WEBVTT

00:00:00.090 --> 00:00:00.990 - From a colleague

00:00:04.730 --> 00:00:08.890 asking for help with planning for the intensive care unit

00:00:10.314 --> 00:00:13.560 and floor bed capacity at the Yale New Haven Hospital

00:00:13.560 --> 00:00:17.540 Health System and Yale New Haven in particular.

00:00:17.540 --> 00:00:20.760 Margret and Sohei had previously, or around the same time,

00:00:20.760 --> 00:00:25.030 been working with the statistics policy

00:00:25.030 --> 00:00:27.790 modeling an epidemiology collective on a queuing model

00:00:27.790 --> 00:00:31.770 or discussing the parameters of the queuing model

00:00:31.770 --> 00:00:35.303 for the dynamics of Covid-19 patient flow through hospitals.

00:00:36.580 --> 00:00:41.060 So we decided to use this model setup to make a concrete

00:00:41.060 --> 00:00:44.140 software product in the form of a web application

00:00:44.140 --> 00:00:46.820 that Yale New Haven Health System and other hospital systems

00:00:46.820 --> 00:00:48.483 could use for capacity planning.

00:00:49.640 --> 00:00:54.170 We wanted to respond to their very immediate need

00:00:54.170 --> 00:00:59.170 to know how full the hospital would get if Covid patients

00:01:00.180 --> 00:01:02.470 kept coming at the rates that they were seeing

00:01:02.470 --> 00:01:05.690 and how they might expand capacity to accommodate

00:01:05.690 --> 00:01:06.763 these new patients.

00:01:08.760 --> 00:01:11.840 So we created a Slack channel,

00:01:11.840 --> 00:01:14.570 a way of communicating directly in real time

00:01:14.570 --> 00:01:17.309 with the team members, who created a GitHub repository.

00:01:17.309 --> 00:01:19.880 Within, I think, only about two hours,

00:01:19.880 --> 00:01:22.290 we had a web application written in R,

00:01:22.290 --> 00:01:23.623 using Shiny framework,

00:01:24.930 --> 00:01:29.700 where you could sort of dial in the

00:01:29.700 --> 00:01:32.240 current bed capacity at a hospital system.

00:01:32.240 --> 00:01:34.800 You could enter parameters that govern the length

00:01:34.800 --> 00:01:37.390 of stay of Covid patients and how they move through

00:01:37.390 --> 00:01:39.600 the hospital from the emergency department

00:01:39.600 --> 00:01:40.970 to the floor to the ICU

00:01:40.970 --> 00:01:44.483 and then toward discharge or possibly death.

00:01:46.630 --> 00:01:50.803 So that product went live very, very quickly.

00:01:52.550 --> 00:01:54.410 There are many other collaborators and contributors

00:01:54.410 --> 00:01:59.120 to the application beyond just our group.

00:01:59.120 --> 00:02:00.980 Our goal here was to produce

00:02:02.780 --> 00:02:05.263 something very quickly and immediately useful.

00:02:07.730 --> 00:02:10.410 The structure of this model is shown

00:02:10.410 --> 00:02:12.080 in this very complicated diagram.

00:02:12.080 --> 00:02:14.390 It's not as complicated as it looks.

00:02:14.390 --> 00:02:18.100 The basic idea is that patients enter through

00:02:18.100 --> 00:02:19.500 to the emergency department.

00:02:21.290 --> 00:02:26.290 They move to the floor then to the ICU.

00:02:26.660 --> 00:02:28.040 There are many things that could happen

00:02:28.040 --> 00:02:30.520 if those places are full.

00:02:30.520 --> 00:02:34.340 Each of those parts of the hospital is treated as a queue.

00:02:34.340 --> 00:02:36.650 That is, it's essentially a pool of patients

00:02:36.650 --> 00:02:39.360 who are waiting to exit.

00:02:39.360 --> 00:02:41.400 One of the ways they can exit is to step up

00:02:41.400 --> 00:02:42.810 from the floor to the ICU.

00:02:42.810 --> 00:02:45.230 One of the ways they can exit is to die.

00:02:45.230 --> 00:02:47.132 Another is to be discharged

00:02:47.132 --> 00:02:49.910 if they are no longer acutely ill.

00:02:49.910 --> 00:02:54.620 So sort of taking into account all of this schematic, this

00:02:55.850 --> 00:02:59.800 stylized depiction of the way Covid patients

00:02:59.800 --> 00:03:01.850 would flow through a hospital,

00:03:01.850 --> 00:03:05.340 we wrote a system of ordinary differential equations,

00:03:05.340 --> 00:03:08.683 which describe formally, the dynamics of this system.

00:03:10.290 --> 00:03:12.540 It's a very simple type of modeling

00:03:13.450 --> 00:03:17.490 that is very useful when the number of patients is large

00:03:17.490 --> 00:03:20.910 and when you want sort of aggregate dynamics over time.

00:03:20.910 --> 00:03:23.560 So we're not modeling, it's not an agent-based model.

00:03:24.451 --> 00:03:26.090 We're not modeling individual patients trajectories

00:03:26.090 --> 00:03:27.170 through the hospital.

00:03:27.170 --> 00:03:31.050 Rather, this idea of patient flow through the hospital.

00:03:31.050 --> 00:03:34.000 So this model, depicted schematically here,

00:03:34.000 --> 00:03:36.540 is formalized in a system about ordinary differential

00:03:36.540 --> 00:03:38.800 equations with many parameters.

00:03:38.800 --> 00:03:41.360 Those parameters are calibrated to data that we have

00:03:41.360 --> 00:03:43.210 from the Yale New Haven Health System

00:03:46.398 --> 00:03:49.100 and to values from the literature.

00:03:49.100 --> 00:03:52.980 We wrote this web application, which is now live

00:03:52.980 --> 00:03:55.890 at the Shiny apps URL that you can see below.

00:03:55.890 --> 00:03:59.243 You can interact with it if you like.

00:04:00.570 --> 00:04:04.050 It basically allows the user to specify time horizon,

00:04:04.050 --> 00:04:07.050 how quickly or slowly they think new Covid patients

00:04:07.050 --> 00:04:10.040 will present to the emergency department

00:04:10.040 --> 00:04:14.960 and then on subsequent tabs, you can dial in the current

00:04:14.960 --> 00:04:17.390 hospital capacity at your institution.

00:04:17.390 --> 00:04:19.977 You can dial in capacity increases that you anticipate

00:04:19.977 --> 00:04:22.516 being able to implement into the future

00:04:22.516 --> 00:04:24.580 to see how dynamics would change if say,

00:04:24.580 --> 00:04:29.580 you could add 100 new ICU beds over the course of two weeks

00:04:29.600 --> 00:04:32.170 a month from now, for example.

00:04:32.170 --> 00:04:34.360 Then there are many, many input parameters.

00:04:34.360 --> 00:04:37.230 Things like the age-specific rates

00:04:39.197 --> 00:04:42.410 of death or of stepping up from the floor in the ICU,

00:04:42.410 --> 00:04:45.720 to the average length of stay in each of those compartments

00:04:47.098 --> 00:04:49.680 for patients who come to the hospital.

00:04:49.680 --> 00:04:52.943 You can generate reports, downloadable PDF reports.

00:04:54.050 --> 00:04:56.700 We sort of envisioned this tool being responsive

00:04:56.700 --> 00:05:00.130 to the needs of hospital decision makers

00:05:00.130 --> 00:05:04.350 who wanted to be able to add this planning capability

00:05:04.350 --> 00:05:08.620 to their existing bed management software applications

00:05:08.620 --> 00:05:11.560 and then to be able to generate reports for say,

00:05:11.560 --> 00:05:13.870 supervisors and higher up decision makers

00:05:13.870 --> 00:05:16.670 that would describe the scenario that the analysts

00:05:16.670 --> 00:05:17.913 was most interested in.

00:05:19.360 --> 00:05:21.890 The reports would also describe the consequences

00:05:21.890 --> 00:05:24.950 of a capacity expansion strategy that might be implemented

00:05:24.950 --> 00:05:25.803 by the system.

00:05:27.020 --> 00:05:29.600 So I think this tool was very useful

00:05:29.600 --> 00:05:32.632 to the Yale New Haven Health System.

00:05:32.632 --> 00:05:36.280 It was publicized kind of broadly and we got some interest

00:05:36.280 --> 00:05:39.000 from hospital systems throughout the U.S..

00:05:39.000 --> 00:05:40.760 I had spoke to some of them about the ways

00:05:40.760 --> 00:05:44.770 that they were making decisions, planning capacity increases

00:05:44.770 --> 00:05:47.030 and using this application and others

00:05:47.030 --> 00:05:49.030 that are also publicly available online,

00:05:50.070 --> 00:05:51.870 to help guide their decision making.

00:05:53.870 --> 00:05:55.710 This is an open source project.

00:05:55.710 --> 00:05:59.150 You can get all of the source code for the Shiny application

00:05:59.150 --> 00:06:02.263 on our GitHub repository here, shown below.

00:06:07.290 --> 00:06:09.880 So what are the next steps for this project?

00:06:09.880 --> 00:06:13.723 Fortunately, hospitalization in Connecticut is declining.

00:06:15.130 --> 00:06:17.460 This figure that I've shown here is kind of compressed.

00:06:17.460 --> 00:06:18.693 It's declining slowly.

00:06:20.740 --> 00:06:22.610 But it has been declining for I think,

00:06:22.610 --> 00:06:24.113 more than three weeks now.

00:06:25.260 --> 00:06:27.950 Yale New Haven Health System, along with hospitals

00:06:27.950 --> 00:06:30.130 heath systems throughout the state,

00:06:30.130 --> 00:06:33.080 are doing much better than they were in mid-April.

00:06:33.080 --> 00:06:35.120 They have enough bed capacity to accommodate

00:06:35.120 --> 00:06:38.620 all the Covid patients and many more who may arrive

00:06:38.620 --> 00:06:40.380 in the coming months.

00:06:40.380 --> 00:06:42.090 So this is very good news for the hospitals

00:06:42.090 --> 00:06:43.150 and for the state.

00:06:43.150 --> 00:06:45.700 It's one of the reasons that the governor initiated

00:06:48.188 --> 00:06:53.030 the first phase of the reopening plan on May 20 this week.

00:06:53.030 --> 00:06:55.610 However, a lot of the projections and some that I'll show

00:06:55.610 --> 00:06:58.460 in a few minutes, indicate a substantial risk of resurgence

00:06:58.460 --> 00:07:00.700 of new cases, hospitalizations and deaths

00:07:00.700 --> 00:07:02.563 following reopening the state.

00:07:03.460 --> 00:07:06.020 This resurgence is anticipated to occur in July,

00:07:06.020 --> 00:07:09.100 August, maybe September, depending on how things go

00:07:09.100 --> 00:07:10.053 with reopening.

00:07:11.410 --> 00:07:13.400 So I think that

00:07:13.400 --> 00:07:15.940 the model, the web application,

00:07:15.940 --> 00:07:19.363 and this work in general will unfortunately,

00:07:20.320 --> 00:07:22.660 become useful again and very relevant again

00:07:22.660 --> 00:07:25.330 later on in the summer if hospitalization

00:07:25.330 --> 00:07:27.323 of Covid patients increases again.

00:07:28.280 --> 00:07:31.230 So we want to maintain our capacity to continue developing

00:07:31.230 --> 00:07:33.570 this model and responding to the needs

00:07:33.570 --> 00:07:36.500 of decision makers within hospital systems.

00:07:36.500 --> 00:07:38.170 We're taking this down time though,

00:07:38.170 --> 00:07:41.540 to write a technical report and a lessons learned paper

00:07:41.540 --> 00:07:44.040 about the way that we interact with health systems

00:07:45.879 --> 00:07:47.770 and how we might improve the way

00:07:47.770 --> 00:07:49.600 that we do that in the future.

00:07:49.600 --> 00:07:52.430 This work is of course also gotten us very interested

00:07:52.430 --> 00:07:54.820 in the ways that hospitals manage Covid patients.

00:07:54.820 --> 00:07:57.360 We're very interested in comparative evaluation

00:07:57.360 --> 00:08:00.180 and comparative effectiveness in the evaluation

00:08:00.180 --> 00:08:02.530 of Covid-19 medical interventions.

00:08:02.530 --> 00:08:05.896 That's something that Margret Erlensdottir

00:08:05.896 --> 00:08:08.046 an MD PhD student in biostat is working on.

00:08:08.886 --> 00:08:09.927 - Forrest? - Yes?

00:08:09.927 --> 00:08:11.580 - Can you take a question?

00:08:11.580 --> 00:08:13.033 - Yes, please go ahead.

00:08:15.510 --> 00:08:17.833 - Have you only applied this to Yale New Haven?

00:08:18.960 --> 00:08:21.800 - We have, the model itself is generic.

00:08:21.800 --> 00:08:26.030 This is a good question, but we have calibrated many

00:08:26.030 --> 00:08:30.080 of the length of stay and probability parameters

00:08:30.080 --> 00:08:32.630 based on data that we received from Yale New Haven.

00:08:33.960 --> 00:08:37.800 So in that sense, the dynamics that we present by default

00:08:39.483 --> 00:08:41.070 are specific to Yale New Haven.

00:08:41.070 --> 00:08:44.690 The user has the ability to change all of those parameters,

00:08:44.690 --> 00:08:47.190 so we anticipate that this could be useful

00:08:47.190 --> 00:08:49.850 for hospital systems of any size

00:08:49.850 --> 00:08:51.330 with different patient demographics,

00:08:51.330 --> 00:08:53.453 different age distributions for example.

00:08:54.390 --> 00:08:56.500 So we want it to be as useful as possible,

00:08:56.500 --> 00:08:59.320 but having said all this, the customer in this case,

00:08:59.320 --> 00:09:02.020 was very clearly for us, Yale New Haven

00:09:02.020 --> 00:09:04.207 and they had a very specific need and--

00:09:04.207 --> 00:09:05.890 - Have you had a reaction?

00:09:05.890 --> 00:09:08.188 Did you have an ongoing reaction with the people

00:09:08.188 --> 00:09:10.120 at Yale New Haven who were using this product,

00:09:10.120 --> 00:09:12.560 whether or not it was helping them or was it accurate

00:09:12.560 --> 00:09:15.600 or did they have any complaints about it?

00:09:15.600 --> 00:09:16.433 I'm sure they did.

00:09:16.433 --> 00:09:19.020 Can you tell me about that interaction?

00:09:19.020 --> 00:09:20.173 - Sure, sure.

00:09:21.630 --> 00:09:25.050 I think that they made a few requests of us.

00:09:25.050 --> 00:09:26.630 Some of them were very qualitative.

00:09:26.630 --> 00:09:29.780 They wanted very early to be able to generate reports.

00:09:29.780 --> 00:09:32.560 A lot of the requests were for additional functionality

00:09:32.560 --> 00:09:36.960 rather than additional structure in the OD model

00:09:36.960 --> 00:09:38.724 but they really,

00:09:38.724 --> 00:09:41.420 I think many of the requests were about flexibility

00:09:41.420 --> 00:09:43.840 and granularity in the predictions.

00:09:43.840 --> 00:09:46.140 They wanted to be able to dial in the exact patient

00:09:46.140 --> 00:09:50.470 demographics and the care parameters that were actually

00:09:50.470 --> 00:09:52.050 being implemented at Yale New Haven.

00:09:52.050 --> 00:09:55.203 So we tried to give them that ability and that control.

00:09:57.923 --> 00:09:59.430 I think mostly, successfully.

00:09:59.430 --> 00:10:01.960 We retained some of the generality of the model,

00:10:01.960 --> 00:10:04.950 while allowing users to input the parameters

00:10:04.950 --> 00:10:07.450 that they felt were right for their system.

00:10:07.450 --> 00:10:11.020 In terms of the way it was used at Yale New Haven,

00:10:11.020 --> 00:10:15.190 I think that by the time they asked us for help,

00:10:15.190 --> 00:10:17.540 many of the actual capacity expansions

00:10:17.540 --> 00:10:18.770 had already been implemented.

00:10:18.770 --> 00:10:21.840 I'm talking about taking over high school gymnasia,

00:10:21.840 --> 00:10:24.930 changing the configuration of parking lots

00:10:24.930 --> 00:10:28.003 to provide drive through testing and turning,

00:10:30.482 --> 00:10:33.413 I guess parts of the hospital into ICUs.

00:10:33.413 --> 00:10:34.287 Many of those--

00:10:35.750 --> 00:10:38.210 - You might say that they over expanded a little bit

00:10:38.210 --> 00:10:41.460 since they quickly came not needed capacity.

00:10:41.460 --> 00:10:43.312 So did you help them, saying hey,

00:10:43.312 --> 00:10:45.112 you guys don't need to do that much?

00:10:47.130 --> 00:10:49.950 - I think that based on the projections for population

00:10:49.950 --> 00:10:52.480 level incidence that they were receiving in early

00:10:52.480 --> 00:10:57.480 to mid-April, the capacity expansion was appropriate.

00:10:58.920 --> 00:11:03.170 This model here did not provide

00:11:03.170 --> 00:11:04.500 population level projections,

00:11:04.500 --> 00:11:06.050 which I'll show in a few minutes.

00:11:06.050 --> 00:11:07.130 So we were not telling them

00:11:07.130 --> 00:11:09.853 that they had over expanded capacity.

00:11:11.000 --> 00:11:12.600 I think that at the state level,

00:11:13.470 --> 00:11:16.860 the total hospitalization in the state came very close

00:11:16.860 --> 00:11:21.860 to the preexisting capacity, as it was in early March.

00:11:21.930 --> 00:11:25.590 So I think that there was a big concern that it was unclear

00:11:25.590 --> 00:11:28.500 what the doubling rate of new cases would be.

00:11:28.500 --> 00:11:31.220 We had not yet seen some of the benefits of state lock down

00:11:31.220 --> 00:11:33.240 and closure of schools.

00:11:33.240 --> 00:11:36.999 So the hospital systems were expanding very aggressively,

00:11:36.999 --> 00:11:38.853 I think for good reason.

00:11:39.980 --> 00:11:43.030 - Okay, but they were just doing that by looking at

00:11:44.200 --> 00:11:47.460 the daily or maybe the weekly case counts right,

00:11:47.460 --> 00:11:50.393 and seeing what the doubling rate was and things like that.

00:11:50.393 --> 00:11:52.250 They were doing anything more subtle than that?

00:11:52.250 --> 00:11:55.330 - That is what they were doing when they called us on.

00:11:55.330 --> 00:11:59.570 We tried to give them projections under their own

00:11:59.570 --> 00:12:02.383 in-house assumed doubling rates.

00:12:03.220 --> 00:12:05.950 So we were very interested in showing them when the hospital

00:12:05.950 --> 00:12:08.260 would fill up and under what circumstance

00:12:08.260 --> 00:12:11.513 and how different parts of the hospital would fill up.

00:12:12.730 --> 00:12:14.130 - Okay.

00:12:14.130 --> 00:12:15.970 I'll let you go on.

00:12:15.970 --> 00:12:18.240 - In a few minutes I'll show state level projections

00:12:18.240 --> 00:12:20.290 that might answer some of your questions.

00:12:24.229 --> 00:12:25.062 All right.

00:12:28.320 --> 00:12:30.913 - By the way, I'm John Hardigen, by the way.

00:12:30.913 --> 00:12:32.810 Used to be in the statistics department.

00:12:32.810 --> 00:12:35.057 - Yes, I know, good to see you.

00:12:38.370 --> 00:12:40.060 All right, second project.

00:12:40.060 --> 00:12:44.320 On April 14, so just as we

00:12:46.540 --> 00:12:49.610 finished the most fundamental software development

00:12:49.610 --> 00:12:52.080 on the application that I just showed you,

00:12:52.080 --> 00:12:55.300 on April 14 we were asked to start producing projections

00:12:55.300 --> 00:12:58.425 for the governor's Reopen Connecticut Advisory Panel,

00:12:58.425 --> 00:13:00.210 which was charged with

00:13:01.220 --> 00:13:04.110 making recommendations to the state, to the government,

00:13:04.110 --> 00:13:06.460 to the Department of Public Health

00:13:06.460 --> 00:13:09.440 on how reopening should proceed and what the timeline

00:13:09.440 --> 00:13:12.470 should be and what business sectors could safely reopen

00:13:12.470 --> 00:13:14.138 at which times.

00:13:14.138 --> 00:13:17.180 The panel consisted of public health researchers,

00:13:17.180 --> 00:13:20.433 including Albert Ko and several other people from Yale

00:13:20.433 --> 00:13:23.440 and many business leaders in Connecticut.

00:13:23.440 --> 00:13:24.490 It was a mixed group.

00:13:26.900 --> 00:13:30.650 The panel needed projections at that time of Covid-19

00:13:30.650 --> 00:13:33.140 incidence, hospitalizations and deaths

00:13:33.140 --> 00:13:36.550 under future reopening scenarios, to plan testing expansion,

00:13:36.550 --> 00:13:39.260 seroprevalence studies and most importantly,

00:13:39.260 --> 00:13:43.250 to assess the risk of a second wave of infections.

00:13:43.250 --> 00:13:45.040 So this was in mid-April,

00:13:45.040 --> 00:13:47.740 around the time when hospitalization was peaking.

00:13:47.740 --> 00:13:51.330 Of course, nobody knew exactly at that time

00:13:51.330 --> 00:13:55.370 that the peak was occurring and there was a lot of concern

00:13:55.370 --> 00:13:57.920 that things would continue to get much worse,

00:13:57.920 --> 00:14:00.083 in terms of hospitalization in Connecticut.

00:14:02.812 --> 00:14:04.112 The work of that committee

00:14:06.580 --> 00:14:09.420 advised the governor in his reopening strategy,

00:14:09.420 --> 00:14:11.190 which we've all probably heard about,

00:14:11.190 --> 00:14:14.350 if you're following press releases from the state.

00:14:14.350 --> 00:14:16.840 The state began reopening on May 20th and there's now,

00:14:16.840 --> 00:14:18.960 I think, although the work

00:14:18.960 --> 00:14:22.090 of the advisory panel may be wrapping up,

00:14:22.090 --> 00:14:24.140 there's now an ongoing need for projections

00:14:24.140 --> 00:14:27.810 to inform decision making and epidemiological study design,

00:14:27.810 --> 00:14:30.370 that further informs decision making

00:14:31.970 --> 00:14:34.120 for the Connecticut response and reopening.

00:14:35.550 --> 00:14:37.220 This part that I'll talk about now is joint work

00:14:37.220 --> 00:14:39.693 with Olga Morozova and Richard Li.

00:14:42.280 --> 00:14:46.440 So at the beginning of this project, we had to explain

00:14:46.440 --> 00:14:49.103 to decision makers and members of the advisory panel,

00:14:50.110 --> 00:14:53.980 how data are different from model projections

00:14:53.980 --> 00:14:55.420 and what sort of...

00:14:58.520 --> 00:15:00.840 What the differences between these two products were.

00:15:00.840 --> 00:15:03.020 But I think there is a recognition at that time

00:15:03.020 --> 00:15:05.000 on the part of policy makers and committee members

00:15:05.000 --> 00:15:07.090 that the policy makers have access

00:15:07.090 --> 00:15:10.800 to a real-time data stream, which is very high quality.

00:15:10.800 --> 00:15:13.410 They have access to all sorts of state dashboards

00:15:14.250 --> 00:15:17.580 describing the current state of the Connecticut pandemic.

00:15:17.580 --> 00:15:20.220 They know about hospitalization and bed capacity

00:15:20.220 --> 00:15:23.340 information from the Connecticut Hospital Association.

00:15:23.340 --> 00:15:25.490 They know about test counts and nearly real-time

00:15:25.490 --> 00:15:28.310 case counts, number of tests positive at hospitals

00:15:28.310 --> 00:15:30.350 and in the community.

00:15:30.350 --> 00:15:32.520 They know how many deaths have occurred to attributable

00:15:32.520 --> 00:15:36.620 to Covid-19 or that are suspicious,

00:15:36.620 --> 00:15:38.900 that are possibly related.

00:15:38.900 --> 00:15:41.930 They might have information about excess deaths

00:15:41.930 --> 00:15:44.670 that are not attributed to Covid-19 but are above

00:15:44.670 --> 00:15:48.233 and beyond what you might normally expect in a typical year.

00:15:49.070 --> 00:15:50.540 They have access to all this information.

00:15:50.540 --> 00:15:52.539 They have access to very responsive staff

00:15:52.539 --> 00:15:56.950 and many very smart people working for the state

00:15:56.950 --> 00:15:59.600 Department of Public Health and other state agencies.

00:16:01.626 --> 00:16:04.280 So there might be a sense that policy makers have access

00:16:04.280 --> 00:16:06.550 to all the information and the most timely information

00:16:06.550 --> 00:16:08.350 they could possibly need to make good decisions

00:16:08.350 --> 00:16:09.203 for the state.

00:16:10.390 --> 00:16:12.233 We tried to argue that there was more information

00:16:12.233 --> 00:16:15.480 that they might be able to use constructively

00:16:16.337 --> 00:16:19.110 to guide reopening, and that was information that was not

00:16:19.110 --> 00:16:23.930 directly derived from contemporaneous data streams,

00:16:23.930 --> 00:16:26.710 but rather these would be projections from transmission

00:16:26.710 --> 00:16:28.633 models about possible futures.

00:16:30.440 --> 00:16:32.670 So projections here can tell us about what might

00:16:32.670 --> 00:16:34.400 happen in the future, possible hypothetical

00:16:34.400 --> 00:16:39.130 or counterfactual scenarios to be defined

00:16:39.130 --> 00:16:42.440 by the governor and the outcomes that would occur

00:16:42.440 --> 00:16:43.830 under those reopening scenarios.

00:16:43.830 --> 00:16:47.400 So I'm talking about phases, business sectors,

00:16:47.400 --> 00:16:50.000 reopening back-to-school, what might happen in late August,

00:16:50.000 --> 00:16:51.995 early September, as children go back to school

00:16:51.995 --> 00:16:56.420 or back to summer camp in June and July.

00:16:56.420 --> 00:16:59.510 What might happen under expanded testing

00:16:59.510 --> 00:17:03.000 and contact tracing or continue to modified

00:17:03.000 --> 00:17:04.370 social distancing guidelines.

00:17:04.370 --> 00:17:08.400 Things like wearing masks or keeping six feet apart

00:17:09.821 --> 00:17:11.190 and all of those things.

00:17:11.190 --> 00:17:15.030 So we tried to explain how projections from these types

00:17:15.030 --> 00:17:18.821 of models might be very different from simple plots

00:17:18.821 --> 00:17:23.316 of the data streams that policy makers have access to.

00:17:23.316 --> 00:17:26.370 This is a figure I showed them at the very beginning.

00:17:26.370 --> 00:17:28.080 On the left, we have the number of death,

00:17:28.080 --> 00:17:32.780 I think by early May, that had accumulated in Connecticut.

00:17:32.780 --> 00:17:35.720 These are the red dots on the left hand side.

00:17:35.720 --> 00:17:38.410 On the right hand side, we have a projection of what might

00:17:38.410 --> 00:17:40.420 occur in the future on this day and I think it was

00:17:40.420 --> 00:17:41.870 first week of May.

00:17:41.870 --> 00:17:46.870 Right, and I think this may seem silly as a projection

00:17:46.910 --> 00:17:48.970 exercise or it seems silly to

00:17:52.250 --> 00:17:55.840 make a distinction between data and predictions,

00:17:55.840 --> 00:17:58.650 but it may have useful in the setting to emphasize

00:17:58.650 --> 00:18:01.720 that the real-time data that policy makers were using

00:18:01.720 --> 00:18:03.730 was just the stuff on the left

00:18:03.730 --> 00:18:07.260 and that if one believed the assumptions underlying

00:18:07.260 --> 00:18:09.373 some of these dynamic transmission models,

00:18:10.220 --> 00:18:13.140 that they could be provided with the stuff on the right,

00:18:13.140 --> 00:18:14.380 which would be a projection

00:18:14.380 --> 00:18:16.490 of what might happen in the future.

00:18:16.490 --> 00:18:18.630 Here, I happen to have shown projections starting

00:18:18.630 --> 00:18:23.610 on March 1, just to emphasize sort of how the line follows

00:18:23.610 --> 00:18:26.590 the data points in the projection.

00:18:26.590 --> 00:18:28.570 But the idea is that these projections would come

00:18:28.570 --> 00:18:32.890 with some sort of uncertainty windows or sets

00:18:33.970 --> 00:18:36.213 that would represent, in some sense,

00:18:37.530 --> 00:18:41.400 the most likely possible futures under what we know today

00:18:41.400 --> 00:18:44.490 and what we believe may happen about the future.

00:18:44.490 --> 00:18:46.532 So the-- - May I stop you for a second?

00:18:46.532 --> 00:18:47.380 - Of course. - Forrest.

00:18:50.370 --> 00:18:53.100 First of all, I think you'll agree that the points

00:18:53.100 --> 00:18:54.950 on the line at the left are extremely highly correlated

00:18:54.950 --> 00:18:57.683 with each other, since they're just cumulatives.

00:18:58.790 --> 00:19:00.870 And that's not a good way to show what's happening,

00:19:00.870 --> 00:19:02.360 is to look at cumulatives.

00:19:02.360 --> 00:19:06.122 You have to kind of guess what the derivatives are

00:19:06.122 --> 00:19:07.406 and people aren't so good at that.

00:19:07.406 --> 00:19:10.360 You would be much better off trying to project

00:19:10.360 --> 00:19:12.540 and look at say, the weekly values.

00:19:12.540 --> 00:19:15.220 Certainly can't look at daily values because God knows

00:19:15.220 --> 00:19:16.817 what the daily values goes from,

00:19:16.817 --> 00:19:19.220 but you know, you see in a week they kind of catch up

00:19:19.220 --> 00:19:20.053 with the truth.

00:19:20.053 --> 00:19:22.360 So if you looked at weekly values, you would tell on

00:19:22.360 --> 00:19:23.790 what the present situation was.

00:19:23.790 --> 00:19:26.678 Surely, that's what the hospitals need to know.

00:19:26.678 --> 00:19:29.400 They don't need to know how many people they had

00:19:29.400 --> 00:19:31.180 a long time ago or what the total was.

00:19:31.180 --> 00:19:33.360 They want to know that the present charge is.

00:19:33.360 --> 00:19:35.510 So I would just suggest that the thing you should be

00:19:35.510 --> 00:19:37.900 working on is something closer.

00:19:37.900 --> 00:19:39.760 Can't use daily values, it's too small,

00:19:39.760 --> 00:19:43.090 but a weekly value and then that's what really matters.

00:19:43.090 --> 00:19:44.603 That's the present situation.

00:19:46.158 --> 00:19:48.100 - Certainly and have access to all that information.

00:19:48.100 --> 00:19:50.300 The State Department of Public Health produces

00:19:50.300 --> 00:19:54.275 weekly smoothed and unsmoothed count.

00:19:54.275 --> 00:19:56.040 In fact, daily counts as well.

00:19:56.040 --> 00:19:58.000 They're very volatile.

00:19:58.000 --> 00:19:58.833 They jump up--

00:19:58.833 --> 00:20:01.557 - The daily counts have a huge weekly effect.

00:20:01.557 --> 00:20:03.707 You just don't want to rely on them at all.

00:20:04.580 --> 00:20:06.630 The docs aren't bothered to do things on the weekends

00:20:06.630 --> 00:20:08.270 is my interpretation of it.

00:20:08.270 --> 00:20:10.800 But maybe it's someone not bothering, but whatever it is,

00:20:10.800 --> 00:20:11.970 it's a big weekly effect.

00:20:11.970 --> 00:20:13.540 It's something you don't want to have.

00:20:13.540 --> 00:20:17.230 But if you take a weekly value, that's always averaged out.

00:20:17.230 --> 00:20:19.980 I just think that projecting the future

00:20:19.980 --> 00:20:21.750 and I think you would find there's quite a lot

00:20:21.750 --> 00:20:23.400 more error in that.

00:20:23.400 --> 00:20:25.820 You're getting the benefit of the fact that all this

00:20:25.820 --> 00:20:28.270 is highly correlated but if you were trying to project

00:20:28.270 --> 00:20:31.580 the future, these things would be whoa, of stuff.

00:20:31.580 --> 00:20:32.890 - Yes, totally agree.

00:20:32.890 --> 00:20:36.160 This figure was generated in response to a very specific

00:20:36.160 --> 00:20:39.340 question, which is how many deaths will the state expect

00:20:39.340 --> 00:20:42.410 to have accumulated on a future date.

00:20:42.410 --> 00:20:43.243 - Okay.

00:20:45.210 --> 00:20:46.043 Thanks.

00:20:47.570 --> 00:20:50.100 - Okay, so I wanted to answer this question

00:20:50.100 --> 00:20:54.430 because I hope that you're all wondering about it.

00:20:54.430 --> 00:20:57.660 Does the world need another Covid-19 projection model?

00:20:57.660 --> 00:21:00.300 There are lots of them out there.

00:21:00.300 --> 00:21:04.580 Vary in quality, some from very experienced research groups

00:21:04.580 --> 00:21:07.190 and experienced epidemiologists, some from

00:21:08.580 --> 00:21:11.200 Silicon Valley software developers

00:21:11.200 --> 00:21:13.060 who just learned about regression.

00:21:13.060 --> 00:21:16.820 I don't think that the world needs another Covid-19 model

00:21:16.820 --> 00:21:19.430 at the national or international level.

00:21:19.430 --> 00:21:23.030 But I think Connecticut does for several reasons

00:21:23.030 --> 00:21:25.133 that I wanted to describe briefly here.

00:21:26.650 --> 00:21:28.890 We wanted to develop a scenario analysis tool

00:21:28.890 --> 00:21:31.040 that was responsive to specific questions

00:21:31.040 --> 00:21:33.080 from the Connecticut leadership,

00:21:33.080 --> 00:21:36.903 who were planning to reopen the state.

00:21:37.760 --> 00:21:39.470 We thought there were several reasons that we could add

00:21:39.470 --> 00:21:42.470 some value here, beyond what is provided by some of the more

00:21:42.470 --> 00:21:45.370 generic models that are available

00:21:47.021 --> 00:21:50.300 for national, state and also local projections.

00:21:50.300 --> 00:21:52.870 The first thing is access to epidemiologists

00:21:52.870 --> 00:21:54.190 at the School of Public Health

00:21:54.190 --> 00:21:56.810 and in the Public Health Modeling Unit.

00:21:56.810 --> 00:21:58.550 We have pretty unique access to data

00:21:58.550 --> 00:22:00.580 from the Connecticut Hospital Association

00:22:00.580 --> 00:22:04.623 on the bed capacity and bed occupancy throughout the state.

00:22:06.380 --> 00:22:09.850 We can use information on individual patient trajectories

00:22:09.850 --> 00:22:11.760 through the healthcare system from using data

00:22:11.760 --> 00:22:12.873 from Yale New Haven.

00:22:14.350 --> 00:22:17.520 We have access to empirical epidemiological studies

00:22:17.520 --> 00:22:20.660 from Yale emerging infections program and data streams

00:22:20.660 --> 00:22:23.360 from the Department of Public Health through Yale EIP.

00:22:24.940 --> 00:22:27.990 We have connection to the people who are running

00:22:27.990 --> 00:22:30.400 the testing and seroprevalence studies

00:22:30.400 --> 00:22:33.710 to be conducted in the future and the model projections

00:22:33.710 --> 00:22:37.660 that we produce will be very closely tied

00:22:37.660 --> 00:22:39.210 to the conduct of those studies.

00:22:39.210 --> 00:22:42.110 Some of them can give information that we can use

00:22:42.110 --> 00:22:43.980 for calibrating the model, and in turn,

00:22:43.980 --> 00:22:45.690 we can use model projections

00:22:47.582 --> 00:22:50.630 to provide preliminary estimates of say,

00:22:50.630 --> 00:22:55.560 cumulative incidence of Covid-19 for study planning,

00:22:55.560 --> 00:22:57.733 in order to do sample size calculations.

00:23:00.470 --> 00:23:04.190 And of course, we are hoping to be able to help

00:23:04.190 --> 00:23:06.060 with the Department of Public Health's

00:23:07.180 --> 00:23:10.150 implementation of optimal testing and sampling strategies

00:23:10.150 --> 00:23:13.037 as they look for new cases and try to control outbreaks

00:23:13.037 --> 00:23:15.633 that may occur in the future in Connecticut.

00:23:19.800 --> 00:23:21.510 So the modeling principle here,

00:23:21.510 --> 00:23:24.761 this is an infections disease model that I'm gonna show you.

00:23:24.761 --> 00:23:28.960 It's not a model for hospital

00:23:28.960 --> 00:23:31.080 patient flow through hospitals.

00:23:31.080 --> 00:23:34.940 But I think in introducing this to people who have not seen

00:23:34.940 --> 00:23:38.450 these models before, the operating principle

00:23:38.450 --> 00:23:40.550 is that of mass action.

00:23:40.550 --> 00:23:43.730 I think if mathematical infectious disease epidemiology

00:23:43.730 --> 00:23:46.710 has a central dogma or a single principle that governs

00:23:46.710 --> 00:23:51.000 the structure of quantitative models for infections,

00:23:51.000 --> 00:23:53.870 it's something like the Law of Mass Action,

00:23:53.870 --> 00:23:57.240 that in a small time interval, the number of new cases

00:23:57.240 --> 00:24:00.930 that accrue is proportional to the number of ways

00:24:00.930 --> 00:24:05.070 that susceptible individuals and infectious individuals

00:24:05.070 --> 00:24:06.243 can come together.

00:24:07.350 --> 00:24:09.340 This means that new cases or incidences

00:24:09.340 --> 00:24:11.300 is driven by the product of--

00:24:11.300 --> 00:24:13.810 Or sorry, I should have said the product of susceptibles

00:24:13.810 --> 00:24:17.889 and infectives or the number of ways that people

00:24:17.889 --> 00:24:20.220 susceptible individual can come into contact

00:24:20.220 --> 00:24:21.663 with an infected person.

00:24:22.570 --> 00:24:26.500 This general principle is what underlies all transmission

00:24:26.500 --> 00:24:29.130 models and many transmission models are compartmentalized

00:24:29.130 --> 00:24:32.520 or they are separated in space and geography

00:24:32.520 --> 00:24:35.560 or by age group or by different risk categories,

00:24:35.560 --> 00:24:37.700 but this is the essential principle.

00:24:37.700 --> 00:24:40.700 That new cases of a certain type and a certain place

00:24:40.700 --> 00:24:45.050 arise at a rate that is proportional to the product

00:24:45.050 --> 00:24:47.250 of the number of susceptibles and infectives.

00:24:47.250 --> 00:24:49.800 The number of ways that disease can be transmitted.

00:24:52.530 --> 00:24:55.990 So we have divided the population of Connecticut

00:24:55.990 --> 00:24:58.650 into many compartments.

00:24:58.650 --> 00:25:00.930 Those who have not had the disease,

00:25:00.930 --> 00:25:02.870 those who are susceptible,

00:25:02.870 --> 00:25:05.760 those who have been infected,

00:25:05.760 --> 00:25:08.410 they are exposed but not yet infectious.

00:25:08.410 --> 00:25:11.490 So they don't have symptoms.

00:25:11.490 --> 00:25:14.480 Those who are infectious but remain asymptomatic,

00:25:14.480 --> 00:25:15.670 those with mild symptoms.

00:25:15.670 --> 00:25:16.503 They know they're sick

00:25:16.503 --> 00:25:19.230 but they do not require hospitalization.

00:25:19.230 --> 00:25:22.853 Those with severe symptoms who do require hospitalization.

00:25:23.871 --> 00:25:27.970 Those who have mild symptoms but are successfully isolated

00:25:27.970 --> 00:25:31.060 because they realized they have symptoms or they got

00:25:32.960 --> 00:25:35.540 a viral test that told them that they are infected.

00:25:35.540 --> 00:25:37.930 So they successful isolate themselves.

00:25:37.930 --> 00:25:41.850 Those people with severe disease who are hospitalized,

00:25:41.850 --> 00:25:44.550 those who have severe disease but remain unhospitalized

00:25:44.550 --> 00:25:46.513 because there's no space for them.

00:25:47.490 --> 00:25:50.330 This is very important in projecting deaths in the future

00:25:50.330 --> 00:25:53.603 scenario, in which we run out of hospital capacity.

00:25:55.260 --> 00:25:57.627 Then we have severe institutionalized populations,

00:25:57.627 --> 00:25:58.890 who are not in the hospital,

00:25:58.890 --> 00:26:03.290 such as people in nursing homes, correctional institutions

00:26:03.290 --> 00:26:06.370 and other long-term care facilities.

00:26:06.370 --> 00:26:08.920 Those who have been infected but did not die

00:26:08.920 --> 00:26:12.170 and are now recovered or successfully isolated

00:26:12.170 --> 00:26:14.483 and recovering and those who have died.

00:26:15.340 --> 00:26:18.310 So the idea here is to divide up the population

00:26:18.310 --> 00:26:22.000 of Connecticut into a number of people

00:26:22.000 --> 00:26:23.500 in each of these compartments.

00:26:27.620 --> 00:26:30.290 The model that we put together is a variation

00:26:30.290 --> 00:26:35.290 on the susceptible exposed infected and removed model.

00:26:37.570 --> 00:26:41.980 We divide up the infectious individuals into three

00:26:41.980 --> 00:26:44.370 categories that I told you about, severe, mild

00:26:44.370 --> 00:26:46.620 and asymptomatic infections.

00:26:46.620 --> 00:26:48.580 We have two different types of patients

00:26:48.580 --> 00:26:50.073 who need hospitalization.

00:26:51.440 --> 00:26:53.133 We have unhospitalized patients.

00:26:54.860 --> 00:26:57.380 We can remove patients by isolating them

00:26:57.380 --> 00:27:01.460 and they can recover after some amount of time,

00:27:01.460 --> 00:27:03.800 if they do not die.

00:27:03.800 --> 00:27:06.853 This is the basic structure of the SEIR model.

00:27:09.360 --> 00:27:12.000 The usual model structure is just this linear part,

00:27:12.000 --> 00:27:15.250 SEI and then R.

00:27:15.250 --> 00:27:18.183 We divided up into these additional components,

00:27:19.140 --> 00:27:21.250 not because we believed that these components

00:27:21.250 --> 00:27:24.700 cover every possible scenario or every possible type

00:27:24.700 --> 00:27:28.420 of illness or state of the world or state of patients,

00:27:28.420 --> 00:27:30.580 but because this is the most parsimonious model

00:27:30.580 --> 00:27:34.000 that we can think of that captures the dynamics

00:27:34.000 --> 00:27:37.580 of infection that are most likely to lead to the outcomes

00:27:37.580 --> 00:27:40.180 that a state government cares most about.

00:27:40.180 --> 00:27:44.130 Those are state-level hospitalizations and deaths

00:27:44.130 --> 00:27:46.543 and possibly cumulative incidents.

00:27:47.740 --> 00:27:50.600 Right, so this model is not intended to capture

00:27:50.600 --> 00:27:54.750 every biological or epidemiological feature of Covid-19

00:27:54.750 --> 00:27:56.640 transmission in Connecticut.

00:27:56.640 --> 00:28:00.050 Rather, it is the simplest model that captures the features

00:28:00.050 --> 00:28:02.563 that policy makers care most about.

00:28:05.870 --> 00:28:08.063 It's also structured by geography.

00:28:10.140 --> 00:28:12.770 We found that the...

00:28:13.976 --> 00:28:16.770 We looked at information about travel and commuting patterns

00:28:16.770 --> 00:28:18.400 throughout the state to look at where people

00:28:18.400 --> 00:28:20.941 might be mixing, where they live, where they work,

00:28:20.941 --> 00:28:22.400 others things like that.

00:28:22.400 --> 00:28:25.640 But we found that that information did not give us

00:28:25.640 --> 00:28:28.220 much more information than simple adjacency matrix

00:28:28.220 --> 00:28:32.880 of counties in the state.

00:28:32.880 --> 00:28:36.260 We're well aware that many people in Connecticut

00:28:37.590 --> 00:28:40.850 work or commute or travel often to New York City area.

00:28:40.850 --> 00:28:45.130 We'll try to accommodate that in the model

00:28:45.130 --> 00:28:47.030 or in our interpretation of the model.

00:28:48.340 --> 00:28:53.340 Rather, the adjacency matrix of counties in Connecticut

00:28:53.580 --> 00:28:55.350 gives us much of the information that we use

00:28:55.350 --> 00:29:00.350 for the geographically dependent nature of transmission.

00:29:03.780 --> 00:29:04.780 Basic idea--

00:29:04.780 --> 00:29:06.760 - Rhode Island and Massachusetts

00:29:06.760 --> 00:29:08.570 aren't doing too good either.

00:29:08.570 --> 00:29:10.563 - They're not doing well, I agree.

00:29:12.180 --> 00:29:17.180 To avoid turning this into a very granular or national model

00:29:18.670 --> 00:29:21.530 we are going to treat the exogenous force of infection

00:29:21.530 --> 00:29:25.333 experience by Connecticut residents as something else.

00:29:27.980 --> 00:29:30.710 So we sort of imagined that it is

00:29:30.710 --> 00:29:32.870 subsumed into the force of infection experience

00:29:32.870 --> 00:29:34.610 by everyone in Connecticut.

00:29:34.610 --> 00:29:38.080 I agree, both a lot of infections

00:29:38.080 --> 00:29:41.610 and a lot of heterogeneity outside of Connecticut

00:29:41.610 --> 00:29:42.793 in bordering states.

00:29:45.200 --> 00:29:48.213 So most of this we don't specifically take into account.

00:29:50.470 --> 00:29:53.950 The basic idea here, I'm just showing two compartments

00:29:53.950 --> 00:29:58.500 of the ODE system, the basic idea is that in county I,

00:29:58.500 --> 00:30:01.890 the number of susceptibles or the rate of new infections

00:30:01.890 --> 00:30:06.890 is governed by the number of infectious individuals

00:30:06.930 --> 00:30:09.990 in that county and the number of infectious individuals

00:30:09.990 --> 00:30:11.463 in neighboring counties.

00:30:12.740 --> 00:30:17.330 Here in beta is the transmission rate of infection.

00:30:17.330 --> 00:30:21.540 So individuals who are susceptible transition to the exposed

00:30:21.540 --> 00:30:24.850 infectious state and then to other states down the road.

00:30:24.850 --> 00:30:27.950 But these are sort of the mass action equations

00:30:27.950 --> 00:30:30.410 for a heterogeneous population in which the force

00:30:30.410 --> 00:30:34.230 of infection is coming from outside and within

00:30:34.230 --> 00:30:35.473 individual counties.

00:30:38.745 --> 00:30:41.592 I'm not going to go into a great deal of detail

00:30:41.592 --> 00:30:46.592 about the system of ODs that is most useful here.

00:30:47.780 --> 00:30:49.700 I'll just say that we solve in numerically.

00:30:49.700 --> 00:30:53.260 It's a system of 11 differential equations

00:30:53.260 --> 00:30:56.060 given the parameters, which I'm just gonna bundle into

00:30:56.060 --> 00:30:57.313 a vector theta.

00:30:58.220 --> 00:31:01.220 Let Y of T given theta, be the solution to the OD system

00:31:01.220 --> 00:31:02.910 at time T with parameters theta.

00:31:02.910 --> 00:31:06.590 You can solve this system with pretty good accuracy

00:31:06.590 --> 00:31:08.703 using modern OD solvers.

00:31:09.660 --> 00:31:11.330 This solution--

00:31:11.330 --> 00:31:12.910 - They're just linear equations, are they?

00:31:12.910 --> 00:31:13.833 Linear right?

00:31:14.730 --> 00:31:17.990 - They're non-linear in the right hand side

00:31:17.990 --> 00:31:21.230 is non-linear in the other model compartments.

00:31:21.230 --> 00:31:23.530 Right, that's what mass action is.

00:31:23.530 --> 00:31:26.110 It's proportional to the product.

00:31:26.110 --> 00:31:31.110 So OD is proportional to the product of S and I.

00:31:31.176 --> 00:31:32.546 So it's--

00:31:32.546 --> 00:31:34.710 - On the other hand, you agree that S doesn't change much

00:31:34.710 --> 00:31:39.410 because unless you've got a very fully infected population,

00:31:39.410 --> 00:31:41.170 S doesn't change that much.

00:31:41.170 --> 00:31:42.320 You've got--

00:31:42.320 --> 00:31:45.330 - S is most quickly when infections are increasing

00:31:45.330 --> 00:31:48.130 most quickly and Connecticut right now,

00:31:48.130 --> 00:31:49.870 S is still pretty large.

00:31:49.870 --> 00:31:54.870 I think cumulative incidence is between 5% and 15%.

00:31:54.920 --> 00:31:56.772 So S has not changed.

00:31:56.772 --> 00:31:59.400 - S is 85% and is gonna change.

00:31:59.400 --> 00:32:02.200 I'm just making it linear for myself, that's all.

00:32:02.200 --> 00:32:04.270 - Sure, yeah.

00:32:04.270 --> 00:32:08.000 So right now S has not decreased that much.

00:32:08.000 --> 00:32:12.920 You know, between, it's still at 95% to maybe 85%,

00:32:12.920 --> 00:32:13.920 something like that.

00:32:14.778 --> 00:32:16.920 As the pandemic progresses and into the fall,

00:32:16.920 --> 00:32:18.840 if there's another resurgence of infections,

00:32:18.840 --> 00:32:22.100 we will expect S to change quite a lot more.

00:32:22.100 --> 00:32:25.310 If it changes a lot, then we'll be in herd immunity

00:32:25.310 --> 00:32:27.889 territory where depletion of susceptibles

00:32:27.889 --> 00:32:30.780 plays a prominent role in altering the dynamics

00:32:31.680 --> 00:32:34.010 of the pandemic, but we're not there yet.

00:32:34.010 --> 00:32:36.110 - But I am right in thinking that this is linear,

00:32:36.110 --> 00:32:37.710 it's really just a matrix problem isn't it,

00:32:37.710 --> 00:32:39.060 that we have to solve.

00:32:39.060 --> 00:32:41.470 - If it were linear it would be a matrix problem.

00:32:41.470 --> 00:32:42.303 - Yeah, okay.

00:32:43.800 --> 00:32:45.243 - Right. - Yeah.

00:32:47.470 --> 00:32:51.063 - So this system is a deterministic system.

00:32:52.490 --> 00:32:54.970 Engineers, mostly and some epidemiologists,

00:32:54.970 --> 00:32:57.740 have been thinking for a very long time about principled

00:32:57.740 --> 00:33:01.590 ways of estimating parameters for deterministic system.

00:33:01.590 --> 00:33:03.650 Unfortunately, for models of this type,

00:33:03.650 --> 00:33:05.970 which is generally the case in infectious disease

00:33:05.970 --> 00:33:10.650 epidemiology, there are some serious

00:33:10.650 --> 00:33:11.483 identifiability problems.

00:33:11.483 --> 00:33:14.310 Not all parameters can be uniquely estimated from the data

00:33:15.708 --> 00:33:17.910 or infinitely many combinations of parameters

00:33:17.910 --> 00:33:20.833 that appear to fit equally well.

00:33:23.050 --> 00:33:24.820 We only observe in this case,

00:33:24.820 --> 00:33:26.910 the hospitalization and death compartments.

00:33:26.910 --> 00:33:30.140 There's some information from PCR testing

00:33:30.140 --> 00:33:33.590 about the prevalence of infection at different times,

00:33:33.590 --> 00:33:36.220 but because the testing strategy in Connecticut

00:33:36.220 --> 00:33:38.570 and elsewhere has varied so dramatically

00:33:39.520 --> 00:33:42.370 over the last few months, we didn't feel like we could use

00:33:42.370 --> 00:33:46.770 any information from testing alone to inform the sizes

00:33:46.770 --> 00:33:49.543 of the currently infected compartments.

00:33:50.680 --> 00:33:53.950 So basically, we're trying to estimate many parameters

00:33:53.950 --> 00:33:58.950 for a system with 11 components using only the time series

00:33:59.170 --> 00:34:02.060 of hospitalizations and deaths.

00:34:02.060 --> 00:34:04.450 So it's quite challenging and in practice,

00:34:04.450 --> 00:34:08.060 this necessitates taking parameter values

00:34:08.060 --> 00:34:09.850 from the literature, from clinical studies,

00:34:09.850 --> 00:34:12.680 from our knowledge of how hospitals treat patients

00:34:13.970 --> 00:34:18.350 and also using a statistical estimation scheme

00:34:18.350 --> 00:34:22.227 to learn about elements of theta, of the unknown parameters.

00:34:22.227 --> 00:34:26.010 I wish that I could give you a more coherent statistical

00:34:26.010 --> 00:34:30.900 inference strategy in which all of the parameters

00:34:30.900 --> 00:34:33.530 were learned from the data and I could tell you

00:34:33.530 --> 00:34:36.010 that they were being consistently estimated

00:34:36.010 --> 00:34:38.680 and that as the epidemic went on, we would get more and more

00:34:38.680 --> 00:34:41.340 precise estimates of each of those parameters.

00:34:41.340 --> 00:34:42.840 Unfortunately, it's just not true.

00:34:42.840 --> 00:34:46.370 That the model structure that we need here to be able

00:34:46.370 --> 00:34:47.210 to accommodate

00:34:51.143 --> 00:34:53.940 the structure of the pandemic is more complicated

00:34:53.940 --> 00:34:57.780 than the model structure that we could possibly identify

00:34:58.910 --> 00:35:01.270 non-parametrically or semi-parametrically

00:35:01.270 --> 00:35:03.123 or even in this parametric model.

00:35:04.580 --> 00:35:05.890 So I just wanted to give you some examples

00:35:05.890 --> 00:35:08.260 of how people do this in practice.

00:35:08.260 --> 00:35:09.880 These are not exactly endorsements

00:35:09.880 --> 00:35:12.400 of statistical frameworks.

00:35:12.400 --> 00:35:14.370 The basic idea is that given theta,

00:35:14.370 --> 00:35:17.210 we can solve the ODE system, it gives us deterministic

00:35:17.210 --> 00:35:21.050 solutions at time points where we have an observation

00:35:21.050 --> 00:35:22.940 and then calibration or statistical inference

00:35:22.940 --> 00:35:25.690 essentially amounts to minimizing a loss criteria

00:35:25.690 --> 00:35:30.690 and are comparing the observed values to model predictions.

00:35:30.750 --> 00:35:33.630 The two frameworks that are most frequently used here

00:35:33.630 --> 00:35:37.042 are imposing a normal errors or gaussian errors,

00:35:37.042 --> 00:35:39.459 almost normal gaussian errors

00:35:40.539 --> 00:35:43.670 or equivalently minimizing at least squares type

00:35:43.670 --> 00:35:48.670 of loss function or doing this plus on maximum likelihood

00:35:48.880 --> 00:35:50.750 estimation for elements of theta

00:35:50.750 --> 00:35:52.573 that you can identify in this way.

00:35:53.425 --> 00:35:57.730 I think in this project we used

00:35:57.730 --> 00:35:59.293 the Poisson maximum likelihood.

00:36:00.520 --> 00:36:02.937 There are many things about this, one of which is that

00:36:02.937 --> 00:36:06.090 a Poisson random variable could take values

00:36:06.090 --> 00:36:08.400 that are larger than the size of the population.

00:36:08.400 --> 00:36:10.470 In practice here, that's not what occurs

00:36:11.790 --> 00:36:14.550 because the number of infections here is small,

00:36:14.550 --> 00:36:17.870 but this is basically a framework for doing a type

00:36:17.870 --> 00:36:20.510 of statistical inference or learning about

00:36:22.374 --> 00:36:24.540 a posterior distribution on parameters

00:36:24.540 --> 00:36:27.030 from a model, which gives deterministic predictions

00:36:27.030 --> 00:36:29.530 and which doesn't have any inherent stochasticity.

00:36:31.200 --> 00:36:33.010 The procedure that we used here, which I'm not gonna

00:36:33.010 --> 00:36:35.610 talk about in great detail here, was developed

00:36:35.610 --> 00:36:39.020 by postdoc Olga, is a hybrid approach that fixes

00:36:39.020 --> 00:36:42.190 some parameters and imposes uncertainty distributions

00:36:42.190 --> 00:36:46.000 on them from our prior knowledge and the literature

00:36:46.000 --> 00:36:48.660 and conducts Bayesian posterior inference

00:36:48.660 --> 00:36:51.240 on known parameters and initial conditions.

00:36:51.240 --> 00:36:53.597 So we try to learn jointly about parameter--

00:36:54.620 --> 00:36:55.924 Yes go.

00:36:55.924 --> 00:36:57.730 - Forrest, there's a question people always ask of this

00:36:57.730 --> 00:36:59.630 whenever I give a talk like this,

00:36:59.630 --> 00:37:01.880 how do you determine your prior distribution?

00:37:03.420 --> 00:37:05.840 - In this case, I would say we're in a very good position

00:37:05.840 --> 00:37:09.443 to interpret priors as literally being prior beliefs.

00:37:10.640 --> 00:37:14.390 We have for example, point estimates and confidence

00:37:14.390 --> 00:37:16.623 intervals from published studies.

00:37:18.940 --> 00:37:21.710 We also have parameters which are intrinsic to the model

00:37:21.710 --> 00:37:24.230 but for which we have very little information.

00:37:24.230 --> 00:37:27.410 So we assign to them, what we believe qualitatively,

00:37:27.410 --> 00:37:31.490 to be an appropriate representation of our uncertainty

00:37:31.490 --> 00:37:33.430 or ignorance about those parameters

00:37:33.430 --> 00:37:35.237 under the parametrization.

00:37:36.464 --> 00:37:38.179 But to your question--

00:37:38.179 --> 00:37:41.590 - What you believe to be true then, is that right?

00:37:41.590 --> 00:37:42.830 - Oh certainly.

00:37:42.830 --> 00:37:45.650 It is a mixture of what other people believe to be true

00:37:45.650 --> 00:37:47.530 and what we believe to be true as well.

00:37:47.530 --> 00:37:49.310 So I would take a subject of interpretation

00:37:49.310 --> 00:37:50.403 to the priors here.

00:37:52.180 --> 00:37:56.250 They are subjective in the sense that we believe

00:37:56.250 --> 00:37:58.672 these uncertainty distributions.

00:37:58.672 --> 00:38:01.620 They are quantitative in the sense in that

00:38:01.620 --> 00:38:03.670 some of them come from published studies.

00:38:06.463 --> 00:38:10.890 - Okay, I'm sorry, I do just a little bit longer.

00:38:10.890 --> 00:38:13.310 You know, I know you've got a lot of parameters in here,

00:38:13.310 --> 00:38:15.270 many of which I don't know anything about,

00:38:15.270 --> 00:38:17.840 but I suspect the very important one is parameter

00:38:17.840 --> 00:38:22.203 which says what is the ratio of new cases,

00:38:23.650 --> 00:38:26.046 assuming that susceptibility isn't changing

00:38:26.046 --> 00:38:28.280 to the infection rate, right.

00:38:28.280 --> 00:38:29.560 What's the...

00:38:29.560 --> 00:38:30.460 That's the number,

00:38:31.830 --> 00:38:34.470 that ratio is an important ratio.

00:38:34.470 --> 00:38:38.080 New cases against the number that are infected

00:38:38.080 --> 00:38:41.840 and that number out to extract is an important number

00:38:41.840 --> 00:38:44.360 because it changes a lot, according to the conditions

00:38:44.360 --> 00:38:45.550 that the government sets.

00:38:45.550 --> 00:38:48.423 Changes all the time because you're trying to reduce

00:38:48.423 --> 00:38:50.410 contacts and effectively reducing that contacts

00:38:50.410 --> 00:38:52.100 is to change that ratio.

00:38:52.100 --> 00:38:54.960 I assume that that's built into the model somehow,

00:38:54.960 --> 00:38:56.930 but I would think you probably don't know very much

00:38:56.930 --> 00:39:00.130 about how the government's policies and whatever

00:39:00.130 --> 00:39:01.996 are gonna change that ratio.

00:39:01.996 --> 00:39:04.110 So if you said you know, I know it's gonna be a month

00:39:04.110 --> 00:39:06.460 from now, I'd say no you don't.

00:39:06.460 --> 00:39:08.160 - Oh sure. - Yeah.

00:39:08.160 --> 00:39:09.540 So how do you handle it?

00:39:09.540 --> 00:39:13.890 - We certainly do parametrize that rate,

00:39:13.890 --> 00:39:16.030 that is the transmission rate that you were talking about.

00:39:16.030 --> 00:39:18.530 It's the parameter that multiples the product

00:39:18.530 --> 00:39:20.137 of the number of susceptibles

00:39:20.137 --> 00:39:22.940 and the number of infectious individuals.

00:39:22.940 --> 00:39:24.900 That's called beta in the model.

00:39:24.900 --> 00:39:26.453 Beta does change over time.

00:39:27.370 --> 00:39:32.370 It's parametrized as a sum of step functions.

00:39:33.110 --> 00:39:36.130 Those step functions change in their value

00:39:36.130 --> 00:39:41.130 around when the governor closes schools, which happened,

00:39:41.890 --> 00:39:45.370 I think on March 25th and when the governor--

00:39:45.370 --> 00:39:47.680 Or sorry, a little bit earlier, maybe March 20th,

00:39:47.680 --> 00:39:48.960 I can't remember.

00:39:48.960 --> 00:39:51.880 Then when the governor issued the stay at home order,

00:39:51.880 --> 00:39:55.710 the stay safe stay at home order,

00:39:55.710 --> 00:39:57.843 which I think took effect on the 23rd.

00:39:58.682 --> 00:40:01.730 So those step functions are in the model for historical

00:40:01.730 --> 00:40:04.100 interventions that were implemented by the state.

00:40:04.100 --> 00:40:06.940 For future interventions which are implemented by the state,

00:40:06.940 --> 00:40:07.773 we are guessing.

00:40:08.630 --> 00:40:11.330 Fortunately, we are guessing using information

00:40:11.330 --> 00:40:14.450 from the people who will actually make those decisions.

00:40:14.450 --> 00:40:19.450 So I will show how we assume that that transmission rate

00:40:19.700 --> 00:40:23.250 or contact rate might change in the future

00:40:23.250 --> 00:40:26.030 under guidelines expressed by the governor

00:40:26.030 --> 00:40:27.820 and policy makers.

00:40:27.820 --> 00:40:29.020 Right, so in the future of course,

00:40:29.020 --> 00:40:30.950 I don't know what going to actually occur.

00:40:30.950 --> 00:40:32.650 The best I can do is ask the people

00:40:32.650 --> 00:40:34.980 who will implement the change.

00:40:34.980 --> 00:40:36.073 - All right, well.

00:40:37.230 --> 00:40:38.800 I'm sorry, this is my last remark.

00:40:38.800 --> 00:40:41.550 I won't keep on doing this, but I would think that

00:40:41.550 --> 00:40:43.400 these rates that we're talking about,

00:40:43.400 --> 00:40:45.380 which seems to be are really critical to what happens

00:40:45.380 --> 00:40:49.150 in the model, that you and find invasion inferency

00:40:49.150 --> 00:40:52.400 you have to give a plausible, defensible probability

00:40:52.400 --> 00:40:55.150 for them, which I would find hard to do,

00:40:55.150 --> 00:40:57.550 and I also find it hard to do because I know that those

00:40:57.550 --> 00:40:59.910 rates differ huge amount in Connecticut

00:40:59.910 --> 00:41:02.930 between the different counties, that you can just see

00:41:02.930 --> 00:41:05.320 if you look at what's happening in different counties.

00:41:05.320 --> 00:41:08.490 Those rates are different because different

00:41:09.803 --> 00:41:10.636 amount of separation and different amount

00:41:11.533 --> 00:41:13.026 of personal contact.

00:41:13.026 --> 00:41:13.982 - Sure.

00:41:13.982 --> 00:41:16.200 - I think so kind of do that on an average way

00:41:16.200 --> 00:41:19.090 of all the counties, seven or eight of them,

00:41:19.090 --> 00:41:22.830 you'd think you at least got a vary among the counties

00:41:22.830 --> 00:41:24.730 and have some number among the counties.

00:41:24.730 --> 00:41:26.690 Then if there's a change of policy from the governor,

00:41:26.690 --> 00:41:29.000 there'd be a change in sum or expected you need

00:41:29.000 --> 00:41:30.740 to have that built in somehow here.

00:41:30.740 --> 00:41:32.087 - Certainly.

00:41:32.087 --> 00:41:36.890 In this work, I guess in all policy-relevant work,

00:41:36.890 --> 00:41:39.450 there is a constant tension between the need

00:41:40.747 --> 00:41:42.983 for parsimony and parametrization

00:41:45.028 --> 00:41:48.230 and the need for these rich ways

00:41:48.230 --> 00:41:50.563 of accommodating heterogeneity.

00:41:51.860 --> 00:41:55.350 What we have found in this setting is that we lacked

00:41:55.350 --> 00:41:58.049 the information or data to be able to separately

00:41:58.049 --> 00:42:02.350 parametrize transmission rates at the county level

00:42:03.750 --> 00:42:07.040 but that we can capture the aggregate number of cases,

00:42:07.040 --> 00:42:09.060 hospitalizations and other relevant outcomes

00:42:09.060 --> 00:42:11.683 at the state level by averaging over them.

00:42:12.540 --> 00:42:15.260 The reason is because the counties themselves

00:42:15.260 --> 00:42:18.500 have very different incidence, which actually does explain

00:42:18.500 --> 00:42:22.420 quite a lot in the differing trajectories

00:42:22.420 --> 00:42:24.540 of case counts and hospitalizations and deaths

00:42:24.540 --> 00:42:25.540 within the counties.

00:42:30.120 --> 00:42:32.260 - Hi Forrest thank you, this is very interesting.

00:42:32.260 --> 00:42:33.170 This is Donna.

00:42:33.170 --> 00:42:35.110 I have a question.

00:42:35.110 --> 00:42:36.849 Do you have, the para--

00:42:36.849 --> 00:42:37.682 Hi.

00:42:37.682 --> 00:42:41.480 Are the parameters identifiable without Bayesian priors

00:42:41.480 --> 00:42:46.110 or just from the data that we have or do you need

00:42:46.110 --> 00:42:49.130 the priors in order to estimate the parameters?

00:42:49.130 --> 00:42:51.880 - A subset of parameters is uniquely identifiable

00:42:51.880 --> 00:42:55.290 by maximum likelihood or is point identified.

00:42:55.290 --> 00:42:58.383 But really speaking, the answer to your question is no.

00:42:59.280 --> 00:43:03.720 There are infinitely many combinations of parameters,

00:43:03.720 --> 00:43:07.400 which fit any given loss function criteria equally well.

00:43:07.400 --> 00:43:09.316 So we do need parameters here.

00:43:09.316 --> 00:43:11.870 It is unfortunate and I think--

00:43:11.870 --> 00:43:12.893 Yeah, go ahead.

00:43:14.800 --> 00:43:15.790 - Priors you mean.

00:43:17.330 --> 00:43:20.500 Do you know like what's the simplest possible model

00:43:20.500 --> 00:43:22.770 that's just identifiable from the data

00:43:22.770 --> 00:43:26.410 and is that model useful at all or is it so simple

00:43:26.410 --> 00:43:28.656 that it's not even helpful?

00:43:28.656 --> 00:43:31.370 - Two parts to that question, the simplest model

00:43:31.370 --> 00:43:34.280 that is identifiable from the data is probably one in which

00:43:34.280 --> 00:43:38.560 there is no heterogeneity in types of infection,

00:43:38.560 --> 00:43:40.030 no asymptomatic infection.

00:43:40.030 --> 00:43:42.090 We just lump all those people together

00:43:42.090 --> 00:43:44.730 and there's only one kind of hospitalization

00:43:44.730 --> 00:43:46.630 and people just transition, a certain proportion

00:43:46.630 --> 00:43:48.500 of people transition to hospitalization.

00:43:48.500 --> 00:43:52.843 That model is probably, has all the parameters identified.

00:43:55.720 --> 00:43:57.373 And no, it's not useful.

00:43:59.650 --> 00:44:02.710 That seems to be what we have found.

00:44:02.710 --> 00:44:04.690 But I would say, I think there are two kinds

00:44:04.690 --> 00:44:05.523 of usefulness, right.

00:44:05.523 --> 00:44:08.620 One is answering the questions that policy makers have

00:44:08.620 --> 00:44:12.350 and the other one is what Charles Manski calls credibility,

00:44:12.350 --> 00:44:15.510 that there is a need to take into account

00:44:15.510 --> 00:44:18.090 known heterogeneity and known mechanisms

00:44:19.587 --> 00:44:21.160 when we construct these models.

00:44:21.160 --> 00:44:24.040 So if I produce a useful projection that a policy maker

00:44:24.040 --> 00:44:28.460 likes but I have not separated out asymptomatic infections,

00:44:28.460 --> 00:44:31.840 then the numbers that I'm producing may become less,

00:44:31.840 --> 00:44:33.620 regarded as less credible, right.

00:44:33.620 --> 00:44:37.610 There's always this rhetorical function of modeling

00:44:37.610 --> 00:44:40.480 beyond the numbers that are being produced,

00:44:40.480 --> 00:44:43.990 to being able to accommodate or capture known mechanisms

00:44:43.990 --> 00:44:46.020 by which data are generated

00:44:47.559 --> 00:44:50.250 is one way that we can produce more believable

00:44:50.250 --> 00:44:53.100 and actionable projections, right.

00:44:53.100 --> 00:44:54.800 So I think there's this balance right,

00:44:54.800 --> 00:44:59.800 between parsimony and richness and also this balance between

00:45:02.550 --> 00:45:06.910 simplicity and believability of the assumptions.

00:45:06.910 --> 00:45:09.350 So here we tried to you know, strike that balance.

00:45:09.350 --> 00:45:14.250 If you think we've done it wrong, then please let us know.

00:45:14.250 --> 00:45:15.914 - No, I definitely don't think you did it wrong,

00:45:15.914 --> 00:45:19.540 but it would be interesting to see how much you lose

00:45:19.540 --> 00:45:20.523 and sort of,

00:45:22.151 --> 00:45:25.500 sort of cross validated predictability

00:45:25.500 --> 00:45:29.570 by adding in priors, as opposed to just using the data

00:45:29.570 --> 00:45:31.840 itself in a very simple model.

00:45:31.840 --> 00:45:33.198 - Right, so--

00:45:33.198 --> 00:45:34.307 - I don't know if you know the answer to that or not

00:45:34.307 --> 00:45:37.030 but you should probably go on and I know other people

00:45:37.030 --> 00:45:39.683 are wanting you to go on and not spend time answering

00:45:39.683 --> 00:45:42.170 a lot of individual questions and we can always

00:45:42.170 --> 00:45:43.650 talk another time.

00:45:43.650 --> 00:45:44.673 - Okay, sounds good.

00:45:45.690 --> 00:45:49.070 The model fits pretty well, fits observe data pretty well.

00:45:49.070 --> 00:45:51.360 Here, I'm showing projections that start on March 1st,

00:45:51.360 --> 00:45:53.820 rather than at the current day or any intermediate day,

00:45:53.820 --> 00:45:56.660 just to emphasize that

00:45:58.360 --> 00:46:00.390 model projections and uncertainty intervals here,

00:46:00.390 --> 00:46:04.320 which are point-wise 95%, I call it--

00:46:04.320 --> 00:46:06.720 They are not proper confidence intervals.

00:46:06.720 --> 00:46:09.540 They're point-wise projections from draws,

00:46:09.540 --> 00:46:12.210 using draws of parameters and initial conditions

00:46:12.210 --> 00:46:15.240 from the posterior distribution over those quantities.

00:46:15.240 --> 00:46:17.890 They're not confidence intervals in the strict sense.

00:46:18.800 --> 00:46:22.200 But they do appear to

00:46:22.200 --> 00:46:24.563 match observed data quite well.

00:46:25.720 --> 00:46:28.510 So I think we're capturing dynamics that govern

00:46:28.510 --> 00:46:30.280 what has occurred already.

00:46:30.280 --> 00:46:33.620 We can learn quite a lot about the transmission rate

00:46:33.620 --> 00:46:36.590 and under historical circumstances because we know

00:46:36.590 --> 00:46:38.700 when those circumstances changed.

00:46:38.700 --> 00:46:40.610 So we can estimate for example,

00:46:40.610 --> 00:46:44.560 the percent decrease in transmission in Connecticut

00:46:44.560 --> 00:46:47.750 following closure of schools and implementation

00:46:47.750 --> 00:46:49.550 of the stay at home order.

00:46:49.550 --> 00:46:50.930 That is what causes actually,

00:46:50.930 --> 00:46:53.830 this downturn in hospitalizations and flattening

00:46:53.830 --> 00:46:56.003 of cumulative deaths in the state.

00:46:58.000 --> 00:47:00.630 So here, just to get a little bit more concrete,

00:47:00.630 --> 00:47:04.270 on the upper left-hand corner, we see what we call

00:47:05.253 --> 00:47:06.300 the contact intervention.

00:47:06.300 --> 00:47:10.220 This is a function that multiples that transmission rate

00:47:10.220 --> 00:47:12.170 parameter that we were discussing.

00:47:12.170 --> 00:47:14.770 So in early March, schools are closed,

00:47:14.770 --> 00:47:16.210 people start staying home

00:47:16.210 --> 00:47:19.150 and so this intervention drops down.

00:47:19.150 --> 00:47:22.700 The level to which it drops is a little more,

00:47:22.700 --> 00:47:27.700 it drops more than 85%, I think, or somewhere around 85%.

00:47:27.750 --> 00:47:30.210 That is an estimated quantity.

00:47:30.210 --> 00:47:33.890 So the drops in historical contact are estimated

00:47:35.130 --> 00:47:39.300 based on the changes in hospitalizations and deaths

00:47:39.300 --> 00:47:42.190 and the implied changes in new infections.

00:47:42.190 --> 00:47:43.950 Then what happens after the dotted line,

00:47:43.950 --> 00:47:48.680 that is after May 20th, this is just a scenario

00:47:48.680 --> 00:47:52.760 in which the amount of contact between individuals

00:47:52.760 --> 00:47:57.180 increases at, I think here, monthly intervals by 10%

00:47:57.180 --> 00:48:00.150 of the suppressed latent contact.

00:48:00.150 --> 00:48:05.150 Under this historical and hypothetical future scenario,

00:48:06.840 --> 00:48:10.940 we see cumulative incidence in the upper right-hand corner,

00:48:10.940 --> 00:48:13.283 projected from March 1st onward.

00:48:14.450 --> 00:48:17.390 Hospitalizations, with the dashed line,

00:48:17.390 --> 00:48:21.203 showing expanded hospital capacity in Connecticut.

00:48:27.230 --> 00:48:30.540 We see projections of deaths under this scenario,

00:48:30.540 --> 00:48:33.640 cumulative incidence as a proportion of the population size

00:48:33.640 --> 00:48:35.460 among people who are alive.

00:48:35.460 --> 00:48:37.480 So this is what you would get if you conducted

00:48:37.480 --> 00:48:39.430 a seroprevalence study in the future.

00:48:39.430 --> 00:48:42.310 We hope this is useful for planning those types of studies,

00:48:42.310 --> 00:48:45.930 and estimates of the affective reproduction number

00:48:45.930 --> 00:48:47.970 in Connecticut over time.

00:48:47.970 --> 00:48:52.970 There are two scenarios in particular that we want to show

00:48:53.550 --> 00:48:56.960 policy makers that correspond to slow and fast reopening.

00:48:56.960 --> 00:48:59.050 Really, this is not reopening scenarios.

00:48:59.050 --> 00:49:02.780 I'm not sure what happened with this green annotation.

00:49:02.780 --> 00:49:03.990 I don't know if you can see it.

00:49:03.990 --> 00:49:08.960 If I did that or somebody else did, but just ignore that.

00:49:08.960 --> 00:49:10.710 I'm not sure where it came from.

00:49:10.710 --> 00:49:13.320 Under slow reopening, we imagine that people

00:49:15.764 --> 00:49:19.060 release 10% of their latent suppressed contact

00:49:19.060 --> 00:49:22.020 every month and under a scenario like this,

00:49:22.020 --> 00:49:24.170 where everybody keeps distancing and everything goes

00:49:24.170 --> 00:49:29.170 very well in the state, new infections continue their drop

00:49:29.360 --> 00:49:32.190 and rise very slowly into the late summer and fall,

00:49:32.190 --> 00:49:34.853 hospitalization stays low throughout the summer.

00:49:38.580 --> 00:49:42.150 Deaths sort of begin to plateau and do not rise above

00:49:43.165 --> 00:49:45.733 10,000 by the end of the summer.

00:49:47.570 --> 00:49:49.820 Right, so this is the scenario that the state

00:49:49.820 --> 00:49:50.980 is really hoping for.

00:49:50.980 --> 00:49:54.780 It's a slow reopening that does not substantially increase

00:49:54.780 --> 00:49:57.390 new infections with very slow rise

00:49:59.137 --> 00:50:01.960 in new infections as the state reopens.

00:50:01.960 --> 00:50:04.672 In contrast, a more pessimistic scenario,

00:50:04.672 --> 00:50:06.750 which I think corresponds more to

00:50:11.784 --> 00:50:16.620 a fast reopening, is one in which contact increases by 10%

00:50:16.620 --> 00:50:21.620 or 10% of suppressed contact is released every two weeks.

00:50:22.060 --> 00:50:26.190 This results in a very fast resurgence of new cases,

00:50:26.190 --> 00:50:28.950 new hospitalizations and deaths by the end of the summer.

00:50:28.950 --> 00:50:31.200 This is what the governor would like to avoid

00:50:33.060 --> 00:50:34.200 when school children are scheduled

00:50:34.200 --> 00:50:36.183 to go back to school in the fall.

00:50:40.350 --> 00:50:42.380 There is a lot of interest right now in seroprevalence

00:50:42.380 --> 00:50:44.930 because of competing claims about herd immunity

00:50:44.930 --> 00:50:47.448 and how many people have been already infected

00:50:47.448 --> 00:50:50.200 and have evidence of prior infection.

00:50:50.200 --> 00:50:52.880 Under these scenarios, we can produce projections

00:50:52.880 --> 00:50:56.330 of the proportion of people in a random sample

00:50:56.330 --> 00:51:01.060 in the state, who might have evidence of prior infection.

00:51:01.060 --> 00:51:03.660 So this is very important for designing seroprevalence

00:51:03.660 --> 00:51:07.063 studies that we can use to further calibrate these models

00:51:07.063 --> 00:51:09.803 and that can be used to guide policy.

00:51:13.610 --> 00:51:17.270 I'm going to try to finish up very quickly here.

00:51:17.270 --> 00:51:18.820 There are a couple of key messages from this work

00:51:18.820 --> 00:51:20.810 that we tried to convey to policy makers.

00:51:20.810 --> 00:51:23.400 The first is that the state is doing pretty well,

00:51:23.400 --> 00:51:26.160 in terms of suppression of contact, closure of schools

00:51:26.160 --> 00:51:28.170 and the stay at home order have effectively reduce

00:51:28.170 --> 00:51:32.370 transmission and hospitalizations in Connecticut.

00:51:32.370 --> 00:51:35.500 If contact increases quickly, the state's at serious risk

00:51:36.684 --> 00:51:39.950 of big resurgence by later summer 2020.

00:51:39.950 --> 00:51:42.430 Real time metrics that policy makers have access to

00:51:42.430 --> 00:51:46.470 are really not going to serve as an early warning system

00:51:46.470 --> 00:51:47.663 for that resurgence.

00:51:48.560 --> 00:51:53.240 The state probably needs to be evaluating future projections

00:51:53.240 --> 00:51:56.163 under realistic contact scenarios for the state.

00:51:57.410 --> 00:52:00.850 We still have a lot of uncertainty that we tried to capture

00:52:00.850 --> 00:52:04.490 in model projections about cumulative incidence,

00:52:04.490 --> 00:52:06.290 asymptomatic fraction,

00:52:06.290 --> 00:52:09.600 how things are going to go with children,

00:52:09.600 --> 00:52:13.350 the effects of enhanced testing and contact tracing

00:52:13.350 --> 00:52:16.463 and how contact patterns may change following reopening.

00:52:18.450 --> 00:52:22.100 So we are issuing a series of reports, which you can read

00:52:22.100 --> 00:52:24.970 online and we will be updating them in real time

00:52:26.942 --> 00:52:27.775 as the summer goes on.

00:52:27.775 --> 00:52:29.170 You can find them at this URL.

00:52:29.170 --> 00:52:32.270 You can also email me and I'll point you to them.

00:52:33.690 --> 00:52:36.037 These are sort of continuously updated research products

00:52:36.037 --> 00:52:38.080 and I hope that they will represent

00:52:38.080 --> 00:52:40.410 the latest information from Connecticut

00:52:40.410 --> 00:52:43.893 and our latest predictions for the state as it reopens.

00:52:45.000 --> 00:52:46.910 Also, there's a document here which summarizes

00:52:46.910 --> 00:52:49.960 much more detail about the transmission model

00:52:49.960 --> 00:52:52.660 that I have given here in this presentation.

00:52:52.660 --> 00:52:56.140 I'm gonna skip over this stuff about our workflow.

00:52:56.140 --> 00:52:58.890 We can talk about it later, if anybody is interested,

00:52:58.890 --> 00:53:02.670 but this is just how we transition from regular research

00:53:02.670 --> 00:53:06.283 to doing this type of very active software development.

00:53:07.170 --> 00:53:08.003 I will end here.

00:53:08.003 --> 00:53:10.780 I want to thank all of the people in the group

00:53:10.780 --> 00:53:12.990 and beyond, who have been working on this tirelessly

00:53:12.990 --> 00:53:15.080 over the last couple of months.

00:53:15.080 --> 00:53:16.690 All of the products that I've told you about

00:53:16.690 --> 00:53:17.630 are publicly available.

00:53:17.630 --> 00:53:20.510 You can find the source code on Git

00:53:20.510 --> 00:53:24.360 on our Git repositories and you can find the web application

00:53:24.360 --> 00:53:26.600 and the reports online as well.

00:53:26.600 --> 00:53:29.440 So I'd be happy to take any questions.

00:53:29.440 --> 00:53:31.870 - Thanks, thanks Forrest for the last part.

00:53:31.870 --> 00:53:36.870 I think some people have some questions using the chat box.

00:53:38.560 --> 00:53:42.737 Ken asked, "Is the model used at currently proposing

00:53:42.737 --> 00:53:45.787 "used at hospital or by your medical group?"

00:53:50.372 --> 00:53:51.900 - The ICU planning app

00:53:52.810 --> 00:53:55.620 has been used, we know, and possibly is being used

00:53:55.620 --> 00:53:57.540 at Yale New Haven Hospital.

00:53:57.540 --> 00:54:01.400 The projections for Connecticut are not intended for use

00:54:01.400 --> 00:54:03.110 in any particular hospital systems,

00:54:03.110 --> 00:54:05.220 though I think they will be of interest

00:54:05.220 --> 00:54:09.560 to leaders of systems who are planning to accommodate

00:54:09.560 --> 00:54:12.150 a potential second wave of infections

00:54:12.150 --> 00:54:14.700 as it might occur later in the summer.

00:54:14.700 --> 00:54:17.920 I hope that as we get farther in the summer,

00:54:17.920 --> 00:54:20.670 if there is a second wave that appears to be coming,

00:54:20.670 --> 00:54:23.180 that the projections will be useful in planning

00:54:23.180 --> 00:54:27.210 capacity expansion efforts, possibly at or beyond levels

00:54:27.210 --> 00:54:30.760 that we already saw in April.

00:54:30.760 --> 00:54:33.240 So we will be generating any information

00:54:33.240 --> 00:54:36.520 that decision makers at those hospital systems

00:54:36.520 --> 00:54:39.770 think would be useful as they plan their response.

00:54:39.770 --> 00:54:40.953 That's a great question.

00:54:42.260 --> 00:54:43.330 - Thanks.

00:54:43.330 --> 00:54:44.250 And...

00:54:48.990 --> 00:54:52.663 Let me see and Sherry asked,

00:54:54.597 --> 00:54:57.637 "In the first reopening model, what amount was the reopening

00:54:57.637 --> 00:54:59.147 "assumed to start in?"

00:55:00.540 --> 00:55:02.510 - Exactly on May 20th,

00:55:02.510 --> 00:55:07.283 which is when the governor began the process of reopening.

00:55:08.240 --> 00:55:10.800 It is also true that the governor has been

00:55:12.680 --> 00:55:15.230 giving information about potential reopening plans

00:55:15.230 --> 00:55:16.810 for a very long time

00:55:16.810 --> 00:55:19.190 and that there is some change in contact as people

00:55:19.190 --> 00:55:23.410 begin to anticipate those changes in policy.

00:55:23.410 --> 00:55:27.580 I think that if you are looking at human mobility data

00:55:27.580 --> 00:55:30.810 from cell phones and other sources,

00:55:30.810 --> 00:55:33.380 you will see that people have been moving around

00:55:33.380 --> 00:55:36.060 for a while, increasing their level of activity

00:55:36.060 --> 00:55:40.610 outside of the home, even before May 20th in Connecticut.

00:55:40.610 --> 00:55:42.310 Whether that has actually resulted

00:55:45.778 --> 00:55:49.520 in a substantial increase in transmission remains to be seen

00:55:49.520 --> 00:55:51.660 but I don't think we should assume that just because

00:55:51.660 --> 00:55:54.030 people are moving around and possibly returning

00:55:54.030 --> 00:55:57.870 to some types of work that there will be a corresponding

00:55:57.870 --> 00:55:59.123 increase in transmission.

00:56:02.157 --> 00:56:03.490 - Okay thanks.

00:56:03.490 --> 00:56:06.787 Daniel asks, "Is the increase in incidence starting

00:56:06.787 --> 00:56:11.787 "in September a cumulative effect of prolonged increase

00:56:14.372 --> 00:56:15.351 "in contact."

00:56:15.351 --> 00:56:16.184 - Can I just ask the question directly?

00:56:16.184 --> 00:56:18.190 So I'm wondering, in the parts where you're showing

00:56:18.190 --> 00:56:21.410 the two reopening models, it looked like the curve

00:56:21.410 --> 00:56:23.030 starts to go back up around August,

00:56:23.030 --> 00:56:25.020 September in the slow one.

00:56:25.020 --> 00:56:27.670 I'm wondering if that's because you reach a threshold

00:56:27.670 --> 00:56:29.800 above a certain percentage of contact

00:56:29.800 --> 00:56:32.030 or if it's a cumulative effect?

00:56:32.030 --> 00:56:35.580 Like, if we were to keep contact at .2 for example,

00:56:35.580 --> 00:56:38.780 throughout all of this time and it weren't to increase

00:56:38.780 --> 00:56:42.370 above a threshold, is there a situation which you don't see

00:56:42.370 --> 00:56:44.730 that tail come up again?

00:56:44.730 --> 00:56:46.617 - Yes, great question.

00:56:46.617 --> 00:56:48.620 If you like to think in terms of the effective

00:56:48.620 --> 00:56:51.710 reproduction number, this increase just corresponds

00:56:51.710 --> 00:56:54.610 to a time about three weeks after

00:56:54.610 --> 00:56:56.223 that number goes above one.

00:56:57.850 --> 00:57:00.480 So there is a threshold effect and to answer your question,

00:57:00.480 --> 00:57:05.480 if contact were to remain below a level

00:57:05.650 --> 00:57:08.140 that would give that value of one,

00:57:08.140 --> 00:57:11.410 then you would not see this type of resurgence.

00:57:11.410 --> 00:57:14.320 I think as a practical matter, it is very unlikely

00:57:14.320 --> 00:57:17.310 that the state can avoid a situation where the effective

00:57:17.310 --> 00:57:19.393 reproduction number does above one.

00:57:21.380 --> 00:57:23.820 I think this is not the stated strategy of anyone

00:57:23.820 --> 00:57:27.370 and it's probably not, but I think it is the realistic

00:57:29.370 --> 00:57:32.180 expectation about what will happen in reality.

00:57:32.180 --> 00:57:34.900 The reality is that the state is going to try very hard

00:57:34.900 --> 00:57:39.220 to increase a level of contact just about to that level,

00:57:39.220 --> 00:57:41.060 where they would see some local outbreaks

00:57:41.060 --> 00:57:45.484 that can be extinguished but they will try to maximize

00:57:45.484 --> 00:57:48.810 the level of contact, meaning economic activity

00:57:48.810 --> 00:57:50.300 and social mobility

00:57:53.390 --> 00:57:54.450 that the state can achieve.

00:57:54.450 --> 00:57:57.010 So they'll try to get as much economic productivity

00:57:57.010 --> 00:58:01.550 and contact as they can without causing resurgence

00:58:03.402 --> 00:58:06.113 or large outbreak or an overrun of hospital capacity.

00:58:08.080 --> 00:58:09.470 - Thank you.

00:58:09.470 --> 00:58:10.303 - Thanks.

00:58:12.003 --> 00:58:14.520 - Akil here have two questions.

00:58:14.520 --> 00:58:16.750 So the first one is are there any assumptions

00:58:16.750 --> 00:58:18.950 of the proposed population who have Covid-19

00:58:20.200 --> 00:58:21.853 but have not been tested?

00:58:23.950 --> 00:58:26.270 - There are implicit and explicit assumptions

00:58:26.270 --> 00:58:27.403 about that proportion.

00:58:28.480 --> 00:58:30.750 I think we can produce predictions

00:58:30.750 --> 00:58:35.580 for the current prevalence and also cumulative incidence

00:58:37.050 --> 00:58:39.490 but those predictions depend quite a lot on our prior

00:58:39.490 --> 00:58:42.923 assumptions about the asymptomatic faction.

00:58:43.920 --> 00:58:47.600 We don't have very precise information about how many

00:58:47.600 --> 00:58:50.600 or what proportion of infections are totally asymptomatic

00:58:50.600 --> 00:58:53.000 and would go undetected by the healthcare system

00:58:54.080 --> 00:58:58.280 because people don't seek testing or seek care of any kind

00:58:58.280 --> 00:58:59.780 when they're not feeling sick.

00:59:01.564 --> 00:59:03.430 So certainly, we can try to learn about those things.

00:59:03.430 --> 00:59:06.920 There's some information in the available case counts

00:59:06.920 --> 00:59:09.603 and in hospitalizations and deaths about that stuff,

00:59:12.037 --> 00:59:14.637 but we still have a lot of uncertainty about current

00:59:15.480 --> 00:59:16.540 cumulative incidence.

00:59:16.540 --> 00:59:18.460 I think it's fair to say that currently prevalence

00:59:18.460 --> 00:59:19.860 is quite low in Connecticut.

00:59:21.630 --> 00:59:22.463 - Okay thanks.

00:59:22.463 --> 00:59:25.668 I guess I saw something new saying they test the people

00:59:25.668 --> 00:59:28.663 (unclear speaking).

00:59:28.663 --> 00:59:31.857 Because they can test other people that have the ability

00:59:31.857 --> 00:59:36.857 and then they have some estimate of the asymptomatic case,

00:59:37.030 --> 00:59:38.320 the rate of them?

00:59:38.320 --> 00:59:39.667 - Yes, that's true.

00:59:40.650 --> 00:59:44.250 In some very specific settings, like institutional settings

00:59:44.250 --> 00:59:47.380 like nursing homes and correctional institutions,

00:59:47.380 --> 00:59:50.310 you can test everybody and then you can learn how many

00:59:51.470 --> 00:59:53.200 infections are asymptomatic.

00:59:53.200 --> 00:59:56.560 The question then becomes of how representative

00:59:56.560 --> 01:00:00.570 those samples are compared to the rest of the state.

01:00:00.570 --> 01:00:04.990 Is it safe to take situations where people

01:00:04.990 --> 01:00:06.690 are living in very close proximity

01:00:07.720 --> 01:00:12.720 and possibly poor health conditions and to generalize

01:00:12.720 --> 01:00:14.550 all of that information to the state?

01:00:14.550 --> 01:00:16.900 I think there is some very good anecdotal evidence

01:00:16.900 --> 01:00:18.470 from prisons, from nursing homes

01:00:18.470 --> 01:00:21.710 and also testing systematic testing of healthcare workers

01:00:22.920 --> 01:00:24.770 that we can try to take into account,

01:00:25.740 --> 01:00:28.580 but it remains unclear how generalizable

01:00:28.580 --> 01:00:29.610 that information is.

01:00:29.610 --> 01:00:33.250 For example, healthcare workers may be immunologically

01:00:33.250 --> 01:00:36.130 somewhat unlike members of the general population

01:00:36.130 --> 01:00:39.860 who are not continuously exposed to different types

01:00:39.860 --> 01:00:42.930 of illness and to coronaviruses in particular.

01:00:42.930 --> 01:00:45.420 So I would hesitate to take large screening studies

01:00:45.420 --> 01:00:48.880 of nurses for example, and apply the asymptomatic fraction

01:00:50.517 --> 01:00:53.270 or prevalence or incidence in that sample

01:00:53.270 --> 01:00:54.570 to the general population.

01:00:55.870 --> 01:00:56.703 - Thanks.

01:00:57.850 --> 01:01:02.850 And the second question of Akil is can Covid-19 models

01:01:03.310 --> 01:01:05.760 from different states learn from each other?

01:01:05.760 --> 01:01:09.660 I have relay the question is because currently your model

01:01:09.660 --> 01:01:11.307 is most about stating the data

01:01:11.307 --> 01:01:13.883 and you can validate how good the model is.

01:01:15.263 --> 01:01:18.120 Because states, maybe they have their reopening plan

01:01:18.120 --> 01:01:21.060 at different times, can this provide useful information

01:01:21.060 --> 01:01:23.670 about how good the model is by learning

01:01:23.670 --> 01:01:25.220 from different states.

01:01:25.220 --> 01:01:26.960 - Yes, great question.

01:01:26.960 --> 01:01:30.450 It is always true that information from other contexts

01:01:30.450 --> 01:01:33.250 can be very useful if you know what is different

01:01:33.250 --> 01:01:35.040 in those other contexts.

01:01:35.040 --> 01:01:37.410 I would love to be able to use more granular information

01:01:37.410 --> 01:01:39.870 from neighboring states throughout the northeast

01:01:39.870 --> 01:01:42.180 to inform projections from Connecticut,

01:01:42.180 --> 01:01:44.640 'cause as we know, Connecticut is not an island

01:01:44.640 --> 01:01:47.300 and as soon as New York opens up and people start working

01:01:47.300 --> 01:01:50.290 in New York, then everything will change quite a lot,

01:01:50.290 --> 01:01:52.043 quite quickly in Connecticut.

01:01:53.050 --> 01:01:56.010 So I would like to share information.

01:01:56.010 --> 01:01:58.350 We have focused on Connecticut here because we have very

01:01:58.350 --> 01:02:02.380 detailed information about Connecticut but no special access

01:02:02.380 --> 01:02:05.343 in Massachusetts, Rhode Island and New York.

01:02:07.130 --> 01:02:09.400 So that's why we've done it, but I think it will become

01:02:09.400 --> 01:02:12.760 very important and I always thought

01:02:12.760 --> 01:02:15.720 it would be the job of the CDC and the US

01:02:15.720 --> 01:02:18.440 to synthesize a national and local projections

01:02:18.440 --> 01:02:20.940 and to gather all the granular local information

01:02:20.940 --> 01:02:22.280 and to put it all together.

01:02:22.280 --> 01:02:25.083 That has not happened in this particular pandemic.

01:02:26.480 --> 01:02:30.505 So I think everyone else is trying to scramble

01:02:30.505 --> 01:02:32.650 to aggregate information at the right levels

01:02:32.650 --> 01:02:35.200 to produce predictions that are actionable locally.

01:02:36.640 --> 01:02:39.360 But there's not coordination right now

01:02:39.360 --> 01:02:42.040 between groups that are doing state-specific

01:02:42.040 --> 01:02:44.420 reopening plans, unfortunately.

01:02:44.420 --> 01:02:47.960 As for whether the differences or staggered reopening

01:02:47.960 --> 01:02:50.420 can be used as a kind of instrument to identify

01:02:50.420 --> 01:02:53.822 the causal effects of reopening, I assume that's the subtext

01:02:53.822 --> 01:02:57.290 of the question, the answer is yes.

01:02:57.290 --> 01:02:59.070 I think people are very interested in doing that.

01:02:59.070 --> 01:03:02.910 The problem is that reopening is somewhat endogenous.

01:03:02.910 --> 01:03:06.070 The states to reopening as a function of the conditions

01:03:06.070 --> 01:03:08.610 currently in the states and also obviously,

01:03:08.610 --> 01:03:11.580 as a function of the political considerations

01:03:11.580 --> 01:03:14.713 of the leadership and of the population.

01:03:15.830 --> 01:03:18.770 Right now I don't think it's safe to say that reopening

01:03:18.770 --> 01:03:21.830 occurs randomly in some time interval

01:03:21.830 --> 01:03:24.488 and that we can exploit that randomness in a simple way

01:03:24.488 --> 01:03:27.000 to assess the effect of reopening.

01:03:27.000 --> 01:03:29.000 Certainly, some of the states that we observe

01:03:29.000 --> 01:03:32.963 reopening quickly, take Georgia for example.

01:03:33.970 --> 01:03:36.400 Those states are likely to see at least local

01:03:36.400 --> 01:03:41.400 and possibly very broad resurgences and outbreaks

01:03:41.700 --> 01:03:45.350 that may result in reversion to more restrictive movement

01:03:45.350 --> 01:03:47.872 conditions in those states.

01:03:47.872 --> 01:03:50.180 So I think really, there's this going to be a long,

01:03:50.180 --> 01:03:52.900 longitudinal sequence of treatments,

01:03:52.900 --> 01:03:57.060 meaning changes in state regulations and then outcomes,

01:03:57.060 --> 01:03:59.560 which the regulators will observe

01:03:59.560 --> 01:04:01.260 and then this kink of cat and mouse game,

01:04:01.260 --> 01:04:06.150 where decision makers try to tamp down on local outbreaks

01:04:06.150 --> 01:04:09.003 and then respond to ones that occur in the future.

01:04:10.779 --> 01:04:12.820 So we will try to learn about the effects of all those

01:04:12.820 --> 01:04:14.670 interventions and changes in policies

01:04:16.450 --> 01:04:20.110 but I think that there is cause for some skepticism

01:04:20.110 --> 01:04:24.010 in really learning a generalizable causable effects

01:04:24.010 --> 01:04:25.310 just from the time series.

01:04:27.240 --> 01:04:28.755 - Thanks.

01:04:28.755 --> 01:04:31.405 I guess one last very specific question about a talk.

01:04:32.747 --> 01:04:35.689 So Paul asked, "Have you considered how real time data

01:04:35.689 --> 01:04:38.877 "metrics, such as oxygen sensors from fitness trackers

01:04:38.877 --> 01:04:41.230 "could effect your predictions?"

01:04:41.230 --> 01:04:44.180 - Very interested in distributed measurements

01:04:44.180 --> 01:04:46.310 at the population level that could be helpful

01:04:46.310 --> 01:04:48.720 to inform some of these things.

01:04:48.720 --> 01:04:53.090 I think that we have not yet seen widespread adoption

01:04:53.090 --> 01:04:54.780 of mobile apps

01:04:57.798 --> 01:05:00.700 for self monitoring for contact tracing.

01:05:03.980 --> 01:05:08.980 There is some adoption of thermometers and oxygen sensors

01:05:09.780 --> 01:05:11.920 but as far as I know, there are no data streams

01:05:11.920 --> 01:05:13.453 that are publicly available.

01:05:14.400 --> 01:05:17.833 - This is Paul Forcher, I asked the question.

01:05:17.833 --> 01:05:19.840 There are some, there's--

01:05:19.840 --> 01:05:22.040 I'm participating in two studies.

01:05:22.040 --> 01:05:26.450 One that's run out of by Mike Snider,

01:05:26.450 --> 01:05:29.243 who use to be at Yale who's head of Stanford Genomics.

01:05:31.050 --> 01:05:33.790 The other one's institute

01:05:33.790 --> 01:05:36.780 and any of you can sign up for these things

01:05:36.780 --> 01:05:40.870 and if you have a fitness tracker that's tracking

01:05:40.870 --> 01:05:45.600 oxygen levels, there's emerging evidence that changing

01:05:45.600 --> 01:05:49.210 oxygen levels can be predictive of Covid infection

01:05:49.210 --> 01:05:52.660 before the patients are symptomatic and there's some...

01:05:53.530 --> 01:05:56.540 So I would, those are two studies that you could

01:05:56.540 --> 01:05:58.670 connect with and I wouldn't be surprised at all

01:05:58.670 --> 01:06:00.640 if they would share all of their realtime data

01:06:00.640 --> 01:06:02.260 that they're collecting with you.

01:06:02.260 --> 01:06:04.300 - Yeah, that is a great idea, thank you.

01:06:04.300 --> 01:06:05.133 With these--

01:06:05.133 --> 01:06:08.440 - Mike Snider's a former Yale person,

01:06:08.440 --> 01:06:12.160 so you already have an inroad with that guy.

01:06:12.160 --> 01:06:14.110 - Yeah, thank you, that's a great idea.

01:06:15.170 --> 01:06:19.630 - Okay thanks, I guess that's all questions for the talk.

01:06:19.630 --> 01:06:23.033 If you have any questions, I guess they can talk to you.

01:06:23.920 --> 01:06:26.763 Like the audience can talk to Forrest offline.

01:06:27.661 --> 01:06:30.210 - Please feel free to email me, anybody who has questions.

01:06:30.210 --> 01:06:33.702 - Some people want to hear more about the talks,

01:06:33.702 --> 01:06:35.470 like you didn't have time to cover,

01:06:35.470 --> 01:06:39.580 that I guess the interest you can talk to Forrest offline.

01:06:39.580 --> 01:06:41.380 Also, this talk will be recorded

01:06:41.380 --> 01:06:43.766 and will be publicly available.

01:06:43.766 --> 01:06:47.278 Also, on the previous talk are also recorded.

01:06:47.278 --> 01:06:50.860 I'll also send out a link to everyone

01:06:50.860 --> 01:06:53.520 in the School of Public Health,

01:06:53.520 --> 01:06:56.310 so if you want you can access it.

01:06:56.310 --> 01:06:58.092 Okay thank, thanks Forrest.

01:06:58.092 --> 01:06:59.042 - Thanks everyone.

01:06:59.042 --> 01:07:01.342 - And thanks for everyone. - Thanks everyone.