APS COVID Webinar: September 23, 2020

Epidemiology of COVID-19

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- The data is terrible, measurements are conflicting, tools are ill-equipped, and thus the data is often not comparable across places and time
    - Data quality also hindered by unmeasured data points and changing delays
    - Delay distribution is not consistent over time
        - Showed plots which demonstrate that delay between symptom onset and diagnosis has been changing with each week since the pandemic started
- Part of the solution = Nowcasting
    - Given how many cases we know about today and in recent past, how many cases will we eventually know about that occurred today and in the recent past?
    - Nowcast 'learns' the delay process
    - NYC department of health has been using a method of Nowcasting to fill in estimates of current cases
- It is now clear that travelers initially spread the virus, often undetected
    - Rough linear relationship between number of cases and daily air travel volume
- Spread has depended on:
    - Time of introduction (and some bad luck)
        - Branching process simulation
            - Large uncertainty in the inputs to the simulation
            - Initial studies found to not be able to narrow the uncertainty at all
                - BUT turned out we really needed to expand uncertainty and broaden hypotheses in order to best advice communities
            - Results of this work contributed to the urgency of the NYC response
    - Mobility
        - Mobility study with Facebook data examined counties in Mass, NY, Florida
            - Found heterogeneity of mobility across time between the states
    - Individual responses and risk factors
    - Seasonality (likely mild effect)
        - Compared to 2 common cold coronaviruses [Kissler et al. *Science* 2020]
            - ~20% reduction in summer from winter in these common colds
        - COVID-19 hasn't looked as seasonal because it has so many hosts to infect
            - Others have a depletion of hosts in summer months
    - A huge number of other possible factors
        - Prior exposures?
        - Demography?
        - Use of the BCG vaccine for TB?
        - T cell cross-immunity
    - Pre-symptomatic transmission is common
        - ~40% of transmission occurs prior to symptom onset (pre/asymptomatic)
            - Was a rough estimate but seems to have stood the test of time thus far
        - This is a challenge for contact tracing

            - Plot that shows strong evidence that individual quarantine is much more effective than just active monitoring, but that neither is really effective unless you have a large number of contacts traced (~75%) (Peak et al. 2020 *Lancet Inf Diseases*)
- Contract tracing data from NYC
    - Only about ~25% of contacts are likely found (told about and able to be contacted), and usually already in the midst of their disease
    - It has worked well for other diseases, but it is likely only making a modest contribution to control in this case
- Infection fatality rate: ~0.07% (not a constant!)
    - IFR increases dramatically with age
        - Log-linear increase up to ~10% between old and young
    - Age, race, and socio-economic status have been shown to have significant influence on IFR
- Most of the world has experienced far less than 20% of population infected, already with catastrophic consequences in many places
- Vaccines:
    - SEIR model
        - Susceptible, exposed, infected,
        - Age-stratified SEIR models allow us to ask more targeted questions
    - Lots of unknowns, but know that vaccine will be scarce
    - Modeled different prioritizations for vaccine distribution:
        - For mortality:
            - Vaccinating the oldest is the best strategy
            - Nearly imperturbable.. no matter the assumption, vaccinating the oldest is the most effective at reduction of deaths (robust across countries, etc)
        - For infections:
            - Vaccination the young adults is most effective (modest difference, can change order of best strategies using different assumptions)
    - Might be a benefit from pairing serology tests with a vaccination strategy
        - Test for antibodies (assuming these are effective) and only vaccinate seronegatives
- Big open questions:
    - Where does transmission occur? How many activities can we do safely?
    - What are the predictors of superspreading and how can we prevent them>
    - Who is at risk for complications?
    - Will vaccines work at all? If so, for what outcome?
- A few questions for physicists (areas our expertise could be useful):
    - Important to have collaboration with relevant epidemiologists/virologists/etc who understand the data very well
    - Role of airborne transmission and ventilation
    - Biophysical mechanisms of seasonality
    - Better ways to account for uncertainty in data
    - Better understanding of the mapping of mobility to transmission
    - Structural biology etc

Question and Answer:

- Can you recommend some review articles with relevant model parameters such as the fatality rate as a function of age, asymptomatic population, incubation time, etc? (anonymous)
- Can you discuss the role of uncertainty in case modeling? What are you doing to model uncertainties in your current approaches?
    - Uncertainty about both past and future!
    - Past: Have an observation model on top of virus model, fit to observed data
        - Difficult, and field has not converged on a universal solution to the possibility that we are not detecting a large portion of cases
        - Deconvolution approaches seem to be the best option for many models
    - Future:
        - Need to include a lot of prediction of human behavior! This is a human model, not just a natural model
        - Must be careful to phrase everything as a conditional prediction
- How do you determine and measure the mobility rate and its reduction?
    - Several data sources, most depend on cell phones
        - Login location for facebook
        - Movement between cell towers your phone is pinging
        - Google dataset (not sure how they generate)
        - Third party vendors making graphs based on where you move with a mobile device
- Where have you seen an effective use of the kinds of models you talked about? Is anyone actually using the information we/you are providing?
    - Marc has advised a few countries, usually more general advice, not specific discussions of his models
    - UK is the epicenter of this type of modeling, so they have plenty of good advice, but don't seem to always be following it
    - Marc doesn't claim to have a whole lot of insight into the policy-making process and who is using what models – we should follow up here!
    - There is a pretty strong divide between countries that have listened to the science and those that haven't (many strong actors)
        - It's rarely the details of the models that matter, but the broad conclusions
- What is role of big data, machine learning for driving epidemiological picture?
    - Really believes in understanding the mechanisms; thus machine learning may have more limited function in this area
    - BUT! Really great work has been done to do more timely predictions of cases and other scattered examples
- Incidence and mortality rates have changed with time…thoughts on the impact of modeling on treatments, improving these numbers?
    - Not a lot
    - Changes in who is getting infected are a big driver of these changing numbers
    - Treatment improvements are beneficial in moving people out of hospitals faster, then improving treatment numbers
- Some reporting that you can get re-infected with the virus…
    - 3 of these cases the last time he checked
    - Might end up being uncommon to get re-infected, but very uncommon to get a severe second case

- The discussion on data quality was really interesting… Do you think COVID will be an impetus to try and improve data capture policy for the future?
- Can/will epidemiology tell us anything about possible long term side effects of COVID?