THE BROOKINGS INSTITUTION

WEBINAR

REOPENING THE CORONAVIRUS-CLOSED ECONOMY -
PRINCIPLES AND TRADEOFFS

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Assessing Strategies for Reopening the Economy

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COVID-19 and Inequalities

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P R O C E E D I N G S

MR. HUTCHINS: Good afternoon, my name is Glenn Hutchins, co-chair of Brookings and it's my pleasure to welcome you to our session today, Reopening the economy, principles and tradeoffs. Decisions about how and when to reopen the economy are tough ones. We want to get out of the shutdown mode as quickly as possible but we don't want to endanger the lives of our colleagues, friends and neighbors. And, in particular, we don't want to spark a second phase of the pandemic. We'll have to make decisions with incomplete information and evolving scientific research and we'll have to do all this during the run up to a hotly contested presidential election.

Today's discussion which blends topical relevance, deeply rigorous analytics and paring Brookings scholars with outside experts is precisely what the we hoped the center would do when David Wessel, Ted Gayer and I launched it. Finally, today's session is a component of a comprehensive Brookings wide effort to take the lead in evaluating policy options as we move toward reopening. Stay tuned for more to come on that vital topic from all across our organization. With that said, welcome again and I'll turn this over to David Wessel.

MR. WESSEL: Thank you very much, Glenn. I'm very pleased to be able to welcome Kevin Hassett to our virtual stage today. Kevin, of course, was the chairman of the Council of Economic Advisors. He liberated himself for that job but then got drafted back into the White House during this crisis. And I'm going to talk to him for a bit and then we will turn to a panel which I'll introduce later. If you've got questions, you can send them to events@brookings.edu or #covideconomy and we'll try and do our best to get to them. Kevin, thanks for being here, we know you have a busy schedule.

MR. HASSETT: Yeah, thanks David. It's a great honor to be back with all my friends at Brookings.

MR. WESSEL: Kevin, at his hearing this morning, Tony Fauci raised an important question, I think, or was asked an important question. Basically, is there a risk that we're moving too fast to reopen the economy without enough testing and contact tracking and PPE to make it both safe and wise economically in the long run.

He warned that if we moved too soon, we could have a set back leading not only to, I'm quoting him now, "some suffering and death that could be avoided could set you back on the road to trying to get the economic recovery going". It would almost turn the clock back rather than going forward. So, I'm just curious how you evaluate the risk of moving too fast to reopening the economy.

MR. HASSETT: Well actually, that judgement was made by the task force, you know, some of the greatest medical minds in the country. Who put out basically an opening up America again document with very careful guidelines for state and local officials about what they should be able to or should look for in order to be able to feel like that it's safe for them to begin a phased, gradual opening.

And so, you know, just in case folks didn't see the document that are watching and since it's the key gaiting criteria or relatively short, I'll actually just quickly read them. But for symptoms, you want a downward trajectory of influenza like illnesses reported within a 14-day period. That condition is something that is, you know, essential but also because the influenza monitoring system is so sophisticated that it's like a pointer to people for data that could actually help them judge what's going on in real time in their locality.

And then a downward trajectory of COVID like syndrome of cases within a 14 day period, those are the symptoms that need to be sort of on the right trajectory. And in terms of cases, they want to see a downward trajectory of documented cases and in the most recent 14 day period and a downward trajectory of positive tests as a percent of total tests within a 14 day period.

And the second one, the downward trajectory of positive tests as a percent of total tests within a 14 day period, that's one that gets to your point, David, about like how do you know if you're doing enough testing. If you're only testing the very, very sick people, then you're clearly not monitoring enough for you to have high confidence that it's safe to open.

And then in terms of hospital capacity, they want hospitals in your locality in order to feel like it's okay to open then you should be able to treat all the patients that you need to and have ample hospital capacity and a robust testing program in place for the healthcare workers as well. So, that you can make sure that they are safe and also not spreading the disease.

And so, all of these conditions are things that as Glenn mentioned in the intro, that we've been learning about this on the fly since I came back in the middle of March, you know, basically working really, really long days watching what the best epidemiological models say is going to happen. And then watching the next day and comparing it to the model predictions and so on.

And meanwhile, while we've been doing that, we've been, for example, gathering data on capacity utilization in hospitals. And so, you can sort of ask yourself the question, hey if the IHME model worst case scenario happens then would you exceed the intensive care capacity of the hospital. If the answer is no, then again, if you're a governor that's an example of the kind of question you might ask yourself as you're thinking about opening up.

But in the end, yeah there's so many states that are different in so many ways and there's some states where there's not a whole lot of disease. There are some states like New York where there's been a whole lot that it looks like God willing, they'll stay there that they're on the other side of the curve. Then I think that the president's judgement was 100 percent correct to use the federal government to produce the sort of best possible guidance based on the best science. But then let the local officials decide whether those conditions hold in their locality.

And there is a final thing, David, I'll give it back to you, I don't mean to filibuster. That one of the things too that we've done is because we've put together the task force and the rest of the economic team, the CEA and, you know me, I'm over in the West Wing now. Just a very, very big database that allows us to sort of see what's happening in real time. And we're definitely having, you know, constant communications with governors who may be don't have the, you know, access to the federal day to day need to understand every nuance of what's going on in their state.

And so, I think that we're taking an active role informing people both about the science and about what's going on on the ground. And I think with that then the people in the towns and the states are going to make the judgements about exactly what they can do.

Final point, one of the things that's interesting that we looked at really early on was that there are a lot of states that had a lot of variation in exactly what they were saying people needed to do in

terms of shutting down businesses, shutting down schools, sheltering in place and so on. And one of the things we noticed pretty early on was that that variation wasn't really highly correlated with say initial claims for unemployment insurance or even social distancing measures which we could pull some of those off the internet.

And so, it suggests that the federal information facility that's really been coordinated by Dr. Birx and Fauci is having a very, very big effect on behavior all across the country almost irrespective of what the governors say. And I think that they've sort of published their guidelines for what they want to see so that they feel comfortable advising a governor to open now that those are public and known then I would expect that people around the country bit by bit will get back to their normal lives.

MR. WESSEL: Are you satisfied that every place that's reopening has met the guidelines as you've elaborated them?

MR. HASSETT: That's not something that -- I'm not, you know, creating a score card for each governor. You know, each state has to decide for itself what it wants to do. But what we do is provide them with the best possible information so that they are, you know, have, you know, sound science and sound empirical evidence when they're making choices.

One of the things, for example, that we're watching very, very closely is when we start to see pick up in economic activity which we can monitor through some real time measures like credit card data then are we also seeing an acceleration of the spread of the disease and things like that. It's, you know, so far and it doesn't mean that we're out of the woods but so far, the data has been moving very, very slowly but in a positive direction.

MR. WESSEL: Kevin, you mentioned the models and you drew a lot of attention for a chart you created and the Council of Economic Advisors publicized. It looked like it was projecting a decline in COVID cases. I don’t want to get into all the cumulative methodology and all that but it seems to me there's two distinct conceptual frameworks at the heart of an important intellectual debate.

One is the framework, I think you'd prefer, call a statistical seems to suggest a quicker reopening which is, as you were elaborating, the alternative model, the more structural ones that are used

by a lot of academic economists and epidemiologists are I think for more caution reopening. And I'm just curious why you're so confident that your approach is the better one.

MR. HASSETT: No, I think that's a mischaracterization, David, of that chart and what we're doing. Again, going back to the middle of March, the models were all over the place. The University of Washington model was something that a lot of folks on the taskforce suggested was extremely useful for the application that we were doing which was thinking about what's going to happen to hospital capacity over the next few weeks.

And all we've done is superimpose the data over the model forecast and we've put like the model forecast from three weeks ago, the model forecast from like a week ago and a lot of forecasts from yesterday. And then if you look like those model forecasts evolve over time but all we did is put a scatter plot of the data over that. And since the data are going like this, especially because of, you know, reporting things around weekends, that we needed to smooth the data and, you know, there are lots of different ways to smooth the data.

If you look online, people smooth the data all the time. The smoothing of the data was never, ever presented to anyone as a forecast or a projection. I think that one of the things I find most striking about like what happens if you throw the data on top of like the very early University of Washington modeling efforts, then you see that they really nailed it. That the curvature from their forecaster at the end of March about what would happen with deaths and, you know, when they'd start to go down and so on. It matches reasonably well.

And so, I think that it's not that there's rivalry between approaches but rather that like an empirical confirmation that this ex anti-forecast of what the world would look like that was presented by the University of Washington IHME guys turned out to be a very accurate forecast.

Now one of the things that's interesting is that recently because their model originally forecasted that people would continue to shelter in place and so on, they revised their model to account for a reduction in social distancing. And in that revised model, they became significantly more pessimistic about how long this thing could drag out.

Now the truth is that that could be true. It might not be true. It will depend in part on the effectiveness of the social distancing measures that employers and citizens adopt along the way. And now what we're doing is we're watching the data come in and seeing whether it matches their new revised forecast or their old forecast. And, of course, you know, you're getting one data observation a day and so you're not going to be able to make a statistical empirical judgement about it until you've got like the whole cycle of data.

But so far, the data are wiggling about. To begin with, they've jumped up to their new forecast and now they've sort of jumped down to their old forecast. And so, there's some uncertainty about what's really going to happen.

I can say that the other thing that this sort of curve hitting exercise can be useful for is just thinking through. So, what you need to do in an emergency situation like this is think through all the different scenarios and then have a plan for each of them.

And so, one of the things you could do if you smooth through the data is ask yourself the question population adjusted. Suppose we have an experience like Italy or suppose we have an experience like Korea or suppose we have an experience like France or the UK. Then to the extent that those countries have sort of gone up and gone down and adopted policy measures then you can sort of say well what if the U.S. has an experience like that. Or even if a U.S. state has an experience like that, what would their experience look like.

And the curve fitting is very useful for exercises like that too. And, you know, one thing as an example, I know there a lot of folks who love to play with this like curve fitting is take, for example, the Austria data and look at how it looks compared to, you know, basically a non-linear kind of metric approach. And you'll see that it's really, you know, very, very well-defined and hopefully it will stay there, a complete curve has gone all the way through.

But when you're going on the upside, then what's going to happen is the econometrics is going to tell you that it's going to keep going up because there won't be any visible curve. And then when you've got a peak, the metrics is going to start to see the peak after a while and then when it goes down it

will see that too if you have sort of flexible non-linear function.

But that's always basically just a sort of model evaluation approach that like basically would, you know, be adopted by --

MR. WESSEL: What was the point of making that curve and distributing it to a layman? Like you were predicting that we were well on --

MR. HASSETT: So, that's, you know, that's just what happened was that a very small group of us who are doing a whole bunch of modeling and making zillions of charts everyday to try to figure out what's going on in the world and learning and updating it each day. That somebody who wasn't part of that group, you know, got a hold of the chart and then, you know, mischaracterized it to the *Washington Post* and they wrote an article about it.

I think, you know, there's a lot more important things, David, to talk about then this. But then once that happens, as you know, I've had a lifelong commitment to transparency. And so, you know, people are saying what's the chart that you guys are talking about and I said well, I'll show you, you know, that this is exactly what we're doing.

And, you know, Jim Tankersley of *The New York Times* described it accurately and, you know, let's, you know, talk about, you know, things that are more important than 30 million people out of work. We've got 80,000 people dead and you're like annoyed about the way I curved it. It's just not exactly (inaudible).

MR. WESSEL: I'm not annoyed about anything, Kevin. All right, so let's turn to the economy. We don't really know what's going to happen, a lot depends on the virus. I'm curious when you look ahead for the next six to nine or twelve months, what you think is the most likely shape of the economic recovery.

MR. HASSETT: You know, I think that we don't have a lot of information about what happens when there's a shock this big. I think that if we shut down for a couple of weeks the way we did and then turn back on, I think most economists would tell you that there's a high likelihood that you'd be able to get going right away without much longer an affect. And then the longer you run, the more you

run into things like long term unemployment, the kind of things that Angus Deaton, I know is going to talk about a little bit later on. And, you know, the impact of long term unemployment on people's lives and their long run connection to the labor force.

And then also business bankruptcies where if firms go under then, of course, it's going to take a while to reorganize and get business activity back. And so, I think the intent of the first three phases of economic policy in this space has been to build a bridge to the other side and, you know, we're not on the other side yet. You can clearly see that in the data.

But the funds, there's still funds that have yet to go out and the hope would be that we would get to the other side. And with the PPP loans, the small business loans, for example, that we would have kept a lot of the businesses in tact so that they can start up again. And they will also have their employees attached to them so they can start up again. And we've got this main street lending facility with the Treasury and the Fed. So, the hope would be that that would help, you know, firms that have liquidity crunches because they don't have a lot of sales right now, you know, be ready to go once we open up.

And so, there's never been an episode like this that's comparable, at least not that I'm aware of. And so, it's very, very hard to model. It's a much bigger shock then we've seen before and a very unusual one. It's not like, you know, that there are massive business failures because, you know, they did something wrong. We shut down the economy in order to save potentially millions of lives and now we're going to attempt to turn it back on. And so, that's just a new experience for us.

I think the Congressional Budget Office outlook is -- of the second half of the year is going to be strong. I'm sure that that's conditional on the disease being under control. And so, you know, I think that that's probably about the median outlook in the White House right now too is about what the CBO says.

MR. WESSEL: I see. And looking ahead to what seems inevitable although the timing and shape are up for discussion. What do you think the principles and priorities ought to be if we do another big CARES Act, another big fiscal package?

MR. HASSETT: I think that right now in the White House, we're in a kind of wait and see

mode, a very short term wait and see mode. But the basic idea is and, you know, I thank Jim Stock for the great paper that he wrote today that he's going to talk about a little bit later. But if you read this incredible economic literature that's emerging that's talking about sort of the challenges from this shut down. And the economic challenges and policy challenges then there is sort of two phases, I think, basically I mentioned them in my previous response.

There are two phases that are kind of different policy phases. There is the, you know, build a bridge to the other side phase and then there's a -- now that we're beginning to phase in opening up then, you know, how do we fix the wounds and make ourselves have an economy that can really take off again. And I think that right now, depending on the path of the disease, it might be that the built bridge to the other side stuff is sufficient to get us to the other side and it could be that it's not.

But it would really be, I think, the president believes and everybody in the White House I think concurs and the Secretary Mnuchin as well that if you were to go into like sort of call it maybe the final phase where you're thinking about long run policy changes that, you know, address some of the serious significant potentially longer run harms. That if you were to legislate that this week then, you know, you might be putting the cart ahead of the horse.

And so, right now we're watching the economies that open up watching how quickly economic activity picks up and watching the response of the disease. And as we, you know, get more information on all that then we can make a judgement about what the next phase might look like.

MR. WESSEL: On the economic side, what are you looking for that would tell you that we still need to be building bridges to the other side?

MR. HASSETT: Well, I think that the bridge to the other side is really all about the control of the disease. And perhaps, you know, that's the judgement that we'll all know it when we see it and, you know, we're pretty far from there right now. And so, I think that economically, that the places like let's, you know, take states that have almost that are kind of on the other side right now in the sense that they have almost no cases.

Then the question is just as they turn on the economy, then does it turn back on now or

do people because they're so concerned about the spread, you know, stay home, not go to work, not produce stuff. Or not really increase activity much because, you know, they produce stuff for the whole country and they're the only state that's open.

And so, how much does economic activity pick up once the places that feel safe to open do so, is a key factor in determining things like what's going to happen to the future of the economy, to state revenues, to federal revenues and so. And so, that's what we're watching very closely. And the opening up that's been happening has been very, very gradual so far economically.

MR. WESSEL: So, when do you think you can make a decision about what the next phase of fiscal support looks like?

MR. HASSETT: Yeah. I think we're going to watch the data and let the data inform us about that. It will be scientifically and empirically driven. And right now, we're watching that.

MR. WESSEL: Are we talking about days, weeks, months?

MR. HASSETT: No, I don't think it would be months, no. But again, that's just an expectation. This is, you know, we're watching new data come in every day. This is not something that's just like something we've seen before. And so, we have to be empirical and science based and, you know, and evidence based. The evidence has to accumulate to the point where we think we understand what's going on before we act and that's the phase we're in right now.

MR. WESSEL: And finally, Kevin, as you know, there are people who look at the amount of borrowing we're doing as a country to fight this pandemic. And while they are comfortable about it was essential, they're worried the debt is just getting so big that we should really begin to worry about the long run fiscal trajectory of the U.S. And I wonder whether you think that is premature or whether we should be worrying about it now or what.

MR. HASSETT: Yeah, it's definitely something that we should worry about. But, you know, right now in the middle of this crisis that we've got like extremely immediate concerns. But as you know, David, it's something that I've been worried about for a long time, long before I ever came into the White House. And, you know, I have a paper with Matt Jensen on fiscal consolidations and how they

affect the economy.

And I think that countries all around the world are, you know, once this, you know, the economy is up and going again are going to have to, you know, face some very, very difficult challenges. Because of all the debt that's been taken on in order to, you know, help the economies keep going through this crisis.

MR. WESSEL: Right. Well, thank you very much for your time and for keeping us on the right track.

MR. HASSETT: Thanks.

MR. WESSEL: I know you have to go but you're welcome to listen in as we go forward if you feel like you want to. So, thank you.

MR. HASSETT: Yeah, thanks so much. It's really been an honor to be here with you guys and thanks to everybody at Brookings for all the hard work they're doing to help us think through these issues right now.

MR. WESSEL: Great. Okay folks, now we're going to turn to a series of questions. The first one by Jim Stock from Harvard who was formally on the Council of Economic Advisors in the Obama administration. He'll be followed by Angus Deaton of Princeton, the Nobel laureate whose been thinking a lot about these issues. Then by Ross Hammond who is a colleague of mine at Brookings and who has done a lot of work on something called agent based modeling which you will understand by the end of this conversation.

And then finally, Caroline Buckee who is an epidemiologist at Harvard will help keep the economists on this panel on the straight and narrow. And my colleague Louse Sheiner will join us at the end to moderate the conversation among the four panelists. So, with that, Jim, I'll turn it over to you.

MR. STOCK: Okay thanks very much, David. And thank you so much for the Hutchins Center for organizing this. So, since I'm going first, I'm going to set the stage with a couple of slides. So, now my guess is that most people here on this call or are on this webinar are familiar with the material in these slides. But I think it's useful to just go over these to set the stage.

So, first of all, the economy has completely fallen off a cliff. The unemployment rate for April of 14.7 percent probably understates or does understate the severity of the situation for a number of reasons. First, the labor force participation rate also fell by 2 and a half percent indicating another two and a half percentage points of workers who are not working but not looking for work because they're on furlough. Part time employment for slack work is up by 5 million workers. So, it's clear that we need to reopen the economy now, this is urgent.

Second slide gets to some comments that Kevin was making and this has to do with the peak and now subsequent decline in deaths and in cases for COVID-19. So, confirmed cases peaked in early April, deaths peaked in mid-April. But as you can see, the decline is slow and at least so far hasn't accelerated.

Moreover, it's important to remember that whether deaths continue to decline depends -- it's not pre-ordained. It depends on our ability to restrain the spread of the virus while reopening. So, the question that faces us is how to get people back to work while managing the risks. And on this, let me just make my main point.

So, the main point that I want to stress is that the purpose of reopening is to get people back to work. So, what we need -- what does that mean? That means we need to focus on selective relaxation of reopening restrictions and keeping a laser focused eye on getting people back to work. So, that has a number of implications.

First of all, some reopening measures give much greater economic benefit than others. So, let me give some examples of high value measures. So, what I mean by a high value measure is that it produces more GDP and more people back to work for a given level of risk that's associated with it.

So, one of those is testing in quarantine which actually reduces risks and makes room for people to go back to work and others mask and gloves and other personal distancing. So, all of these make room for people to get back to work. They facilitate the reopening of the economy.

Second, if you view things from the perspective of trading off economic gain versus incremental risk, many high contact activities actually have a very low value to risk ratio. So, let me just

give you some examples. A lot of people like to go to pro sports but pro sports are really high contact relative to the economic value that's created. Auto shows, flower shows, 4th of July celebrations, all of these are high risk low value activities. So, it might be the case that suspending such high contact activities indefinitely will make room for people getting back to work.

Third, for many industries, there doesn't appear to be much of a gain in staging the reopening and we should just get on with it. The reason is that a lot of work is actually low contact work. You know, we normally think about going to a restaurant or a bar, something like that, high contact economic activities. But many economic activities are ones that are done in offices or on shop floors or in delivery situations where it is possible either they're already low contact activities or ones that could be made so by moderate modifications in the work place.

Those modifications will have some costs, they'll probably in some cases reduce productivity but we ought to get on with it. There's no reason to delay, in my view, allowing low contact activities including reopening bricks and mortar shopping with protections. There's no reason to delay doing that.

Fourth, for any of those to work, consumers and workers have to be confident that they're going to be safe and that they're going to be willing to participate. So, governments need to convey accurate information. They need to be consistent and use scientific information to base scientific information about risks.

So, to do that, we need better data on what those risks are. One of those risks is well, we don't actually know at this point how many people have been or are infected. So, we need more random testing. That random can be a combination of serological testing and viral testing to see how widespread the virus is, how widespread recoveries actually are so far in the population.

Consumers need to be confident that they can be protected by measures like distancing in stores, no middle seats on planes and that sort of thing. So, there needs to be actual studies and data and that needs to be conveyed to individuals and need to be accurate.

Testing does play a really critical role in all of this. If you test serologically positive then

you might be more comfortable shopping and going back to work since you've had the virus. Virus tests and with isolation so that workers who haven't been exposed have the confidence that their workplaces will not become a hot spot is important.

And overall, workers need to really believe that the company has their backs. That they're going to encourage work by private sector and there's been some great work by think tanks along these lines about how the company can adapt a workplace. So, just one example I was looking at this morning is the conference board has a human resources checklist for reopening your company. But there's a lot of other places that have been working on this.

So, let me actually wrap up with actually two sobering comments. So, first our team has been simulating reopenings that follow the CDC White House guidelines. And in particular, allowing people to get back to work based on a pattern of declining deaths and infections just like Kevin mentioned.

So, what we find is consistent with Kevin's optimism that in fact an optimistic outcome is possible with the unemployment rate dropping sharply over the summer and the fall. But the thing is, the conditions for that optimism are delicate. And in particular, if people go back to an even near normal social life, the virus can rekindle and deaths will rise no matter what protections there are at the workplace.

So, unless governors are willing to ignore rising death rates, which seems unlikely, they'll shut down the economy again and we'll see a double dip and a prolonged period of high unemployment. And if that's the case, then all bets are off. We have serious problems, waives of bankruptcies, long term unemployment, likely reductions in fiscal support, major issues.

So, it's super important, in my view, that we prioritize the non-economic activities and keep a laser like focus on what's going to allow people to get back to work while restraining non-work social activities. It doesn't sound like a lot of fun but I think it's better than the alternative.

Let me share one more slide which is a slide of forecasts from the *Wall Street Journal* survey of economists. And I think that this clarifies the concern and the uncertainty in this stark situation.

So, these forecasts are a little bit out of date, they're from April, but they still, I think, make the main point.

So, as Kevin indicted, a lot of professional forecasters are looking at a quick rebound. So, a very terrible second quarter. And then assuming that we're able to reopen the economy, our growth back from that second quarter. I think the two comments I would make are this. So, first of all yes, there's a rebound. But even with this optimistic scenario, two years from now we're still sitting at 4 percentage points below where we would have been thinking about the projections as a January. So, the long term consequences, even in the best case scenario, are likely to be substantial, at least according to these projections.

Second, this is an optimistic scenario. It says there's no double dip, it says that we're able to turn things around, that deaths are kept under control and that we reopen the economy. If we don't see that situation, well we're going to be in a situation like or maybe even worse than coming out of the financial crisis, a couple years after the financial crisis. And I think that's the really severe long term situation that is essential to avoid.

I think the trick there to avoiding that situation is to make sure that we focus on those activities and those reopening activities and those structures that are going to facilitate more people getting back to work. While maybe putting off for a year those backyard barbeques and little league games and trips to the baseball park and that sort of stuff. So, with those comments, I'm going to turn this over to Angus Deaton.

MR. DEATON: (audio skip). I'm going to work with these. Is that working for everyone? Yeah, okay. So, I'm going to use these slides. I'm want to talk a little bit about opening up and also about inequality.

There are four quotes here that I like very much. One by one of the greatest physicians of the 19th century who noticed that medical statistics tell you a lot about the economy. And we will weigh life for life and see where the dead lie thicker, among the workers or among the privileged.

From Paul Farmer whose book is called, “Infections and Inequalities,” this very important point of inequalities powerfully shape not only the distribution of infectious diseases but also the course of

help that comes among the afflicted. From Walter Schiedel in a more recent book noticed that these things, mass globalization, warfare, transformative resolution and state failure and lethal pandemics are about the only things that have dealt with have flattened inequality in the past.

And the more recently, a very nice quote by Anderson Cooper. He said in a situation like this, it highlights problems that already exist in society that people have noticed. Suddenly you see things. It's like an x-ray machine. So, I want to deal -- here's a warning that these numbers, as Kevin said, they come in day by day. They change and we're all capable of making mistakes.

Let me talk first about the rise and fall and the SIR model which does work. Predicts a rise and fall in the number of deaths. The sort of thing that IHME in Washington, the Washington group has been predicting. And their curve fitting claim to show that the fall would be complete with zero deaths by May the 1st. That was actually long before there was any relaxation in social distancing and 60,000 in total. Now they're predicting no deaths after August 4th but there will be 137,000 deaths of the same shape.

So, this is really a curve fitting exercise. There's very little structure or theory in this. But if you believe in this up and down curve, then the reopening problem is simply one of waiting until deaths are low enough. Or in a more sophisticated following guidelines that Kevin talked about.

So, the way I like to think about it is, is it safe to come out now. So, it's safe to come out when the deaths are below a certain level. And the New York shape looks quite a lot like this. Now many economists have calculated the values statistical life and recommended that social distancing would save enough lives to be hugely worthwhile.

But my argument is that a lot of this is problematic. And talking to the epidemiologists, it seems pretty clear that without a vaccine, there could be a million, even two million COVID deaths. And we only have slowed that down and flattened the curve but that number is still there. And even that assumes that immunity exists so that herd immunity is possible and we don't know that yet.

To get there from where we are now, there will be a series of small, local epidemics or temporal ways. Each one of those may conform to the SIR model but not for the U.S. as a whole. We

don't get this up and down shape for the country as a whole. Social distancing saves lives by relieving pressure on healthcare which, of course, saves some COVID people and other patients but it doesn't stop the number of being infected that is necessary to stop this disease.

The nasty thing about such successful social distancing is that it prolongs the epidemic in the absence of a vaccine. And that's a good thing, of course, if a vaccine is going to come and it's good to save lives temporarily for a year or two even if they die later. But it's a somewhat different calculation. There may be time for a vaccine or there may be a medicine such as anti-viral cocktail. But the safe to come out time in this scenario without the simple up and down is intolerably far ahead and may be two, three or even four years.

Now what I take away from that is that we need a smart opening up now which is beginning to happen. I don't know how smart it is but it's beginning to happen. That means infection proofing workplaces and leisure places for that is possible with protection for vulnerable groups. For old, large guys like me in particular. And that's very much in accordance with what Jim just told you.

I just want to show you these curves. I mean, here's New Jersey as of yesterday. The brown line is a seven-day moving average and the daily numbers jump around a lot. You can see that you can interpret this as coming down on the other side but it's not coming down very fast. And, in fact, today's figures are around 200 which would edge that a little bit.

But the graph I really want you to see is the United States other than New York and New Jersey. And you can see there's no evidence at all at even having reached the peak, let alone turning down the other side. So, if one's waiting for this to turn down before you open up, then you're inviting disaster, I think. I think we're going to have to open up anyways but do it in a very selective way.

Let me talk a little about inequalities, let me talk about life and death first. And it's easy to forget the dead in this. And in some ways, the central inequality is between those of us who are still alive and those of us who have died. The risk here is interesting. It's close to proportional to preexisting risk which means, of course, that old people who are more likely to die anyway are even more likely to die here. Young people are less so.

Some people might regard that as fair. I mean, it's a proportional increase in risk for everyone. Of course, if you regard that some of these inequalities and risks as unjust, then this makes them even more unjust. But here are some calculations. I saw a paper by some demographers this morning which is consistent with this so I probably didn't get it too wrong.

If mortality doubles at all ages, life expectancy falls from 78.6 in 2017 to 70.1. That's 7.5 years of life expectancy which was the level in the United States in 1963 which means we lose 57 years of progress. A more realistic number corresponding to about a million deaths is mortality rises per year by 35 percent. Life expectancy falls now only by 3.6 years taking us back to the 1989 level.

Another way of thinking about this is everybody adds 3.5 years to their age for a year and that ups your risk in the appropriate way. The 1918 pandemic reduced life expectancy 7 years but it increased by 8 years in 1919. So, there is a bounce back and that's what the demographers call harvesting. A lot of the people who have died were going to die anyway and so you get a reduction in deaths the next year.

Let's talk a little bit about education, labor markets and COVID and as Kevin predicted that I would. Anne Case and I have just written a book called “Deaths of Despair” about suicide, overdoses and alcoholic liver disease which have risen rapidly in the U.S. for those without a BA since 1995. In 2018, there were 158,000 deaths, about a hundredth of that is over what you would expect.

So, COVID-19 is likely to have second waves but eventually, it will stop. But these hundred thousand deaths of despair are likely to go on every year for as long as far as we can see. Overdoses may fall. We don't know what COVID is doing. Suicides are rising and probably likely to increase because of the isolation. These excess deaths are almost entirely among those without a four year college degree.

And those people have suffered in every sort of dimension imaginable. And that includes a large decline in employment population ration and reduction in their earnings. Now as Jim pointed out, you know, the unemployment figures and (inaudible) ratio that came out the other day are just dreadful.

And you can see that after the -- this is for everybody for men, not everybody but for men. And you

can see there's a long term decline in this catastrophic drop. But this is for men with or without a B.A. and you can see here that -- and I couldn't get the ones for people without a B.A. But unemployment went from 6.8 percent in March to 21.2 percent in April.

For people with a BA or more, it went up by almost the same fraction but there's only 8.4 percent unemployed versus 21.2. The employment population ratio, you can see again there's a drop for people with a B.A. but a much bigger drop for people without a B.A. So, these people have been doing very badly through deaths of despair for the past 20 years are now being hit yet again.

And if you think about what social distancing does, it further widens the gap between those with and without a BA. So, if you don't have a B.A., say you work with your hands, you're either an essential or a non-essential worker. The essential workers risk their lives. The non-essential workers risk their livelihoods and there's some other things there. So, opening up risks losing unemployment of benefit if these people are too scared to go back to work. That's a policy issue that as far as I know have not been settled.

We, meaning the educated elite, stay at home, get on Zoom webinars, we go on working, we stay safe and we get paid. And, in fact, our productivity is probably increased, if anything. So, this epidemic is going to widen the earning premium because some lose and the rest of us are fine as well as the mortality differentials. And so, that inequality is going to get worse.

I'm going to say a few words about political inequalities. And this, in fact, something this is like the Anderson Cooper quote, something that we may not have noticed before. The power in the Senate is very unequally distributed. Four states, California, Texas, Florida and New York have a third of the U.S. population but only eight percent of the Senate seats. You can calculate a Gini coefficient for that inequality and it's .75 comparatively. That's a very high figure.

Even more unequal, if you do it for COVID deaths because the deaths are concentrated in a few states and their Senate representation is even less. So, if you do a Gini coefficient for the Senate power of the people who've died of COVID, it's about .88. That means that red states with very few deaths have blocking power over blue states with many deaths.

The House is better but because the deaths are concentrated that even the gene there is 7.8. For those of you who like to look at Lorenz curves, here's the Lorenz curve for the Senate and here's the Lorenz curve for the dead, people who've died and their power in the Senate.

So, 25 states have a Republican governor, 25 have a Democratic governor. As of March 31st, the ratio of red state deaths to blue state deaths was .22. By April the 14th it was still .22, by April the 28th it was .27 and as of May the 10th which is the latest data I had it's up to .31. COVID deaths are moving from blue states to red states.

Now William Frey at Brookings had documented this (inaudible) I saw yesterday. So, a red state governor is losing his business in exchange for blue state lives. So, for him opening up is a no brainer which is sort of why it's happening. I like to joke that the value of statistical life should be noticed the value of someone else's life. And it's a lot to ask those governors to kill their businesses and their GDP for people who live far away and they may not even like very much.

But this is going to change and it's clear that as deaths move into red states, there will be less political difficulty about helping states in trouble. And there will be a greater consensus for a smart opening for the sort of policies that Jim talked about.

Finally, I want to say a few words about racial and ethnic inequalities which have gotten a lot of press. There are higher COVID-19 mortality rates among blacks and Hispanics. And the CDC argues that these inequalities are largely spatial which doesn't mean they're good.

So, here's the numbers. So, the percentage of COVID deaths as of May 8th, 52 percent white, 21 black, 16.5 Hispanic and the population you can see is only 12 percent black. So, the relative mortality rates which you get by dividing the top row by the second row are much, much higher, much bigger than one for black and much less than one for whites.

The CDC, however, has reweighted the population. So, it calculates the population county by county waiting by the number of COVID deaths and then you get a different picture in which the whites are actually doing worse than the blacks. Now this doesn't tell you it's okay, it just tells you that it's got to do with spatial segregation and density.

And my last slide tells you what happens in New York State. Where you can see that if you look at New York State, 66.5 percent of the deaths are white compared to 73 percent of the population and among blacks, you get this inequality again. But if you look at New York City which is much more diverse than the state is, you know, there are all these white interlands in the north, the percentage of COVID deaths is much more equally distributed. And what's more is the percentage of population it's much less severe than it was before though there's still worse outcomes for blacks then for Hispanics and for whites.

In New Jersey, it's sort of the other way around. And understanding these as we go forward is going to be a very important task. New Jersey makes up more than 50 percent of the deaths in New Jersey are the elderly into your homes, but in New York, a lot of what's going on here is segregation, where people live and the use of the subway, and I think we're going to hear more about that in the next presentations.

So, now I'm done and I'm going to hand over to Ross Hammond.

MR. HAMMOND: All right, let me set this up. Here we go. I'm going to make a quick disclaimer before I start. I do have formal advisory roles at FDA, the NIH, the National Academies, and elsewhere, but nothing I'm going to say in this presentation should represent any kind of official view of anyone.

As we've already heard from the previous two speakers, the costs of the status quo are very high, while we can also not simply reopen everything abruptly, where we risk additional ways of infection that could be just as bad or worse.

So, we need a middle path; a way to reopen while still controlling resurgent beck-shed (phonetic). And as we heard earlier, testing, contact tracing, and other MPIs, or non-pharmaceutical interventions, can be a key part of how we do this.

And as you'll see here, there's huge variance in the amount of testing that is going on around the world, and in the level of detection of underlying disease that is possible with different testing scenarios.

So, testing, along with any of these other measures, actually involve quite a few variables, and will require quite a few specific decisions about how to implement them. They will only work well if they are a good match for the actual underlying dynamics of the epidemic.

Some of the factors that policymakers will have to get right for testing, for example, would be what kind of tests. There are multiple kinds of tests that look for the presence of infection with different pros and cons. Plus, there are the serological tests that we heard about earlier, which tests for the presence of antibodies.

How many tests will need to be available per day? We've heard widely varying estimates about this in different news outlets, from different models. How accurate do those tests have to be?

How do you use the tests you have? Should you, in fact, sample at random with them? Should you give the test with high priority to people who have symptoms, or to people who are high-risk, or some combinations of these? Or some other strategy?

And then, how is the information from the test going to be used to take containment actions such as quarantine, or self-isolation, or social distancing measures of one kind or another?

The right answers to these questions actually depend on features of the epidemiology. They depend on how many infections are there, or how contagious are people with disease, and for how long.

How many infections are asymptomatic? And are people who are asymptomatic as contagious as people who have symptoms?

How much immunity is conferred by antibodies and for how long? We don’t know with certainty the answers to these questions.

And this leads me to my next point, which is that models from epidemiology can help us pinpoint what actually is required. How many cases we are likely missing? How to target most effectively with our non-pharmaceutical interventions and so on. They can help ensure this match between the implementation choices and the epidemic dynamics.

A recent report, which I've listed here from a group at Johns Hopkins, reviewed and

evaluated the use of models in public health decision making over the last several decades. And it stresses throughout the report the importance of these models as a key decision aid for policymakers and discuss two very different uses of models.

One, which is as a forecasting tool, which we've heard a bit about already today. And the other is the use of models as an intervention design tool, which is what I'm going to emphasize in my presentation today.

But, for models to be useful, and do more good than harm, it's essential that they are built and applied appropriately. There are many key best practices, both for model producers, modelers, and for model consumers, decision makers. And the National Academy of Sciences' piece, that I helped write, that's listed here, reviews many of these.

But one important best practice that I want to highlight today is that the features of a model should suit the features of the problem.

So, in this case, models built to inform design of policies to contain COVID-19 need to have several characteristics.

First, to give the kind of guidance I refer to earlier on the specifics of implementation choices, they need to be quantitative models. They need to by dynamic; they can speak to how things will unfold over time.

And preferably, they need to leverage our knowledge from epidemiology of how the mechanisms of contagion work to help us speak to counterfactuals we cannot directly observe, for example, the impact of yet to be tried interventions.

Second, the models for COVID-19 need to be suited to capturing the underlying features of the epidemic itself. And the simplest epidemic models -- the so-called SIR models that we've already heard about -- including many of the forecasting models, are widely used and offer many advantages.

But they do carry with them some assumptions like very little heterogeneity, and mostly at random mixing of the population that may not suit the current situation entirely.

There are three features of the problem of COVID-19 containment that are really

important, in my view, for the questions we are addressing on this panel, and I tried to illustrate them with data taken from published literature here.

The first of these features is that there is enormous heterogeneity. So, what is shown in this plot are estimates of the likely fatality by age obtained from aggregate data from mainland China, and you'll see that there is a very uneven picture of risk by age. And this is just one of many heterogeneities that we know of in how COVID-19 is affecting our populations.

The second characteristic is spatial structure. This is a plot which shows the density of contact between people of different ages. On the X axis ages go from 0 to 80, and then again on the Y axis from 0 - 80, and at the intersection of any two ages you can see the density of contact.

This is drawn from data and simulations; again, coming from China. And it's simulated at the top both for normal life, and then at the bottom again for a situation in which schools are closed and only half the population is at work.

And what you'll see is that this is not all uniform color. That there's actually quite a bit of heterogeneity in the underlying contact pattern that is driving exposure to disease and the spread of the epidemic.

And the third thing on my list is uncertainty. These are all different estimates from a working group in the U.K., through time, of the percentage of actual symptomatic cases that are out there that are reported. And you'll see that there's huge heterogeneity across countries, but also that there's wide variation through time within the countries. And this kind of uncertainty characterizes much of the data we have about the epidemic.

So, a model will need to match the underlying heterogeneity, spatial structure, and uncertainty that we see in the epidemic.

These features -- heterogeneity, spatial structure, and uncertainty -- happen to be very well aligned with a specific kind of model that is widely used in epidemiology in the last 15 years, but that is very different from a simple SIR model. And this kind of model is called an agent-based model.

What is an agent-based model? An agent-based model, or ABM, is a computational

model that explicitly represents each and every individual in a population, called an agent, and them simulates the dynamics that comes from their interactions.

In this case, because each individual is explicitly represented, they can have lots of heterogeneity at the population level (phonetic), and we can represent sophisticated contact patterns, such as social networks, to understand how they impact an agent, and thus, policy interventions.

In addition, these are stochastic simulations that allow exploration over wide ranges of uncertainty to try to find policies which are robust across many, many different settings for underlying epidemiological variables. And the agent-based model approach allows us to represent full distributions across the population, not just averages, which is crucially important for considering inequalities and disparities.

Such models have been widely used in epidemiology over the last 15 years. In fact, NIH made a huge investment in capacity for this kind of modeling through the MIDAS study -- which I have listed the acronym for here, in which both Caroline and I have participated -- and during the last pandemic -- the H1N1 pandemic in 2009/2010 -- models from MIDAS, including agent-based models, were heavily used as inputs into decision making about policy response.

And one such model that I pulled from my archives, it was developed here at Brookings, is shown at the bottom of this slide.

With the very limited time that I have left, I want to briefly preview a new model that we have been working on at NIH Center in collaboration with Wash U. It is designed specifically as a policy reboratory to provide insights into how testing and contact tracing might help contain the COVID-19 pandemic, and what kinds of specific implementation it would take for them to be successful at doing so.

It also takes into account the enormous uncertainty that remains regarding many aspects of COVID-19 and is designed to help policy makers manage that uncertainty.

This model is called TRACE, Testing Responses Through Agent-Based Computational Epidemiology, and we plan to release our initial version of the model, and our results in paper in just a few days.

But since I have you here, and you're all on the event today, I decided to give you a quick sneak preview of the model both so that you can see what it may look like, but also to give you a sense of a kind of modeling that I think we need more of and that can inform the debate that we're having today.

The first thing I want to show you is an interactive dashboard that will come with this model that's designed to allow direct interaction with the simulated output of the model. And as you can see here, we simulated many, many different combinations of policy parameters.

Down the left side there's a whole bunch of dropdown menus in which you can dial in different assumptions about how many tests will be available, how good they will be, who they'll be given to, how much contact tracing capacity there will be, how many people will adhere to quarantine orders, and so on.

In total, we actually simulated about 10,000 different combinations and policy options. And then you can also vary the background settings, what the assumptions about the underlying epidemiology are.

So in total, we explored 160,000 different combinations of the match between policy and epidemiology to look for policies that work well across a wider range of these, and to be able to say under what circumstances Policy A or Policy B might be indicated.

TRACE is also a true agent-based model, so it takes into account lots of the heterogeneity that I discussed earlier, and non-random age specific activity and contact patterns based on real world data, shown in the little network slice I took here from the larger model.

And I just want to preview that one of our key six results that we will have in our forthcoming paper is that we find that there are actually multiple ways in which you can actually suppress the epidemic -- not just flatten the curve and push incidents into the future -- but actually suppress it entirely while releasing most social distancing and unfurling from this economic shutdown.

So, to learn how and what this kind of success will depend on, tune in later this week to the Brookings website, and I will now turn it over to Caroline Buckee for the next presentation. Thank you.

MS. BUCKEE: Thank you, Ross, and thank you for having me. I'm going to try to share my screen.

So I'm going to build on what some of the previous speakers have talked about and the first thing I just want to make very clear -- and I know we've talked about curve fitting as opposed to SIR models -- I think that there's an important, very simple, point here, and that's that the characteristic epidemic curve that we are used to seeing from SIR models, there are really two ways that an epidemic can go down, can have that characteristic downturn.

One way is that we run out of susceptibles, and the other way is that we change something fundamental. In this case, the contact rate between susceptible people and infectious people, and that's why we're seeing the curve start to go down.

Because simply statistically models, such as the original HME framework, does not include that mechanistic distinction between running out of susceptibles and changing something about contact patterns, by definition, it cannot examine the possibility of resurgence.

So that's why those curve fitting exercises where you take a curve from somewhere else and apply it to a different place do not think about what happens under different types of scenarios for reopening, as well as resurgence. And in their more recent revision, they've actually included a mechanistic component in order to be able to improve their ability to test these different pathways.

So, I'm going to discuss here, I think, some of the major epidemiological uncertainties, and Ross talked about some of them, in the context of what we think might happen in the future. And them finish by discussing what the epidemiological considerations might be for reopening; what we have to think about for the U.S. in particular.

So, the first open question is immunity and we've already discussed this. We don't know yet whether infection with this virus leads to immunity. We also don't know how that varies with antibody titer and with your clinical outcomes. So, we don't know whether asymptomatic people are immune afterwards; we don't know how that varies by antibody titers, so how many immune cells you have in your body.

I've shown here two outcomes from a deterministic mechanistic model developed by Steven Kissler, Christine Tedijanto, and others at Harvard, that simply ask the question, “What do we expect in the long-term, in terms of recurrence and seasonal epidemics under different plausible scenarios for immunity to this disease?”

And I think that the feasibility of immune pass-forwards, and returning to work if you’ve got antibodies, is really going to hinge on what we think and what we believe is going to happen within immunity, as well as whether we’re going to have to deal with seasonal peaks of this virus that will continue well into the future. And that may have in important implication for what we choose to do in terms of reopening.

The second open question is this issue of people that have no symptoms, or very, very mild symptoms. We simply don’t know how many people contract the virus and have no symptoms at all, and we don’t know the extent to which they contribute to transmission. This is a recent preprint here on the left that just shows some estimate of how many cases have been recorded, and how many we think may be infected.

The important piece here is that the number of unmeasured cases -- and there are various cases for not being measured well -- but it’s going to vary by location, and we don’t know whether asymptomatic people are going to play an important part of this epidemic.

The thing that that affects in terms of our outlook is how close we are to the epidemic peak. So, we don’t know how far along the epidemic curve we are if we haven't measured asymptomatic people. And we also don’t know the case fatality rate because we actually don’t have our denominators correct.

In terms of the models, most models, most mechanistic models -- and this is a characteristic SEIR model with two categories of infected people; some of them have no symptoms are some of them are symptomatic. There are many uncertainties associated with these parameters, both the fraction of people who are asymptomatic and the extent to which they contribute to the force of infection on the rest of the population.

That's a really important uncertainty that may vary across orders of magnitude in terms of what we're getting out of the results of these models.

So, even if you have a very, very detailed agent-based model, you still have to make the same assumptions as simple models about how these epidemiologic transitions occur in individual people. And there's going to be a lot of uncertainty simply because we just don't know about asymptomatics.

The third open question is the contact rates, and Ross showed this graph from the London school about the age structure of those contacts.

So, these types of data are mainly parameterized from diary studies; you ask people of different age groups who they contact during the day, and how old those contacts are. And you can build up a picture of the frequency and age structure of the contact patterns in your population.

Now, what is assumed in the models under different physical distancing interventions is that these contact rates that we may have measured at some point in time and in some countries, how that changes under physical distancing. The fact is we don't know how they've changed. We have to make assumptions about it and it's challenging.

What we're doing with these interventions is we're driving transmission from the workplace and the public areas into our households. So, household structures become very important for determining risk. And when we think about reopening and going back to work, we have to formulate how we think that's going to impact contact rates in this age structured way.

And so, the challenge there is that many of these types of contact rates are very poorly understood and different to measure. So, even if you have an agent-based simulation framework, those social networks that are going to determine how transmission happens are not well understood; the data is not good in many places.

And so, when we think about what the response of the population has been to some of these closures, we can look on a population level at how that's affecting our societies.

This is just looking at mobility data from people using Facebook on their phones. This

dashboard is provided by Facebook data and you can see that the relative mobility patterns, as we put in place shelter-in-place policies, goes down as people are staying home, and it varies very much by county and by location.

And so, the response to shelter-in-place orders and the response to reopening may well have a lot of variation and that's very hard to predict in our models, because we don't really know what to expect, and there's nonlinear feedbacks between human behaviors and the epidemic itself. So that's a major source of uncertainty as well.

What we do know -- and this speaks to Angus' point about inequality -- is that we have hyperlocal epidemics that we think result from the distribution of populations of varying socioeconomic status who can or cannot afford to do physical distancing interventions.

So, this is a recent preprint looking at seroprevalence estimated from heel pricks of newborns; so, it gives an idea of how many of those pregnant women have antibodies; it's a cumulative incidence estimate. And you can see from New York, there's distinct heterogeneities in the seroprevalence among those populations.

If we look at how that relates to commuting patterns -- so, this is, again, a heat map that just shows the extent of commuting patterns in these different neighborhoods measured by people using their mobile devices, you can see that there's a strong correlation between the percent declining commuting and the estimated prevalence of the disease.

So, people that needed to commute, needed to keep working for various reasons, they were more exposed to the virus and as a result they've had higher cumulative incidents.

What that means is that we have to be making decisions that are hyperlocal. This is not one big epidemic. It's multiple small epidemics and the decisions we make have to reflect the inequalities in the location in question, and how reopening is going to impact the relationship between different neighborhoods.

And then speaking to inequality, again, for a large country like the U.S., there's a huge amount of state by state heterogeneity, and even within states, by county.

So, this just looks at variate risk factors for COVID-19 related mobility and mortality. And here you can see households under the poverty line, and populations who are elderly and at risk for hospitalization and death, and you can see that it varies a lot across the states, and even within states.

And so again, decision making is going to have to reflect where you are in your epidemic curve -- which relies on testing, so that we know that -- as well as what your population is dealing with, and what types of economies are important for local populations.

And this is another one. This just shows ICU beds per 100,000 and populations living in crowded homes. And again, you can see that within every state there are pockets of really high-risk populations.

So, just to finish up, I think that, of course, we need to be able to monitor the epidemic while we reopen. And monitoring, yes, it's virologic testing; so, if you have the virus, but serology is really important. So, what is your cumulative incidence.

And that gets set whether you're 20% virus positive because you're on the way up your epidemic curve, or 20% virus positive because you're on your way down your epidemic curve. And only serological testing can establish that.

Without testing in a way to monito the epidemic, it's going to be extremely challenging to keep track of what success looks like for reopening.

Second, every state is going to have to decide -- or every location is going to have to decide -- what is their decision rule going to be for deciding that they have to change policy. We may want to reopen and then may have to change course if an unacceptable number of deaths start to happen.

What is that number? And how do we make decisions that are evidence-based as opposed to reactive?

Again, the epidemic is hyperlocal, and it's staggered. So, what is the right spatial scale to be making policies on? We have to make sure that we're collecting data on the scale of the population that we're making policies for.

And lastly, I think there's a more kind of underlying value question about what we're willing to tolerate and how many deaths is acceptable. If we expand ICU capacity, does that mean that we're willing for the epidemic to spread faster, and that will inevitably lead to more deaths.

And so, I think that there's a larger question, which is the kinds of epidemiological thresholds that we're willing to suffer through in order to reopen the economy. And that's something that will have to be made on various state and local levels as well.

So, I'll stop sharing. Thank you. I don't know who goes next.

MR. HUTCHINS: I think we have the panel now.

MS. SHEINER: Floor Panel. I'm Louise Sheiner. Thank you all for such really interesting presentations. And so now we're going to have a chance to talk a little bit more.

I just want to start with, sort of, this big picture. When we first started hearing about the epidemic, we heard a lot about flattening the curve. The idea is that we were going to, kind of, change our behaviors in order to not overwhelm the health system.

Now, as we see what's happening around the world, and we see what's happened in places like South Korea, that sort of had the potential to have the same kind of deaths as we have, but didn't, never really locked down as much, so was that idea, flatten the curve, the wrong thing to strive for? And can we get to the place where South Korea is, where they really haven't had, had sort of minimal deaths, and not as much economic consequences, I think, as we have?

Why don't we start with Ross because you sort of hinted at what you were going to come out with on Friday. So, how do we think about that?

MR. HAMMOND: I think given how we started in the early months of the epidemic, here at ed (phonetic), flattening the curve was the right thing to do and it was essential because the risk that healthcare systems would be completely overrun leading to a really huge death toll was very real, and I think it was very important.

That said, I do think that now we are entering the phase where we can start thinking about how to be more like South Korea. And the model that I put forward -- and others, actually -- are

indicating some ways we might go about that.

And my sense is that the requirements for a testing, contact tracing, MPI regiment to work, are not quite as daunting and demanding as you've heard about in some of these reports; that this might be actually somewhat more feasible, particularly if we focus on a smaller scale and respond at a microlevel to what's going on, as Caroline has suggested that we should.

MS. SHEINER: Does anyone --

MS. BUCKEE: Yeah, I would say that the biggest difference -- so, in Korea, they started ramping up testing incredibly rapidly. Their response was characterized by early action, very fast ramp up of not just testing, but also technological intervention.

Some of their technology use I think included surveillance that we may not be comfortable with in this country, and that's an important consideration for our own, kind of, approaches to contact tracing.

But, nevertheless, their early action and their insistence on widespread testing, not just in hospitals and among severe cases, I think really made the difference and that is something that we can learn from.

MS. SHEINER: And is it just testing, or is it sort of the tracing a key part of that, because I know we are ramping up our testing.

MS. BUCKEE: Yeah, I think you need to do testing and tracing, and then you can't just do contact tracing. You have to have follow-up and have a health system response that integrates contact tracing, and isolation, and so on into the system in a meaningful way.

MS. SHEINER: Now Caroline, you talked about things at a microlevel, sort of a neighborhood by neighborhood, or community by community level, and yet people have this idea -- so, for example, let's say, Maryland instituted a very strong contact tracing quarantining, sort of did the right thing, but Virginia didn't, right. How confident can we be that you can actually make something like that effective at a local level where there are people traveling back and forth? How easy is that to break, sort of, get the surge started anyhow?

MS. BUCKEE: Yeah, I think there are always going to be challenges because you have a constant risk of importation from places that have a higher epidemic than you do. So, that's a challenge, buy you could imagine coordination across states, or some kind of coordinated surveillance so that those risks are managed.

And again, if the roll out of contact tracing and testing is local, then at least with importation, you can come up with policies to try to mitigate and prevent resurgence in your own local area.

So, yes, that's always going to be a risk, and that's going to continue to be a risk for international travel also for some time.

MS. SHEINER: Does anybody know if any states are on their way to implementing the kinds of things that you and Ross think are necessary? Or is this something that we're hoping they start?

MR. HAMMOND: Huge heterogeneity --

MR. DEATON: Can I ask something --

MR. HAMMOND: Oh, go ahead.

MS. SHEINER: Yeah, Angus?

MR. DEATON: I was just going to say that it's clear that if we had way more testing than we have, there's lots of things we can do that we can't do now. It's also true that if we had contact tracing, we could do lots of things that we can't do now.

Are we to assume that Ross' suggestion that we actually suppress the thing depends on the contract tracing and on testing, I'm not convinced -- or at least let me ask the experts -- SARS was eliminated by contract tracing but SARS is a very different virus that was not infectious before there were symptoms.

So, you saw the symptoms and you knew you had the people and you could track that and trace that back, and you could kill the virus. And that sort of happened.

This is much, much, much harder because these people having been sharing the virus for days before you even know they're there.

The testing seems to be a real bottleneck worldwide, and not just one that we failed to do in this country or it's both things together.

The other thing about contact tracing is, the stories I've heard, they're going to try to do it by telephone. I think that's -- I'm not sure that's ever been done because you're going to look someone in the face and know whether they're telling you the truth or not?

And you're going to ask these half-trained contract tracers to go out there and talk to infectious people and ask them about their contacts in the past. I'm very skeptical as to whether tats going to happen here, but I may be missing something, and Ross and Caroline can tell me.

MS. BUCKEE: I --

MR. HAMMOND: I would just say that -- oh, go ahead, Caroline, please.

MS. BUCKEE: I would just say that I think it is challenging. And I think with the contact tracing for this type of disease, the speed of catching people is the important thing; so, you have to catch people quickly. And that has been one of the arguments for these contact tracing apps, right. That it's a way that you can automate it and bring the time to finding contacts down. I think that there are many challenges.

And as you say, one of the challenges is that we haven't done this before. And so, we're rolling out an intervention that hasn't been really thoroughly tested yet.

So, while I think that Korea's example is a good one for trying to follow-up as much as we can, and testing has to be included, there are going to be a lot of challenges to rolling this out and scaling it.

MR. HAMMOND: Let me jump in here. Of course, it's the case that testing, and contact tracing, and quarantine -- the extent that it's available and effective -- has got to be an important element of this. But I guess one worry I have is that -- not really this conversation -- but the public discussion around testing and tracing makes it sound like maybe it's a silver bullet.

Well, you know, it's a ways away. We don't have the testing. We don't have the contact tracers. This is super urgent, and we can't say, "Well then, we're going to be set and ready to go in

August." That's not going to work.

It seems like we've got to have a multipronged strategy and what I would love to see and what I'm advocating for, is a multiprong strategy that allows people to get back to work but does lots of divert things like everyone is wearing masks, everyone is doing the social distancing when they're going shopping at the mall, and the other sorts of MPIs that we've talked about.

And then to the extent that contact tracing, and testing, and quarantine can facilitate additional reductions in transmission, then that's something that we should -- and then, of course, it just becomes a matter of probabilities, and everything is reducing, the probability of transmission by a certain amount, and they work together.

MS. SHEINER: Great. So, let's talk about what that's going to look like, these partial reopenings, as you say, sort of doing the best we can. If we're thinking about some parts of the country being shut down while some parts are open; some businesses being shutdown while others are open; some people going into the office -- younger people -- while others -- older people -- are home, how do we think about sort of the GDP effects of all that?

I mean, if you can't get parts because the parts people are not a safe business, then maybe you can't operate even though it's a low frequency business. How do we think about what they mention the priotivity (phonetic) hit, how big is that? How interconnected are we?

MR. HAMMOND: So, there are many things that are uncertain (laughter). The short-term elasticity, so substitution and production are probably -- there's probably not a lot of elasticity. So, if you need to get your car repaired with new brake pads, and there's no brake pads, then that's a problem. And there's probably not a good supplier than can jump in.

That said, I bet that that manufacturing plant that makes brake pads either it's already a low contact facility, or it can be a low contact facility. And there's only a few facilities, there are only a few sections of the economy that are really high contact.

Obviously, meat packing plants are in the news and we think about healthcare workers, and we think about teachers and the kids at school, and so forth, and those are all very salient. But large

chunks of the economy are actually people filling out insurance claims or filing insurance claims online, and some of that can be done at work.

So, I think that the real way to focus on this is to say, “Well, let's reopen everything that we can. And let's get people back to shopping and get people back to work in those areas where we really can do fairly minimal things to make them low contact activities, and at the same time, you know, no BBQs, no Little Leagues.” That sort of -- you know, the No Fun Economy, I call it.

MS. SHEINER: (Laughter) So, what about how people get to work, and sort of the potential disparate impact on people who can drive in their safe car, versus people who have to take public transportation?

MR. HAMMOND: Big deal. That’s a big deal, that’s a big deal. And so, that might mean more staggered shifts, if that’s possible in your workplace so that it spreads out the commuting load.

In New York City, that’s a problem. This is a big problem for New York City.

There are vast swaths of the country where public transportation is pretty limited anyway, so it’s not going to be as much of an issue.

This is really an issue for some of the big urban areas and we might need to figure out ways to allow additional transportation or carpooling, which will have high contact but with a small number of people. So, that’s an important thing to pay attention to.

MR. DEATON: One of the things that we have to find out too, right, is, is it possible to make an airplane really safe?

MR. HAMMOND: Yeah.

MR. DEATON: And what does that look like? And you can imagine tests and science, I mean, there are ways of finding that out.

There was that piece from the CDC today saying, I think, 90 people were in a choir practice for an hour and a half, and I think 64% of them got the disease from the one carrier that was there.

So, it’s clear that choir practice in a confined space, and maybe being in an airplane is

like choir practice. But, of course, you're not singing, which is really a good way of projecting the (inaudible) cells.

But I think there's a lot of other things. You know, we're having this Zoom thing, and these webinars, and those are inferior in many ways, they're superior in some ways; it's much easier to get a big audience.

You know, I only have to put a bowtie on, I don't have to have anything beneath the waist (laughter) that I don't want to wear, and so, in some ways, it makes life easier, especially if I have to spend the rest of my life in this (inaudible), which seems like might be possible.

I also wonder about GDP measurement. We have a lot of problems already about measuring online activities. And if a tremendous amount of the economy moves online, and we lose the airplanes because everyone is Zooming, and we'll lose the GPD, are we picking up the GDP from the Zooming, or are we just losing that?

So, I think there's going to be a real threat to the integrity of the GPD statistics when we're doing that too.

MR. HAMMOND: Can I just add one thing, Louise.

MS. SHEINER: Yes.

MR. HAMMOND: I think this is, really, this conversation is speaking to why we need this intersection of the economic models and the epidemiology models because we might have an intuitive sense that airplanes, and singing lessons, and backyard BBQs are the high contact points, but there's actual data and science that can tell us for sure what the high risk touch points are, and it comes from the kind of epidemiology that Caroline was talking about, and it comes from the kind of models I'm suggesting.

So, what we need is to get both halves of that equation so that we are, in fact, optimizing getting the economy back to work, while maximizing the protecting of the epidemiology risk.

MR. STOCK: Can I jump in so I can screen share --

MS. SHEINER: Yeah --

MR. STOCK: So I can screen share since we're -- I had thought we weren't going to be doing models here, but since we're doing models, this is a simulation here that uses a five-age compartment SEIQRD model, that's merged with an economic model.

And what it is, is a simulation that our team did that looks at, what if governors follow the CDC/White House guidelines for when you can reopen, and it only varies one thing between the left and right panel, which is what I'll call the backyard BBQs; so, it's the non-work, non-home, social interactions.

And what you can see is that if you behave yourself and you don't go to Little League, and you don't have a backyard BBQ, there is room for a decline in the unemployment rate, and a decline in the death rate.

But, if instead you open up in a broad based way, then those contacts -- essentially, you're expanding your contacts on the backyard BBQs -- and none of the governors are comfortable, if they're following the CDC guidelines, they're not going to start declining the unemployment rate, they are not just reopening business until September.

So that's just a simulation, and as our governor says, models are models are models, but I think it illustrates those using -- that actually age contact base recedes just like what Ross and Caroline show.

MR. HAMMOND: Yeah, but I think its an open question whether the actual data about where people are mostly contracting COVID-19 matches anybody's assumptions., and that's what we need to find out.

MR. STOCK: Yep.

MR. HAMMOND: And that's what we need to find out --

MR. STOCK: Totally --

MR. HAMMOND: In order to make the kinds of decisions you're suggesting.

MR. STOCK: Agreed.

MS. SHEINER: Jim, you keep on talking about backyard BBQs, but I sort of thought that some of the recent evidence says there's really not much outdoor transmission at all.

MR. STOCK: Mm-hmm.

MS. SHEINER: For example, and that would be a real benefit to people, if they could have those backyard BBQs (laughter), so yeah, knowing that stuff is important.

I have a question about policy or two. So, I saw a Tweet recently about -- it was a United flight where they had promised people they would leave the middle seat empty and every seat was taken, for example. So, what is the rule for OSHA?

We're also hearing this stuff on The Hill that they want to get rid of liability for businesses for people who get COVID-19. So, how much can we rely on businesses doing the right things? And how do we make sure that happens?

MR. DEATON: I think we need some pretty serious science. I mean exactly these things about what can you do in a subway, or what can you do in an airplane, or what can you do at a backyard BBQ.

I get the impression that Jim invites more people to his backyard for BBQs (laughter). I mean, it might (inaudible) noticed, probably he'll tell us, by every feet -- all being six feet apart (laughter). They might not even need to take their mask off.

But, I mean, I'm not sure. I believe the agent-based models are all reasonable. But how would you pick up the difference? What do you exactly have to do in an airplane? To mean that those pictures you saw and that I saw -- I think they were all bobkits (phonetic), so maybe bunker bobkits are okay wearing face masks, but looking terrified in this airplane.

MS. SHEINER: Yeah.

MR. DEATON: And United is advertising that that's not happening.

MR. HAMMOND: Well, clearly not all the science that's needed is epidemiological science or economic science. It's full of dynamics and theriology, and all sorts of other things that need to come together here.

But I do believe that models have a lot of utility over mental models (laughter) and intuition in making decisions, and particularly quantitative decisions about the matter of proceeding.

MS. BUCKEE: I think one thing that's going to be really important in this back to work, in this commuting airplanes and Zoom calls, we have seen a massive displacement of urban populations into suburb and in rural areas in this country, really astonishingly so.

And those are largely, presumably, people who are able to afford to leave the city, and who are white collar workers as well. So that's another thing, as we talk about opening up for different sectors, what do we mean by that?

Do we have a much-reduced population density in urban centers anyway so that our commuters who are doing so-called more essential jobs are in a different situation than we were before anyway?

So, there's been this strange shift in population distribution and density, as well, that I think will fall along economic lines, and that's going to be interesting to see what happens as states decide to reopen.

MS. SHEINER: Is there a need for fiscal policy to -- not just the regulatory policy -- but for firms to get the money to buy the shields that they need for people to have -- I don't know, help people who are commuters so that maybe they can get to work a different way; for people to make sure, you know, to continue with the Unemployment Insurance in some way so that people who can stay away, do stay away? What is the role of the Federal government in trying to maximize the conditions for opening up safely and not risking people sort of not obeying them?

MR. DEATON: I think it should facilitation, but it's a very blunt instrument as you've seen from the previous so-called stimulus package, it's a (inaudible) stimulus package that are called essential relief packages, and if there are things like that that we can see that would be a deal from money from, that would be really terrific.

But I think right now, it's much more the epidemiological stuff, and Jim said he didn't quite see it in his presentation, but I think it was in his background notes and is incredibly important, which is, you know, economists like to talk about decision making under uncertainty (laughter). I've never seen an environment in which there was so much uncertainty about the effects of economic policy, and the effects

of what happens if you don't do economic policy. I mean, these models are all over the place.

And I'm really worried that in Washington there seems to be this feeling that ultimately this thing will go up and come down the swing, and if you look at the data, I mean, looking for every day waiting for some sign that that's going to happen. That's like in New York. And it really isn't there.

And it's quite possible that this thing will stay at however many deaths it is a day indefinitely, just wobbling up and down a little bit, as epidemics move into different places around the country. And that this sort of social distancing we're prepared to put up with is not going to do very much for that.

So, we really, really need some sort of medicine that would make you less likely to die from this, or less likely to suffer from it. Something like we have for HIV AIDS, for example, and of course, a vaccine.

I'm not convinced there will ever be a vaccine. I think there's a much better chance of getting some sort of anti-retroviral cocktail, which helps turn this thing to a less fatal disease.

MR. STOCK: Can I amplify that. In theory, there are a couple of ways -- and I think maybe it was Caroline who started out saying this -- a couple of ways to think about how this might -- traditionally -- I'm saying, like this might be managed. And one is you just move to herd immunity so that nobody -- you know, there hasn't been any -- suppose there's no interventions and it's a very mild disease and you just move to herd immunity.

And the other one is you do really a severe -- you do all the contact tracing, you squash it, you sort of go the South Korea or Singapore route, and you really hold it down.

Those both -- you know, the herd immunity route, in real time certainly will have some economic damage, but it's very short lived and you have a couple of million deaths maybe, or a million and a half deaths, and then you're over it assuming that we have the herd immunity.

The other route you've got to be eternally vigilant and then hope that you get the vaccine.

I don't think -- we're not on either route. I think my view is sort of like Angus' which is, I'm really concerned that we're just going to hang out, we'll have reopening, we'll reopen across the Board,

not in a smart way. Then the governors will get nervous, and they'll slam on the brakes, and well have more months and months and months of 15 or 20 percent unemployment. And it's hard to imagine -- it's hard to state how damaging that would be in the long-term for our society and for the economy.

So, I guess in my more pessimistic moments, I think we've just got to sop it in and make some really tough decisions about how we're going to manage this or else we're really screwed.

MS. SHEINER: So, bring me to the politics of this. Kevin was talking about before how they put out these guidelines and then basically left it to the governors to not listen to them (laughter), and also did not provide businesses -- they decided not to push out the CDC specific guidelines for how to run your business. So, really, every state that's on its own.

Does that -- is this failure of leadership important? Is there some chance that we would be have better off with better leadership? Or is it sort of just the fact that we haven't had the experience with testing, that we are not the kind of country to put up with an APP that traces every movement.

There's something special about the U.S. in its kind of libertarian streak, that means it's going to be hard for us to manage. Or could this have gone a lot better if there had been quicker leadership, and even now, more leadership on all these really hard questions?

MR. DEATON: We'd always be better off with better leadership. You know, that's always true. But actually, I think that judged by past pandemics, what's happened is not -- it's some of what you would expect.

I mean, people get frightened, they do stupid things. You know, the local political pressures seem to be the right ones.

We're a huge country. It's very different in Montana from what it is in Washington D.C. or New Jersey. The governors are more in touch with what's going on there, and I think they have to take it the way they see it.

And remember, we're learning stuff along the way. So, for instance, we've learned just how incredibly dangerous old-folks' homes are.

MS. SHEINER: Mm-mm.

MR. DEATON: Or (inaudible) for the elderly. And with luck, we're going to do something about that and actually make them safer. And that will be a lot of deaths that would have been avoided.

And if we can do that -- you see, it might have been better for the governors not to lockdown in those places where they didn't need to lockdown.

So, they can get a lot of economic gain for probably very little health -- sorry, a lot of economic buzz for not much health gain. But now they may be opening up at just the wrong time. But what Jim said was right, they'll back away pretty quickly.

And so, we really have to have these smart middle measures in between. And we going to spend almost infinite sums of money in trying to get medicines and a vaccine for this.

MS. BUCKEE: I do think that testing was really not scaled up quickly enough. There's no question of that because apart from anything, if we'd had a proper testing, states wouldn't have had to shut down because their prevalence would have still been zero or very low.

So, in my opinion, the failure to be very early in ramping up testing has had major consequences for the epidemic in this country, and will continue to, I think, play a role in what Jim was talking about, which is ad hoc decisions, reactions to sudden increases in deaths, and no sustained plan that is transparent and transparently communicated to people.

So, I think, again, you have to monitor and keep track of what's going on or you can't make sensible decisions.

MS. SHEINER: One thing I've read about, it's become such a political issue, the pandemic, which is kind of crazy, but, you know, people talk about it's like democrats wear masks and republicans don't wear masks. And I think, Angus, you thought that all that was going to change as the virus actually kind of spread more broadly.

But do you think that there's going to be this sort of constant backlash against people taking those measures because it's viewed as sort of political?

MR. DEATON: Well, I mean, the other thing you have to remember is the vast majority of Americans are very much in favor of social distancing. So, we hear a lot of noise with a libertarian fringe,

but that's not the way most Americans think about this.

And most Americans are solid behind this, and it doesn't really matter whether they're democrats or republicans.

But I do think it was a lot to ask republican governors in these states that are almost unaffected to take a big slice out of their economy to save lives somewhere else. I mean, think of we'd been asked to save lives in India, for instance, by shutting down the U.S. economy, we wouldn't have considered that for a minute.

So, I think it will change, and Matt Romney is (inaudible) to be running around with a poster saying this is a republican problem as well as a democratic problem. And what has been done at Brookings, and my simple calculations, show that that is changing, that that's moving.

And in New Jersey that it was originally part of the New York epidemic in the northern counties, and it's now moving down to us, and it's going to move down into what are further, more conservative parts of the state. And that will certainly change peoples' views.

So, it's very easy to dismiss these things if you're not at any risk, but I think they'll change pretty quickly when they see the risk.

MS. SHEINER: So, I'm just going to play on something that you said before -- and Caroline, I think you were talking about testing -- do you think they were shutting down to save other peoples' lives, or because they thought it was imminent in their communities? I mean, did it really matter if Montana for New York's lives, or?

MR. DEATON: No, I think they were all scared at the beginning, and you know, there's this pandemic and people were looking at the (inaudible) levels, and saying, "Okay, if we shut down for a month all the deaths will be done by May and we can get on with our lives again." And that made a lot of sense under those circumstances, but that's not where we are anymore.

MR. STOCK: There's also, I mean, again, everything is uncertain, but there is some interesting evidence, or preliminary evidence suggesting that a substantial amount of the shutdown was not in response to, or because of, governmental activities, but because people were just getting really

scared, so they decided not to go shopping.

And if you look at spending patterns, one of my colleagues, Raj Chetty, has a website that looks at spending patterns over time and aligns them with shut down announcements, and the spending patterns start going down well in advance of the shutdown; except of course, for groceries and toilet paper.

But the other spending patterns indicate you're not going to restaurants in advance of being told not to go to restaurants.

MS. SHEINER: Yeah.

MR. STOCK: So, what that means on the upside is that it's not as simple as saying, "Okay, now, everybody back to the restaurants." That's going to have to be managed very carefully, and that is actually a really important part of what I would consider to be the failure of credibility of this administration in terms of really being a reliable source of thoughtful, adult advice. And people are going to have to be able to trust that to go back to their normal activities.

MR. HAMMOND: I do think that it's important to think a little bit about what lessons we can learn moving forward about this, whether it's about governance, or about testing, or about politics or anything else, because this will almost certainly not be the last time something like this happens in this world.

So, we need to -- there's a proliferation of emerging pathogens that's very worrisome. So, I think it's really important to try to build toward a better response in the future.

MS. BUCKEE: To Jim's point, I think that the changes that people are making -- we already know that things like hand hygiene and wearing masks can have an impact. I suspect that we will have a somewhat permanently altered contact rate across our societies, just because people have witnessed this and experienced it now.

So that might mean, of course, the contact rate is linearly relate to the reproduction number. And so, we may have a permanently altered disease situation also moving forward.

So, until we really understand how this kind of reaction by people is changing some of

these fundamental parameters of the disease, it will be hard to know how much we have to do to keep it at bay.

MS. SHEINER: Okay, we're out of time, unless anybody has a question for each other that you think wasn't addressed and you'd like to bring up.

MR. DEATON: I just have one final point. We haven't really talked much about this, but just to pick up on what Caroline just said. I think it is true that we have been a hundred years without a major pandemic -- an infectious, respiratory pandemic like this -- and our economy is not set up in a way to deal with something like that.

And it's clear that even -- you know, I agree with what Caroline said, that people are going to change their behaviors semi-permanently, but we also need to set up our factories, and set up our living arrangements and things so that we build that in, and we'd have a somewhat different economy, and that we're proofed against these sort of threats.

I mean, its true that lots of people said that this was going to happen. But there were also lots of people who thought it was not going to happen, and they had good arguments on their side, too.

You know, people like worried a lot that (inaudible) and said, "Here, it's coming," but then it killed it and not all that many people advantaged. And HIV AIDS was knocked out by the anti-retroviral cocktail.

So, you could have a certain amount of confidence that we've dealt with these things, and so this one took a lot of people by surprise. And I think it should make permanent changes, and I think it will make permanent changes.

MS. SHEINER: Do you think we will have more appetite across both sides of the isle to invest in public health? Is that another lesson from this, or?

MR. DEATON: I hope so (laughter).

MR. STOCK: On the private side, there's a clear externality here. Why should a firm invest in those sorts of preventative measures, when what it's really doing is just providing a social

benefit?

So, this is an area in which going forward, hopefully after this is over, we'll be able to have a conversation about those public benefits can be transformed into private actions.

MR. DEATON: Exactly.

MS. SHEINER: Great. Okay, thank you all very, very much for a really interesting discussion. Of course, this is an ever-evolving thing, so maybe we'll do it again sometime. Thank you.

MR. DEATON: I hope not (laughter).

MS. SHEINER: (Laughter).

MS. BUCKEE: Thank you.

MR. HAMMOND: Thank you.

MS. SHEINER: Bye, thank you so much.

MR. DEATON: Bye, bye.

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