Qianying Lin:

So let's, yes. Shall we start?

James Walsh:

Mm-hmm (affirmative).

Qianying Lin:

Good afternoon. My name is Qianying Lin. I am going to present these topics but first off there's a few things that I should tell all of you guys. During the presenting everyone except me will have their microphone or their camera turned off and if you have questions or comments on my presentation, please enter it into the Q&A section at the bottom of the screen, and I will answer the questions once I am done with the slides and we are getting to the Q&A section.

Qianying Lin:

A copy of the slides will be sent after the presentation. A copy of the recording with captions will be available in our website in a week or so. If you want an uncaptioned version, please reply to the email with the slides and just let us know. The information about this webinar including what to do if there is a technical issue links to publications, etc., can be found on the MIDAS website. That is midas.umich.edu on the calendar under events.

Qianying Lin:

If everything, everybody is okay so I will just start. Hi, everybody. Good afternoon. Welcome to this webinar. It is my first time doing this. This topic is coronavirus 19 outbreak in Wuhan, China because I'm from China, in retrospect and in prospect. First of all I would give a little bit background introduction of myself. Right now I am a data science fellow of Michigan Institute for Data Science at the University of Michigan, Ann Arbor.

Qianying Lin:

Before joining this position I gained my PhD degree in applied mathematics at Hong Kong Polytechnic University last year. My research interest focused on mathematical epidemiology including various kinds of infectious diseases including influenza, MERS, coronavirus, HIV, etc. Also, I studied some human factors the impact on epidemics and the chain and the trends.

Qianying Lin:

Here is the outline of this presentation. So far I will give an introduction on the coronavirus infectious disease and the review on the epidemics in Wuhan, China and also the government's actions. Then I will give a basic concept in epidemiology for better understanding of the study of our mathematical models. Then I will talk about two of my previous publications on my reporting rates and R naught that I will explain a little bit later. Then, also, the impact of governmental actions and individual, which is closely related to the situation right now in the United States. Last is the Q&A section which may be like 10 or 15 minutes.

Qianying Lin:

Here is the single introduction on the virus for all of you to understand, have some knowledge on the virus. It was first confirmed in December 2019 in Wuhan, China. It is the novel coronavirus which means at the very beginnings no one knows things about this like everything is unknown. It is genetically close to the other two, the previous coronavirus which starts in Hong Kong in 2003, and the Middle East respiratory syndrome coronavirus basically in Saudi Arabia in 2015.

Qianying Lin:

This virus would cause pneumonia and the symptoms of infection is nonspecific. It could be cough, fever, shortness of breath, diarrhea, swollen eyes, etc. It could be transmitted through respiratory droplets, through contact with other people, especially with infecting individuals and until now the intermediate host is still unknown.

Qianying Lin:

As of today, there are over 81,000 confirmations and with over 3,000 deaths in China. There are ongoing major outbreaks in Italy, Iran, and South Korea. The outbreaks in the United States right now are at the very early stage, although as of today, just like three minutes ago, there are 1,919 confirmations with 12 confirmations in Michigan with 41 deaths in the United States.

Qianying Lin:

Before we go dip into the research, I'll give a brief review of the events and actions taken by the government in Wuhan throughout these outbreaks in China. The first hospital admission in Wuhan was on December 16th, although the first confirmation can be dated back to December 1, 2019, which was not related to the seafood market that is reported to be the so called source of the outbreaks. Then the seafood market shut down on January 1, 2020. Then the genome sequences of the novel coronavirus released on January 12th.

Qianying Lin:

There's a first household human-to-human transmission confirmed in Guangdong Province in China. Before that it was reported that the transmission between humans were limited. Though on January 23rd the Wuhan government shut down the public transportation. Then they shut down the whole province, the Hubei Province public transportation and also the government banned all cars in downtown.

Qianying Lin:

On February 11, the WHO officially named the disease caused by the novel coronavirus as coronavirus infectious disease 2019. The reason why I go through this reviews or the events and action because one of my focus in the studies was to model the trends of the outbreaks incorporating some human factors including individual response to the outbreaks and also governmental actions.

Qianying Lin:

Though here are some basic concepts in epidemiology in case someone may be unfamiliar with this very crucial concepts though let's go to the primary case first. The whole duration of infections which is from the start of the infection and so called the end of the infection can be divided into different periods. The first category is we divided into latent period which is from the start of the infection to the start of infectioness, which means this patient had the ability to spread the disease to infect other people after that.

Qianying Lin:

Then from the start of the infection is to the end of the infection is the so called infectious period. During this period, this primary case can infect other people which can be the secondary case. By the end of the infection is the end of the infection. The second way to divide this whole duration of infection is from the start of infection to the start of onset of the symptoms which is called the incubation period.

Qianying Lin:

So by comparing the latent period and the incubation periods we can see that this individual can spread the disease even before the symptoms appears. From the onset of the symptoms we have the end of the symptoms and then the end of the infection. So there are two concepts defined by this period. One is called the generation time which is the time intervals between the primary infection and the secondary infection.

Qianying Lin:

Another one which is [inaudible 00:11:12] through the generation time in values is called the critical and severe intervals which you can find everywhere. It is defined as the onset of the symptoms in the primary case to the onset of the symptoms in the secondary case. These two concepts, these two time intervals are equal in values, but obviously the zero interval could be much more observable and then from previous literature, the median incubation period of coronavirus 2019 is about 5.1 days and reported by the news it could be as long as 14 days. That's why a lot of people would suggest 14 days self-isolation when you contacted with infected individuals.

Qianying Lin:

Another important or maybe well known concept is called R naught or R 0 like the basic reproduction number. So it has the expected number of secondary cases infected by one primary infection in the pure susceptible population. What is the pure susceptible population which means that these people are healthy and not protected by vaccine or maybe by other antibodies. So when these properties, when R naught is less than one, the disease would die out in the long run. Otherwise, it would probably spread across the population. This is a very critical property to evaluate the contagiousness and the severity, contagiousness of the infectious diseases and the severities of the epidemics.

Qianying Lin:

Here I share some information on the severe intervals and R naughts of other diseases. For example, measles is highly contagious and very severe diseases which has serial intervals of 10 to 13 days and R naught of 12 to 18. MERS in human, I mean in human, has serial intervals of six to 7.8 days and R naught of 0.3 to 0.8.

Qianying Lin:

I emphasize humans because it's reported that there's very limited transmission between humans. The outbreaks was due to the zoonotics like camel-to-human transmissions. Though one thing that I should emphasize is the influenza, like the Spanish pandemic in 1918, has serial intervals of two to four days and R naught two to three. So please remember these two quantities. I would compare it to the coronaviruses because they are both pandemics right now.

Qianying Lin:

My previous publication, my first publication, mainly focused on estimating R naught, the basic reproduction number of coronavirus in 2019 in Wuhan. I highlight the key components that we used to estimate the R naught which is first the growth rate we assumed as the cases increased exponentially when one individual could infect more than two, the cases grows exponentially.

Qianying Lin:

Then there is the serial interval that I mentioned before. Because it differs from people-to-people so we assume that it follows a distribution. The third one is the reporting rate, which is a pretty crucial factor here in both in modeling the epidemic or estimating the R naught. That is the ratio of reported confirmations over the actual infections.

Qianying Lin:

When reporting rate is 100% which means is perfectly correct in reported new cases. But when it's lower than 100% there's some underreported cases. There is potential cases that can spread the disease on overreported, which means that it is larger than 100% it can be due to the previous underreported cases. So we use these formula to calculate, to estimate the R naught.

Qianying Lin:

Here are some summary thoughts. Though I showed this figure in order to mention that's the reporting rate and it's pretty crucial in estimating the basic reproduction number. Actually we assume difference reporting ratios increments and these two are the extreme cases here. First of all from the first row we assume 100% reporting rate. All the time there is no underreported, no overreported. Every case is accurately reported.

Qianying Lin:

Here is the figure in the middle is the daily new cases. Blue dot is the so called adjusted cases. Green circle is the reported cases. They match perfectly then we can use the curve and the formula I mentioned before to estimate the basic reproduction number as 5.71 with 95% interval, 95% confidence interval as 4.24 to 7.54.

Qianying Lin:

Then in the second row we assume eight-fold increment which means that at the beginning of the outbreaks, that is only 12.5% reported rate. Then it increased generally, gradually, to the end to peak at 100% on January 21st. From the middle figures we can see the daily new cases. The first one is about 41 cases is underreported. The actual number here is eight times of the reported cases which is over 300 here.

Qianying Lin:

That one is zero cases, and from here we increase the reporting rate and then on January 21st is 100%. So here is the figure of cumulative cases then using these increment of reporting rate. We have this blue dots here. We use these so called adjusted actual infections to estimate the basic reproduction number so we can estimate the R naught at 2.24 with a 95% confidence interval; 1.96 to 2.55. These two examples shows that the reporting rate is very, very important in estimating the basic reproduction number, which is a critical property on evaluating the contagiousness and severity of the epidemic.

Qianying Lin:

As we all know that at the beginning because nobody is familiar with this virus. Everybody knew nothing about the virus and is due to various factors. For example, lack of the tube kits to testing the results, or people are not aware of this diseases, so there will be many underreporting here. But when the public aware of this disease, the reporting rates were increased. The reporting rate is not a constant. It varies through time.

Qianying Lin:

Here is the main conclusion here. The changing reporting rate over time had a great impact on estimation of the basic reproduction number R naught as I showed before. So the underreported could make an overestimation of the basic reproduction number. Also, the estimation of R naught dropped from 5.7 to 2.24 when we adopted for ranges of increment in reporting rates. One of our publications actually estimates the reporting rate can be as low as 5% at the beginning and with that rates we estimate the R naught at 2.56 with a confidence, 95% confidence interval of 2.49 to 2.63.

Qianying Lin:

Next, we should talk about the relations between the coronavirus disease 2019 and the 1918 influenza pandemic. They share a lot of similarities here. For example, they have a very similar R naught which is two to three reported by suggested by the WHO, actually. They have a relatively short and mean serial intervals. For example, coronavirus have around four to five days, and influenza have 3.6 days.

Qianying Lin:

Here, I highlighted the four to five days. If you guys remember I mentioned that the incubation, mean incubation period, of the coronavirus is about 5.1 days, so a relatively short serial interval with a relatively long incubation period could actually imply asymptomatic transmission that is like people can infect, a patient can infect other people even before the symptoms appears, which is a pretty crucial properties of this virus is here. Then they also have shared a relatively low fatality rate is around 2% and also they have a significant proportion of deaths due to pneumonia after infection. So with all this similarities between these two pandemics, we can refer some properties of the 1918 Spanish pandemic to model the dynamics right now in Wuhan, China or maybe around the world.

Qianying Lin:

First I will introduce the epidemiological compartmental models. Basically you have [inaudible 00:24:24]. Basically, this model is divide the whole population into different classes, which is different stages of infection. Then we assume the rates of transition between these classes or interactions between these classes and we modeled these transitions, the number of, the size of these classes in ordinary differential equations.

Qianying Lin:

By this definitions it seems that is very, very flexible because we can divide the classes as detailed as we want, as long as we have the rates of transmission between them, so it could be very complicated and very realistic to the data. Then let me introduce the conceptual model for the coronavirus 2019 outbreaks in Wuhan that we used in our paper just published.

Qianying Lin:

Then there's a few assumptions we make for the models for better fitting, or not better fitting, for more realistic and also much easier to understand. First we have the zoonotic that is the animal-to-human transmission at the first month because we have about 41 cases that at the very beginning.

Qianying Lin:

Then we assume that these first 41 cases are due to animal-to-human infections. After that all infections were caused by human-to-human transmission. Then because the outbreaks is during the period of Chinese New Year so everybody is rushing to go back to their hometown so there would be around five million people left Wuhan from December 31, 2019, to January 22, 2020. The whole population in Wuhan city is 40 million, which means that the outbreaks after the city was locked down, there are only nine million people stayed at the city.

Qianying Lin:

Also, we assume that 10% of the populations are not susceptible to the coronavirus because from previous reports, the infective rates among children, especially around children under 15 is pretty low. We assume that children is not that susceptible to the virus than adults or then elderly people.

Qianying Lin:

So here are two things, two components are not included here due to limited knowledge. For example, we did not include asymptomatic transmission because right now we do not know the proportion, how large is the proportion of the population could have asymptomatic transmission and also we did not include the temperature because the impact of the temperature on the outbreaks was still unknown.

Qianying Lin:

Here is a detailed explanation on the model. I know it is a little bit bands and too much information, but it's very crucial so just pay a little bit attention to this. So as I previously mentioned the compartmental models divided the whole population into different classes or different stages. For example, in this model is the very basic and classic SEIR model framework.

Qianying Lin:

For example, this population was divided into susceptible, S. E is the exposed or latent which is infected but not infectious. I is infectious, that portion of population can have the ability to spread the disease. R is for recovered or removed. Sometime just, i.e., eliminated from the population by isolation, quarantine, etc.

Qianying Lin:

F here, as I mentioned, we include the zoonotic introduction, the previous 41 cases. Then D here represent the daily number of severe cases. It also represents the perception of risk like of risk regarding the severity of the epidemics which play a crucial role in human response or human behavioral response towards the diseases. Because when you find out the number is pretty high, for example, the number of cases is pretty high, you could be very cautious about your daily life.

Qianying Lin:

For example, frequent handwashing and maybe keep some distance when contacting with people. C here is the number of all infections including the reported or unreported. That's how we include underreporting the changing, underreporting ratios here. For beta zero is the initial transmission between S and I, before the government's action before everybody know the virus and have some response to it.

Qianying Lin:

Beta T is the time-varying transmission rate. It's changing due to the governmental action. Due to the individual response that I will explain that in detail in the next slides that how we model this change in transmission rate. All those parameters is like the inverse sigma is the latent period in days, and inverse gamma actually is the infectious period in days and also because five million people left Wuhan before the lockdown of the city. So we have the emigration rate here and we have the rate of severe cases and decay of the perception which means that people is really easy to forgot about the severity of the diseases. So just lose their cautions, I guess.

Qianying Lin:

In this slide I will explain how we model the governmental action and individual reaction and incorporate them into the time we are in transmission. N is the total population in Wuhan. It starts from 14 million and then dropped to nine million after the lockdown of the city. And then D, as I explained previously, is the daily number of severe cases like also represent the perception of rates on the virus.

Qianying Lin:

Alpha here we pull at the strength of governmental action. Kappa here represents the intensity of individual reaction. Though these three components here could build up the whole time we are in transmission. Though one minus alpha which increased the reduction of transmission rates by governmental action.

Qianying Lin:

For example, governmental action including transportation shutdown and quarantine and also hospitalizations, isolation, etc. There's personal, I mean, individual reaction includes handwashing like decreasing contacts with people. For example, also and represent a reduction of transmission rate by personal reaction to the proportion of the severe cases.

Qianying Lin:

Right now we go into the finding of this paper. From Figure (a) we have the daily new infections with a reporting delay which we assumed as a 40 days of reporting delay. Here please pay attention to the Y axis here as in lock 10, as in lock 10 so the axis is a little bit not realistic but I'll explain why.

Qianying Lin:

There we have the gray dotted line here which represents the reported cases. We have assumed three scenarios here. One is called naïve which means the government did nothing to control the diseases as well as the individuals did nothing to prevent infections. So you see that if everybody did nothing it will go up as a peak over, let's see, over 100,000 cases one day. That is the daily new infections.

Qianying Lin:

So the second scenario here is we only included individual reaction which means only depends on individuals to wash their hands, canceling gathering, decreased contacts with other people though you become about 10,000 a day here and keep for a long time. Once we include both factors which is the individual reaction and also the governmental action here which is the green light, you can see it's a very effective control here drop fastly and by the end of April the epidemic will be totally controlled.

Qianying Lin:

All the perimeters are referenced from a previous paper on 1918 influenza epidemics and other official news releases. So in Figure (b) we also calculated the reported rate here. So reported rate means the green line, the number of green line. The number in gray dotted line over the number in green line here. So at the very beginning at early January here the reporting rate is very low and then it jumped a little bit into about 50% in early February. It shows that the reporting rates is exactly time changing.

Qianying Lin:

Some of you may ask how about like this, over 200% reporting cases here? Because it's due to the underreported cases in the early stage. So the government just assigned examination on the previous cases, so that's why it have an overestimated condition here. We also did some sensitivities on the governmental actions which is alpha, the strength of the governmental action. Also, the individual reactions controlled by kappa.

Qianying Lin:

From Figure (a) also is daily new infection with reporting delay in lock arm, in lock 10. We used different strengths here from weak to strong. You may see that is a very, very effective way to control or maybe end the outbreaks, end the outbreaks with strong governmental actions. For example, shutdown the transportation, shut down the schools, etc.

Qianying Lin:

Then in the second figures here, in Figure (b), we also use a weak intensity, weak intensity of individual response to a strong intensity here. We find out that it helps to control and you have to accelerate, accelerate the control at the end of the outbreaks with under a very strong governmental actions.

Qianying Lin:

The second part conclusion here is the outbreak in Wuhan would be completely controlled by the end of April under current policies and restrictions. Second, the reporting rate is time-varying. At the beginning in early January it was below 10% and then increased to around 15% in early February. And individual caution in daily life helps to reduce the transmission and accelerates the end of the outbreaks. Governmental actions, for example, holiday extension, travel restriction, quarantine, etc., are very effective means to control and end the outbreaks.

Qianying Lin:

Last part, right now we have some discussion here. So since United States is actually is at the very, very beginning of the outbreaks, United States is actually here at the very beginning of the outbreaks by comparing to stages of other countries. For example, China is at the end, almost end the outbreaks here. South Korea, Japan and Singapore and United States is only at the beginning stages. So should the government of United States should do the same thing? What kind of factors we should consider to make political decisions?

Qianying Lin:

In my opinion, there's some factors including population density, age structure because I mentioned that young people or maybe young children are less susceptible to the disease than older people. Also, the transportation patterns because the outbreaks in Wuhan. Wuhan is actually the central of the high rate ring in China so hundreds of thousands of travelers, passengers, would go to Wuhan and transfer to other cities every day.

Qianying Lin:

Also, the individual reaction here, for example, in South Korea, once the government announced the outbreaks, everybody just on the streets, nobody on the streets and everybody was wearing masks and do very frequent handwashing. So these factors we should consider. But I should emphasize that governmental action would be very, very effective cure. Effective means to control and end the outbreaks. Here is the references that I mentioned or that I use for the parameters. Thank you for you guys. Here we can have the Q&A section or if you want further questions like in detailed discussion you can just email me after the presentation. Thank you, guys, for your coming.

James Walsh:

All right. This is James Walsh here. I'm administrative support here at MIDAS. I'm going to be helping with the Q&A. We're just going to take a second to read through some of the questions that have come through during the presentation. Then I will read those out loud and going to answer as many as we can in the time that we have left.

Qianying Lin:

All right.

James Walsh:

Going to start with the first one that came through. First question we had today was, "Why would we not allow young, healthy individuals to interact with one another in the community in order to allow for transmission of COVID-19 within this low-risk population, which would then generate herd immunity, therefore, protecting community at large?"

Qianying Lin:

The question here is we do not really understand the mechanics of the disease. So it would be very risky to just allow so called young individuals because sometimes young individuals can have various devious symptoms after infected. I would say it's very risky. It's very risky here to just allow them to contact. Yes.

James Walsh:

More that have come through here. (silence)

Speaker 3:

Yes, this one.

James Walsh:

This one?

Speaker 3:

Mm-hmm (affirmative).

James Walsh:

All right. Next question. "Is the mortality rate of COVID-19 likely substantially different than statistics being published by the World Health Organization and the Centers for Disease Control, for example, data from South Korea where population-based testing is being conducted appear quite different from data in places where just symptomatic individuals are being tested?"

Qianying Lin:

I would say of course because for a country who only has state symptomatic infections, which means in my opinion that is a lot of underreported rates here. You do not know it is asymptomatic. Actually, for the asymptomatic transmission, we do not know whether these individuals are asymptomatic or pre-symptomatic, which means that the symptoms just not appear yet and maybe appear later, though the rate are better, the fatality rates would be huge difference. Also, South Korea government did a really great job in controlling the outbreaks.

Qianying Lin:

It's a different story in South Korea because South Korea, the outbreaks in South Korea is due to in part infectious event. A patient that belongs to religious groups, they just wandering around and also the group members wandering around and there is a major outbreaks in one of the cities with a relatively dense population.

Qianying Lin:

After that the South Korea government immediately locked down the religious facilities and also have a very restrict testing, or examination, or quarantine to everybody. The public in South Korea very cautious about an outbreak so they did a very good controlling measures to stop, to end, or maybe to stop the disease. Actually, South Korea is almost at the end of the outbreaks. Yes.

James Walsh:

Answering some of the questions that we can handle in here. So we'll look through some of the next ones coming through. (silence)

Qianying Lin:

I do not know those.

James Walsh:

Sure, okay. I'll let you ... (silence)

Speaker 3:

Take this.

James Walsh:

Okay. "What is the risk of reemergence of epidemic in Wuhan after a complete control has been achieved by the end of April?"

Qianying Lin:

I would say the reemergence actually is most of the cases in China or maybe we have right now actually imported cases from other countries, for example, from Italy or maybe from Iran. The risk of reemergence would totally depend on the testing or the quarantine at the airport. Right now I would say the risk is very low because the Chinese government did a pretty great job on surveillance or testing the incoming travelers right now.

James Walsh:

Mm-hmm (affirmative). (silence)

Qianying Lin:

Things a whole years, I ...

James Walsh:

Don't.

Qianying Lin:

Don't, yes.

James Walsh:

From Erin King. "You effectively used the data on the time course of the epidemic in Wuhan to infer the effectiveness of the government in popular response. With more data the spread of the disease to other localities within China, can you test these inferences?"

Qianying Lin:

Yes. I mean, with more datas including, I would say including the transportation data like how many passengers go and leave Wuhan every day to other locations in China and the population densities. Also because the government action varies in different location, we could test it and use statistical inference methods to test it this data and also compare the strands or compare intensities of the strands of government actions. And also the intensities on individual response and in different locations within China or even in other countries. (silence) Opens, I guess.

James Walsh:

Sure. So from Paul Frankel we have, "Many thanks for this important discussion. Would you say that the serial interval and the R naught are very similar to the flu of 1918 in that the main difference is the higher fatality rate of COVID-19?"

Qianying Lin:

Yes. I would say that. But another major difference between pandemic 1918 and COVID-2019 is that COVID have suspected or maybe some proportion of asymptomatic transmission so which line we are not clear about that part. Also, in COVID-19, the incubation periods could be as long as 14 days. So that's why because due to these asymptomatic transmission here that's why I would say the prompt and also in-time measure taken by the government would be very crucial and critical to decrease the number of infections or even end these outbreaks.

Qianying Lin:

The fatality rate, it actually depends on many other factors because as far as I know the fatality rate in South Korea is very, very low, is under 1%. But in China is about 2% and also in United States is about 3% because the major outbreaks in Seattle is around elderly people, so yes. (silence) I don't know actually.

James Walsh:

I think it looks like our Q&A has slowed down just a little bit here. If we weren't able to get to your question it's either just out of the scope of what we're working with, or there may just not have been enough time to prepare an answer. I think at this point we will wrap things up.

Qianying Lin:

And thank you all for coming to this webinar. Thank you so much.