtesy of Gerson*
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